Seaweed in Norway

Towards a social-ecological understanding of management and ecosystem service benefits

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Photo: Troels Rosenkrantz

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Abstract

The backdrop for this research builds on a growing momentum that appreciates nature and the environment as the very cornerstone of our existence. The study examines the recently renewed ambition to develop a Norwegian seaweed industry, with a particular urge to explore the benefits that arise when recognizing the wider social-ecological values that exist in coupled human-nature systems such as this. The social-ecological systems framework, including seven resilience-building principles, are employed to better understand how the key stakeholders embedded in the system think and act in the context of resilience. In the current state of development, seaweed is regarded primarily as a resource that can deliver food provisioning and to some extent regulating services (including nutrient uptake and climate regulation). A minority of key actors also highlight the non-instrumental value of seaweed and emphasize such social and cultural ecosystem service benefits in their approach to management. While the resilience-principles offer a strong framework and tool for analysis to highlight stakeholder priorities and objectives in this respect, the study also examines two explanatory limits of the framework to adequately address dynamics pertaining to the social realm, 1) recognizing the underlying political and power structures inherent to the system, and 2) recognizing the broader social and cultural benefits as a critical factor to further build resilience. Ensuring that ecosystem services, a critical integrator between people and nature, continue to benefit society in a diverse and inclusive manner will depend on the recognition that systems and landscapes are complex and contested. Recognizing that there exist many, sometimes contradicting, perspectives on what the system could or should offer provides compelling evidence in favor of integrating the resilience and cultural landscape approach.

Key words: seaweed, social-ecological system, resilience, ecosystem services, cultural landscape

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Abbreviations

SES: Social-ecological system

ES: Ecosystem service

IMTA: Integrated multi-trophic aquaculture

PCS: Prospective case study

CAS: Complex adaptive thinking

IPCC: Intergovernmental panel on climate change

SINTEF: *Norwegian*: Stiftelsen for Industriell og Teknisk Forskning (Foundation for Industrial and Technical Research)

MEA: Millennium Ecosystem Assessment

PEGASUS: Phycomorph European Guidelines for a Sustainable Aquaculture of Seaweeds

1 INTRODUCTION

> *"There is a shift in perspective reconnecting water governance to the life-supporting ecosystems, emphasizing the role of water as the bloodstream of the biosphere with people as embedded parts" (Folke et al. 2011).*

1.1 An Ocean of Opportunity

According to National Geographic, Norway's coastline is one of the most complex land edges on the planet (Klinkenborg 2013). With its characteristic cold, rocky and pristine waters, featuring an abundance of islands, islets, fjords and archipelagos, the coastline is also an intriguing space to consider new food resources as the population size approaches 9.7 billion by 2050 (UN 2019). The backdrop for this research builds on a growing momentum that appreciates nature and the environment as the very cornerstone of our existence. There is a particular urge to explore the benefits that arise when humans recognize the wider social-ecological values that exist in coupled human-nature systems (Folke et al. 2011).

In 2019, the Norwegian Ministry of Foreign Affairs hosted the *Our Ocean* (2019) conference with the ambition to turn scientific knowledge about the role of ocean in the fight against climate change and feeding humanity into sustainable action. The conference led to 374 new commitments, valued at an estimated USD 63 billion, aimed at tackling issues of climate change, marine pollution, sustainable fisheries, marine protected areas, and a sustainable ocean economy (Our Ocean 2019). Clean and healthy oceans provide a range of different services and are vital for our present and future generations. Humans are dependent on ecosystems, such as the ocean, to provide life-giving services, and ocean ecosystems are entirely affected by coupled human and natural systems (Biggs, Schlüter, and Schoon 2015).

The questions and objectives of this research emerge in the nexus between the call for ocean-based climate action (Our Ocean 2019), the opportunity for the ocean to provide essential services for humanity (Duarte et al. 2009) and the new social contract required for true sustainability, involving a shift in perception aimed at reconnecting people and nature as interdependent social-ecological systems (Folke et al. 2011).

1.2 Putting it to the Test: An Industry on the Rise

One recent development in Norway that puts the promise of sustainable ocean governance to the test is the development of a seaweed industry. Historically in Norway, the harvesting of wild seaweed has been exploited for commercial purposes including animal feed and raw material for alginate production (Efstathiou and Myskja 2019). In more recent years, there has been a renewed ambition in the Norwegian seaweed industry to produce high-quality and high-value products. A large amount is still being sold for feed, but now also increasingly targeting the market for direct human consumption amongst other applications. Together, the first distribution of cultivation licenses in 2014, coupled with new technologies, expected expansion in the exploitation of marine resources, and shifting trends in the way we produce and consume food, undoubtedly marks a shift in the Norwegian seaweed seascape. Both the harvesting of wild seaweed and the cultivation of seaweed play an important ecological and socioeconomic role for communities and ecosystems along the Norwegian coast.

Although Norway hosts nearly 500 different seaweed species in diverse ecosystems, only a handful of these have been exploited commercially (Stévant, Rebours, and Chapman 2017). Many native species can, however, be sustainably utilized if well managed, encouraged by a growing acceptance of seaweed as a sea vegetable as well as growing international influences in the food scene as a result of globalization (FAO 2018). Farmed or harvested seaweed, if produced sustainably and distributed locally for human or animal consumption, is in line with efforts to keep the food system within sustainable limits (Springmann et al. 2018). In addition to food, seaweed can provide an alternative source of feed, pharmaceuticals, raw materials (Abdul Khalil et al. 2017) and biofuels (Fernand et al. 2017). Working with seaweed has also demonstrated the potential to improve livelihoods for a growing population (Rebours et al. 2014). It is worth noting that seaweed cultivation does not require the standard agricultural input, such as arable farmland, water, fertilizers, and pesticides. Also significant are the positive externalities associated with seaweed in coastal ecosystems (Buschmann et al. 2017), from supporting the food web as a low trophic species to serving as habitats for wildlife and unique undersea experiences for divers.

1.2.1 Research question

Emerging industries can encourage exciting opportunities for innovation, including solutions to pressing global concerns such as climate change, as well as development in social realms

that occur in tune with the biosphere (Folke et al. 2011). It is necessary, however, to recognize how new industries can also lead to unforeseen ecological, social, and economic consequences (Cottier-Cook et al. 2016; NIVA 2019). While various regulating and provisioning ecosystem services provided by seaweed, including oxygenation and food provisioning, are well established (Buschmann et al. 2017), it remains less clear what the wider social-ecological impacts are. To contribute to this gap in the literature, my research seeks to explore how stakeholders in the emerging seaweed industry think about coupled human-nature systems in relation to resilience, and whether resilience thinking has the explanatory power to recognize wider social-ecological impacts.

Resilience describes how systems on local, regional, and global scales are able to respond and develop in the face of adversity, change, or disturbance (Biggs, Schlüter, and Schoon 2015). When we talk about future shocks and disturbances happening, it is not a question of 'if', but rather a question of 'when'. Particularly important, therefore, is fostering the ability of a system to deal with change, uncertainty and complexity on multiple levels, be it preparing a coordinated response from government authorities in the face of a pandemic, or cultivating a diversity of food crops to ensure less vulnerability to species-specific disease outbreaks, avoiding catastrophic impacts on food provisioning. Fostering resilience allows the system, which in this study is the emerging seaweed industry, to be better prepared to deal with unexpected disturbance whenever and wherever it may occur. With this in mind, the leading research question asks:

> *"How do stakeholder objectives and priorities in the Norwegian seaweed industry reflect social-ecological resilience thinking, and what is the impact of these objectives and priorities upon the delivery of ecosystem services?"*

To answer this question I employ the social-ecological systems (SES) framework, which rests on the assumption that "there are no ecosystems without people and no human development without support from the biosphere, hence, social-ecological systems" (Biggs, Schlüter, and Schoon 2015, xix). Understanding how industry stakeholders think and act, guided by key resilience-building principles, can provide guidance to tackle a major challenge of the 21st century: "ensuring an adequate and reliable flow of essential ecosystem services to meet the needs of the world's burgeoning and increasingly wealthy population" (Biggs, Schlüter, and Schoon 2015, 1). This includes exploring what dynamics, or lack thereof, are likely to foster or compromise resilience. Although seaweed remains a niche subject matter in Norway, a

small but growing community have made significant advances to highlight its untapped potential (Stévant, Rebours, and Chapman 2017; Rebours et al. 2014). To complement these efforts, resilience thinking can be a valuable asset to reflect on interrelated social, economic, and environmental impacts resulting from the emergence of a new marine industry.

1.2.2 Aims and objectives: broadening values to foster resilience

Promoting resilient systems can seem like a daunting task, as the resilience of a system can never be understood in its entirety. However, a growing research community is working on deconstructing how humans and nature can deal with shocks and disturbances proactively so that it may lead to renewal and innovation (Biggs, Schlüter, and Schoon 2015; Folke et al. 2011). The Stockholm Resilience Center (2020, n.p.) describe three major factors at the core of resilience thinking: 1) the interdependencies between people and ecosystems, 2) the acceleration of human development and unprecedented global transformations, and 3) "the paradox that the innovative capacity that has put us in the current environmental predicament can also be used to push us out of it". Building on this understanding, Biggs, Schlüter, and Schoon (2015) have come up with seven adaptable principles that can be used both to analyze and foster resilience. These seven principles, described in detail in chapter 3 after a brief background chapter (chapter 2), have guided this research from the methods to the analysis.

The first aim of this thesis is to ask how and why industry stakeholders make and respond to decisions concerning the management of the industry and associated ecosystem services. Understanding what factors limit and what factors foster resilience in a social-ecological system is complex. Yet, the combined decisions taken by key stakeholders – in this study being producers, managers, and policy-makers – within the systems are one important driver. In chapter 4 I outline the methodological approach I have taken to collect an impression of these stakeholder objectives and priorities, including how my role as a researcher and as an 'insider' has shaped this process. The expectation is to assemble a snapshot of current management practices and prospects for seaweed production in Norway, according to the producers and experts at the forefront. The developing seaweed industry has been praised for its potential ability to provide ecosystem service benefits, and the resilience-building principles can serve as a useful tool to clarify the parameters of these benefits while strengthening social-ecological insights. These findings and reflections will make up the substance of chapter 5.

The notion of what the sustainable success of the industry entails, however, is not straightforward; while the provisioning services, including food provisioning and economic benefits, that have been attributed to seaweed capture and culture are well documented and increasingly valued, other services, and particularly socio-cultural benefits, remain less clear. According to Rodriguez et al. (2006, cited in Biggs, Schlüter, and Schoon 2015, 40) "human preferences often prioritize provisioning services over regulating services, and both of these are prioritized over cultural and supporting services". A broadened understanding of the values and benefits that a seaweed industry can offer, as well as the social and political dynamics that exist in a cultural landscape and potentially impact the delivery of these services, remains unresearched (Plieninger and Bieling 2012). Characterization and recognition of such dynamics could in itself be a means to foster resilience within the system and will be the subject of chapter 6, before offering some concluding remarks in chapter 7.

2 BACKGROUND

In this background chapter, I begin by describing the cultural landscape of Norway and why it is important to appreciate the role of the ocean in providing essential ecosystem services. As the primary focus of the seaweed industry at this stage of development is food for human consumption, I then contextualize the significance and emerging demand for lower-trophic and more plant-based species in Norway in section 2.2. In the last section (2.3) I provide some background on what seaweed is, including how it is used in the global context, followed by an overview of the current status and bottlenecks regarding production and utilization of seaweed in Norway.

2.1 The Cultural Landscape: Recognizing Human-Shaped Environments

Traveling through Norway, you are likely to reminisce over its unique landscapes: deep fjords, towering mountains, dancing northern lights, and dense forest sceneries. The words 'raw' and 'untouched' are often used to describe these landscapes. Yet, virtually every feature is the cumulative result of many small and large interactions between humans and the environment. Norway's inhabitants have shaped these landscapes in numerous ways, and the landscapes have in turn shaped the culture, values, and traditions of Norwegian people and ecosystems. These social and natural features embody a relationship between humans and nature that has evolved over centuries and continues to evolve today (Plieninger and Bieling 2012). The underpinning of my conceptual framework (chapter 3) is viewing the landscape, or in this case study the seaweed seascape, as a coupled social-ecological system.

Grimseth (1998) credits the national romantics for the creation of a Norwegian national identity, where the farming people have become the ideal of The Norwegian Landscape. Indeed, "the Norwegian farmer is the steward of a cultural landscape shaped by generations of use" (Regjeringen.no 2014, n.p.). Painters and scientists, Grimseth (1998, 140) adds, "began the aesthetic and moral construction of a national identity built on the studies of landscapes, folk-tales, customs and language of rural Norway". Vast areas now transformed into livestock husbandry and crop cultivation continue to serve as a reminder of the archetypal Norwegian farmer. The conception of *roots* is recognized as vital for the feeling of identity; "the national

romantics constructed a new way of thinking, feeling, perceiving and dreaming – a book of the nature of man, identity, culture, landscape and nature" (Grimseth 1998, 140).

Yet, so much of the Norwegian identity is also the product of a relationship between the people and the vast seas. The abundance of islands, archipelagos, fjords, glaciers, and fishing villages are equally central to the history and culture of Norwegian society and Norwegian landscapes. The borders of Norway encompass six times as much ocean compared to land areas, and around 80% of the population live less than 10 km from the coastline (Directorate of Fisheries 2016). Additionally, considering that 99% of all habitat on earth is found under the sea (Dipper, Dando, and Carwardine 2016), this 'hidden' abundance of life must be recognized in what can be viewed as the cultural landscape of Norway. Still, the role of the ocean in providing life-supporting ecosystem services is less recognized relative to terrestrial counterparts (Townsend et al. 2018).

2.2 Reimagining the Food System

Based on multiple sources of evidence, producing seaweed for direct human consumption was the market that the overwhelming majority of stakeholders were engaged in at the time the study was being carried out. For example, at a participatory stakeholder workshop I attended with over 30 experts across the value chain, it was unanimously agreed upon that food and to a lesser extent feed are the highest value markets with the greatest potential when considering the current state of the industry. There is still a long way to go before seaweed is recognized as a common ingredient in cooking here in Norway. Except for select markets, specifically high-end restaurants, the sale and use of seaweed as food is minimal compared to other countries. Yet, as will become evident when I present my findings, contemporary 'trends' regarding food sustainability have opened a particularly significant window of opportunity for the industry to re-emerge in recent years. As the food application is central to the development of the industry, I contextualize the importance and emerging demand for a more sustainable food system next.

The *Our Ocean* (2019, 4) committee recognizes that "unsustainable practices that are resulting in climate change, pollution, and loss of biodiversity make it a matter of urgency to find ways of improving our stewardship of the oceans and ensure their sustainable use for the benefit of current and future generations". Amongst other things, the sustainable use of the ocean includes examining how the ocean can help feed humanity (Duarte et al. 2009). Indeed,

two of the most pressing challenges on the current global agenda are feeding a population expected to reach 9.7 billion by 2050 (UN 2019) and strengthening the global response to the threat of climate change (IPCC 2018). However, there is some disagreement regarding what food provision for a healthy population and a healthy planet entails.

Efforts to transform the current food sector must consider the environmental costs and environmental limits to a much larger extent than is currently done. These interconnected concerns embodied by the Sustainable Development Goals have encouraged a growing body of research to highlight the options for a sustainable food system kept within environmental limits (Springmann et al. 2018; Willett et al. 2019; Poore and Nemecek 2018). The transition towards consuming a greater proportion of healthy and sustainable plant-based foods is no longer a 'green' trend, but a necessary step to mitigate irreversible environmental degradation. Poore and Nemecek (2018, 987) declare that "impacts of the lowest-impact animal products typically exceed those of vegetable substitutes, providing new evidence for the importance of dietary change". Similarly, Springmann et al. (2018) confirm that a more plant-based diet scenario could reduce GHG emissions and other environmental impacts significantly more than a medium-ambition change, and will be necessary to reach the 1.5°C target (IPCC 2018).

As important as the debate around food consumption and climate change is, the issue of overproduction of meat and food more generally has also gained increased attention in Norway in the last years. Norway produces over 350 000 tonnes of meat every year for human consumption (SSB 2019a). Cattle, considered to have the biggest effect on climate change, increased by 4.9% from 2017 to 2018 (SSB 2019a). One of the arguments often brought up in public debates regarding why Norway does, and should, continue to produce animal-based products at such high rates is that the best way to contribute to a sustainable food system is by using the local land resources that are available while also maintaining the cultural landscape through grazing and haying (Øpstad, Sturite, and Riley 2019).

Additionally, one argument against producing more plant-based crops on Norwegian soil is that there is not enough arable land suitable for this kind of production. Norway is often regarded as a grass and pasture land, building on the cultural narrative described in the previous section, and it is claimed that only grazing animals can convert these resources into food (Øpstad, Sturite, and Riley 2019). However, others disagree, stating that if we use the arable land we have left to produce more plant-based food that is better for population health and for the planet, we can increase the degree of self-sufficiency in Norway from 50% to 80%

(Vangelsten 2018). This is partly due to the alarming fact that 90% of farmland is currently used to feed livestock, while only 10% is used to grow food crops for human consumption (Vangelsten 2018). FoodProFuture, hosted by the Norwegian University of Life Sciences, is one of few current projects exploring the wider possibilities for cultivating protein sources from Norwegian-grown plants, mainly peas and beans (Nofima 2018). Nevertheless, producing enough food to sustain Norway's population in a country with a cold climate and primarily rocky, mountainous landscapes is a legitimate concern. This brings me back to the role of the ocean.

While farmed fish has contributed significantly to food provisioning nationally and internationally, intensive aquaculture is also associated with environmental concerns such as pollution and genetic contamination (Taranger et al. 2015). Beyond fish aquaculture, regular fishing activities have also been an important contributor to the nutritional status of the country. However, the role of lower-trophic species in contributing to a more sustainable food system is now being increasingly recognized (Havforskningsinstituttet 2019). The demand for lower-trophic species, and more plant-based foods in particular, is increasing and will demand policies aimed at "providing incentives for primary producers to produce nutritious plant-based foods, focusing investments in agricultural research on identifying pathways for increasing nutrition and sustainability or developing programs to support diverse and environmentally sustainable production systems" (Willett et al. 2019, 480). New business opportunities and production systems will emerge to meet this demand (MEA 2005a), requiring renewed assessments of emerging and interconnected environmental, economic, and social impacts.

2.3 Seaweeds and Their Role in Globally Changing Environments

Seaweed is increasingly recognized as a valuable resource in Norway and has indeed inspired new business opportunities and production systems. Yet, most people in Norway do not think about seaweed in their day-to-day lives. Compared to land plants, the general population knows very little about seaweed, including where and how it grows, or what shapes and colors are common. People are not accustomed to paying attention to the details of life beneath the surface. In comparison, knowledge about terrestrial plant species is often absorbed through direct sensory contact, particularly visually, and the ability to differentiate between, say, a bush and a tree is rarely questioned.

Figure 1: Kelp forest in Træna, Norway. Photo: Troels Rosenkrantz

When it comes to seaweed, and most other creatures and species that live and grow below the surface, there are few things that are considered 'common knowledge'. The connotation of the word sea*weed* in itself implies an understanding that is misleading and says something about our relationship to these aquatic species. Weeds are generally viewed as a nuisance and tend to grow uncontrollably and often in the 'wrong' places, although many would also disagree with this outlook. Seaweeds, however, are a collection of highly beneficial and important species for both local and global ecosystems (Israel, Einav, and Seckbach 2010), and provide a range of benefits for humans as well, which I outline in the coming section.

Seaweed is the common name for a broad range of plants and algae that grow in water, including in rivers, lakes, and at all depths of the ocean. In contrast to seagrass, which are flowering plants with roots and internal transport systems, algae have a simple holdfast and transport nutrients by diffusion. Algae are neither plants nor animals, but a third category called protists that can be both unicellular or multicellular. Thus, algae can be divided into two broad categories; microalgae, such as chlorella or spirulina, typically used to produce niche food supplements and; macroalgae, a term used to describe a wide range of species visible to the eye. Macroalgae vary dramatically in size, from larger kelps (the largest subgroup) that often grow in kelp forests in the depths of the ocean, to small and medium-sized species of red, green, brown and black algae that exist in the littoral zones or along the shorelines in every corner of the world. In this paper, as microalgae lie outside the scope of the research, I will use the term seaweed as synonymous with macroalgae species that are either cultivated or that grow in natural environments.

2.3.1 The Global Status of Seaweed Production and Utilization

Before returning to seaweed in the Norwegian landscape, it is worth briefly contextualizing seaweed production and utilization more generally. Globally, the large-scale cultivation of algae – ranging from microscopic species to giant macro kelps – for commercial purposes started gaining popularity in the mid 20th century (Trentacoste, Martinez, and Zenk 2015). Today, algaculture[1] has numerous applications, including food, feed, fertilizers, and pharmaceuticals (Buschmann et al. 2017), biofuels (Fernand et al. 2017) and other raw materials including plastic replacements (Abdul Khalil et al. 2017). In light of pressing global environmental concerns, algae are being tested for various sustainable innovations, ranging

[1] Algaculture refers to the form of aquaculture involving the farming of species of algae.

from pollution control via CO_2 fixation (Chung, Sondak, and Beardall 2017) to the production of high-capacity, energy-efficient bio-batteries (Kovalenko et al. 2011). Particularly intriguing, however, is the potential for cultivated and wild-growing seaweed to offer a partial solution in the strive towards a more sustainable food system that can meet the global, growing demand for food (Troell et al. 2014; Buschmann et al. 2017).

Indeed, global demand for algae and algae-derived foods and food products is growing (Wells et al. 2017). The global seaweed industry is worth over USD 6 billion, and an estimated 85% of total production is used for direct human consumption (FAO 2018). Asia is responsible for the vast majority of seaweed cultivation for commercial purposes, with China and Indonesia making up 87% of the total global supply (FAO 2018). This includes carrageenan extraction, which together with agar and alginates, make up close to 40% of the global market for the thickening or gelling agents used in food, also known as hydrocolloids (Ibid.). China, Japan, and Korea are also the primary consumers of seaweed, but seaweed is becoming more popular in Europe and north and south America due to the growing popularity of sushi in particular. Besides sushi, which commonly uses *nori* sheets for wrapping, common uses of seaweed in food include *kombu* as a soup stock ingredient and *wakame* as sea-vegetable in soups and salads.

There is substantial evidence to suggest that there are health benefits and high nutritional value associated with algae and algae-derived food products (Wells et al. 2017; Fleurence 2016). This includes high levels of minerals, such as calcium and magnesium (Fleurence 2016), as well as vitamins of nutritional interest, particularly B-group vitamins such as B_1 and B_{12}, A vitamins and E vitamins[2] (Wells et al. 2017). Algae has also demonstrated the potential to meet the global population's protein demand (Caporgno and Mathys 2018). In their report, Caporgno and Mathys (2018, 2) reiterate that "animal-based proteins are consumed in greater quantity than plant-based proteins; however, concerns about health and environmental issues as well as animal welfare could give a boost to plant-based sources".

Still, considering the varying nutritional value of algae across geographical regions and seasons, Wells et al. (2017) highlight the remaining challenge in quantifying the range of benefits as well as calculating the adverse effects of potential toxicants. For example, Fleurence (2016) notes that the protein content can vary from <15% of dry weight for many

[2] See Wells et al. (2017) for an extensive overview of the composition and nutritional value of seaweed.

brown seaweed species to 47% of dry weight for some red species. Caporgno and Mathys (2018) also note the inconclusive evidence on some highly specific biological activities that have previously been directly attributed to microalgae derived compounds, including antihypertensive, anticancerogenic, and anticoagulant qualities. Nevertheless, the FAO (2018) affirm that seaweed production overall plays a significant role in contributing to the nutritional status of communities and that concerns about health and environmental impact could further increase the demand for sustainable algae products.

2.3.2 Current Status of the Norwegian Industry in a European Context

Compared to the Asian market, the consumer markets for seaweed remain immature in the Nordic countries and Europe (Nikolajsen and Bech 2014). The majority of producers are still in the piloting phase of development. Seaweed exports both within and outside the EU were just over 100 000 tonnes in 2016 (FAO 2018). However, Stévant, Rebours, and Chapman (2017, 1377) note that "seaweed cultivation has been subject to increasing interest in Europe over the past decades, and activities have benefited from recent trends towards a bio-economy based on natural, and especially marine, biological resources".

Indeed, The European Commission has recognized the important role of seaweed for the blue economy in the coming years (EC 2019). Research projects such as GeniAlg and AquaVitae have recently received large amounts of funding through the EU Horizon 2022 program, and are only two of several emerging projects studying the industry's potential in Europe. The Norwegian Institute for Water Research has also recognized the prospect that seaweed can remove some of the pressure from an overloaded agriculture system (NIVA 2019).

According to SINTEF, one of Europe's largest independent research centers for applied research, technology, and innovation, Norway is in an ideal position to develop a large-scale macroalgal seaweed industry (Skjermo et al. 2014). As the export value of oil and gas is expected to decrease, development in other ocean-based value chains is also deemed necessary to maintain the current export value from ocean-based industries, which is estimated at around 70% (Almås and Ratvik 2017). The country's extensive coastline, boasting clear and cold waters, is particularly acknowledged for having the perfect conditions for production. Considered also one of the most significant unexploited biomass resources in Norway, seaweed is expected to offer a new entry into a growing global bioeconomy, which

by 2020 will have an estimated market value of $300 billion (Skjermo et al. 2014). An integrated macroalgae industry is generally a welcome and well-received development in Norway, some even claiming that "Norway might have an obligation to develop a new sustainable bio-based industry based on production, harvesting, and processing of macroalgae" (Skjermo et al. 2014, 9).

The emerging industry in Norway includes both seaweed capture and seaweed culture. Capture involves the harvesting of wild and native seaweed-species, which traditionally has been done using specifically designed trawling equipment (Stévant, Rebours, and Chapman 2017). In more recent years, however, more actors are emerging who forage wild seaweed by hand, engaging in mostly local and smaller-scale activity. Seaweed culture, on the other hand, refers to the farming or cultivation of seaweed species in a market geared towards scaling to industrial production. Stévant, Rebours, and Chapman (2017, 1377) outline the general process: “Sporelings are grown from microscopic stages i.e. zoospores or gametophytes (derived from zoospores) under controlled conditions and directly seeded onto appropriate substrata (e.g. twine, nets, ribbons, sheets) which are later on deployed at sea for further growth under natural conditions”. The benefits of capture methods include minimal impact on local biodiversity and natural habitats, although the scale is a limiting factor. With culture, the benefits include the potential for much larger production and harvest of renewable biomass as well as the potential for various environmental benefits including oxygenation and nutrient uptake (Buschmann et al. 2017).

It is interesting to consider the renewed vigor to create a market for seaweed in Norway in more recent years, considering the lack of acknowledgment on this topic just over a decade ago. Since 2008, however, the number of research projects and the number of participants involved in seaweed production has increased every year (Skjermo et al. 2014). In 2014, the first permits were granted for the commercial cultivation of macroalgae, marking the first milestone for seaweed production as a renewed industry in Norway. The same year, 54 licenses were distributed, and approximately 100 more have been distributed every year since then, although numbers have been reportedly declining in the last year. In 2017, the industry had triple the quantity and was almost four times the value estimated in 2015 (Directorate of Fisheries 2020). In 2018, Norway had 23 registered seaweed companies with 406 licenses distributed in 83 cites along the coast (Directorate of Fisheries 2020). One respondent from

my investigation claimed that there are now over 50 companies with licenses for production, although it is estimated that half of these are not in active production.

Looking more specifically at the numbers, the total quantity of kelp sold in Norway in 2017 for feed and human consumption was 149 tonnes estimated at a value of 701 000 NOK (Directorate of Fisheries 2020). One company, by the name of Ocean Forrest, was responsible for 40 tonnes of this total estimate that same year (Lerøy 2017). To put this scale into perspective, Ocean Forrest has stated that to reach industrial scale they alone need to reach at least 1000 tonnes a year (Lerøy 2017). For the Norwegian industry as a whole, the estimated production of kelp in 2050 is 20 million tonnes (NIVA 2019).

Moreover, the initial interest to commercialize production in 2014 was largely based on the potential to produce seaweed in large volumes for use as renewable biomass (Skjermo et al. 2014). In addition to the lack of input required to cultivate seaweed, their rich carbohydrate content makes the resource highly suitable for 3rd generation biofuel production (Ibid.). In more recent years, cultivating macroalgae for food has been a primary focus amongst Norwegian producers, as mentioned earlier. Seaweed Energy Solutions (SES) is one example of a company in Norway that was initially established to produce large-scale seaweed for carbon-neutral fuel, biochemicals, and feed but has more recently turned their attention to food in anticipation of market demand. Stévant, Rebours, and Chapman (2017) confirm this shift as a wider trend, stating that initial efforts to scale up seaweed production were driven by an interest in more sustainable bioenergy but that more relevant applications now include human food and animal feed. As of 2019, Seaweed Energy Solutions (SES) is running one of the largest pilot projects for sustainable food-directed seaweed farming in Europe, with a goal to increase the popularity and demand for seaweed in the food industry.

Skjermo et al. (2014, 24) predict that "as the public perception of local and sustainable food production increases, cultivated macroalgae used directly in food products may provide a significant contribution to Norwegian value creation". Indeed, the expansion of a seaweed industry in Norway offers great potential for the development of more sustainable food products to meet this demand (Skjermo et al. 2014). Before the first licenses for cultivation were distributed, there was an almost exclusive focus on the commercial harvesting of Laminaria hyperborea using trawling methods. Now, the main species of seaweed harvested and sold in Norway for food-related applications is sugar kelp (Saccharina latissima) as well as some smaller amounts of winged kelp (Alaria esculenta) (Directorate of Fisheries 2020).

Sugar kelp is one of the fastest-growing species and is associated with particularly high biomass yields and nutritional content (Stévant, Rebours, and Chapman 2017). Nonetheless, despite necessary prerequisites – including a long coastline and increased licenses for production – for commercial cultivation of seaweed in Norway being in order, seaweed farms remain scarce and unevenly scattered along the coast (Stévant, Rebours, and Chapman 2017).

2.3.3 Bottlenecks

A cluster of scientists specializing in seaweed have further supported the development of the European industry by releasing an extensive report titled PEGASUS: Phycomorph European Guidelines for a Sustainable Seaweed Aquaculture (EC 2019). The report, which was presented to the European Parliament in early 2019, is primarily focused on seaweed as food or food supplements. In addition to presenting an overview of legislation and regulations that are relevant for production, it also provides general guidelines for best practice as well as an integrated knowledge on the biology and physiology of seaweed and how this impacts both the industry and the ecosystem.

According to the PEGASUS report, "developing the sector also depends on overcoming technological, market and regulatory constraints – such as upscaling production and simplifying legal procedures" (EC 2019). The report has set out the following recommendations to overcome these bottlenecks: "1) harmonising EU regulation and simplifying procedures across Member States; 2) adopting a risk assessment approach to the cultivation of non-native species; 3) improving standardisation and traceability frameworks; 4) adapting food security monitoring programmes for seaweeds; and 5) dedicated research to support market claims" (EC 2019).

Specific to Norway, several challenges or potential bottlenecks for mainstreaming the seaweed industry have also been identified in the literature. In their report, Skjermo et al. (2014) highlight three key stakeholders whose synergy will be essential for the sustainable success of a Norwegian seaweed industry: the industry itself, responsible for high, predictable and quality production; the ecosystem, where the importance of environmental consideration and potential impact cannot be stressed enough; and the regulatory authorities, responsible for ensuring sustainability at all stages as well as managing area conflicts. Other concerns for production and commercialization that have been identified to date include seasonality, environmental interactions of seaweed cultivation, genetics, disease problems, diversification

of species, area conflicts, and lacking R&D (for a detailed overview see Skjermo et al. 2014). Current efforts to overcome some of the challenges associated with the commercialization of seaweed have been stated as "developing efficient farming strategies that reduce the need for technical maintenance, along with marine technology, including the mechanization of seedling deployment, biomass harvest, and crop handling logistics" (Stévant, Rebours, and Chapman 2017, 1375).

Lastly, one looming challenge facing seaweed production in Norway and many other parts of the world is the impact of globally changing environments, most notably rapid climate change (Stévant, Rebours, and Chapman 2017; Israel, Einav, and Seckbach 2010). This is particularly important as the pressure from human activity continues to increase. In many parts of Europe, there has been a reduction in the abundance of commercially important species, and climate change is partly to blame (EC 2019). For example, warmer water will cause a shift in harvesting season, promoting an earlier growth and maturity of the seaweeds during spring and early summer (Israel, Einav, and Seckbach 2010, 85). Changes in species and populations are predicted to have environmental and ecological impacts with regards to genetic variations and interactions between species (Evankow et al. 2019). In Norway, this has already started to affect production and harvesting season and schedules along the coast.

3 CONCEPTUAL FRAMEWORK

In the following chapter, I outline the conceptual underpinning of my study. I begin with an overview of the conceptual framework of social-ecological systems (SES) (3.1) coupled with resilience thinking (3.2) as both a framework and an analytical tool for the study of such systems. In 3.3 I then describe how I apply the chosen framework for the study at hand. In this final section, I also discuss the history and context of resilience as a concept, being mindful to draw some parameters around the use of the term, and conclude with a note on bridging the gap between SES research and social research, which is a core objective for this thesis.

3.1 The Social-Ecological System (SES)

Landscapes and ecosystems are the result of a "10 000 years love story between man and nature" (Plieninger and Bieling 2012, 3, referencing Blondel 2006), and continue to be molded by human footprints today. The idea that society and nature influence and depend on one another is not new. It is generally accepted that a traditional view of natural systems as stable and predictable is outdated (Biggs, Schlüter, and Schoon 2015). Still, a change in perception to view societies and economies as entirely integrated with the biosphere is not reflected in policy arenas or in practice if we consider how natural systems are currently managed (Folke et al. 2011). In the age of the Anthropocene, the rate and magnitude of interconnectedness and change is also higher than ever (Chapin, Kofinas, and Folke 2009). Analyzing a particular SES, a system where there is interaction between people and their environment (Chapin et al. 2009), can help create a more manageable framework for research. In this thesis, the seaweed industry as a social-ecological system, or a "coupled human and natural system" (Plieninger and Bieling 2012, 18), becomes the object of study.

Globalization dynamics have further underscored the urgency to integrate the perspective brought forward by the SES framework grounded in systems thinking (Berkes 2015). *Speed*, *scale*, and *connectivity* are keywords that demand a rethinking of approaches and collaborations towards creating a more fair and equal society (Biggs, Schlüter, and Schoon 2015, xix). In a globally interconnected world, “drivers of change like rising human numbers, urbanization, migration patterns, emerging markets, diffusion of new technologies or social innovations may combine with shocks like ecological crises, rapid shifts in fuel prices, and volatile financial markets” (Folke et al. 2011, 724). These characteristics of complex social-ecological systems highlight the challenges, but also opportunities, that an SES can offer.

Moreover, to continue to benefit from our ecosystems in a way that maintains rather than degrades the natural environment, it is necessary to adopt a more holistic, and flexible management approach. This includes recognizing that change and disturbance are inevitable and can be an opportunity for innovation, rather than being viewed as a threat or as something to be overcome (Folke et al. 2011). In this thesis, I draw from insights in the field of social-ecological systems (Berkes, Colding, and Folke 2003; Folke 2006; Chapin, Kofinas, and Folke 2009; Folke et al. 2011; Biggs, Schlüter, and Schoon 2015) to recognize and explore the development, priorities, and management objectives of an emerging seaweed industry in Norway. Again, this includes exploring how such priorities and objectives may enhance resilience – a concept which I dissect promptly in 3.2 – and the implications of this for social-ecological systems (Folke et al. 2011) and their ability to deliver life-giving services.

3.1.1 Sustaining Ecosystem Services In SES

Chapin, Kofinas, and Folke (2009, 9) detail that "[a] social-ecological system consists of physical components, including soil, water, and rocks; organisms (plants, microbes, and animals – including people); and the products of human activities, such as food, money, credit, computers, buildings, and pollution". These components interact to produce different ecosystem services (ES), which can be defined as the benefits people receive from their interaction with the environment (MEA 2005a). ES affect human life and well-being in every way, from basic needs such as food and good health, to climate regulation, healthy social relationships, and freedom of choice (MEA 2005a). Social systems depend on and are significantly influenced by such services and social systems also shape ecosystems in return.

Ocean ecosystems, including coastal environments such as natural seaweed communities, produce a combination of regulating, provisioning, and cultural services (MEA 2005b). Seaweeds can provide regulating benefits, such as water purification, flood regulation, and climate regulation (Chung, Sondak, and Beardall 2017). Provisioning services include food, shelter, clothing, medicine, and energy (Buschmann et al. 2017). Cultural services comprise tourism as well as spiritual, aesthetic, inspirational, educational, and other recreational benefits (Chung, Sondak, and Beardall 2017; Reddy 2017). Although not always included in ecosystem services assessments, supporting services such as nutrient cycling are also important as they help maintain all other services. Ecosystems can provide services on local, regional and global levels, or a combination of these.

Objectives and priorities for the future of seaweed production globally include sustaining ecosystem services (Chung, Sondak, and Beardall 2017). One of the ambitions for building resilience in an SES is also to sustain the supply and opportunities for use of ecosystem services (Biggs, Schlüter, and Schoon 2015; Chapin, Kofinas, and Folke 2009). Biggs, Schlüter, and Schoon (2015, 7) describe ecosystem services as "a critical integrator between people and nature, and a potential focus for resilience-building initiatives and SES stewardship". Ecosystem service assessment is well-recognized and has proven useful to evaluate trade-offs and priorities in interconnected social and environmental systems. This method has been used to evaluate a range of different ecosystems, including aquaculture systems around the world. However, few scholars have used this method to assess seaweed cultivation. To their knowledge, Hasselström et al. (2018) were the first to qualitatively assess ecosystem services, looking at both positive and negative impacts of seaweed cultivation.

3.2 The Conceptual Framework of Resilience

Understanding SES requires first becoming familiar with the concept of resilience. Biggs, Schlüter, and Schoon (2015, xx) define resilience in its most simple form as "having the ability to live with change, and develop with it". *Change*, *complexity*, and *uncertainty* are three keywords that underpin resilience thinking. When speaking about the resilience of an SES, this refers to the ability of the system to absorb disturbance without changing states (Gunderson 2000). Taking the example of a vulnerable global food system, Western consumption patterns are resulting in environmental pressures that are leading humankind to quickly approach the planetary boundaries for global freshwater use, arable land use and ocean acidification (Springmann et al. 2018). If these disturbances continue at the current rate, the system could risk major destabilization and loss of essential live-giving services (Ibid.).

3.2.1 Holling's 'Science of Surprise'

Considered the father of resilience research, ecologist C.S. Holling (1973) pioneered the 'science of surprise' (Stockholm Resilience Center 2019). Indeed, resilience first emerged as a descriptive concept in the field of ecology in 1973. In his influential review, Holling (1973, 17) discussed ecological theory and the behavior of natural systems to illustrate how "resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and

parameters, and still persist". Amongst other insights, he found that natural systems exhibit multiple stability domains as opposed to one stable equilibrium, and are influenced by a combination of ecological processes and random disturbances (Folke 2006). Holling (1973) understood that shifting from a focus on equilibrium states to a focus on the conditions for persistence could be valuable. The notion of adaptive cycles and panarchy are two important conceptualizations underpinning Holling's work on social-ecological resilience.

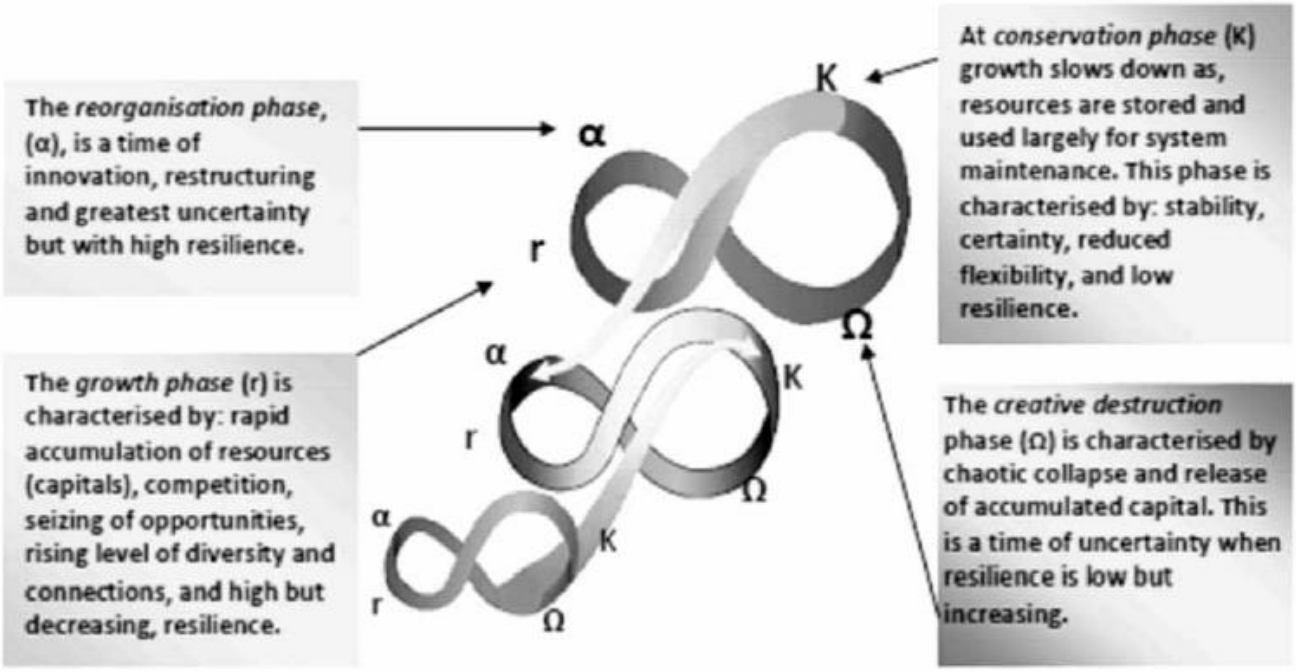

Figure 2: Adaptive cycles in a panarchy, adapted from Holling and Gunderson (2002, 34-41). (r) growth phase: rapid and cumulative, high but decreasing resilience; (k) conservation phase: slow and relatively stable as the system matures, low resilience; (Ω) release phase: chaotic collapse and uncertainty; low but increasing resilience; (α) reorganization phase: innovation and new growth/restructuring; high uncertainty and resilience.

Adaptive cycle: The structures and functions of a system change over time and the outcome can be divided into the following four characteristic phases: growth *(r),* conservation *(k),* release (Ω) and reorganization (α) (Walker et al. 2006). The first two, *r* and *k,* make up the fore loop in figure 2. The growth phase is characterized by an abundance of resources and high resilience, while the conservation phase is characterized by a decrease in net growth as the structures and interconnections within and between systems increases, resulting in higher vulnerability and a decrease in resilience as a result of disturbance. Following disturbance or shock, the system is brought into the back loop, consisting of the Ω and α phases. In the release phase, the structure consisting of accumulated resources collapses. This moves the

system into a state of reorganization, which is characterized by innovation and novelty, potentially leading to another growth phase in a new cycle. Many systems, including social-ecological systems, appear to move through the phases describes by the adaptive cycle (Walker et al. 2006).

Panarchy: The model of interlinked systems in the context of social-ecological systems is what Holling (1973) referred to as *panarchy*. The structures and functions in an SES, defined by both internal and external dynamics, vary across spatial and temporal scales (Walker et al. 2006). These structures and functions also interlink across scales, affecting the four phases described above. This means that the analysis of any one interconnection, or group of connections, is shaped by both slow or broad variables constraining fast feedback loops (hierarchical confinement) and a combination of top-down and bottom-up interactions.

Holling's conceptualization of the adaptive cycles and panarchy was first used in the modeling of boreal forests. Taking the example of a forest is a good way to see how these phases and levels are interconnected in multiple ways and across scales. For example, in the case of a forest, a tree, and a leaf, each level is subject to continuous internal change, renewal, and threshold effects. A forest may undergo deforestation or reorganization with the arrival of new animal or plant species. An individual tree, which in this analogy would represent the second adaptive cycle, will eventually decompose and reorganized with the soil. The third cycle in this analogy (see figure 2) could be a leaf, where the change in color (fast process) is one indicator of the seasonal cycle. In addition to internal changes, each cycle is subject to external factors (often slow processes) such as long periods of drought, which would affect the leaf, the tree, and the entire forest.

To summarize, an SES can be described by the adaptive cycles in a four-stage arrangement. The expansion of SES in time and space is conceptualized as the panarchy, linking cycles of the small and fast processes with large and slow processes at different scales. Berkes (2015, 72) adds that timing is a key factor in moving between phases stating that "windows of opportunity also provide pathways to innovation and adaption for the next cycle". Understanding the windows of opportunity that led to the renewed interest in seaweed as a valuable resource in Norway, for example, can be relevant to help prepare for and respond to changes further down the road. Before moving on to the methodology chapter, it is necessary to first outline how I will employ the framework of resilience for the study at hand, and the potential limitations of this approach. I also use the following section to provide some more

context around the history and social-political dimensions that underpin the resilience-building initiatives shaping this investigation.

3.3 Applicability of the Framework

In the field of ecology, resilience has been used both as a concept and as a theory to explain the behavior of natural systems as shown above. Holling (1973, 2) did remark humans in his discussion to some extent; in his own words, "as man's numbers and economic demands increase, his use of resources shifts equilibrium states and moves populations away from equilibria". Yet it was not until 30 years ago that resilience thinking was more explicitly coupled with an understanding of social determinants (Berkes 2015), and 20 years ago when the concept was adopted as a framework to study coupled human-nature systems (Colding and Barthel 2019). Thus, the emphasis on social dynamics and a qualitative perspective for resilience is relatively recent and marks a key progression in the resilience literature, particularly for the social sciences.

Carl Folke and Fikret Berkes are regarded as originators of SES research in this more recent use of the framework and are the two scholars that are most frequently cited on the topic (Colding and Barthel 2019). Amongst other important contributions, Berkes, Colding, and Folke (2003) used the SES framework to understand the adaptability of SES, which led to the initial identification of four key resilience-building principles. Biggs, Schlüter, and Schoon (2015) later expanded upon these four to produce seven key principles for building resilience, which are: 1) Maintain diversity and redundancy; 2) Manage connectivity; 3) Manage slow variables and feedbacks; 4) Foster complex adaptive systems thinking; 5) Encourage learning; 6) Broaden participation and 7) Promote polycentric governance systems. Folke also contributed to defining these seven principles, which together make up a prominent framework for the study of resilience, and which have guided my investigation from data collection to analysis. I detail each principle in turn in chapter 4.

For the study at hand, the emerging seaweed industry in Norway represents a social-ecological system shaped by interconnected social and ecological processes. I engage with resilience in this thesis as "an approach and set of assumptions for analyzing, understanding, and managing changes in SES" (Biggs, Schlüter, and Schoon 2015, 13). In other words, I use resilience both as a conceptual framework and as an analytical approach to uncover, assess,

and discuss how stakeholders understand the linkages between social and ecological dynamics of the Norwegian seaweed industry.

As a conceptual framework, a core strength of resilience is its ability to simplify the pursuit of a more general framework to understand the inherent complexity of SES (Kinzig 2012). In the context of this thesis, such an approach can facilitate the study of what actors make up the system, including the relationships that exist between these actors, and how these actors think and act with regards to the emerging industry. The application of resilience as a conceptual framework has its origins from systems approaches (Berkes 2015), whereby a system is understood to be more than the sum of its parts. Moreover, the framework views actions and outcomes as integrated across social, ecological, political, economic, and cultural domains. A resilience approach also fundamentally views humans as embedded in the biosphere, which is a core assumption underlying this research.

Resilience thinking is also increasingly being used as a tool for the analyses of SES. To answer the first part of my research question, I engage with resilience as a tool for analyses in chapter 5 to better understand how actors within the system are responding to – or engaging with – the seven resilience principles. In chapter 6 I then employ resilience as an analytical tool to assess more specifically the social factors and underlying political or power dynamics inherent to any complex system (Biggs, Schlüter, and Schoon 2015). This includes the interactions between structures, or landscapes, and stakeholders (Folke 2006). Resilience as an analytical tool is therefore different from resilience as a framework, and should not be confused with resilience as a property of SES, defined as "the capacity of social-ecological systems to produced desired sets of ecosystem services in the face of disturbance and change" (Biggs, Schlüter, and Schoon 2015, 2).

In summary, I employ resilience as a conceptual framework, using seven resilience-building principles to guide my data collection and to structure my analysis. I also engage with resilience thinking as an analytical tool to better understand how actors within the system think. Using this framework and approach to explore the fundamental links and processes in SES can provide insight into "how these systems respond to variability and change and discuss many of the ecological, economic, cultural, and institutional processes that contribute to these dynamics, enabling society to respond to and shape change" (Chapin, Kofinas, and Folke 2009, v). While this approach calls for an integration of concepts from various disciplines, it will also require establishing some parameters, which I do next.

3.3.1 Limitations and Parameters

While resilience offers a good framework to examine issues across disciplines, it has also received criticism for being overused to the point where the parameters the term first set out to create have been far transcended (Welsh 2014; Cretney 2014). Similar to buzzwords such as sustainability (Scoones 2007), this popularized term can be used in virtually every discipline to discuss essentially any topic (Park 2011). When first engaging with this field of research, I was also mindful of the term concerning SES considering its more recent and extensive use in analyzing issues in the fields of security, development, and international relations. Berkes (2015) confirms that resilience in academia today is applied across disciplines from development economics to terrorism.

However, although the arguments for using the word with caution are valid, resilience thinking does offer a chance to consider very specific matters that shape or influence a system, as long as the parameters are clearly outlined. In contrast to words like sustainability or sustainable development, I argue in line with Biggs, Schlüter, and Schoon (2015) that resilience offers a more direct link to the exploration of policy options for uncertainty and change; when we start to think about the world as complex, uncertain and in constant flux, we are encouraged to move from a linear approach based on predictive models to an approach that emphasizes dynamic, fluid and adaptive management or governance.

Still, as with all conceptual frameworks and their application in practice, social-ecological resilience falls short of expectations in more than one way (Berkes 2015, 269-270). As of yet, there is no scientific evidence to show that engaging with resilience thinking or adopting an ecosystem-based management approach has yielded its expected benefits, including “adopting a holistic view of managing resources in the context of their environment” (Ibid., 247). Since Holling’s work on boreal forests, the concept of resilience, and its application, has also evolved considerably. Worth noting is how resilience has been adopted by many researchers in more recent works, who "assign [resilience] normative content by assuming that management for resilience opens up desirable pathways for society, especially in changing environments where the future is unpredictable" (Plieninger and Bieling 2012, 19). These assumptions are necessary to highlight as they have encouraged the bulk of research done on social-ecological systems, including this study.

Yet, through my engagement with social-ecological systems I am not suggesting that any stakeholders must, or even should, have a fully contextualized understanding of how this

conceptual underpinning can lead to political implications where resilience is at stake. Rather, sharing the view of Biggs, Schlüter, and Schoon (2015, 46), “what is required is a measure of awareness and transparency regarding the political dimensions of potential ecosystem-service choices as well as potential futures for which we can build resilience”. In a web of complex SES transformations in a globalized world, rethinking assumptions while fostering awareness and transparency has the potential to enhance “the ability to exercise good judgment and make right choices in the face of imperfect knowledge” (Witoszek 2016, 148).

With this in mind, one of the real strengths that a resilience approach *does* offer is the chance to highlight how the actors who dominate the SES think and act. The hope is that such insights into the current path of development can indicate the very real but as of yet untapped benefits from viewing management and policy decisions as neither a 'one size fits all' or with a perspective of 'to each their own'. As (Kinzig 2012, 325) puts it, and to which I agree, there is often a "few sizes fit most" view in studies of SES. This outlook can also be applied in the context and development of a Norwegian seaweed industry. More than trying to inform any single approach to the management of coastal and aquatic resources in Norway, the hope is that this research can contribute important reflections that emerge with the creation of a new industry characterized by complex and interconnected landscape transformations.

Investigating how and why industry stakeholders make and respond to decisions concerning the management of ecosystem services opens up for a discussion around the priorities of the seaweed industry as an SES more generally, including how the resilience approach can be part of a larger solution, and where it may fall short. This answers to the first part of my research question. Exploring stakeholder preferences, including visions for the sustainable success of the industry, can also help uncover explicit and implicit trade-offs that result from decision making concerning ecosystem services, and under what conditions these visions may enhance or compromise the resilience of ecosystem services in SES (Biggs, Schlüter, and Schoon 2015). Discussing these potential implications answers more specifically to the second part of my central research question.

Lastly, I wish to stress that is not my aim to assess which bundle of ecosystem services or set of priorities in management are the most correct or desirable for society. As will become evident in my discussion, a ‘desired’ set of ecosystem services cannot be defined in absolute terms, as it will vary between people and places, and changes in accordance with societal preferences over time (Biggs, Schlüter, and Schoon 2015, 35). Thus, while it is not the aim

with this thesis to conduct a formal ecosystem service assessment, where the objective is typically a cost-benefit analysis (Hasselström et al. 2018), I engage with the concept as a 'critical' integrator between people and nature.

3.3.2 Bridging the Gap Between Social Research and SES Research

Resilience has been criticized for being both ahistorical and apolitical (Welsh 2014; Cretney 2014; Cote and Nightingale 2012). Although the concept has evolved since it was first introduced by Holling (1973), it originated in the field of ecology in an attempt to understand ecological processes, including the concepts of panarchy and adaptive cycles. It is from this point of departure that it is trying to understand the social dynamics that in fact dominate the system (Walker et al. 2006), which could indicate a shortcoming of the framework for research on social inquiry. There are also issues to consider as a social scientist trying to understand the forces of nature and ecological principles if the aim is to fully integrate an understanding of the social and the ecological dynamics of the system.

Yet, a core objective of this study is to contribute to the growing body of work aimed at strengthening the social analyses in resilience, which in itself is an integral component to building resilience in SES (Welsh 2014; Cretney 2014; Cote and Nightingale 2012). The framework of social-ecological systems emerged, and remains strongly grounded, in the field of ecology, which has been shown to limit the depth of social analyses in SES (Kinzig 2012). An increasing number of scholars are therefore addressing this shortcoming precisely by contributing concrete recommendations to further emphasize the social in social-ecological systems. This includes coupling the resilience framework with more socially-loaded concepts such as adaptability, defined as "the capacity of the actors in a system to manage resilience" Walker et al. (2006, 3), which I engage with in my discussion in order to more fully capture the social dynamics that impact the SES (Young et al. 2006).

Thus, addressing this potential limitation of the framework more generally, the dominant focus of my inquiry intentionally pertains to the social domain. While this is arguably contradictory to the intention of an SES as an interdisciplinary approach, the fact remains that the social analyses is lacking (Kinzig 2012). Only by addressing specific issues rooted in the social domain will it become possible to address complex social-ecological dynamics at large. For example, Cote and Nightingale (2012, 476) confirm that "critical examinations of the role of knowledge at the intersection between social and environmental dynamics helps to address

normative questions and to capture how power and competing value systems are not external to, but rather integral to the development and functioning of SES". Acknowledging this gap in the literature and conceptual framework, and appreciating the emerging efforts to address this gap, this thesis will reinforce these efforts to bring the social dynamics of the system to the forefront of the discussion.

3.4 Chapter Summary

The resilience approach offers a framework and analytical tool to understand the relationship between social systems and ecological systems. The remaining challenge, according to Beymer-Farris, Bassett, and Bryceson (2012, 286) is recognizing how these processes interact, and the implication of this for resilience and for society. Deliberating on these processes can help uncover what are often implicit assumptions in resilience thinking, such as the existence of a single desirable configuration for the system (Beymer-Farris, Bassett, and Bryceson 2012). Thus, it is not my intention to analyze the quantity or desirability of ecosystem services produced, as indeed, different SES configurations produce different services, which in turn benefit different people (Biggs, Schlüter, and Schoon 2015). Nevertheless, because human actions dominate SES (Walker et al. 2006) this research can contribute to the literature by deliberating on how stakeholders think and act, employing the resilience principles as a tool to also discuss the potential implications for resilience and society.

I would like to reiterate that resilience in this investigation is not solely concerned with the ability to absorb shocks, live with change, and persistently maintain function. This is a common assumption in the resilience literature. More relevant for this investigation is the aspect of resilience concerned with the ability to re-organize and the capacity for renewal (Folke 2006). This includes understanding how resilience and the dynamics of an SES can be used as an opportunity, opening up a space for policy-makers and other stakeholders to innovate, improve and to some extent take an active role in guiding the path of development towards a more fair and inclusive system. My investigation aims to contribute to the literature by looking more closely at the benefits of broadening our understanding of ecosystem service benefits. This includes strengthening the social analyses of what we know about how these systems do and can work, rather than making assumptions about how they should work (Kinzig 2012).

4 METHODOLOGICAL APPROACH

In this chapter, I present the methodological approach I have used to investigate the Norwegian seaweed industry. I start by outlining the qualitative lens that has led to the main empirical contributions of the research. This is followed by an overview of seven resilience-building principles that have shaped my research, from constructing my interview guide to structuring my analyses, and which inform my primary theoretical contribution. In section 4.3 I elaborate on how I have exercised this qualitative approach to achieve a modified form of deductive theory testing, also known as prospective case study design (PCS), for the social-ecological resilience framework. In the remaining sub-sections, I outline my study design, including participants and sample, followed by an outline of my data processing and analysis. I end with a reflection on positionality and insider research, including possible limitations, and the importance of exercising reflexivity as a researcher.

4.1 A Qualitative Case Study

The method used in this thesis is a qualitative case study. The setting is the seaweed industry in Norway, understood as a social-ecological system. In particular, the research is concerned with the harvest, production, and approaches to management, which is explored based on the accounts of experts in the field: producers, researchers, network representatives, and regulatory authorities. In the exploration of an emerging seaweed industry in Norway this research has made empirical contributions based on a series of interviews, conversations, and observations during various forms of event participation. Questions are extracted from the SES and resilience literature to better understand to what extent actors reflect with resilience thinking. The investigation is also concerned with where the conceptual framework of resilience may be lacking, or where another framework can better explain the collected data.

According to Biggs, Schlüter, and Schoon (2015, 143) "the resilience of an SES is partly driven by decisions taken by actors – the resource users, managers, and policy-makers – within the systems. To understand SES therefore requires an understanding of how actors within the SES think". A qualitative lens can be used to recognize and interpret the social aspects of individual and collective decision making. More specifically, Biggs, Schlüter, and Schoon (2015, 144) use the concept of mental models, described as "'habits of the mind' that represent a pattern or cluster of cognitive behavior that leads to action", as a tool for analyses.

It is important to acknowledge that these are not perfect models, but rather context-dependent and highly variable, and can only offer a partial or limited view of the world (Ibid.). I will revisit the concept of mental models in my analyses in an attempt to decipher not only how stakeholders understand resilience in social-ecological systems, but also how this may translate into action.

A qualitative approach has the potential to reinstate the often-sidelined social aspects of a framework that has its origins and groundwork in the field of biology. As mentioned in the previous chapter, resilience thinking was not explicitly coupled with an understanding of social determinants until the 1990s (Berkes 2015). With this in mind, a qualitative case study is also a strong methodological fit to better understand the complex interconnections between social and ecological systems and how actors perceive and address these same connections in their management approach. Furthermore, open-ended interviews allow respondents to describe what issues they consider to be the most important or relevant in relation to the industry's current trajectory, as well as future visions for management that will lead to what the actors themselves understand as sustainable success. Coupled with observation and an insider perspective, this methodological approach invites the researcher and reader alike to consider how varying priorities around seaweed culture and capture can be valuable or even favorable.

4.2 Principles for Building Resilience

Seven theoretical principles for understanding and building resilience are used to extract knowledge about existing perspectives of and engagement with the current path of industry development. These seven principles are adapted from the book *Principles for building resilience: sustaining ecosystem services in social-ecological systems* by Biggs, Schlüter, and Schoon (2015). The main theoretical contribution is therefore testing how the framework of social-ecological systems and resilience thinking is useful in practice to explore the resilience of a developing industry, and where it may fall short. In addition to shaping my interview guide and navigating the process of answering my research question, the principles will also be used to organize my findings and the first stage of analysis in chapter 5 into seven thematic sections.

Biggs, Schlüter, and Schoon (2015) suggest that the seven resilience-building principles are critical to manage SES and foster resilience. By grounding my methodological approach in these seven principles I invite actors to reflect on how each principle is relevant for SES management and governance. I detail the seven principles in more detail next.

4.2.1 The seven principles

The first three principles shown in figure 3 represent SES properties that can be managed. Principle one calls for maintaining diversity and redundancy. The way that seaweed is being produced in Norway today varies in many ways; producers are producing at different scales, they are producing different species of seaweed and the seaweed is being used to produce a range of different goods and services. Analyzing this domain can help decipher to what extent efforts are being made to maintain this diversity, as well as how important or relevant this effort actually is to different actors.

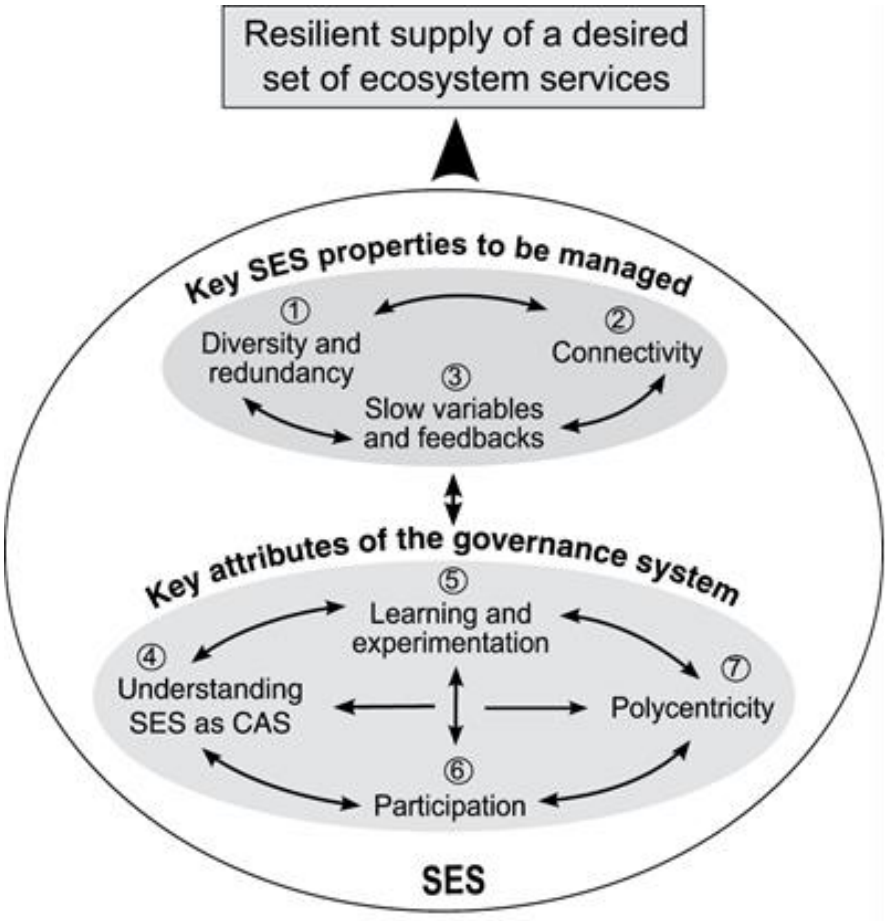

Figure 3: The seven principles for building resilience, adapted from Biggs et al. (2012). Principles 1-3 relate to the key SES properties that require management, while principles 4-7 are key properties shaped primarily by the SES governance system.

The second principle calls for managing connectivity. Exploring connectivity can help elucidate in what ways and to what extent the industry is, or is not, connected. Examples include the degree of connectivity between seaweed and its various applications or between industries, such as with other forms of aquaculture. The interaction or collaboration between stakeholders or institutions, as well as the spread of resources and information, can also reveal important features relevant for the resilience of the SES. According to the Stockholm Resilience Center (2020), maintaining biodiversity is perhaps one of the most important positive outcomes of landscape connectivity.

The third principle involves managing slow variables and feedbacks. There are many underlying variables or external factors that can affect the industry as it stands now, and which are hard for a single producer or company to address on their own. It is useful to consider when and how stakeholders engage with these variables, which include the legal system, social values, demands by consumers, or even climate change.

The remaining four principles relate to the governance dynamics that influences the SES. Principle four deals with fostering complex adaptive systems thinking, also known as CAS. This principle relates more specifically to how various actors relate to uncertainty and complexity within the system, particularly being such a young industry. Insights on CAS thinking can help interpret how stakeholders engage with this uncertainty, and how it might influence the potential and willingness for innovation.

The fifth principle is to encourage learning and experimentation. This principle is also particularly relevant for an industry in its early stages, where surprise and uncertainty is to be expected. As will become evident, this uncertainty can also translate into innovation and new thinking, which can be a key factor for resilience and for the sustainable success of the industry.

Principle number six is concerned with broadening participation, which includes the active engagement of various actors in both management and governance structures. This lens can be used to disentangle which actors participate the most, where participation takes place, and whether the ‘right’ people are participating. Questions of transparency are also relevant and important to consider here.

The seventh and last principle deals with promoting polycentric governance systems. There are multiple institutions or governing bodies involved in the management of this industry, responsible for tasks from coordinating the processing of seaweed farming applications to regulating the food safety of the products used for human consumption. This principle can help deduce whether this form of polycentric governance is considered effective according to actors and whether there is any way it could or should be done differently.

4.2.2 Applying the principles in practice

When analyzing how actors think and respond with regards to these principles it is important to distinguish between the two terms shown in figure 3: management and governance. How actors take action to reach their goals, which includes keeping the state of resources within certain parameters, is what is meant when we talk about management (Pahl-Wostl 2009). This differs from governance, which considers the social and political processes that shape access and implementation of policy underlying SES (Pahl-Wostl 2009). Monitoring is one concrete example of an action or management practice, while resolving trade-offs or defining goals for management are key characteristics of governance (Biggs, Schlüter, and Schoon 2015).

Lastly, while the seven principles are presented as independent variables for the sake of clarity and to facilitate analyses, they are deeply interlinked and interdependent (Biggs et al. 2012). The principles are not ranked in order of importance, nor do they make up an exhaustive list (Biggs, Schlüter, and Schoon 2015). The authors behind the principles acknowledge the need for further refinement and discussion when engaging with the framework, which this investigation aims to contribute.

4.3 Bitekine's Prospective Case Study Design

I use stage one of Bitektine's (2008) prospective case study (PCS) design as a qualitative method of deductive theory or framework testing. PCS involves using data on live social processes to better understand the explanatory power or applicability of a framework in addressing the reality of these social processes. It can also provide some insight into the explanatory power of competing frameworks. Bitektine (2008, 177) indicates that studies on institutional entrepreneurship, on diffusion and adoption of innovations and social movements, are all domains that could benefit from this approach to a qualitative case study. The social-ecological system examined in this case study represents a domain where change

and uncertainty are key characteristics and where complex social processes are hard to quantify. A qualitative deductive theory testing of resilience can therefore be a strong fit for this case study and can offer some conceptual generalizability. As mentioned in chapter 3.3.1., this is without insisting that 'one framework fits all', but can rather strengthen the case for SES and resilience as a framework that can fit most.

With a PCS design "the researcher formulates a set of theory-based hypotheses in respect to the evolution of an ongoing social process" (Bitektine 2008, 161). In the case of this investigation, the seven principles function as a direct link between the SES framework and ongoing social processes, where it is hypothesized that actors can answer questions in relation to- or based on these principles. However, this approach does recommend a time span of up to several years in order to compare such theory-based hypotheses with process outcomes in the future. Looking at process outcomes lies beyond the scope of my thesis, thus I employ the first stage of the design, which is the baseline case study, and leave open the possibility for completing the second stage in future research. I use PCS design in this study to strengthen the discussion around the explanatory power of resilience in vivo. More specifically, this method can be a tool to address both to what extent actors engage with the social-ecological processes outlined by the seven principles of resilience as well as to what extent they *should* engage with the principles of this framework at all.

4.3.1 Negative results and applicability

PCS design stresses the possibility of the study in question yielding negative results (Bitektine 2008). For example, one partial conclusion could be that the framework of resilience and social-ecological systems does not adequately explain seemingly arbitrary or self-organizing dynamics of social processes in the system. A great advantage of qualitative research, however, is the ability to pursue potentially unexpected findings and dig deeper into the narratives and perspectives of the industry stakeholders based on multiple sources of evidence. A discussion of 'negative' results, therefore, can lead to equally valuable empirical and conceptual contributions through a qualitative lens.

Lastly, this approach does not apply typical techniques for analysis such as coding to decipher a testable research question. The investigation takes a deductive approach, where the seven resilience principles derived from the social-ecological resilience framework are known before starting the analyses. This does not necessarily guarantee that data collection will fit

nicely within the seven principles of resilience. Yet, part of the conceptual contribution of the deductive approach is indeed to test the applicability, and potential limitations, of this framework for a presently developing industry.

4.4 Data Collection

The data for this research was collected over the period of one year, starting with a production facility visit in March 2019 and ending with my last interview in March 2020. My primary data comes from varied sources: site and event participation (primarily in the form of an internship, as well as conferences, a participatory workshop, and public seminars), ten qualitative interviews with various domain experts, secondary data (primarily reports, articles, and other public records) and lastly academic literature on social-ecological systems and the resilience approach to contextualize my findings.

4.4.1 Site and event participation

In March 2019, I paid my first visit to a larger-scale production facility, and I was given a tour followed by an informal chat with the environmental manager of the company. Around the same time, I established contact with The Northern Company, a small-scale business harvesting wild seaweed by hand far out in the North-Atlantic ocean. Taking a somewhat impulsive decision, I contacted the CEO with only four weeks until harvesting season to ask if there was any possibility I could join for the duration of the season as an intern. Four weeks later I was standing on a tiny islet in the middle of the ocean in 5-degree temperatures, equipped with waders and a kitchen knife.

My home for the next 10 weeks was an island with 40 inhabitants, surrounded by endless stretches of wild seaweed. I assumed a completely participatory role and put away my 'researcher hat' for some time, wishing to immerse myself as much as time allowed. This insider role was immensely valuable to understand both what different actors and structures were involved in the molding of such a company, as well as what impacts beyond the obvious provisioning of food that this business had. In particular, the company has played, and continues to play an important role as a knowledge platform raising awareness about Nordic seaweed, with a focus on sustainability and value creation in a circular economy. I continued to work with the company in and around Oslo until March 2020.

As a result of this experience, I was introduced to a range of stakeholders within the industry, including producers, harvesters, chefs, consumers, seaweed enthusiasts, and other students and researchers who were in some way connected to the topic of seaweed. I approached these people either as a researcher in the early phases of my investigation or at times as a seaweed harvester myself. Beginning in February 2019, this pre-data collection phase based on numerous informal conversations quickly inspired a passionate enthusiasm for seaweed and an urge to better understand the dynamics between stakeholders in the industry. It also got me thinking about the 'right' questions to ask once I would start interviewing.

Furthermore, I also met many actors and stakeholders at the various conferences and seaweed-related talks I attended in Oslo and Trondheim. In October 2019, I participated in the full-day national conference titled Alge2019 on the cultivation and harvest of seaweed in Norway, hosted by the Confederation of Norwegian Enterprise (Næringslivets Hus) in Oslo. In November 2019 I attended a public seminar titled 'Sustainable Food', hosted by Tekna[3]. The speakers included the CEO of one of the larger seaweed company in Norway, answering to the question "What does the future of food look like and is it sustainable?" Later that same month I was in the city of Trondheim for the SIG Seaweed conference hosted by the independent research organization SINTEF, where I came across many of the same faces, but also many new actors.

In February 2020, I attended a full day participatory stakeholder workshop hosted by the environmental foundation Bellona, with 30 relevant stakeholders all connected to the industry. In several smaller groups the aim was to discuss and advance the debate on socio-environmental benefits and policy frameworks relevant for the development of seaweed aquaculture in Norway. The findings from this workshop are expected to be published in two reports for the research projects GeniAlg[4] and Aquavitae[5] in June and November 2020 respectively. With permission, some of the extracted notes from this session have also been used as data findings for my thesis, and are integrated into chapter 5.

In addition to observing and gathering reflections at these different events, I was able to network with many actors who I then either recruited the same day or through e-mail

3 Tekna is The Norwegian Society of Graduate Technical and Scientific Professionals
4 https://genialgproject.eu/
5 https://aquavitaeproject.eu/

correspondence in the days following the events. I also had some e-mail correspondence with respondents after an interview to follow up on or clarify specific questions. Additional reflections based on site participation, observations and public presentations will be integrated into chapter 5 together with the primary data from interviews, which I describe next.

4.4.2 Interviews and interview guide

The bulk of my findings, which will be presented in chapter 5, are based on primary data in the form of interviews. When I refer to 'respondents' in my analysis and discussion, I am referring to those of which I have interviewed formally. Ten semi-structured qualitative interviews were carried out over the span of six months, from October 2019 to March 2020. Interviews were carried out face-to-face; the majority conducted over Skype or telephone with respondents in various parts of the country, while others were held in Oslo at cafes or the homes or offices of my respondents. Both the questions and responses were open-ended, and all interviews lasted between 45 minutes and 2 hours. Four interviews were conducted in Norwegian and the remaining six in English.

The interview guide was comprised of seven thematic talking points, based on the seven resilience principles and tailored for the investigation at hand, as described in the previous section. Each category consisted of 4 to 6 sub-categorical open-ended questions. Thus, a total of 32 questions were prepared for each interview, although the specific questions asked within each principle category varied between respondents (see appendix A). After the first interview, the interview guide was significantly adjusted to better suit the flexible dialogue I was aiming for. Having multiple, but similar, sub-categorical questions under each core theme was a good way for me as an interviewer to adjust each interview to the background of the respondent, while also maintain some consistency.

4.4.3 Informants and sampling

The informants were primarily producers cultivating seaweed in Norway as well as two actors harvesting wild seaweed for commercial purposes. While I had initially intended to only interview producers, I later decided to include interviews with one seaweed network representative, one researcher, one expert with a seaweed-specific knowledge platform, and one representative from a county governor office. All respondents, except the researcher and county governor, were also the CEOs or founders of their company or organization. I

considered all respondents to be experts in the field, or 'key informants', who have insider knowledge that goes beyond private experience and beliefs (O'Leary 2017). Working with insiders or experts means that as a researcher I assume that the answer to my research questions lies with the specialized knowledge and experience of individuals who play an active role in the current and future development of the industry.

A combination of snowball sampling and purposive sampling was used to recruit my participants. The first three interviews I had were with producers that I had established contact with during the pre-data collection phase. These companies represented small, medium, and larger-scale production. Having established contact with these companies at different scales early on reinforced some initial assumptions I had regarding different priorities in accordance with scale, which I describe at the start of chapter 5.

My experience as an 'insider' working with a company, combined with having attended various conferences and events, gave me a sense or intuition about what actors could be worth speaking to in order to collect a diverse set of data and perspectives. During most conversations with my respondents who were familiar with all or most other industry actors that could be worth speaking to, I also had most of my intuitions confirmed about what actors to include in my sample to collect varied viewpoints. This method of purposive sampling was used for 8 of my respondents, whereas I used snowball sampling for the remaining two – one researcher and one seaweed farmer – who were recommended by another respondent. I had reached out to an additional five people, four purposively and one through snowball sampling, who did not respond to my invitation for an interview.

As mentioned in chapter 2, by the end of 2018 there were 23 registered seaweed farming companies in active production (Directorate of Fisheries 2019) as well as a handful of companies harvesting wild seaweed by hand. Out of 10 respondents, 6 were working specifically with the commercial harvest or production of seaweed themselves. Assuming that the views of these producers reflect the views of their companies (as all respondents were also the CEOs or founders of their company or organization) this population represents the views of approximately 25% of the total number of seaweed production companies at the time of the study. The remaining 4 respondents represent four additional domains were the familiarity with the developing industry has offered significant insights for this study.

The respondents were located in 7 of the 10 coastal counties (not including Inland Norway, or 'Innlandet') between Viken county and Troms and Finnmark county. The general localities of my informants are demonstrated in figure 4.

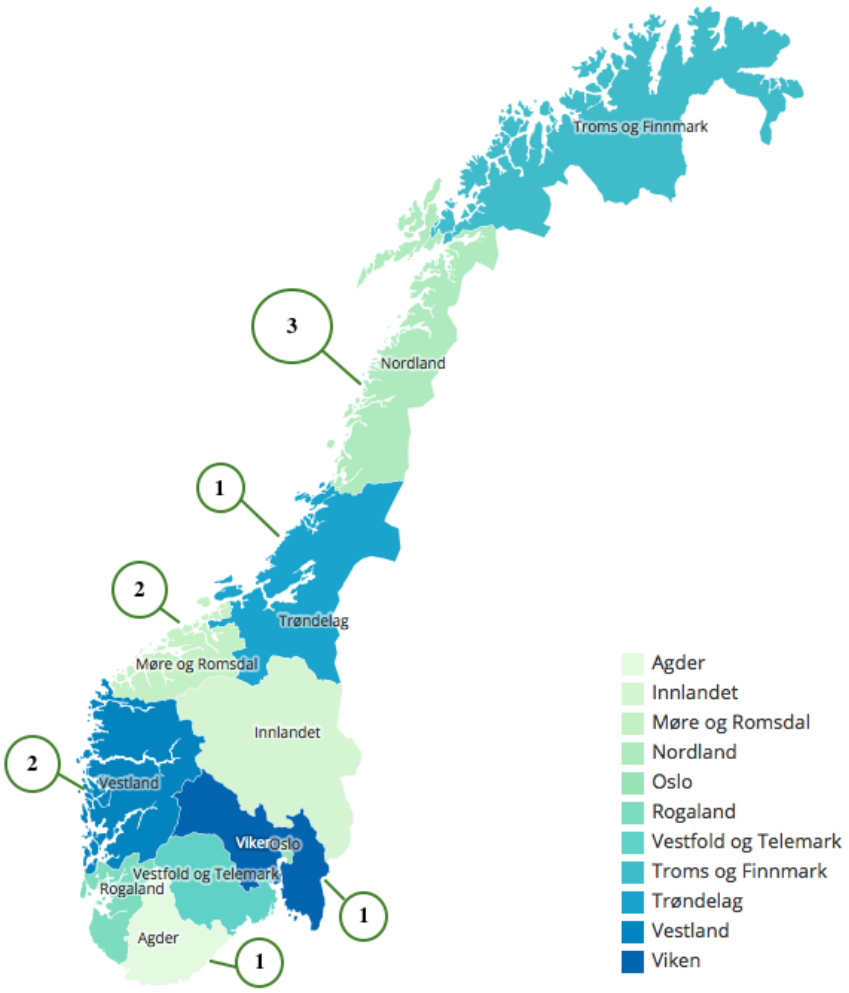

Figure 4: Respondents by locality. Map adapted from the Ministry of Local Government and Modernization website, at Regjeringen.no (2019)

Amongst the producers I spoke to I found significant variation in terms of the scale of production and harvesting sites, as well as diversity in harvesting techniques and production methods. Although some participants were interested in other applications or had visions to expand their portfolio in the future, all respondents had a particular focus on or interest in the production of seaweed for human food and in some cases feed, as described in chapter 2.

I had an aim to conduct between 10 and 15 interviews before commencing my research, which I achieved. After 10 interviews, however, I found that many of the same themes and

perceptions were being repeated, which is a sign of data saturation. Although I only had the perspectives of one researcher, one regulatory authority, one network representative, and one expert with a seaweed-specific knowledge platform, these were mostly answering questions that related more specifically to the farmers or harvesters, so I found these supplementary perspectives to be sufficient. Overall, I found that the number of interviews coupled with the experience in the field, the event participation on three occasions, and the observation done over a year and a half was adequate to answer my research question in the context of a Master's thesis.

Moreover, the study was approved by the Norwegian Center for Research Data (NSD) in September 2019. It was a priority to protect the interests and identity of my informants. The NSD suggested measures to deal with the collection and processing of personal data, which I followed closely. No personal names have been used in the final publication of this paper. I have also taken measures such as not mentioning company names (other than the company for which I worked, with permission) or localities (other than general geographical regions, also with permission), as this information could be traced back to personally identify respondents.

However, the seaweed network in Norway remains small, and anyone familiar with the industry or the actors working within the industry may still be able to identify certain informants based on their responses or general descriptions such as scale and type of production. Although I informed each respondent that interviews would be anonymous, this concern about anonymization in a small community was also brought up, but no informants expressed concern. In the consent form I also included a box stating that information about the participant could be published in a way that could be recognized (e.g. occupation and location), and all respondents consented. Most informants also requested to fact check their responses in the final work before submitting, to which I agreed and followed up on. To my knowledge, this work contains no sensitive information.

4.5 Findings and Analysis

All of the interviews were recorded using a University of Oslo (UiO) based app-service (Nettskjema-diktafon), which saves the recording on a protected server for a limited period of time. The interviews were later transcribed using either the software Temi or manually. As mentioned, coding was not used due to the chosen method. Instead, seven pre-established

themes based on existing resilience literature were used to systematize my findings and discussion. The responses were then categorized in a cyclic process of segregation, regrouping, and relinking based on how I as a researcher interpreted the ideas, perceptions, and insights of my respondent in relation to resilience thinking.

In chapter 5 I present my findings. This includes narratives and observations from fieldwork, event participation, and general reflections, in addition to the findings derived specifically from interviews. The quotes I have chosen to include reflect the perspective of the respondents, but as a researcher I have organized the responses underneath the resilience principle I found to best capture the statement or opinion. The 'filter' covering my analytical lens as a researcher, therefore, is derived from the resilience literature. The issues that each respondent chose to focus on are assumed to reflect what they find to be the most important or relevant to the discourse, in their own words. It is not my aim to generalize the findings or statements from my respondents to other case studies. Instead, the raw data material can offer a snapshot of the current path of development based on actors established in different parts of the country working at varying scales and various stages of production.

At the end of each interview I asked respondents if they had additional comments that they felt were important in relation to achieving the sustainable success of the industry. Where respondents had alternative concerns or priorities that they wished to bring up, which were not covered by the seven thematic areas in my interview guide, these were also taken into consideration in my analyses. As will become evident, such 'negative' results are equally valuable to the discussion that will commence in chapter 6. In particular, these responses offer a chance to consider where there may be gaps in the applicability of the SES framework in practice, or areas where the explanatory power of the resilience approach is lacking.

4.5.1 Limitations

An undeniable risk with qualitative research is that respondents answer the questions in a manner that they believe will satisfy the researcher. However, because I spoke to many of my respondents in various settings – such as having an informal chat at a conference first and then later in a more formal interview setting – I found that I was able to partially overcome this limitation of the chosen method. Because the majority of my respondents are also active in the public sphere, and in many cases I had seen them talk about the same themes or topics on stage or in the media, I was able to compare responses across multiple sources of evidence.

Moreover, I found that the interviews where I had established previous contact with the respondent created a lot more room for open dialogue and trust. In my analyses, I found that I derived more findings from these interviews compared to those which were only done over the phone with respondents in remote areas. This may have created some bias regarding the data presented. Additionally, as mentioned, the industry is relatively new and changes are happening at a very rapid rate. The experts I have chosen to speak to at this stage may therefore only remain relevant for the topic at the time of data collection. The data, therefore, represents the opinions of a diverse range of stakeholders but at a very specific point in time.

4.6 Establishing Quality in Research

> *"There is little to guide a practicing scientist other than one's own intuition and passion, and the optimism that the prevailing thought style may change" (Dash 2009, 4).*

Establishing quality in research is an ongoing debate between research traditions. Whether qualitative research meets the fixed quality criteria of the quantitative tradition - validity, reliability, reproducibility, and replicability – is at the core of the debate (Reddy 2017). Researchers have yet to agree on whether the judgment of quality should be limited to the parameters of their philosophical foundation, or if a universal concept model is a better solution (Mårtensson et al. 2016). One key difference between the traditions, however, is the notion of truth-value; whereas the positivist tradition associated with quantitative research believes there is a single truth, the interpretivist or naturalistic tradition takes the view of multiple constructed realities, a common assumption in qualitative research (Seale 1999).

As a qualitative researcher taking a case study approach to the topic of seaweed in Norway I share the assumption that there exists more than one truth, and a different researcher may very well interpret the data I have collected with a different set of conclusions. Rather than going into more detail on the debate on quality, however, I share the view of Seale (1999, 466) on the importance of "breaking free from the obligation to fulfil philosophical schemes through research practice, while remaining aware of the value of philosophical and political reflexivity". For this research I have chosen to operate with the concepts of reflexivity (Seale 2018) and trustworthiness (Bryman 2016) to establish quality. In reference to the quote introducing this section, I have also exercised my intuition, a concept that is receiving increasingly positive attention in the qualitative tradition when it comes to establishing quality (Mårtensson et al. 2016, 594).

4.6.1 Positionality, insider research, and trustworthiness

Before arriving at a research question or conceptual foundation I was drawn to the topic of seaweed more generally as a future food that could contribute to bettering what I understand to be a broken food system. I started exploring literature on socio-technical transformations 6/2/2020 8:34:00 AM to ask questions related to the social and technical barriers challenging the mainstreaming of a niche seaweed industry in Norway. After some time, my perceptions of what this industry represented changed, leading my questions to change as well. I soon found that the questions that most intrigued me were those that encouraged me to look for assumptions about the industry and its development. This included rethinking concepts, agendas, and goals that – often randomly, and not always accurately – adhere together.

During my early research stages, I was reading many articles with bold sustainability claims about the role of seaweed in globally changing environments. The cultivation and harvest of seaweed was depicted as the 'silver bullet' for sustainability, from feeding the world to capturing and storing impressive amounts of carbon from the atmosphere. I was interested to dig deeper into what sustainability entails to different people, and in different contexts, when humans interact with the biosphere. I slowly began to change my angle as a researcher towards an approach that could allow me to better understand how actors within these systems think, and how this impacts both the system and the conceptualization of the system. This eventually led me to also change the literature I would draw from.

The decision to ground my approach in the framework of SES thus came after having already started the data collection process, and with the realization that my interest was fundamentally guided by a personal desire to better understand how we can, and should, co-exist with the natural world. I took a class on Coastal and Aquatic resource management, and with some tips from my professor started to read up on the framework of SES. The view grounded in the works of Folke and colleagues, amongst other scholars, strongly resonated with me: "humans need to be reconnected to the biosphere, and a new social contract is required for sustainability based on a shift in perception - from people and nature seen as separate parts to interacting, co-evolving and interdependent social-ecological systems" (Berkes 2015, 46, citing Folke et al. 2011).

Moreover, doing insider research as part of my fieldwork has been a significant asset in my research process, particularly when recruiting informants. It is my impression that having the

experience of harvesting, processing, and selling seaweed was a great way to gain trust and confidence in my conversations with various experts. It also allowed me to put on the hat of 'seaweed harvester' instead of 'researcher' when attending conferences and workshops, which I found made it significantly easier and more importantly compelling to do fieldwork. For my personal awareness and judgment of 'what was going on' I also cannot stress the advantage of my 'insiderness' enough.

Some scholars may argue that special considerations apply when a researcher has personal entanglement in the field, such as lacking distance and objectivity (Brannick and Coghlan 2007). However, reflecting on this positionality to establish quality in research can help clarify the context, content, and parameters of the work for both the reader and the researcher alike.

Indeed, I am on some level 'native' to the setting and have gained many insights from lived experience. On one level, I am an advocate for the industry and its development and consider myself to have a biased opinion regarding the benefits and value of using seaweed to a much larger extent than is currently done. I also hold a bias regarding any efforts to increase the use of plant-based resources in food more generally. On a more significant level, I am an insider in the sense that I can consider myself a member of the organizational system that is the 'seaweed community', having worked directly with a seaweed harvest, production, and sales for a company for over a year. Although this engagement started at the same time as my research, and my placement internship was temporary, my role working with seaweed did also extend beyond the time spent working.

There are certainly critiques of insider research worth considering, but let me return to one of its real strengths- my initial curiosity regarding the potential for making better use of plant-based resources from the ocean has led me to explore connections between academic literature and an emerging industry which may otherwise be overlooked. Furthermore, this insider-outside dichotomy is arguably unconstructive when it comes to determining quality in research, and may not be particularly useful in addressing one's positionality. In the view of Naples (1996, cited in Greene 2014, 3) "insiderness or outsiderness are not fixed or static positions, rather they are ever-shifting and permeable social locations..." The degree of 'insiderness' can also change during the course of the research. While there are certain biases to consider with insider research, such as making assumptions about the meanings of actions or events (Unluer 2012) or establishing a desired degree of objectivity, these challenges are

not limited to insider research. Indeed, “we are all insiders of many systems – our families, communities, and organizations” (Brannick and Coghlan 2007, 60).

I feel confident that my personal entanglement has first and foremost served the insights of my research. The ability to share a personal enthusiasm and expertise with respondents about seaweed, coupled with a more academic mannerism, has led to conducive and engaging conversations and reflections. Reinforcing the quote above, “there is little to guide a practicing scientist other than one’s own intuition and passion, and the optimism that the prevailing thought style may change” (Dash 2009, 4). It is my responsibility as a researcher to reflect on my positionality and to offer a clear overview of the approach taken, leaving it up to the reader to then establish trustworthiness from hereon.

4.6.2 Reflexivity

> *"Preconceptions are not the same as bias, unless the researcher fails to mention them" (Malterud 2001, 484).*

Building on the reflections on insider research, reflexivity is another important tool that can help establish quality by allowing the researcher to explain their potential influence on the findings, which also helps the reader establish trustworthiness (Seale 2018, 537). To reiterate, addressing one’s position in research has the potential to enhance research quality regardless of the methodological approach. However, it is not always evident what personal information should be disclosed in relation to what may influence the ‘truth’. It is also important to recognize that reflecting on reflexivity and the potential for bias does not by default indicate good research. Rather than striving to minimize bias, which we all carry, it can be more constructive to reflect on the bias and again let the reader determine whether the research findings meet their quality threshold.

While I confirm in this chapter that reflexivity in an integral part of ensuring transparency, and thus quality, in research, the real task is to follow up on this in practice by practicing continuous data analyses. In the following chapter, in addition to the data findings from my interviews, I also feature some reflections and impressions from my experience during event participation and the 10-week internship. These early experiences shaped the data collection to a large extent, including the people I chose to include as my respondents. While the bulk of my data is based on multiple ‘truth claims’ derived from what participants have told me in interviews, these other ‘insider’ experiences translate into a different set of ‘truth claims’ that

are based on personalized observations and perceptions in specific social settings (Jarzabkowski, Bednarek, and Lê 2014).

The hope is that including some elements of more personal ethnographic storytelling will enhance the authenticity of the data and analysis in a reflexive process grounded in the experience of the research participants world, which I refer to as the 'seaweed community'. Jarzabkowski, Bednarek, and Lê (2014) also underline that such narratives can be particularly evidential because they provide a form of triangulation and offer "vivid portrayals of specific incidents – such as conversation, a critical event or moment in the field, or particular practices or routines – that illuminate a theoretical concept the author wishes to convey" (Jarzabkowski, Bednarek, and Lê 2014, 280).

In addition to reinforcing reflexivity, such narratives can also strengthen the conceptual generalizability (Jarzabkowski, Bednarek, and Lê 2014). As mentioned, I will not be using codes as a means to analyze my data due to the chosen method. In the words of Jarzabkowski, Bednarek, and Lê (2014, citing Hammersley, 1992; Hammersley and Atkinson, 2007) "the test of the truth claims does not lie in the presentation of an ever-greater number of data extracts to illustrate a concept, or frequency counts of the codes and themes developed, as if proof somehow emerges from the amount of data tabulated". Instead, rich accounts of the field and vivid portrayals of specific events "are both revelatory of and validate the theoretical frameworks developed from deep immersion in the field" (Jarzabkowski, Bednarek, and Lê 2014, 284). Lastly, with regards to anonymization, these narratives avoid the need to include exact reporting that encompasses identifiable information. Instead, "evidence lies in the construction of convincing text in which the authenticity of the author's field experience is made accessible to the reader—the tale rings true or can be imagined even where it is outside that reader's actual experience (Jarzabkowski, Bednarek, and Lê 2014, citing Golden-Biddle and Locke, 1993; Van Maanen, 2011; Yanow et al., 2012).

Figure 5: Seasonal harvesters in Træna, Norway. Photo: Troels Rosenkrantz

5 FINDINGS & ANALYSIS

Chapter 5 will reveal how stakeholder objectives and priorities in the Norwegian seaweed industry reflect an understanding of social-ecological resilience, which answers specifically to the first part of the central research question guiding this investigation. This chapter will also begin the first stage of analysis of these findings regarding the implications for resilience. The analyses reflect general objectives or management approaches of the industry as a whole, unless stated otherwise, such as in the case of disagreement amongst stakeholders or if only a minority of respondents commented on a specific issue.

Recalling the conceptual framework outlined in chapter 3, Biggs, Schlüter, and Schoon (2015) suggest seven generic principles that build resilience in a social-ecological system. How stakeholder objectives and priorities reflect upon each of these principles is therefore used to answer how social-ecological resilience is understood by actors more generally. To recap, the seven principles are: 1) Maintaining diversity and redundancy; 2) Managing connectivity; 3) Managing slow variables and feedbacks; 4) Fostering complex adaptive systems thinking; 5) Encourage learning and experimentation; 6) Broadening participation; and 7) Promoting polycentric governance systems. I organize my findings under the same seven principles as they have guided the data collection, but also with the hope that this may facilitate the connection between the reader and the research process, inviting reflexivity on the part of the reader as well.

5.1 Maintain Diversity and Redundancy

The social-ecological system components involved in producing seaweed in Norway range from species, actors, scales, knowledge systems, landscapes, and institutions. Maintaining diversity in such components, which is the first resilience-building principle, can help provide options and alternatives for dealing with complexity and uncertainty. This can lead to redundancy in the system, which is a means to provide insurance; where there is a loss or failure of some components, other components may compensate. According to (Biggs, Schlüter, and Schoon 2015, 51), “evidence from several fields of study suggests that systems with many different components are generally more resilient than systems with few components or less heterogenous components, whether the components are molecules, species, habitat patches, livelihoods, actors, knowledge systems or institutions”. The

following sub-section will describe how stakeholders reflected upon scale, scalability, species, applications, landscapes, and institutions in relation to diversity.

When describing the range of stakeholders within the industry, respondents broadly categorized actors into small-scale and large-scale, which often translated into 'having no money' versus 'having money' respectively. On one hand, in addition to some smaller farms still working on prototypes and models, wild harvesters described themselves as small-scale. On the other hand, the more established farms with access to more significant amounts of financial capital and often more than one locality (although this was not always the case for the more established companies) were comparatively large-scale in the Norwegian context.[6]

Although the emergence of different actors operating at different scales was not necessarily an intentional progression, it was my impression that diversity with regards to scale was high. From speaking to a diversity of actors at different scales, I also found that there were some similarities between how smaller-scale and larger-scale producers described their core priorities and objectives respectively. Amongst the larger-scale producers with established farms, the business model was primarily market-oriented. One such actor commented:

> *"…our main business model is to grow seaweed and sell it as a bulk food material for the food industry and for other markets in the future…we also are establishing a business of supplying seeds to other farmers that can enable other companies to start growing seaweed from our internal hatchery."*

Another respondent on the larger scale indicated that their initial inspiration was to:

> *"…grow kelp more efficiently than traditional methods…This includes mechanization and seeding, making deployment more efficient, reducing land use, making structures less visually unappealing…Then later, the idea of direct stabilization came after we learned a bit more about the market…" (my translation)*

A third larger-scale actor stated the following business goals: to industrialize the production of lower trophic organisms, to establish a production of raw material for human consumption and animal feed, to establish the capture of nitrogen, phosphorous and CO2, and finally to establish a new aquaculture branch in Norway so that the sector no longer stood on a 'single leg' (referring to the salmon industry). All three actors also described economic sustainability as an overarching goal. Coupled with observation and event participation, keywords

[6] Note that these scales described here are in the context of an overall niche industry. See current status of the Norwegian industry in comparison to the global status seaweed production in chapter 2 for more details.

describing how actors at this scale defined their goals or objectives can be summarized, in broad terms, as: attaining profitable biomass, mechanization, industrialization, effectivization, economic sustainability, and to some extent providing provisioning and regulating ecosystem services.

On the other side of the spectrum, smaller-scale respondents expressed their priorities and objectives somewhat differently. According to one respondent, the initial objective was to:

> *"…understand more about our food system and how this is involved with our economic system and sustainability, and how these things weave together..."*

Operating on the same scale, another respondent recalled their initial goals as well as how they have changed:

> *"The motivation at the start was….researching the health benefits of seaweed… it was more health rather than sustainable reasons…also not exploiting, that is the wrong word, but utilizing a resource that was so readily available…since [then] it has been more about being on the sustainable side of it."*

Better understanding and attaining sustainability, especially concerning food, was more explicitly mentioned as a primary goal amongst the actors I spoke to working at smaller scales. These respondents more often described their goals or objectives in terms of understanding 'the sustainable side of it', and how this was connected to food systems and/or nutrition as well as the economic system. A third actor, which can be placed somewhere in the middle in terms of scale, had a similar outlook that they expressed in the form of four goals:

> *"…the first is to produce seaweed raw material and products and sell them according to what we call nature's principles…where we emphasize finding out how we define this green production for all parts of our production and the value chain. The second is circularity, or the cycling of resources, and the third is diversity. Another one might be the resilience of the ecosystem…and how we translate that into what we do in each step of the value chain. That is really what we try to define every day…"*

The respondent also added that they were working towards selling ecosystem services from the seaweed farm in the long term perspective, similar to the large-scale producer quoted above. Moreover, the same actor referred specifically to the benefit of fostering diversity within the system as a way to develop the industry sustainably, which is an explicit reflection of resilience thinking. In their words:

> *"I think we have a chance to develop an industry from scratch in a way that will be more sustainable than other large-scale food production systems we have seen, both on land and in water…diversity is a key issue, which I apply to all elements in the value chain….[this includes] diversity in the species that we produce, in production systems, in scales, as well as in the types of products, processing, and markets."*

Moreover, respondents who were not themselves producers described industry priorities and objectives more generally as involving a wide range of factors, irrespective of scale. According to the seaweed network representative:

> *"Many of those who have been involved [in aquaculture] from the start now see that we are at a limit when it comes to fish…we have become aware that this is an opportunity that does not require feed, and does not require fertilizer, and which is really big internationally... we have used little [seaweed], we have produced little, and it does not need freshwater or land area..." (my translation)*

The same respondent mentioned that many of those now working with seaweed were already working in aquaculture. In this context, the respondent described the emerging industry as 'the next salmon adventure', salmon being the dominant industry in the Norwegian aquaculture sector since aquaculture emerged in the 1970s. They also mentioned the expectation that the industry could help 'solve' some environmental challenges, specifically 'bioremediation' and 'improving the salmon situation' by making use of the surplus nutrition, but added that this would require very large volumes.

Despite the noted differences in expression, all the respondents I spoke to confirmed that making good use of a natural resource and sustainably realizing economic opportunities was a key motivation behind their interest in seaweed. Yet, it was not clear what making 'good use' of a natural resource, or 'sustainable' production, entailed. It was, however, my impression that respondents did not abide by the same criteria. For example, there was some disagreement regarding what applications were thought of as sustainable, which I come back to later in this section.

Moreover, it is important to recognize that scale is not a static measure, and stakeholders are developing all the time. The question of whether or not a business model is scalable or to what extent it is transferable is therefore also relevant to consider. One producer pointed out:

> *"…we know too little… In principle, it is all very good and climate-friendly, but of course, any large monoculture, both on land and in the ocean leads to problems with disease or genetic imbalances and impacts on natural populations…It is our*

> *responsibility to really understand what is going on before scaling up…to start anticipating [problems]or thinking about them already now, and not fix the problem once it arises."*

Beyond reflecting a cautious attitude with regards to scalability, this quote reflects a management mentality that is aligned with resilience thinking, including the need to anticipate problems and complexities before it is 'too late'. This perspective is also closely linked to principle 4, on fostering complex adaptive thinking, which is the subject of section 5.4.

Furthermore, although Norwegian waters contain a diverse and substantial variety of seaweed species, only a few are of these are exploited commercially. The scale of production seemed also to be connected to this. The number of species harvested in Norway overall reflects an element of 'variety' as an aspect of diversity, which simply describes how many elements of something there are (Biggs, Schlüter, and Schoon 2015). Amongst the larger-scale producers, the focus was primarily on the farmed species of *Saccharina latissima*, as well as some smaller amounts of *Alaria esculenta*. According to one respondent, the focus on two or three species was 'what could be expected' from the industry at this stage in the development. These species were chosen due to their suitability in farming, having demonstrated fast growth, high yielding biomass, and valuable nutritional contents.

In comparison, amongst smaller-scale producers, respondents described up to 5 or 6 different species being harvested and tested for their various applications, particularly food products. One of the producers harvesting wild species specified that they had chosen to continue harvesting some species which were not common amongst other producers to give them a competitive edge, or to reach a slightly different market. They explained:

> *"If everyone just goes for Alaria and Saccharina then the competition would be too hard, it is still a very new market. Especially in Norway, the change is so slow and the market is too small for us all to do the same thing, like the same style of products and species."*

This remark reflects an understanding of the notion of diversity as important for the success of the industry. Not all respondents described diversity in species as something central to their management approach, yet amongst those who did, the reasoning behind selecting a wider variation in species to cultivate was more often explained in terms of market access and competition, and not as a means to respond to change and disturbance, per se.

Still, what all respondents whom I discussed this issue with did seem to agree on regarding diversity was the problematic scenario of having only large-scale monoculture farms. One respondent said:

> *"…we do what everybody can do right now, we do the three species. But the long-term perspective is definitely to be able to cultivate more species… and to extend the season, and to use the farm the whole year round, but also to create resilience against potential monoculture problems."*

Speaking to the researcher about diversity both in terms of scale and species, and whether they found industry stakeholders to reflect on aspects of diversity in their production, the respondent highlighted that this was not coordinated, at least in the short- to medium-term perspective. In their words

> *"…well I think that it has not been coordinated at all. The focus so far has been first to develop the techniques for cultivation. And it is pretty much only Sugar kelp and Winged kelp…but I think large-scale seaweed aquaculture is going to focusing mainly on kelps because that is what you get most biomass from."*

It is important to differentiate between the short and long term perspectives here, as was pointed out by the respondent. For example, relatively high biomass yields can be achieved with a wider range of species in the long term, but different cultivation techniques are required. Moreover, when asked about the extent to which a diversity of actors was apparent, the same respondent commented that this was not something that was explicitly coordinated either. The respondent also mentioned how it was their impression some actors with licenses for cultivation did not have a corresponding business plan. In their words:

> *"…there are many actors that are involved...and actually the large majority do not do anything with [the seaweed]. They do not produce anything..."*

Indeed, the question of diversity in species is also very much linked to the matter of diversity in applications. Because the industry is still in its early stages, I heard a lot of discussion amongst producers, as well as in conferences, around what to actually do with the harvested biomass and how the different species can and should be used. The primary application in Norway at this stage, however, was cited as food for humans and feed for animals, as outlined in chapter 2. This is the market that all respondents, regardless of scale and species portfolio, agreed had the highest value and greatest potential for development, based on public interest and value creation. In reference to figure 6, one respondent noted:

"Quite a lot of applications at the top of the triangle, which is food and pharmaceuticals… and cosmetics, these three things, they do not need so much biomass. These are also what I think are the most interesting things to work with."

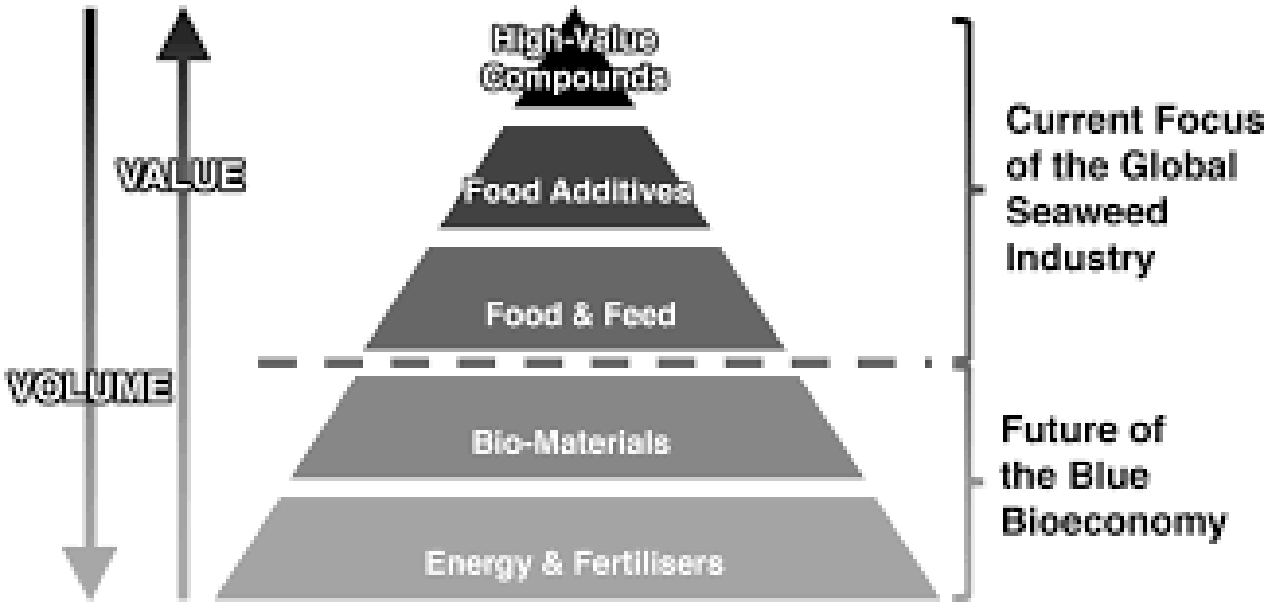

Figure 6: Value pyramid for the seaweed industry. Source: Hasselström et al. (2018).

When asked about how much active thought was given to the diversity of applications within the industry, most respondents explicitly stated their appreciation for the multiplicity of *potential* applications for seaweed, as described in chapter 2. However, there was an underlying understanding that food and feed, and in some cases pharmaceuticals, were still the most attractive to work with at the current stage of development. Investment in a wider diversity of applications was not yet a priority. When devising a 10-year vision for the industry at the stakeholder workshop, all groups unanimously agreed that food and feed should ideally be an established market by 2030 and that at this stage it might *then* be interesting to start considering visions to expand into other markets as well.

However, about the human food application specifically, one respondent involved in research on this matter stated that while everyone seemed to agree this was the most interesting application for current production, there was a need for more research on matters such as improving safety, taste and the nutritional value of seaweed. This was something the respondent felt had been largely ignored by producers who until recently were almost exclusively focused on production systems. Yet, the respondent added that producers were

increasingly concerned with these matters now that food was becoming more and more established as an important market output.

Moreover, it was the opinion of the network representative that the fact that wild harvesters and farmers together produced different species and products, which in turn were suitable for different kinds of applications, inevitably led to diversification. Still, according to the same respondent, there was also a question of value to consider in this regard. They explained:

> *"If you harvest a really nice, super-quality sugar kelp... then it is difficult to argue that something hand-picked is better. And when it comes to bioenergy, this [application] is kind of suspended, we should be aware of this… First, it pays so little, which is a very straightforward point. The second point is that if it has much greater value or quality for other uses, then processing large amounts to burn would be the simplest use of a fine product. Then it is at least better to use it for bioplastics or something." (my translation)*

On the first comment about quality, the respondent contended that there is no evidence to suggest that the quality of wild-harvested seaweed is any better or worse than that of farmed seaweed. Thus, while there was a sense of appreciation for actors harvesting at different scales with products for distinctive uses, there was also a sense that 'we know too little' and that claims around the quality of the harvested biomass at this stage were pre-emptive. However, for many actors, the substantiation around quality seemed to be a critical factor in the decision-making around what applications are most suitable. On the comment about biofuel in the same quote, several other respondents also remarked the fact that stakeholders should disregard this application for the time being as it was considered a waste of a product that could reach much fuller potential with other applications. According to various respondents, if you are going out of your way to cultivate at very large scales, and invest in expensive processing methods, then burning the biomass for fuel would not make much sense.

Overall, all respondents acknowledged that the potential applications for seaweed are wide-ranging. Stakeholders in Norway were engaged and reflected regarding the many possible benefits of seaweed biomass once harvested, even though the range of applications currently invested in remains limited. This was seen as a significant strength of the industry in itself, with the potential to foster resilience and provide opportunities for redundancy. While there was some disagreement around what applications were the most interesting to consider, there was a consensus around the fact that different species *could* be used for a variety of different

applications, and more importantly that this was considered a significant strength for sustainable success of the industry.

Lastly, several respondents commented on the wide range of stakeholders involved in developing the industry, which can facilitate the potential for considering multiple viewpoints and knowledge systems (Biggs et al. 2015). At each conference I attended I found there to be a good combination of producers, researchers, regulatory authorities, and actors working with communication. At the same time, however, there was also a sense that it was often the same stakeholders representing each of these groups of people that were appearing at the conferences and seminars over and over again. When asked about this, one respondent confirmed my observation but also emphasized that things were changing as the industry continued to grow. In their words:

> *"I agree that you get a lot of the same people showing up year after year…[but] it is also a growing process. So every year there is a large increase in the number of licenses and new companies starting up… and it seems like most of these new companies or newcomers also show up to these events and join the community."*

The connectivity and interaction with more market players could offer significant advantages for the sustainable success of the industry, particularly considering that the market is repeatedly cited as the industry's primary bottleneck. In this regard, the respondent went on to mention the value of network groups or seaweed farmer associations as an important meeting point for different actors, where collaboration was considered strong overall. On the same note, the diversity in regulatory institutions governing the industry was described by all respondents as a positive and constructive form of polycentric governance. However, I elaborate on the dynamics of connectivity in the form of network groups (principle 2) and polycentric governance (principle 7) in their own right in the coming sections.

5.2 Manage Connectivity

The next resilience-building principle, also the second theme of my interview guide, is concerned with understanding in what ways stakeholders felt the industry nurtures or lacks connectivity. This can be about the interaction or collaboration between producers, product users, researchers and authorities but also concerns how resources and information is spread (Biggs, Schlüter, and Schoon 2015). Other forms of connectivity include connectivity between industries – particularly fisheries as will become evident in this chapter – or

connectivity on a social or institutional level amongst stakeholders. Systems that are well connected may recover or adapt to disturbance more quickly than systems that are less connected (Biggs, Schlüter, and Schoon 2015). If a system is overly connected, however, this may have negative consequences including the more rapid spread of disturbance.

The component of connectivity that was most frequently referred to by respondents was the direct collaboration between stakeholders, primarily producers, regulatory authorities, and researchers. All the respondents I spoke to indicated a generally positive and constructive spirit for collaboration. This included knowledge exchange as well as sharing experiences with related challenges and insights, and in some cases sharing equipment as well. One respondent described the collaboration as impressive, referring specifically to how producers were getting organized through networks. The networks pertaining to the industry were mentioned many times, and particularly in relation to serving as a hub for learning and experimentation (principle 5).

However, on the topic of collaboration amongst stakeholders involved in research, the respondent who was a researcher themselves expressed a desire for more openness, stating:

> *"There is quite a competitive environment…we compete for funding with SINTEF a lot, and also Nofima and other institutions…the competition should not be that harsh, I think, and there should be more room for collaboration..."*

Furthermore, one actor at the stakeholder workshop also remarked that they felt there is currently more money invested in research on seaweed compared to the amount invested 'on the ground'. In other words, they felt it was easier to get funding for researching seaweed compared to funding for the actual production or harvest of seaweed. The same actor expressed that more collaboration between seaweed producers and the research community would be desirable. One smaller-scale respondent expressed that this was indeed experienced as an issue, and was very positive to the notion that there should be more emphasis on the collaboration between producers and research. In their words:

> *"…we have so much that we could offer in terms of knowledge and numbers, and real fieldwork, because that is what we have been doing for four years now, just going out and harvesting and recording…at the same time we do not have the funding that a research institute might have, or the skills that a researcher might have to use…it would just be amazing if there was better cooperation. And we also have the right questions, we know what needs to be answered."*

The researcher I interviewed, however, did not identify with this view and remarked:

> *"In every research project that I am involved in, we work together with companies. We are dealing with applied research, so we always need to have companies with us to do practical [work], but also to show that this is relevant for the industry. I mean we do not only do research because we think it is fun, it is because someone also needs it."*

Nevertheless, to put the overall level of collaboration into perspective, several respondents compared the current state of collaboration within the seaweed industry with that of the salmon industry, where the high level of collaboration was explained to me as a defining factor in their success. One respondent spoke about how if you compare the salmon industry with the other kinds of fish and mussel industries that tried to establish themselves in Norway in the last decades of the 20th century, one of the defining differences for success was the level of collaboration amongst producers and other relevant stakeholders in relation to production at the time. Within the seaweed industry, several respondents described the situation to be very similar to the collaboration that led to the success within salmon aquaculture. Still, a few respondents did remark a certain degree of secrecy, for example regarding production and target audiences, but added that this was to be expected. In the words of one respondent:

> *"…absolutely, we really have a very open dialogue within the industry. That is part of what is quite fun with the seaweed industry, that there is so much openness. We talk a lot, we share experiences, and of course there are some things that people keep for themselves as what we are doing is quite investment-intensive…but, business is like that… the things you keep for yourself is quite normal..." (my translation)*

Yet, high levels of connectivity can also be detrimental to a system. The emergence of COVID-19 that became an epidemic in a matter of weeks as it spread across the globe is an extreme, yet very concrete example of how disturbance can impact a system like the seaweed industry. Following up on the interviews I had with my respondents, I wrote an e-mail to ask if they would be willing to share how these times of change and uncertainty had influenced them and in what ways actors dealt with, adapted, or coped with these changes. In this context, one producer replied that consumer products in Norway had essentially stopped, due to this being "tightly connected to events, conferences, and communication in general". The same was said for competence and consulting, which the producer added had stopped temporarily as a result of the dependence on close connectivity with the seaweed community. Although a global pandemic is an extreme example of disturbance in a system, it offers a clear example of how connectivity may to some extent define the dynamics of a system, and

in this case how dependence on connectivity can have dire consequences in the face of disturbance.

Moreover, there were split views on one form of connectivity, which was that between industries, and particularly with salmon aquaculture. I found this to be a reoccurring and noteworthy theme in my investigation concerning various matters, including how the connectivity impacted regulation and funding, both positively and negatively. For example, on the topic of investment and expertise in the realm of aquaculture, several respondents referred to the connectivity with the salmon industry as beneficial to the seaweed industry development. When asked about whether or not a producer experienced positive connectivity by being associated with this sector, the following was expressed:

> *"In Norway it is because they like aquaculture in Norway…it brings employment and tax income. It has a positive ring to it… and in that sense we are lucky because we operate in Norway... investors have an easier time understanding what to do…And suppliers work in aquaculture already so they might just have to make some adaptions to their equipment and we can use it for seaweed. So it fits into a type of industry."*

Because salmon aquaculture has gained such a prominent foothold in Norway, contributing significantly to the economic and cultural status of the country, the respondent points out that the aquaculture sector as a whole has gained increasing trust amongst investors. Despite the industry being less than 50 years old, the country is often regarded as having 'expert status' and is continuously referred to as a 'world leader' when it comes to aquaculture. Connectivity with this sector was thus seen as beneficial for some producers who relied on advanced equipment, investment, and public trust more generally.

On the topic of regulation, however, the connectivity with the salmon industry was generally referred to as having negative impacts on the development of a seaweed industry. The first time the subject came up was during my first visit to a seaweed farm in 2019. When asked about what general challenges they had faced as a company, the representative I spoke to, who was also the environmental manager, described the major issue of environmental guidelines for seaweed production being adopted from existing guidelines used for fisheries. Several respondents described how because of the dominance of salmon farming in Norwegian aquaculture, the same regulations, specifically in relation to environmental considerations, were simply 'recycled' for this emerging industry. Many respondents regarded this as highly problematic for the sustainable success of the industry because of the key

differences between the industries, noting particularly the lack of input factors for seaweed aquaculture compared to salmon aquaculture. Several respondents also emphasized how seaweed farming can contribute to maintaining a healthy ocean, and should not be subject to the same regulations as an industry where there is conclusive evidence regarding hazards, contamination and other forms of environmental degradation (Taranger et al. 2015). As a response to this issue, one respondent mentioned a project they had been involved in together with the municipality to establish better and more accurate guidelines for seaweed farming. Referring to the application process for seaweed farmers, they explained:

> *"We looked at the existing regulations for how you have to apply and which forms to use, but we involved the different regulators and tried to get them to think about 'well why are seaweeds different from salmon'. Because at the beginning everything you had to do was modeled after salmon, and that did not fit… it is an educational process for everyone to understand what is actually going on…and how seaweeds are different than the fish that we are more used to."*

Moreover, a county governor representative made a comment in an interview on the assessment process regarding concessions for seaweed versus salmon aquaculture, stating:

> *"…we will do a minor assessment as to whether the zone should perhaps be used for salmon farming instead. Because, in terms of business, salmon farming has greater economic significance compared to the farming of seaweed and kelp…in a competitive situation, we would then prioritize the salmon before seaweed and kelp. Because we have pretty clear guidelines on that we should develop the salmon industry. Both from the department and from politicians." (my translation)*

The respondent stressed that the process of handing out concessions was not politically steered, meaning that if an application for a seaweed farm met all the criteria, they should receive a concession. Nevertheless, the economic prospect that was associated with salmon was a clear priority. It became evident that salmon aquaculture still very much dominates the decision-making around aquaculture in the maritime sector more generally. The respondent did, however, add that the emerging seaweed industry *was* seen as something positive and that the municipality's role in the management process was not to make evaluations based on factors such as the sustainability aspect, the aesthetic impact in the landscape, or social impacts for communities. Nevertheless, as the respondent themselves stated, the 'guidelines for what we *should* prioritize' was unmistakeably those developments expected to generate the greatest profits.

Whether producers benefit from it or not, the connectivity between seaweed farming and the state of aquaculture more generally has played an important role in defining and shaping the emerging seaweed industry. Yet, despite the infancy of aquaculture in Norway compared to many other parts of the world, and despite salmon having contributed significantly to the country's economy in a matter of decades, one respondent expressed that aquaculture globally has acquired a bad reputation. In this regard, the connectivity with aquaculture could also compromise the resilience of the seaweed industry. Talking about the connectivity between seaweed farming and fish aquaculture, one respondent elaborated on the negative reputation of aquaculture, stating:

> *"Aquaculture is a bad word in many markets…we do not really use the term aquaculture, we just call it seaweed farming or seaweed cultivation…in other countries like France for instance, it is really difficult to get licenses in the sea because of the competition for space, and aquaculture is associated both with environmental problems and just taking up space in the sea… and they cannot just dodge that by calling it seaweed farming because it is still going to occupy space in the sea."*

In contrast to France, the respondent added that in Norway it was still possible to distinguish between 'good' and 'bad' aquaculture and that it remained possible to claim seaweed farming as the 'good' kind. The respondent added that as opposed to fisheries seaweed farming does not only demand little input, but it can, in fact, solve some of the problems *caused* by fish aquaculture in the first place. The same respondent remarked

> *"…we can use that to explain why what we are doing is good for the environment. So you can kind of link the two into a positive thing, which it really is….it is a nice story and in some [contexts] it works… but generally, we just talk about seaweed cultivation and try not to link it too much with aquaculture or fish farming"*

This last quote demonstrates how industry actors in some instances intentionally avoid the potential negative impacts of connectivity with a sector that has acquired a bad reputation. In addition, the 'story' that the respondent refers to is linked to the question of integrated multi-trophic aquaculture (IMTA), where it is possible to combine fish and seaweed aquaculture such that the seaweed is fertilized with the excess nutrients from fisheries, promoting growth and dealing with one of the major issues of pollution associated with fisheries. For reasons described earlier, respondents did identify several benefits to the association with the industry, but there seemed to be an underlying wish to dissociate from the industry unless it was in the context of a 'story' such as IMTA, where seaweed aquaculture could offer some remediation.

Moreover, the notion of linking or connecting the seaweed industry to a 'story' or narrative to gain public acceptance was also discussed by other respondents. One producer described the association that seaweed had to animal feed, and specifically the use of seaweed in times of scarcity. In their words:

> *"There is not a lot of stories about people eating seaweeds in Norway. It is given to the animals and people would maybe eat it when there were crop failures. So, when there was war or when there was little food. But it is considered poor man's food..."*

Working to change this narrative, or strengthening the connectivity with a cultural landscape that people are familiar with, was something several respondents described as important for the development of the industry. Indeed, high levels of connectivity between social networks, and in this case between social networks and social narratives, may "help develop trust and reciprocity necessary for collective action…[where] certain actors can serve as connectors to other actors or landscapes" (Biggs, Schlüter, and Schoon 2015, 87-88). This includes building knowledge, awareness, and positive associations around seaweed, which many respondents acknowledged.

As we have seen so far, high levels of connectivity amongst both social actors and sectors can be both positive and negative. However, in a situation where connectivity is maintained within the same structure, this can be a particular cause for concern. Biggs, Schlüter, and Schoon (2015, 94) note that "strong links may lead to synchronized behavior that translates into intense unsustainable resource extraction or strong norm barriers for giving up unsustainable practices". Reflecting on this at one of the national seaweed conferences I attended in November 2019, I made notice of the fact that only one producer mentioned the importance of ecosystem services in their presentation. When asked about this in an interview one respondent answered that the reason topics such as ecosystem service benefits were not covered in more detail was because:

> *"... it is like preaching to the choir."*

However, after discussing the provisioning and regulating services associated with seaweed production that the respondent described as 'obvious', I went on to ask about the consideration of cultural or social services, to which the respondent admitted they had given little thought to. With the conception that ecosystem services is something all producers involved in the industry are thinking about, and that talking about ecosystem services would be 'stating the

obvious', it appears that cultural values and services have been neglected or marginalized in the general discourse or design of interventions and management strategies. Confirming this trend, Chan et al. (2012, 744 citing Groot et al. 2002; MA 2005) note that "cultural services are regularly mentioned as a category of ES and thus recognized as important, but the incorporation of such services into decision making remains far behind that associated with more tangible services".

Biggs, Schlüter, and Schoon (2015, 94) further point out that "[m]odelling studies show that when homogenization of norms occurs, explorative ability drops, leading to a lock-in situation in which actors believe themselves to be doing well while they are actually driving their managed ecosystem towards unsustainable pathways". The impact of this lock-in situation on ecosystem integrity and sustainability has of yet not been measured, and it is not possible to claim that this marginalization of social and cultural services has driven management towards unsustainable pathways. Nevertheless, although these ecosystem-based social and cultural benefits are undoubtedly complex to measure, Kinzig (2012) highlights the lacking social analyses in the resilience literature as a crucial limitation. I return to this point specifically in chapter 6, as it is a cornerstone finding from my research.

Moreover, issues regarding genetics and genetic contamination as elements of connectivity were repeatedly brought up as an important consideration amongst industry stakeholders, both in interviews and during event participation. While these matters have a clear link to the resilience principle of connectivity, there was a lack of consensus around the extent to which seaweed aquaculture and particularly industrialization could impact local biodiversity.

For example, the topic of genetics came up during the participatory workshop, where each focus group was asked to rank statements related to genetic contamination in order of importance from ‘most agree’ to ‘least agree’; for instance, ‘seaweed aquaculture will decrease genetic biodiversity in the local populations’. Statements were arranged in a pyramid known as Q methodology, used to study participants’ subjectivity or viewpoint. In my group, the issue of genetics contamination did not seem to be of a particular priority compared to other issues such as the potential of seaweed to offer a range of ecosystem services or the need for the emerging industry to be both environmentally and economically sustainable. Any statement related to the potential impact on the genetic pool was placed either in the middle of the pyramid, indicating ‘neither agree or disagree’, or towards the spectrum of ‘least agree’. At other stakeholder tables, however, the issue of genetic contamination was ranked higher in

the order of importance. Still, there was a certain level of inconsistency with regard to how important stakeholders viewed this issue. In general, most participants seemed to align with the notion that this was something we still know very little about, which has led some actors to down-prioritize genetic consideration in their management approach, while others explained taking a precautionary approach to try and take measures where possible. In an interview, one respondent discussed their experience on this matter, explaining:

> *"There are also issues regarding genetic materials. When we cultivate seaweed we use local mother plants, which are local genes that we cultivate….we are now getting requests from other farmers in other places to buy seeds from us… it is not quite clear how local genes have to be. Can we use the same strains as we use when we ship them 10 kilometers, 100 kilometers, or 1000 kilometers? There is no clear regulation on that. So, that is a bottleneck that is already quite relevant…"*

The lack of clear and coordinated regulation has also been flagged in the PEGASUS report described in chapter 2. In the interview with the researcher, however, it was very clearly stated that matters of genetics were of critical importance. The respondent pointed to several studies with conclusive evidence on national as well as more local-level genetic differentiation, asserting:

> *"…this has been proved. And Norway, the coast is gigantic…so of course you would expect that there is some differentiation. So this is very important to look at."*

The respondent added that the level of concern amongst many stakeholders was lacking, but that this would be critical for the long term sustainable success of the industry. Indeed, a more recent study of genetic diversity amongst wild kelp populations in Norway has found that "Without adequate resilience in the form of genetic diversity within and across populations and given the potential introduction of deleterious alleles from translocations, such anthropogenically pressured populations may not be able to sufficiently respond to future climate and other stressors" (Evankow et al. 2019, 1).

Moreover, another respondent also touched on an interesting dynamic that brought up the issue of connectivity and genetic consideration also between industries and between countries. They explained:

> *"It is so new. I mean, we can ship a Norwegian fish egg to Chile and nobody cares, but with seaweed they are suddenly very, very strict. And I think it is mainly because of lack of knowledge, just the fact that it is new and there has been little research on it, which means that it is more difficult to regulate."*

Again, the reference to the connectivity with the fishery industry, and how respondents describe this as only serving them in particular contexts, is a reoccurring theme. Following up on the assertion that there was a 'lack of knowledge' amongst key stakeholders, I also asked the same respondent whether parallel research on the topic of genetics had not been done in countries with a longer history working with seaweed, such as China or Indonesia. I was interested in how they reflected on the level of connectivity in terms of knowledge exchange also between countries, and the extent to which elements of connectivity between these industries transcended borders. To this question my respondent answered:

> *"They do not really care about that so much. So that is not an issue in Asia I would say. But it is an issue in Europe because we are very precautionary. So I have been getting requests from China to send our material from Norway to China. I mean, I told them, 'listen, are you allowed to do that?' They say 'we don't care'. But we care about that in Europe. So we did not do that… it is very different from Asia, definitely."*

While I did not get a sense that knowledge exchange was particularly high *between* countries, there was a sense amongst several of the respondents I talked to that the precautionary principle was important for decision making. In the context of resilience thinking, this reflects an element of complex adaptive systems thinking (principle 4). Moreover, the respondent touches on noteworthy dynamics here which put the topic of connectivity in the context of globalization. Plieninger and Bieling (2012, 9) cite two ways in which globalization and globalization policies have shaped, and continue to shape, landscapes:

> "(1) a neo-liberal market agenda that aims to open global markets for agricultural production and in which decision-making is detached from sites of production and determined mainly by financial interest; (2) a sustainability agenda (including the Convention on Biological Diversity and the Framework Convention on Climate Change) that aims to conserve resources, ecosystems and cultural values for future generations and which is typically implemented at national and local levels".

Indeed, the global markets for food and aquaculture production have contributed to the renewed vigor in the Norwegian seaweed industry in more recent years. However, the prospect that 'decision-making is detached from sites of production and determined mainly by financial interest' raises an immediate concern. As the respondent mentioning the requests from China pointed out, it is necessary to consider the site of production in its totality when making decisions related to the management, especially on the topic of genetics. Taking the decision to import foreign strains to a production site in Norway may impact the local

biodiversity in ways that are often difficult to predict. While there is still uncertainty around the definite impact, there is conclusive evidence to suggest the environmental changes of greatest concern to seaweed production include alteration of population genetics, such as through genetic contamination (Campbell et al. 2019). In addition, new evidence from a study on seaweed environments in Norway has shown that "care should be taken to prevent translocation of kelp between ecoregions in the ongoing industrialization of kelp cultivation, to maintain a healthy coastal ecosystem and sound natural population genetic diversity" (Evankow et al. 2019).

Several respondents also remarked that producers were in fact very attached to their land areas, and indeed highly concerned with how decision making was relevant to their specific localities. In the words of one respondent:

> *"It is my perception that no one is interested in damaging their sites…There may be some capital interests that are less concerned with the areas, and who only want to lunge at full speed. That is possible. But the locals do not think like that." (my translation)*

Nonetheless, the concern regarding capital interest sometimes overriding proper regulation, specifically environmental regulation, is worth noting. Another respondent touched on the fact that a lack of synchronized regulation within the European Union was problematic in this regard. Indeed, poor connectivity on the regional scale may also cause issues for production locally, and decision-making that is detached from the sites of production may overlook important considerations. One respondent commented that they were dealing with this uncertainty by lobbying for more research. In their words:

> *"…on the genetic side, one way we can deal with this is to lobby for more research on the area so that we can equip the government with more data so they can make better regulations…we have been part of several projects where seaweed genetics is the topic and we are now trying to push for more research on that…that is one way of dealing with risk, and reducing the risk and uncertainty…"*

As global markets continue to expand, where decision making takes place on local, national, and even global levels, it is critical to complement these changing dynamics with adequate research and critical thinking. The respondent highlights this engagement through lobbying specifically as a proactive means to address uncertainty, which is integral to SES. Again, this thinking suggests an alignment with resilience in addressing matters of connectivity, or in the case of genetics, a lack of connectivity for synchronized regulation.

Reflecting back to the second way globalization politics have shaped landscapes, Plieninger and Bieling (2012, 9) refer to the sustainability agenda. The implications of the connectivity between the global sustainability agenda and the development of a Norwegian seaweed industry remain unclear, but the fact that many respondents reflected upon this connectivity is noteworthy. Several respondents remarked that the focus around sustainability and particularly the Sustainable Development Goals was increasingly necessary to incorporate as part of any business model in order to be recognized within the industry. For example, in the majority of talks and conferences I attended, the SDGs were displayed on the first slide of their presentations. One respondent commented on this, stating:

> *"…everybody has now found out that you cannot do anything without naming the Sustainable Development Goals, or sustainability…. And 'green' your business."*

Indeed, sustainability is a buzzword in many parts of the world (Pargman and Raghavan 2014), including Norway. What I found particularly interesting in the context of the Norwegian seaweed industry, however, was the tendency to differentiate seaweed farming under 'Nordic standards' as a clean development, boasting sustainable outcomes and various environmental benefits. In the words of one respondent:

> *"There are big environmental challenges in other places in the world and others look to and are interested in our coast because, in a way, Norway is big and not populated. No one lives here, in the big picture, if you compare with the intensively exploited coast in Asian countries. We have very large, available areas, and we have cold and fresh clean water and so on… But you have to produce both sustainably and enough to get it into a market." (my translation)*

Another respondent went as far as to claim that it was virtually impossible to go wrong with seaweed farming. They expressed:

> *"In my perspective, it is almost impossible to do seaweed cultivation without it being sustainable. We use a resource that has been untapped until now, we do not harvest from existing substance – rather we add new biomass – we do not use any chemical fertilizers, we use - in the cultivation at least - no fresh water. We use energy minimally. And the outcome is a high-value product that has many uses as a raw material. And it is low-trophic, using very little energy consumption in that regard." (my translation)*

This viewpoint was echoed by another larger-scale producer, stating:

> *"There really is no other biological production that does not require any input factors. No freshwater, no arable land areas, not fertilizers…. All it needs is sunlight and nourishment, which already exists in the ocean, and which is often considered waste already…it does not get much more sustainable than that." (my translation)*

However, another respondent, a producer harvesting wild seaweed, was more cautious when speaking about sustainability, and deliberated on what sustainability entailed to them, stating:

> *"…it is such a new industry and people really do not know. Even if you have these sustainable harvesting methods, you really do not know if it is truly sustainable…we look at lots of different variables like the way you harvest, and from many angles, so not just how you cut the species, but how much of the area you take, and at what time of the year you take it…that is one of our big projects at the moment, trying to prove, or investigate, whether we truly are harvesting sustainably."*

Innovation or entrepreneurship that is eager to align with sustainability may result in taken-for-granted assumptions about sustainability. This was a reoccurring and significant finding which I revisit in my discussion in the following chapter. Yet, what I also found particularly interesting about the comments around sustainability in the industry was that the same respondents who described 'Nordic ideals' in relation to sustainability also discussed the potential inconsistency or contradiction with regards to potential taken-for-granted assumptions. For example:

> *"People are going to say, 'well we put the 5% of seaweed in this deep-frozen pizza or fish pudding' and then they would call it sustainable. But a lot of other things in this product is not sustainable… it is not right to use it in that way. But I think there will also be rules and regulations for that soon. So you cannot say that you are sustainable if you are not…you are not sustainable just because you are dealing with seaweed."*

Another respondent pointed out that to make claims about sustainability it is indeed necessary to consider the entire value chain. They described it as problematic when…:

> *"…you mix 'very sustainable' with a way of doing it that is not sustainable at all. Because it is not sustainable to use seaweed as fire fuel."*

Yet, as demonstrated by a third respondent, different stakeholders indeed have different interpretations regarding what sustainability entails. Contradicting the previous statement, for example, one seaweed farmer in particular was very positive to the possibility of using seaweed for biofuel in the future. The reason why it was not feasible now, according to them, was because of the scale required. In their own words:

> *"…energy is really difficult to make profitable because you need very large volumes and very low prices. So I still think energy will happen someday…it is a very important area where seaweed can make a big contribution to the world, and we can use a sustainable biofuel, but it is going to take a long time."*

To deal with the different opinions regarding how to make the best use of the total biomass one respondent described a potential solution:

> *"…what I always thought is that you could use the best part of the seaweed for food, and then you could actually use the rest of the seaweed to for example make feed or something else like fertilizer."*

The different opinions around what sustainability entails suggest that there is, in fact, a lack of consensus in this regard. Strengthening efforts to encouraging knowledge and knowledge co-production and collaboration can help build resilience. The connectivity between the sustainability agenda and management objectives has certainly impacted how stakeholders think about their priorities in management, and deliberating on these differences can help uncover where assumptions are being made and where true sustainability prospects exist.

Figure 7: Winged kelp (Alaria esculenta) drying. Photo: Troels Rosenkrantz.

5.3 Manage Slow Variables and Feedbacks

According to Biggs, Schlüter, and Schoon (2015, 107), certain variables and internal feedback processes tend to interact to control the prevailing configuration of a system. The development of the Norwegian seaweed industry is linked to various such slowly changing variables. Identifying and managing the slow variables that make up the underlying structures and thresholds of an SES, including characterization and recognition of feedbacks, requires an awareness around how these variables and feedbacks function (Biggs, Schlüter, and Schoon 2015). Respondents reflected an understanding of various slow variables that were observed to directly impact the harvesting season in particular, such as biofouling. Other variables identified in the social domain included changing societal trends and political sanctioning, which can influence preference or desire for certain ecosystem services in society. The concept of feedbacks refers to the two-ways responses happening between variables or signals and changes in the system, which either support or reduce the likelihood of change (Biggs, Schlüter, and Schoon 2015).

Amongst the ecological slow variables that respondents addressed were salinization, biofouling, and warmer temperatures. All three variables have a direct impact on the provisioning service of the industry by potentially limiting the period of harvest. This was regarded as a barrier for development, particularly with regards to the provisioning of food for human consumption, where the quality of the seaweed is of primary concern. For example, one respondent mentioned salinization from changing rainfall patterns as something that was directly impacting production and which needed to be taken into consideration on a yearly basis. Another respondent commented on the impact of daylight and temperatures, stating:

> *"For example, bad dark winters with little light mean that we get a bad start to the crop. Varying temperatures mean that we meet challenges during the harvest period, like last year when the fouling came earlier than expected. And that is because the temperature suddenly rose very fast. It is these kinds of parameters that are a challenge for us, but it is not something that we have to focus on very much." (my translation)*

One respondent located further North shared their experience with algal blooms, explaining:

> *"…when we were harvesting Butare, or Alaria, there was a growth of this algae on it that we have never seen before. And I wondered if it was the same that was affecting the salmon…it really made us think, is it because of warmer water that these algae are suddenly able to grow? And it happened quite late in the season so we could not actually harvest after that, or we had to avoid any areas that were affected by the*

growth. So we think about that and we think about the contamination in the water like with microplastics…"

Many of these variables are linked to a changing climate, and indeed evidence of climate change exists all around us. Cues relevant for the seaweed industry include systemic changes such as higher mean temperatures and sea-level rise. For example, changing water temperatures can lead to the growth of certain seaweeds with a much greater ability to withstand changing temperatures (eurythermal capacity) or to a greater likelihood of invasive species (Israel, Einav, and Seckbach 2010, 86). Both cases are likely to affect ecosystems profoundly, such as colonization in certain areas, leading to a loss of resilience.

However, when asked about their concern around changing temperatures in the ocean as a result of climate change specifically, the large majority of producers answered that this was not of immediate concern to their production, and not something they kept in the back of their minds. Out of ten interviews, only two respondents described a changing climate as a concern having a direct impact on management and decision making within the industry. If climate change was something stakeholders reflected upon it was regarded as a personal concern, and not in relation to the business. As stated by one respondent, climate change is:

"…something you think about in general. Like, not specific to us, but just in general."

Another stakeholder spoke along the same lines, affirming that it was of course 'unfortunate' that the environment changes so quickly. Yet, rather than seeing climate change as a general concern, respondents reflected much more on specific changes that could be observed in real-time, or from year-to-year, such as salinization mentioned above. They state:

" No, we do not have this in the back of our mind in the management process. It is mostly the issue of salinity, or rain, that can have an immediate impact and that is something we take into consideration in our process." (my translation)

The researcher I interviewed confirmed the mentality reflected in the quotes above, stating:

"…it does not seem that it is something that they worry too much about, at least they don't express it that much… I cannot really say that I have heard that many direct worries from seaweed producers."

The respondent clarified that although producers may be concerned with climate change, and particularly how it may affect productivity by having an impact on growth or by increasing

biofouling, it was not expressed as a direct concern for management. However, when asked to what extent the researcher felt this *should* be addressed, they remarked that it most definitely should be followed up more closely. How climate change affects the genetic structure of the natural population was of particular concern, as the respondent explained that this is where the genetic material for cultivation is extracted.

The network and communication respondents also expressed concern around the impact of warmer temperatures as a direct effect of climate change on the resilience of the system. For example, the network representative described how climate change and rising sea temperatures were having an impact on fisheries already, and that geographical location and positioning along the coastline was an important consideration for any aquaculture industry. They explained:

> *"But of course, there is a reason why there is interest in northern Norway, as we are seeing that quite a lot of the fish farms have to be moved North due to temperatures. There is a temperature optimum that may be too high in the summer in the south of Norway, for example for salmon." (my translation)*

From these conversations, it was my impression that climate change and rising sea temperatures as a slow variable affecting the industry was of concern primarily when there were visible cues directly affected the biomass. Where we still have knowledge gaps is, therefore, identifying the relevant cues by strengthening evidence in support of species-specific impact or direct bearing on production. This could be useful to raise awareness amongst industry stakeholders, and help decision-makers be prepared for change in the face of uncertainty.

Still, when asked about how climate change impacted management, more respondents spoke about climate change in relation to the 'positive' impact it had for the industry, in the sense that it brought attention to seaweed as a partial solution. One producer explains:

> *"...we feel that the macro trends in society are moving in our direction. So, with climate change and general awareness of environmental issues, like the loss of biodiversity. People really want to do things that are good for the world, and seaweed can be seen as that…without [these trends] I think it would be much harder to develop this industry right now. And I think that is also the reason that it was much harder 10 years ago."*

Indeed, societal or 'macro' trends alongside changing worldviews make up a set of variables with the potential to influence ecosystem service preferences. In the social domain, one such trend is sustainability, built on the underpinning of protecting the planet and recognizing that resources are not infinite. Sustainability has become part of a global commitment to protect the earth and ensure a future for the coming generations (Brundtland et al. 1987). A growing number of businesses and institutions are 'going green', by for example making pledges to incorporate Sustainable Development Goals in their business model, as described in the previous section. Society is demanding that businesses and industries take responsibility, which leads to changes in which ecosystem services are being demanded and what stakeholders may choose to prioritize. This narrative was something a handful of respondents described as a significant motivation amongst producers, and which according to one respondent would directly impact the resilience of the industry. In their words:

> *"I think the industry will be a lot more resilient than many others, it is just so slow… there are changes happening, but these changes are in the favor of seaweed. So if you compare it to the meat industry for example, or another industry which is not following the trend so much, then maybe there would be less resilience."*

Other key variables stakeholders reflected upon in the social realm included changing food trends and an increasing wave of green investment. At the event on Sustainable Food arranged by Tekna, the CEO of Seaweed Energy Solutions remarked that we only use 2% of food from the ocean, which is shocking considering the competition for finite resource and arable land for land-based food cultivation. His presentation on seaweed as a novel food group, and as an answer to the question "What is actually sustainable food", concluded that eating seaweed ticks all the right boxes when speaking about current food trends and what we should be eating: it is healthy, tastes good, comes packed with umami flavors and has the potential to replace many other less sustainable ingredients.

Indeed, actors mentioned changing food trends as significant for the development of a Norwegian seaweed industry at every food or seaweed event I attended over the last year. Buschmann et al. (2017, 392) confirm that "while seaweed consumption in South-east Asia has been common and traditional, and has depended on taste and price, seaweed use as food in non-Asian European and USA markets has considered additional parameters such as nutritional value and 'food for health', with a strong consumer preference towards organic, sustainable and fair trade products". In Norway and many parts of Europe, seaweed has not

yet gained status as common food. However, in an increasingly globalized society, where food trends and food cultures are increasingly diffusing across borders, several respondents stated that the perception of seaweed was changing. As described by the one respondent:

> *"…with the influence of the Asian kitchen and fusion kitchen, and the attitude that seaweed is something that you can give to Kings and to peasants alike, and that it is delicious, started to influence the way the different [Nordic] kitchen chefs were using this in their menu…the Nordic seaweed is especially interesting for its quality because of the cold water."*

The growing awareness around the environmental consequences associated with the food industry described in chapter 2, and the increasing knowledge around the benefits of consuming primarily plant-based foods, has also created a wave of interest for more vegan and vegetarian products. Thus, according to several respondents, the emergence of an industry that offers a product that fits this description perfectly could not have come at a better time. One respondent confirmed:

> *"…we fit into the food market…especially built around vegetarian food for instance. There is a lot of innovation going on there. Replacing meats with plant-based sources…we fit in perfectly there because of the properties of seaweed, it is kind of plant from the ocean in terms of nutrients. So these food trends, global food trends, are helping us… so it is not really the uncertainty as much as it is the fact that these global megatrends are…helping us."*

Moreover, concerning green investment, many producers mentioned that despite meeting various financial barriers, they had experienced a surge in investment and efforts to fund projects aligned with these sustainability trends. For example, the Horizon 2020 program is the biggest EU Research and Innovation program with nearly €80 billion of funding over 7 years, ending in 2020 (EC 2019). In July 2019, it was announced that the commission was going to invest the remaining €11 billion of the final budget in 'new solutions for societal challenges that drive innovation-led sustainable growth'. One stakeholder from the workshop confirmed that the two big projects on ocean aquaculture that received funding in this group are both led by Norway, and specifically target low-trophic aquaculture farming such as seaweed.

Some respondents remarked that the increase in 'green' investment was closely linked to the fact that it was now possible to work with seaweed in Norway compared to say 10 years ago. One respondent explains:

> *"I think when it comes to investments, there are more and more investors looking to invest in sustainable green industries. And it was not like that just a few years ago. So that is a general societal trend that is impacting us a lot."*

Another respondent confirmed this, stating:

> *"…a lot of people want to participate in this transformation into a green society…it happened when people realized that they could make money on green solutions….and that was not a long time ago. It could be a maximum of 10 years ago. Pretty fascinating."*

Lastly, on the topic of social trends more generally, the network representative I interviewed described wider social and environmental ambitions amongst producers that align with this overarching sustainability trend. Referring to producers in general, they stated:

> *"…they feel that they have found a production that is environmentally friendly, that is not causing a lot of damage, and which is compatible with the other interests held in society. Right, we do not want pollution, we do not want to exhaust nature, there should be room for many... so there are other motives there, it is not just about selling hot-dogs and making a lot of money that is the motive…They feel that they have found an industry where they can do something good, in many ways." (my translation)*

The reflections of seaweed industry stakeholders around this global sustainability agenda, including 'green' societal trends, is an example of positive reinforcing feedback. The more stakeholders and business models respond to these trends and changing values in society, the more 'necessary' it becomes for other actors in the industry to align with this 'green' profile. It can also contribute to creating the conditions or standards for other industries. However, changing societal trends are a context-dependent collection of many smaller and larger movements, and while they represent a slow variable affecting the seaweed industry as an SES now, it does necessarily reflect how this may act as a slow variable in another industry or in a different time (Biggs, Schlüter, and Schoon 2015, 109). Still, identifying and managing key variables that shape an SES can be a means to maintain or foster resilience, either by maintaining a current configuration or by weakening the potential feedbacks that are keeping the configuration in an undesirable state (Biggs, Schlüter, and Schoon 2015, 108).

Moreover, several respondents identified the notion of values when asked about what factors had influenced their objectives in their work with seaweed. The narrative around how seaweed in many ways represents sustainability for present and future generations, for example, was something respondents cited as significant for their own motivation as well as

for the development and sustainable success of the industry more generally. Several mentioned how changing values in society towards more sustainable industries and a desire to take care of the planet was also affecting the demands of society, which leads to gradual changes in ecosystem service preferences. One respondent described their changing values in relation to their background, and how this line of work 'made sense'. In their words:

> *"We operate in an industry that makes sense, for the environment and for the future. So that is motivating in itself, you are doing something that has meaning. I come from a background in oil and gas, and that is not the future. What we are doing here by utilizing the ocean, and finding ways of doing it sustainably, finding ways to build an industry that benefits the next generation, that is motivating." (my translation)*

The discussion around values and their significance for management objectives and the development of the industry was also mentioned in relation to finding investors and funding. This ties into what has already been discussed on the topic of green investment, but is also highly linked to the idea that if more investors are seeking 'green' investment, this will have significant impacts on the decision-making and opportunities available to stakeholders. Confirming this, one respondent described how their priorities changed upon meeting an investor with the same values. In their words:

> *"I was really relieved to talk to somebody who has a lot of money and who also thinks that value can be looked at in another way. But as he said, which I actually agree with, 'you have to make money one place and then you have to do the good stuff another place'. You have to balance that. Because nobody can do anything if there is no money accessible."*

It remains unclear to what extent the idea of 'making money in one place…to do the good stuff another place' translates in practice, particularly with regards to environmental sustainability. Nonetheless, as mentioned in chapter 3, Cote and Nightingale 2012, 476) point out that "power and competing value systems are not external to, but rather integral to the development and functioning of SES". If accurate, this perspective may strengthen the evidence in favor of fostering production at multiple scales with multiple management approaches. For example, facilitating industrial scale-production to produce profitable large-scale biomass, on the one hand, while at the same time promoting the development of producers that have the ability to deliver a wider range of specific and more localized social and cultural ecosystem services benefits, on the other hand, could be a key to a functioning and resilient SES. I discuss this thought in more detail in chapter 6.

The last finding I present concerning slow variables, before moving on to the fourth principle of resilience, is how policy and governance have supported or hindered seaweed aquaculture development. One key take-home messages from the stakeholder workshop I attended in February 2020 was the disconnect between policy deliberation and policy action. Several of the stakeholders from my focus group referred to this as a double standard and is an example of negative feedback based on formal and informal political sanctions.

One respondent in particular described this double standard as short-sightedness in management and politics. On the one hand, they remarked, politicians are insisting on further exploiting the ocean with the goal to double the value from the sector. There is a strong push to develop a blue bioeconomy, where stakeholders are enthusiastic and driven to find solutions for bio-based clean energy and other green solutions for the future through more efficient and sustainable use of the ocean. However, at the same time, these same politicians are issuing policies aimed at coastal protection and conservation of the ocean and seascapes. In addition, they are placing restrictions on novel foods, novel technologies, and novel production systems. Another respondent at the workshop remarked that you simply cannot push for ocean development and ocean conservation at the same time, at least not if both interests are in the same localities. One respondent drew a parallel with another current debate in Norway regarding the building of roads, remarking that the same people in government who are lobbying for a four-lane road to be built between the cities of Oslo and Stavanger are also demanding that in ten years' time we need less car traffic. This lack of connectivity was expressed as an issue and indeed may have significant consequences for the industry's development in the long-run.

Lastly, the regulatory authority representative from the workshop, who I later interviewed, confirmed that since the introduction of a new guarantee fee (per decametre of area) in 2019, there have been no new applications for concessions in the municipality. The respondent, who worked with processing applications for seaweed aquaculture, anticipated that the issuing of a 3000,- NOK fee between 2018 and 2019 was a direct cause of fewer applicants. The respondent did not know of any other applications received in any other municipalities either. Such a measure will inevitably have financial implications for producers, yet what is particularly concerning is how this will impact smaller-scale or less financially capable actors disproportionately. I discuss the potential implications of this in chapter 6.2.

5.4 Foster Complex Adaptive Systems Thinking

Complex adaptive systems (CAS) thinking is an approach or mental model that fundamentally accepts that there are many overlapping and interconnected factors to consider when evaluating an SES (Biggs, Schlüter, and Schoon 2015). Key characteristics include accepting, or even embracing, uncertainty, complexity, and unpredictability. In addition, CAS thinking embraces a high level of interconnectedness, while fundamentally acknowledging that a multitude of perspectives exist. It also expects non-linear changes and transformations. Again, in the context of an industry still in its early stages, deliberating on these assumptions of complex adaptive systems is a valuable opportunity to invite stakeholders to recognize the wide range of opportunities as well as challenges that exists within the system.

Thus, my study is concerned with how or to what extent stakeholders were aligned with this mental model, as it is cited as crucial for resilience-building. Indeed, it was my impression that respondents were generally aligned with a way of thinking that embraced and expected uncertainty and complexity. For example, innovation was frequently talked about as integral to the current state of the industry. In the words of one respondent:

> *"We have to innovate because there is no industry yet. So the whole concept of seaweed farming is innovation… If you do not innovate there is no company, and there is no industry. It is kind of the foundation for everything we do, it is research, development, and innovation."*

Indeed, this kind of mindset is highly linked to the fact that the industry is in its early stages, which demands flexibility and adaptation. One respondent described the aquaculture industry as an innovative sector overall, considering its relatively recent development, which they saw as contributing to what I describe here as complex adaptive systems thinking. The same respondent also described the function of networks in providing a space for such CAS thinking. In their words:

> *"…people here come from an innovative industry that has had to endure quite a lot. So when I started in salmon farming, for example, we had lost almost all our fish after a year due to disease, but we continued either way… So those who are involved with this now, these are people who have understood that there is a lot that is not static, and there is a lot that is changing. That is also the point of this network, that you meet and discuss with each other…All the surprises, everything that is new, everything that has happened since last spring, since last month, since last week..." (my translation)*

Innovative stakeholders and actors were identified as vital for the development of the industry, and which would significantly impact the potential of the industry to achieve sustainable success. In their book, Biggs, Schlüter, and Schoon (2015) provide a list of conventional views of ecosystems and identify specifically how these views have shifted in recognition of CAS properties. Some examples include how rather than treating individual elements in isolation, stakeholders aligned with CAS thinking view a system as complex and composed of many smaller and larger entities that interact at different spatial and temporal scales. It was my impression that stakeholders were generally affiliated with such a shift. Touching on this, and specifically the notion of multiple variables being integral to the system, one respondent describes:

> *"…there are some things that have come as a little surprising to us, of course, including that there are so many variations from year to year. I think that has really surprised all the producers. And there are no good clear answers to how it happens, why one year it grows incredibly fast, and another year you get almost nothing. And there are exceptionally many variables that in fact can influence the process" (my translation)*

Biggs, Schlüter, and Schoon (2015, 147) further outline how in conventional views of ecosystems, uncertainty is largely ignored: "probability distributions for key drivers and decision variables are treated as known". Reflecting CAS thinking over this conventional view, the same respondent quoted above indeed acknowledged the fact that such variables were something out of their control, and that this was embraced by stakeholders and acted upon accordingly. Referring to change and uncertainty in production, they expressed:

> *"First of all, we have no influence on that. We have no influence so all we can do is just take measures accordingly. One measure that we have focused on is spreading risk…we cooperate a little more closely with some specific producers in relation to production and volumes… we want to have a solution where we can grow in several locations, so that if for whatever reason it should fail in one location, then we have several other areas where we can have production." (my translation)*

Furthermore, Biggs, Schlüter, and Schoon (2015) discuss the need to match institutions to CAS processes in order to foster CAS thinking. Reflecting on the question of whose understanding of CAS matters, brought up in chapter 3, it is necessary to consider the role of funding institutions. One important body of funding that made an appearance at both conferences I attended was Innovation Norway. They represent the Norwegian government's most prominent instrument for innovation and development of industries in the country,

distributing 6,7 billion NOK in 2019 (Innovasjon Norge 2019). Several producers mentioned that they had received funding from Innovation Norway when they first became involved with seaweed, but that once the funding stopped, the innovation period was deprioritized. According to one respondent:

> *"Now there is a lot of pressure…the first year we had funding from Innovation Norway, and we could spend enough money to survive. But once that wind has broken, the pressure is on to meet our sales targets so that the company can afford to pay to survive. So the [innovation] side of it is not so strong anymore."*

Innovation and learning are key to building resilience, yet several respondents identified this financial limitation as a barrier to their innovation capacity. At the Alge2019 conference, a representative from the Norwegian Seafood Federation (Sjømat Norge) described how most funding in Norway is allocated during the initial phases of basic research and development, while when the time comes to reach the market – a phase characterized by high capital intensity and few opportunities for risk management – there was little funding available. The representative concluded that the upscaling phase in Norway is perceived as very challenging for many new businesses and in this case entire industries.

Adding to this, one stakeholder whom I sat next to at the conference commented on the fact the conditions to receive funding from an institution such as Innovation Norway include that an actor must be able to document all the potential impacts of the business. However, according to the respondent, this was an impossible task, precisely because there is so much uncertainty and change characterizing this emerging industry. In their view, this funding body in particular had much too high expectations for newcomers in the industry which made it difficult to innovate and experiment and did not have a vision for development that made room for uncertainty as an integral component. In this regard, the alignment of institutions such as Innovation Norway with a CAS thinking mentality was regarded as poor.

Moreover, returning to the topic of ecosystem services, one noteworthy reflection of CAS thinking that I picked up on from multiple stakeholders was the expectation of non-linear changes in the system. Referring to provisioning and regulating ecosystem services, in particular, many stakeholders pointed to the fact that assessing what services are actually being provided was a highly complex matter influenced by many interconnected factors. Still, many added that there was a tendency to claim the delivery of ecosystem services as a direct outcome of working with seaweed and that these claims were in many cases premature.

For example, in the case of seaweed environments serving as wildlife habitats, both wild harvesters and farmers mentioned the prospect of ecosystem service benefits in the form of shelter for fish and other ocean-based species. However, there was less consensus amongst seaweed farmers when discussing the potential for the cultivated farms to serve as wildlife habitats in practice. Several respondents raised concerns about to what extent it was actually possible to claim these ecosystem service benefits, due to the lack of quantitative research done in this respect. When asked whether or not they felt that ecosystem services were prioritized amongst both producers as well as in research and in the general discourse around seaweed, one researcher remarked:

> *"We have ongoing projects looking at ecosystem services… for example in the context of integrated aquaculture. But the ecosystem services still have to be proven, or to be quantified…What is the actual ecosystem service? You can easily figure out how much carbon, for example, you bind, from producing so many tonnes of seaweeds, or how much nitrogen and so on. This is a mass balance."*

The respondent also remarked that the question of what happens to the fauna and flora in these seaweed environments remained an 'unanswered question', concluding that you can not claim an ecosystem service in such respects. In their words:

> *"It has been talked about a lot that having seaweed farms can provide shelter for fish or other organisms. And this is true, if you go to a seaweed farm in April before its harvested you can see a lot of small fish and lumpsuckers…but what happens when you harvest everything? Because that is what happens, they harvest everything. So can you claim the ecosystem service there?*

Indeed, once you harvest the biomass, the temporary shelter is often discontinued for the remainder of the season. Referring more specifically to off-shore production, a respondent states:

> *"Also further out at sea, at bigger scales, what is the ecosystem service in terms of shelter for organisms? Do you find organisms? At what range?... and should you harvest everything or should you leave one part of the farm to provide a shelter, to provide this ecosystem service?"*

Another respondent suggested that the issue was a lack of adequate systems in place to value these ecosystem service benefits and what they entail, which was the cause for the uncertainty and vagueness. Referring to potential investors, they state:

> *"…for them the seaweed, or the bioresource sector, is very interesting…and that is because of these potential ecosystem services…then we are suddenly talking about very big money, but what is lacking at the moment is that we do not have the systems in place to value these services…"*

The same respondent also elaborated on what they felt needed to be done to establish more clear parameters for how to define ecosystem services, stating:

> *"…the first step is to talk about it. And name it as a possibility. But then of course the next step will be to get involved in research projects and participate, and that is where this is being more defined. Which ecosystem service are we actually providing? What, for example, is happening in terms diversity in such a farm, and over what time periods?. And how could we view that in a system? Maybe that is not relevant for very small-scale farms, but at least for bigger ones."*

The respondent concluded by stating that efforts to systematize ecosystem service benefits were also a means to:

> *"…prepare mainly our own shareholders and loan givers, so that this is not just a green mark in our records, but a business model. And that is still very foreign."*

As was pointed out by several respondents, it is still unclear exactly what ecosystems are actually being provided, and to what extent these are significant when considering that the biomass is ultimately harvested. In other words, if a farmer grows a seaweed farm in the fall season which attracts a diversity of species and contributes to local biodiversity, but then harvests all the biomass in the spring, what ecosystem service benefit is actually being provided? To what extent do short term benefits 'count'? Yet, as was pointed out by the last respondent, talking about and deliberating on these issues is the first step towards gathering the right information, and eventually turn this into more than just a 'green mark'. In this respect, the mental model exhibited reflects resilience thinking to a large extent.

5.5 Encourage Learning and Experimentation

The following two principles, learning and experimentation, are also specifically relevant for an industry still in its early stages of development. Because social-ecological systems are always developing there is generally room for innovation. However, this also requires that stakeholders continuously revise existing knowledge and encourage learning. Collaboration is a key process for encouraging learning and experimentation; "collaborative processes can also support learning and therefore decision-making by helping to make the value regarding

different ecosystem services explicit" (Biggs, Schlüter, and Schoon (2015, 181). Again, this demonstrates that indeed many of these principles are intrinsically interconnected. As the topic of collaboration has already been covered in 5.2 I, therefore, begin this section with how stakeholders reflected upon innovation and entrepreneurship as defining characteristics of the industry.

The topic of learning and innovation was described by effectively all my respondents as intrinsic to the industry. Many remarked that learning and experimenting was essentially all producers have been doing up until this stage. As discussed in section 5.4, the network representative respondent described the community working with seaweed as members of an innovative branch "that have had to endure a lot". When asked to what extent learning and experimentation was encouraged, another respondent exclaimed that where we are now "it has *only* been innovation". Another respondent elaborated slightly on this, adding:

> *"There is an established seaweed industry in Asia, but we have such different contexts, mainly due to labor costs. So it is not possible to do exactly what they do. We have to do it differently and build the value chain from scratch, and innovate across the value chain."*

Building on the question of uncertainty in the system, and whether or not this could be a factor directly linked to learning and experimentation, one respondent remarked that uncertainty was an element that not only encouraged, but in their words 'demanded', learning. They continued, explaining:

> *"At the moment we have 30-meter ropes, but that might not be appropriate at all if we learn some new things. And so what we build now, in terms of infrastructure, is of course determined by what we know now. Yet, we have to try to do it in a way that is flexible enough so that it will also accommodate what we have learned in, for example, five years."*

This quote reflects an appreciation for learning and experimentation, as well as an understanding of CAS thinking. Stakeholders inevitably have to experiment in order to find out the most effective way to operate. Yet, as noted, there is also a need to build equipment as well as a knowledge base that can adapt to the changes that can be expected further down the road. Another way in which respondents described this way of thinking by example was by borrowing or repurposing equipment from fisheries. For smaller-scale business in particular, it was also mentioned that by collaborating with other producers they could buy seaweed off them in the case of temporary shortages. That way, when sales are unpredictable, they can use

the network and collaboration with other actors as a safeguarding mechanism until they have found a more permanent solution to adjust their production to the demand.

Not surprisingly, the value of networks for the principle of learning and experimentation was emphasized by the network representative in particular. Biggs, Schlüter, and Schoon (2015, 192) confirm that "one of the most meaningful ways to ensure the resilience of social learning processes is to embed them within learning networks or communities of practice." Indeed, all respondents referred to the benefit of seaweed networks for constructive collaboration and learning as well. Most respondents were also members or in some way connected to such networks themselves, referring to them as a highly constructive meeting space. Describing the purpose of their network, the network representative stated:

> *"What the seaweed network does is first and foremost provide a space to meet and exchange experiences and discuss what you learn, including from what you produce yourself and what you learn through contacts. So you share. That is the main and most important purpose of the seaweed network."(my translation)*

I heard mention of two networks in particular, one based in the North of Norway and another that was specifically for wild harvesters. Both networks were described as formal meeting points where dialogue was highly constructive. Despite being a wild harvester, one respondent also remarked that they were, in fact, welcome and included in both networks and that the learning and experimentation also extended between actors at different scales and approaches. Speaking about both networks, the producer described:

> *"With the Norwegian Network of wild harvesters…we have had meetings in Scotland, and now recently in Bergen. We also work together with Norges Vel to promote the seaweed industry, and we work on challenges with Mattilsynet, the food authorities, and it is a really nice collaborative environment…there is also Algenettverk Nord, which is another network, more for farmers, but we've also been invited to take part of that as well. So there is a lot of collaboration and you can also apply for funding through the network…"*

The fact that there was good communication and learning between wild harvesters and cultivators was also a positive finding with regards to building resilience. I asked one respondent to elaborate on this specific interface, to which they responded:

> *"Yeah, because in one respect we do not have the same challenges. They might be talking about seedlings, or ropes, they have issues with completely different things. And with sales we are looking at tonnes of seaweed in one go to Asia for example, so these are completely different challenges…"*

The respondent added that there was also some talk of joining the networks together into one, stating that the industry was too small to have two separate networks, and was positive to this prospect. Indeed, networks can construct a knowledge pool and strengthen interpretations and resources relevant for the development of the industry. On this topic, respondents were very much in line with a resilience mindset, recognizing in agreement with Biggs, Schlüter, and Schoon (2015, 192) that "such networks can be mobilized to respond to threats to SES, and they can provide opportunities to link local activities with other actors and activities at other scales".

Moreover, some actors commented on how innovation also led to learning and experimentation in the field. Building on the reflections presented in 5.1 on diversity, when observing a disturbance of unexpected algal blooms during the seasonal harvest, one respondent described having cut the harvest period of *Alaria* short due to the growth of algae. I had a similar experience during my fieldwork with The Northern Company, where the benefit of harvesting multiple species became very evident in this regard. When at one point towards the end of the harvesting period for *Alaria* we started noticing some thin hair-like growth on the seaweed, we were required to switch to a different species starting the next day. These growths or abnormal characteristics were seemingly impossible to predict, but because we had knowledge about multiple species and an aim to harvest a diverse portfolio of species, it was not overly problematic to harvest less of this species and instead spend more time foraging other species more suitable for harvest in the warmer months of the season.

Another respondent working with communication around edible seaweed and its use in food by laypeople described how regulatory authorities such as The Food Safety Authorities, the Institute of Marine Research, and Norges Vel[7] related to the topic of both diversity and knowledge building in this regard. Based on recommendations from these authorities, industry stakeholders should aim to familiarize themselves and communicate knowledge on a maximum of 10 species. Referring to the above organizations:

> *"They recognize that there are probably close to 500 species. 'But talk about these 10 here. Because that is what people find. And everything else – forget it!'" (my translation)*

[7] Norges Vel, or the Royal Norwegian Society for Development, is an independent non-profit member organisation concerned with job and product creation within food, agriculture and marine industries (Norges Vel 2020).

Yet, one issue that several respondents mentioned when asked about the extent to which diversity in species was important was that despite all species along the Norwegian coast being edible, not all wild species have been approved by the Food Safety Authorities in accordance with the Novel Foods Act[8]. Thus, regulatory authorities may in fact limit producers wishing to increase their species portfolio, which may limit knowledge and diversity. The disagreement about what constitutes 'novel foods' came up in the context of what several respondents described as a lack of awareness amongst critical stakeholders.

Figure 8: Palmaria palmata, commonly known as dulse, is a highly demanded red species of seaweed. The commercial availability remains limited in Norway. Photo: Troels Rosenkrantz.

8 A Novel Food is defined as a type of food that has not been consumed in Norway or other EEA countries before 15. May 1997 (Mattilsynet 2019).

Indeed, the reoccurring mention of a 'lack of knowledge' was an area where I found that stakeholders desired more attention to the principle of learning. Several respondents remarked that there is too little awareness and knowledge regarding basic principles in biology, including the functioning of seaweed environments, as well as misconceptions regarding regulation amongst governing bodies such as the Food Safety Authority and the municipalities. Recalling the early days of the industry, one respondent states:

> *"They [would] call everything for seaweed, which is crazy because there are different kinds of seaweed, and there are different kinds of treating the seaweed, and there are different prices. But that is not what you are presented with, it is not clear…And that is basically everybody who started with this 10 years ago. They didn't know a lot about it, but it sounded really good…I realize now in retrospect because I remember the questions that some of these people would pose me… gold-digging, that is what it was. This is also what they called it. Green gold. It is just really disgusting."*

As an actor involved with the industry from the very beginning, the respondent reflects specifically on the early appeal that many seemed to have regarding seaweed and the promise of a new 'green gold'. In their view, this outlook has dominated the interest for seaweed, at least amongst early actors, while the social and ecological characteristics of seaweed and what the industry needs to learn to develop sustainably have been overlooked.

Another respondent described a lack of knowledge amongst representatives in the municipality, in particular, asserting that these stakeholders have a duty to familiarize themselves with the right information, but that in many cases they had failed. In the words of the respondent:

> *"I have sat in meetings where the county governor has stood up and said out loud that they will reject all applications that have to do with seaweed because 'they don't know'. I get so fed up with this kind of power arrogance. This is the highest authority, which is the municipality, and they have failed in their duty of information." (my translation)*

On the same topic, the same respondent also commented on the process of acquiring a concession, claiming that there are many inequalities with regards to how different actors were treated and that this often led to longer processing time. They expressed:

> *"… and whenever you are seeking access to area you get the full lecture on ocean pollution, antibiotics, and noise pollution from industry. But this has nothing to do with seaweed production. But they are not able to communicate this or to make a distinction between the two…The municipality is the big bottleneck here. After this, the*

process with other regulatory authorities is more straight forward. It is democracy at its best and worst. But it does hinder actors from developing." (my translation)

Moreover, the research respondent I spoke to also remarked a lack of awareness amongst many actors who had acquired licenses for production without a clear business plan, stating:

"… I think in the future there is going to be fewer actors, I think that some will disappear, and some larger more established actors who have established a strategy… the survival of companies like this is depending a lot on, yeah, a business model…until now, they've been giving pretty much licenses to everyone who asks."

Moreover, in many ways, the desire to explore the untapped potential of seaweed in Norway is indeed inspired by the food culture around seaweed in other parts of the world. Recognizing this, I was interested in finding out if industry stakeholders looked to other more experienced countries or regions for models or knowledge about where to begin the experimentation that would eventually lead to the development of a seaweed industry. Yet, only one respondent indicated having acquired or sought knowledge from other countries or regions. Rather, it was a reoccurring affirmation that the majority of stakeholders felt they had to learn everything about the industry from scratch, as nothing similar had been done in Norway, or Europe, until very recently. The Norwegian context was regarded as too different and context-dependent.

One respondent did, however, mention specifically a desire for a stronger sense of collaboration and knowledge exchange between countries. They brought this up in relation to the recurring topic of lacking knowledge amongst key stakeholders, described earlier, and expressed that learning from other perhaps more experienced actors could be helpful in this regard. When looking into exporting, one respondent stated:

"…we asked [The Food Safety Authorities] 'do we need any certificates', and they said 'well, not really, because seaweeds are not plants, so you do not need a plant certificate', but, it was determined in Norway that seaweeds cannot be sold without a plant certificate… there are so many things that are really odd, and not in place…it would be very helpful, and this is kind of a barrier I feel, to take in more expertise from all kinds of stakeholders from outside Norway. Both EU markets and industries and not least researchers… I think that it is too closed…"

The respondent, who themselves had been active in the research and academia, added that in their experience the research environment was also comparatively more closed in Norway. They describe:

> *"…with people who are more on the science side who do not have a stake in production, there I find that actually outside Norway it is much more open than inside Norway…When I was in the research sector in Norway I found it to be quite closed. I come from a background where academics should be more open to knowledge as something public, especially if it is publicly financed..."*

As has been mentioned already, the Norwegian aquaculture sector is not even 50 years old, so investing in learning or collaboration across borders could be worth considering as a means to foster resilience in the system. Based on principle 5, there is a potential value to be gained in considering how learning and experimentation could be extended to include lessons learned from countries where seaweed production and harvest has an extensive background and history. At the very least, it may be worthwhile to consider what management approaches or methods to avoid.

Furthermore, an area where the Norwegian seaweed industry has not yet reached, but which is prominent in many parts of the world, is the offshore cultivation of seaweed. Offshore cultivation has been repeatedly cited as an interesting prospect for upscaling as the industry continues to develop. Based on a modeling study by Broch and colleagues (2019), Stévant, Rebours, and Chapman (2017, 1384) explain how "although the current demand for seaweed biomass can be met by cultivation sites in the Norwegian coastal zone, model simulations including environmental variable critical to seaweed growth (e.g. light intensity, nutrient, temperature, and current speed) showed better and more stable conditions off the continental shelf than closer to the coast".

Although the topic of off-shore production was not brought up during my interviews, it came up repeatedly during the participatory workshop as well as being mentioned at various conferences. It was my impression that the prospect of off-shore production was debated primarily on the basis of feasibility as well as sustainability, as opposed to an interest driven primarily by the prospect of productivity. The way that respondents deliberated on off-shore production, however, reflected a sense of learning and curiosity around how offshore production could enhance the industry overall, rather than simply establishing off-shore production as a goal. One respondent stated:

> *"…now all the seaweed farms are relatively close to the coast. But everybody says that if this [industry] is going to be increased by ten times for instance, then we cannot have it so close to the coast, because there is going to be conflicts in coastal area… perhaps there you do not need to harvest everything, or you only harvest the biomass you are going to use…maybe biofouling is not a problem further out at sea."*

Another respondent also touched on the issues associated with having such a short season for seaweed, and how off-shore production could perhaps be a solution, stating:

> *"…what they are doing now is problematic, the fact that they harvest everything in May… it works for a couple of months and then you have to wait for the next season…one solution is maybe if you manage to produce the seaweed without this biofouling…one idea is to go further out at sea where we might not have this problem, but this is yet to be proved."*

All current and future developments, such as the prospect of off-shore cultivation, will undoubtedly demand learning and experimentation on the part of all stakeholders. When it comes to conflicts around space allocation, for example, one producer at the workshop suggested off-shore solutions as a way to overcome this. While this could offer a very practical and even sustainable solution in many ways, another researcher from the same workshop commented that the amount of nutrients along the coastline is much higher compared to the deep seas, which is virtually an ocean desert. Thus, if you then have to compensate with nutrient enrichment and fertilizer, the sustainability claim of this industry will most certainly be weakened. In addition to the producer and the researcher, there was a regulatory authority representative, an aquaculture consultant, a university professor, and myself, a master's student, sitting around a table to deliberate on this issue, amongst many others. Just the fact that these conversations and debates are encouraged, and more important facilitated through for example participatory workshops, is indeed a positive indicator for reflection amongst stakeholders on the principle of learning and experimentation.

5.6 Broadening Participation

I found that principle 6 on broadening participation had a lot of overlap with the question of connectivity, but this section relates more specifically to participation in the sense of "active engagement of relevant stakeholders in the management process" (Biggs, Schlüter, and Schoon 2015, 201). An informed and collaborative community has the potential to build greater trust and a wider knowledge pool, which can foster collective action. As I have already covered the extent to which respondents engaged with participation in the context of networks as well as partaking in conferences and seminars, I will use the following section to describe how participation from various stakeholders can help strengthen the many important values and functions derived from cultural landscapes and social-ecological systems.

As mentioned in chapter 4, I met many of my respondents at the various seaweed conferences and seminars I attended. In November I was in Trondheim for the SIG Seaweed conference hosted by the independent research organization SINTEF, where I came across many of the same faces, but also many new actors. The theme of this conference was: "How do we create a market for seaweed products and biomass to develop the seaweed industry?" Before the conference, I was uncertain about to what extent the market-oriented focus would be relevant for my production-oriented research. I attended the conference despite this initial scepticism in the hopes of still being able to meet and talk to some of the many producers attending. I remarked the market-oriented focus to one of the first attendees I encountered, as this question of how to reach the market seemed to be a reoccurring theme. The attendee confirmed that pretty much all conferences and events of this kind opened with a statement on the main challenge facing the industry: no market and no demand.

Indeed, in the opening speech the organizer, Jorunn Skjermo, from SINTEF announced that we were all gathered to discuss how to create a market and a demand for seaweed. Yet, the attendee added that while this was always what was mentioned as the most important barrier, it rarely ended up being the main focus due to the simple fact that nobody had the answer. Rather, these gatherings had become an arena for sharing knowledge and for networking, and with increasingly broadened participation from different actors. Indeed, I noticed in particular that there was a broader selection of actors involved in the value chain that were not involved in the cultivation at all (such as a start-up using seaweed to replace single-use plastic) compared to the first conference I attended just a few months prior.

When asked about what elements of participation were 'missing' in order to continue to develop the industry, including where the industry could benefit from the inclusion of marginalized voices or perspectives, one respondent reflected on a more general but related thought, stating:

> *"I see that a lot of things have been done in other places already, and if we had just talked to them before or been a bit more open, we would not have to invent the wheel from scratch. And maybe especially with the green values, or regarding circularity."*

The respondent compared the development of this industry with more general business models observed in the Netherlands, stating:

> *"Seaweeds are not big in the Netherlands, but what they have done on the Bioeconomy, circularity, cradle-to-cradle design…and how this can be applied to*

> *aquaculture, marine operations in general, or food production…it is a huge amount. So, I feel that is a little closed, and maybe it is because the research side of things is still very much driven by the research sector."*

The same respondent added that as of now, 'good research' pertaining to the industry was defined by the researchers themselves, which was seen as problematic. The respondent, who had been involved in research themselves, described the research sector and the producers as having two different agendas. This comment challenges the fact that although many respondents confirmed that broad participation should certainly include the research community, there is a need to also consider what agenda these participants have.

Moreover, Plieninger and Bieling (2012) state that possessing cultural heritage is a value or function of cultural landscapes that societies tend to appreciate. As was indeed pointed out by several respondents, broadening participation or inclusion by developing the industry in more remote localities, in particular, could be a positive contributor to the cultural heritage or landscape. One respondent felt particularly strongly about the development of a seaweed industry in this respect. The following was expressed in an interview:

> *"In these small municipalities that we have up here…the diversification that we have been talking about is also a very important point…to have more opportunities for a young person so that they are not stuck doing the same as everyone before them, but they can actually be a part of something new… this aspect of diversification can mean opportunities for the locals. So hanging on to a small space such as this…is also an ambition when an industry such as this one begins to develop." (my translation)*

The respondent reflects particularly on the potential for the industry to lead to diversification within remote or 'small spaces', and to include local communities. This is also strongly linked to the first resilience-building principle on fostering diversity. With the wider societal trends of urbanization observed globally, fostering diversity in local communities has the potential to make a significant contribution to the development of cultural heritage. Yet, the respondent pointed out that in many of the smaller communities, where the potential for seaweed production is often greater due to the uncontaminated waters, it is often not the lack of jobs and workplaces that poses an issue. They clarified:

> *"We also have to take into account that in many places it is not the jobs that are the biggest problem, the biggest problem is the lack of people. So there is an ambition to draw people to a town that has lost its people." (my translation)*

On one hand, there is potential value in drawing people to areas and landscapes where populations are declining in order to maintain the cultural heritage. On the other hand, Norgaard (2010) reminds us that questions of sustainability, including resilience-building initiatives, are not just a matter of ethics or justice within generations but also between generations. Schmidt, Sachse, and Walz (2016, 53) term the "importance people attach to nature for inter-generational equity" as 'bequest', which encompasses the consolation of knowing that future generations will also benefit from ecosystem services. It is certainly valid for a current generation living in a remote area to have the ambition to encourage more diverse occupational opportunities and livelihoods for the coming generations. Yet, the fact remains, that the coming generations will come equipped with their own desires and aspirations, and whether or not working with seaweed will remain desirable is yet to be known.

Lastly, the principle of broadening participation does not only apply to individual stakeholders but can also be extended to describe dynamics between localities or regions. The network representative I interviewed commented on an important issue regarding what they referred to as a marginalization of the North from the rest of the country. According to the respondent, some companies have worked for many years to build their high status, while in some instances this status was simply the outcome of the locality. They added that in their experience, it appeared more difficult to be recognized when operating in certain parts of the country, and particularly the North. They explain:

> *"Regarding centralization, and everything we lose…we notice here that there is a certain tendency for marginalization when moving further North in the country, even if we produce a lot and there are people living here... it takes time to build status if you come from here... if someone from Oslo comes to visit they say, 'oh you have electricity'. Ok, it is not quite like that, but people question 'what do you have here' and 'what are the opportunities here'. Sometimes you feel that there is Norway, and then there is Northern Norway... It is so hard to be national and have national significance when you are here in the North. I ask, is it Norway and Northern Norway, or is it just Norway?"(my translation)*

The respondent also remarked that there is no reason why it should not be possible to establish a professional base in the North of Norway to develop the seaweed industry, in the same way is has been done with the heavy focus on R&D in the city of Trondheim and on the West coast more generally. However, this was something the respondent claimed was very difficult due to the marginalization dynamics described in the quote, and something the

industry had to work towards collectively. They concluded that although there are not many companies with large-scale production at this stage, there are start-ups and innovators appearing all over the country, and this should be recognized. Participation in this regard, therefore, extends beyond just individuals or businesses, to include regions in all parts of the country. Moreover, recognizing the voices of the marginalized requires deliberation and participation on all scales. Confirming this notion, Biggs, Schlüter, and Schoon (2015, 44) describe how "openly deliberative processes may better incorporate feedbacks from the marginalized through providing for more inclusion, but will require the more powerful to incorporate pluralistic local needs and values into the domain paradigms that they seek to maintain".

5.7 Promote Polycentric Governance Systems

The last resilience-building principle under which I present key findings from my investigation is the topic of polycentricity. Polycentricity is defined as "a governance system in which multiple governing bodies interact to make and enforce rules within a specific policy arena or location… considered to be one of the best ways to achieve collective action in the face of disturbance and change" (Stockholm Resilience Center (2020). I asked respondents to reflect on how polycentric governance was perceived amongst stakeholders in the industry. To produce in Norway, the evaluation of applications involves several authorities, including the Directorate of Fisheries, The Norwegian Coastal Administration, the Norwegian Food Safety Authority, The County Governor's Environmental Department, and The Norwegian Water Resources and Energy Directorate. Each governing body considers potential conflicts within their area of responsibility. Some stakeholders very pleased with this level of governance, which allows for flexible solutions for self-organization, while others were more skeptical about the inherent complexity and sometimes lengthy time frames. Amongst other considerations, governing bodies have to negotiate trade-offs between various users of ecosystem services, which can be a key issue.

In his opening statement of the 2019 seaweed conference at the Confederation of Norwegian Enterprise (NHO), the CEO of the Norwegian Seafood Federation (Sjømat Norge) stated that "the seafood industry will be Norway's most important contribution to achieving the UN's sustainability goals" (Ystmark 2019, my translation). Ystmark detailed that the aim was to double the value of the seafood industry, but that political unwillingness remained a bottleneck. Currently, this lack of political willingness and apt political frameworks was seen

as problematic in relation to the salmon industry but was believed to become equally problematic for seaweed and other ocean resources if this emerging industry were to reach a certain level of mainstreaming or commercial scale. The apt political frameworks that Ystmark was referring to included ones that believe in harnessing the power of technology for a better future and where the conception of green growth is fundamentally adopted. This as opposed to what he referred to as the "passive downsizing", such as through aquaculture taxes, in the business policy of certain industries without adequate compensation in other industries.

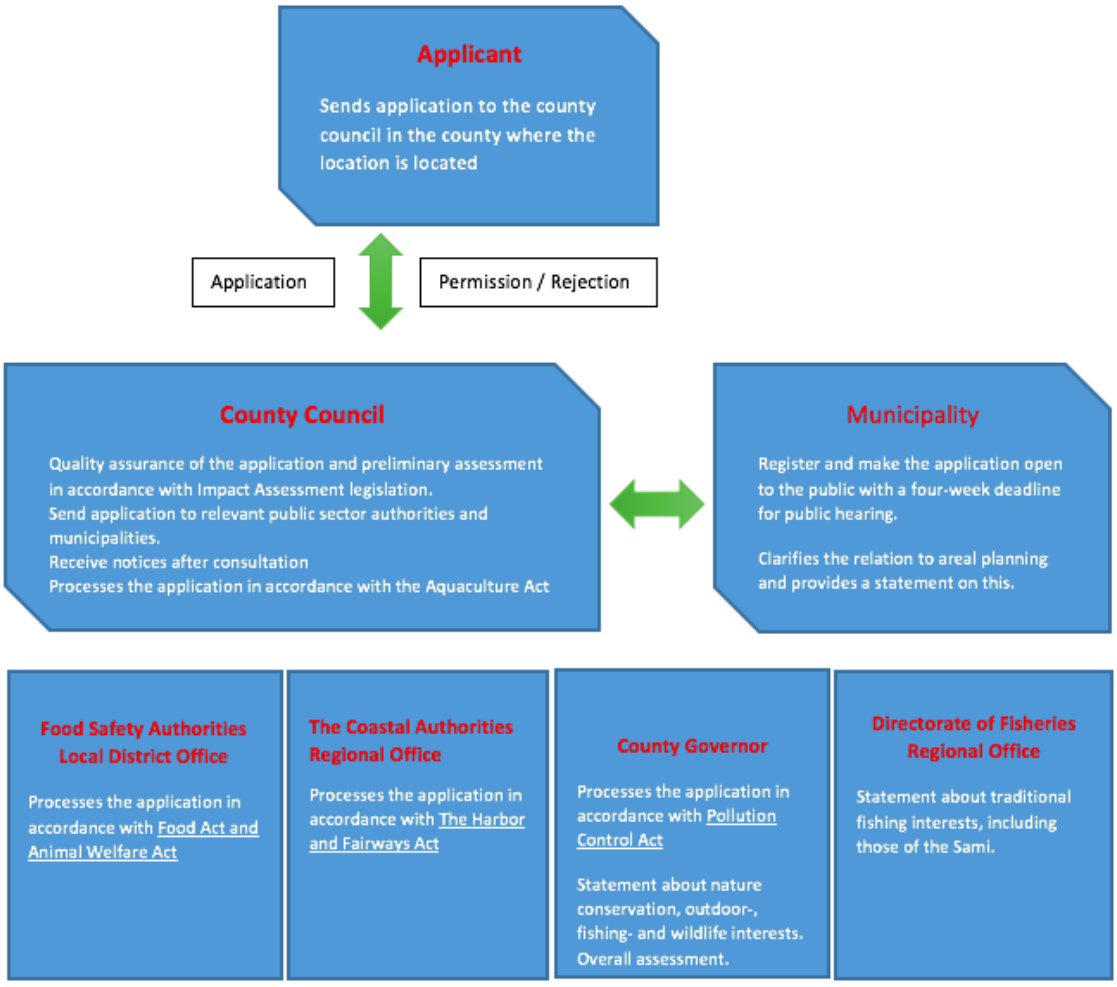

Figure 9: Processing of ordinary aquaculture applications from 2010.

Compared to the oil industry, Ystmark continued, the aquaculture industry currently has to correspond to many regulatory authorities. He compared this to the oil industry, which is primarily regulated with a more monocentric strategy, which he concluded would in many ways be easier. Indeed, polycentric governance may raise some key challenges. According to

Biggs, Schlüter, and Schoon (2015, 235-236) "the transaction costs may rise due to the accelerating needs for coordination with other centers of authority, both horizontally and vertically, as well as problems emerging from a lack of coordination, unnecessary overlapping of authority and escalating communication and information costs in general". In addition, there are noteworthy issues that arise when negotiating trade-offs between ecosystem-service users, for example due to conflicting goals and preferences (Biggs, Schlüter, and Schoon 2015).

When the question of polycentricity was brought up in my interviews, however, all respondents were in favor of a more broadly inclusive system with multiple centers of authority. One respondent remarked in a rather irritated tone:

> *"Yes, many people complain that there are so many regulatory authorities. 'We should have had a single governing body'. But seriously…I think in a way it is kind of neglecting history to say that one body should decide everything… when we recognize that there are many interests in an area, for example environmental interests, health interests…coastal management…then it is quite natural that those who utilize the area should have the right to comment on it… Yes, we have a complicated society. That is because we are a pretty highly developed society. But if shout 'oh, let's have a strong man who can say yes or no'. It is nonsense. I am very provoked by it." (my translation)*

After getting through about half of my interviews, I got the sense that producers and other closely associated actors such as those working with networks or communication were very much aligned with resilience thinking when it came to viewing polycentric governance as an ideal. None of my respondents expressed that multi-stakeholder management was more problematic than it was beneficial. In fact, many felt very strongly about the critical importance of a multiplicity of perspectives, some even expressing that if anything there should be more regulation. For example, one respondent raised the concern that there remained an underrepresentation of voices advocating for the environmental issues that need to be addressed. In their words:

> *"…having worked with coastal management for a long time, and having seen the challenges and multi-stakeholder issues in coastal zones in general, I think it is very important that these different stakeholders have a say, and that this is systemized... the coastal administration and the department of the environment have very different perspectives that are crucial to have. And I am rather a little more concerned that there is a tendency to value economic interest and potential too highly for the short term gain, and that the environmental interests are underrepresented…it definitely should not be less strong than it is…because what happens out in nature and what we do is complicated, and not everything is reversible."*

Several participants at the stakeholder workshop also described thorough regulation in itself as a decisive factor for the sustainable success of the industry. In addition, they added, it was critical for the predictability and stability of the industry. Good regulation in the current development creates a strong outset for future development, and there is value in multiple stakeholders having a say.

Nonetheless, although respondents agreed that regulations were not a barrier to development at this stage, one respondent mentioned that the situation may be different for more small-scale businesses, and especially wild harvesters. However, they still agreed that "that's the way it should be, because there *are* many issues to consider". When asked about this directly, wild-harvesters and smaller-scaler producers agreed with this standpoint as well, and were positive to the level of regulation. When it came to the licensing itself, or acquiring permits, it was described as somewhat more complicated, but still not unmanageable; "everybody got through it".

Yet, as one respondent at the stakeholder workshop pointed out, too much regulation can also kill a business. This is especially true in an industry that is very much characterized by small-scale entrepreneurs and a high degree of innovation. Regulation needs to be evidence-based, and constantly reassessed and updated. While there was consensus around the need to strengthen the polycentric management approach, it is equally important for the industry and for resilience that the right stakeholders are participating (principle 6), that these stakeholders are informed and up-to-date (principle 5), and finally that there is constructive collaboration and co-operation between stakeholders (principle 2).

Moreover, when discussing specific regulatory authorities, respondents identified some more nuances to the question of polycentricity. The Food Safety Authority was most frequently brought up as an example. For the most part, my respondents seemed positive to their involvement and found their supervision helpful and constructive. One of the network representatives I spoke to affirmed:

> *"We also have a dynamic discussion with the Food Safety Authorities, [they] are willing to take part and talk about everything…a lot of things are not entirely certain, but we are not interested in kicking each other out of business. Producers accept the Food Safety Authority and the Food Safety Authority understand the thinking and strategies of producers." (my translation)*

Another respondent agreed, and referring to the Food Safety Authority stated:

> *"I think we have had three or four visits from them, and they are there to support and correct us, rather than to throw a wrench in the works. So they want to help us forward. And they want to help the industry forward." (my translation)*

However, for some of the other stakeholders, particularly the smaller producers or wild harvesters, the Food Safety Authorities were seen as more of a potential challenge to their development. Although they recognized the important role of regulation with regards to health and safety, their regulation appeared to be more of a barrier. Referring to a request to get a specific type of seaweed approved for the food market, one respondent concluded that:

> *"…we are working really closely with them to try and make that happen, but it seems like it might be an impossible task".*

Moreover, another respondent also mentioned that the lack of consensus on food safety-related issues was not only problematic for some actors in Norway but was an issue between countries as well. They explained:

> *"What is maybe more tricky now is the regulations on the food side, like the food authorities in Norway and I guess in all of Europe. There are some uncertainties regarding for instance iodine… there is quite a lot of iodine in seaweed and it is unclear what is accepted by food authorities across Europe. There are even different regulations in different countries even though it should be synchronized because it is the European Union. So there are different national regulations on some things…that can be an issue."*

The same respondent also mentioned the issue of potential contaminants as something that the Food Authority had flagged. The reflection around the lack of synchronized regulation amongst countries in the European Union also ties back to the question of connectivity, where the respondent perceived the lack of connectivity on the regional level as an issue for the Norwegian industry. According to the respondent, however, there were ongoing processes taking place in Europe with the aim to try to synchronize the status of these issues, including the PEGASUS recommendations. Still, the respondent specified the potential issue for using seaweed for food and feed applications. The respondent added that they had recently done some testing on seaweed for animal feed, with promising results, but that as of now it looked like they might not be able to make use of it due to these food safety regulations.

Ultimately, respondents stressed the importance of knowledge-based evidence in the context of polycentric governance. One respondent stated:

> *"… everybody agrees we need knowledge-based dispositions, and therefore I think of it as a kind of safeguarding mechanism if you get different departments and stakeholders and experts involved in this. So I do not think it should be any easier, no."*

This statement reinforces the importance of having multiple stakeholders who can manage not just individual existing industries, but the co-existence between industries and long-term visions. One recommendation mentioned in a SINTEF report (Almås and Ratvik 2017) to deal with the wide range of matters that require an 'integrated initiative' was the prospect of a centralized Aquaculture Directorate. The authors suggest that this could facilitate further growth of the industry, prevent that the development of exposed aquaculture leads to new conflict areas at seas, prevent that the development of close aquaculture leads to conflict areas in local fjords and that Norwegian authorities work in different forums and contexts to reduce barriers to trade for Norwegian seafood. The idea of an Aquaculture Directorate was further endorsed by Roy Angelvik, a former state secretary of the Ministry of Trade, Industry and Fisheries during the Alge2019 conference. However, to what extent an integrated Aquaculture Directorate can meet all the critical aspects of a developing industry is hard to predict. Amongst other things, there are still critical knowledge gaps on the basic biology of seaweed, including physiology and reproduction, genetics and genetic contamination (Buschmann et al. 2017) as well as a need for a deeper understanding of the ecological and social benefits and consequences of seaweed cultivation and harvest. Ensuring that all these bases are met, whether enforced by a centralized Aquaculture Directorate or not, will ultimately define the outcome and success of the industry in the long term.

5.8 …The Marginalized Social and Cultural Services

When analyzing how management objectives and priorities reflected each of the seven resilience-building principles, I found that what was lacking from my analysis as a critical factor for resilience was the consideration of cultural or social services or benefits. In fact, I found this to be one of the most critical findings from my investigation, and which perhaps has the most critical implications for resilience as well as will become evident in the approaching discussion chapter. Recalling that "the concept of ecosystem goods and services offers a system of traits to measure resilience of cultural landscapes" (Bürgi, Kienast, and Hersperger 2012, 114), it is necessary to deliberate on the extent to which cultural and social services are recognized. I have dedicated this sub-section to highlight the reflections from a

minority of stakeholders who *did* explicitly address these issues. In chapter 6 I then look more closely at how deliberating on these often sidelines benefits is crucial for building resilience.

Amongst the interview respondents I spoke to, I found that only three elaborated specifically on social and cultural ecosystem services that can benefit a wider and more diverse population, all of which were smaller-scale actors. This was also a general observation that I picked up on during event participation and through informal conversations. Referring to the concept of ecosystem goods and services, Bürgi, Kienast, and Hersperger (2012, 114) add that "the concept implies that ecosystems have the capacity to provide many goods and services, from which society and policy decide which service is to be exploited and to what degree". Societies inevitably depend on social and cultural services for their well-being and for essential life-giving purposes, yet the ecosystem service paradigm has been criticized for not representing these services adequately (Biggs, Schlüter, and Schoon 2015; Plieninger and Bieling 2012).

Although it did not necessarily come up spontaneously for some, predominantly larger-scale, producers to mention social, cultural, and aesthetic elements as core to their management, when asked, these respondents did contemplate some noteworthy reflections. For example, when asked to what extent social and cultural ecosystem services was something they had given thought to, one large-scale producer responded:

> *"Yeah. Very little. That is a good point. I mean, it is also about developing new coastal communities... And there are places where the fish industry is declining, so they are kind of losing the whole culture around that. So maybe we can build up new industries there…it is interesting to look at Asia, like Japan, Korea, and China, and how important seaweed is for their culture…you could imagine doing the same here in Europe and creating this culture around it. Um, and no, we are not really talking much about that. Yeah, maybe we should do a lot more..."*

However, as demonstrated in this quote, the respondent themselves points out that the cultural and social services were not something that was talked about very much, and probably something that should be given more thought to.

The social and cultural services that a social-ecological system has the potential to deliver are variable, and preferences are likely to change over time. Yet, the opportunity to be able to pursue and achieve what an individual or community values is an integral constituent of well-being (Biggs, Schlüter, and Schoon 2015, 14). One of the smaller-scale producers whose

perspectives I have chosen to highlight in this section described value and prospect for the industry that goes beyond what has already been discussed in this chapter. In their words:

> *"…we have a lot of knowledge in Norway on the technical side, and on marine operations, but I think we kind of underestimate the potential for this really being a holistic and sustainable future industry in every way. Also focusing on the positive aspects of biology and ecology here, where we still know very little. I think that is my personal role and the role of my company in helping this industry to come along."*

The respondent added that this more holistic perspective stood out from the majority of producers or stakeholders within the industry, adding that their view is:

> *"…a little bit different from most others that start…"*

For example, the same respondent described the participation of the local community as something vital that they aimed to incorporate into their business model, intenting to inspire learning. Speaking about ideas for participation that would involve school children in particular, they state:

> *"… they will learn about what is under the water, what is happening, how do these things grow, when do they grow... This could build an identity, a little bit like school gardens, where children learn about how peas grow…"*

The act of including laypeople in the process and development of a farm links directly the benefits of widening participation, as well as to the notion of broadening values with regards to ecosystem services, which is a key finding which I highlight in chapter 6. Beyond participation as the active engagement of relevant stakeholders in the management of the industry, broadening participation to include the local community, who also represent important constituents of the landscape, can also be very positive for the acceptance of the industry more generally. In addition, participation on multiple levels has the potential to help in the construction of a space or scenery that is appreciated by both industry stakeholders and community members alike.

The respondent described additional social impacts that could be derived from extending participation to the local community. They explain:

> *"What is very important in terms of social things or culture… and what I am experiencing as very interesting and encouraging and positive, also in the larger sense of how business can be done, is the idea of taking immaterial ownership…with people*

taking ownership here locally, they feel that this is something they can be part of, it is happening in Norway, they can get the products here, it is something that belongs to them. They can be proud of it…it does not appear in a bank account but it is definitely value that is worth having been created I think."

The respondent touches on several noteworthy elements related to the benefit of expanding values and notions around what ecosystem service benefits entail. The first is questioning the 'business as usual' approach, suggesting that deliberating on the social and cultural values of such an industry can be a way to improve how business is done, including a deeper assessment of the social and environmental impacts. The second is the idea of immaterial ownership, in this case amongst the residents of the local community, where the respondent describes the inclusion of a larger community in the development process. Recognizing the agency and desires of multiple stakeholders or members of society can be a constructive way to distribute ecosystem services in a more inclusive and fair manner.

A different respondent touched on the notion of extending participation to the local community as well, including the inclusion of different members of society to create a platform for social benefits such as knowledge exchange. In their words:

"…I would love to have more people connected to us… we could be a test site for a way of doing things in a sustainable way, being close to the source of things… it can also be a place for knowledge transfer and communication and to set examples of how to do things…And also to bring people from different areas in society together…"

The respondent also mentioned that what they understood as the sustainable success of their business was in many ways dependent on and strengthened through the collaboration with the local community. Describing the relationship with some local members of the community around their production facility, one wild harvester explained:

"…they are so curious. They come down and check on what we are doing and I find it very moving….It is part of a small society, which is also of course challenging…for them what is important is that we keep coming back and that we do not give up. And this is why we have respect… we do things where we invite the local community…we do not do enough but we do some… I did not want us to come up there and just do our things and then go back. We have to have a relation to the local community. It is really important…"

Building and maintaining such relationships naturally requires a significant investment of time and effort. Yet, fostering these connections with the local community can also be a way to contribute a sense of agency and ownership to those people and communities affected by

the developing industry. Equally important, these connections and the element of respect described by the quoted respondent can foster resilience by strengthening connectivity (principle 2), learning and experimentation (principle 5), and participation (principle 6).

Similarly, another smaller-scale actor described how their understanding of learning and experimentation in relation to their business model was fundamentally dependent on the local community:

> *"… when we mention research and development, and consultancy, as part of our business model this also includes communication…for example, this year we arranged a seaweed festival here…we invited lots of community groups to participate, artists and musicians, and we worked together with the trade school…they made seaweed meals, and we taught them about seaweed… it is not just so we can sell more products, but the kids go home and talk about what they did or learned in school. And they influence their parents… we also had a session where we invited elderly people from the region, because actually seaweed was used here in the past… I think that is a really exciting part."*

Moreover, one respondent spoke considerably about the essential social and cultural benefits of food, and communication through food. In their words:

> *"…food is something we are all deeply connected to. And this means that you can reach people from other places, and cross borders and different ideas about politics and cultures. Food always brings people together. It is a very interesting and very important place to be if you want to do something about important matters, like sustainability...With food, I can make the changes to myself and my family and my friends.. and you can show people how they can make a difference by choosing differently every day."*

The respondent describes several significant connectors between food and culture, social systems, and sustainability in the larger picture that are worth noting. Indeed, beyond viewing food as a provisioning service (although it is more easily amenable to quantification in monetary terms in this regard), it is valuable to acknowledge the impacts on human and psychological well-being, culture, identity, and life-purpose, amongst other things. Fostering the connection between food and various needs and desires in society may also be a way to inversely foster resilience in the system as a positive feedback loop. The same respondent also described how despite being complex, the multiplicity of connections that food can generate was a motivation in itself to work with seaweed, and by extension sustainability. In their words:

> *"…food systems are really complicated but I wanted it to be food because I am very passionate about food. And I think food also has a cultural value and it communicates very personal things… about society and about our culture, and what we are, how we understand things that mean something to us…I am also convinced that there is a very important battle to be won in this area."*

Indeed, food is a fundamental connector between humans and the environment, which ties back to the shifting view of seeing people and nature as interdependent social-ecological systems. Hale et al. (2011, 1853) confirm that "food is our most basic need and most fundamental connection with our environment and yet modern conveniences and an industrialized food system have created a culture of cheap food while alienating people from the landscapes that sustain them". As a fundamental connector between humans and the environment, identifying and recognizing this broader consideration of food as an essential ecosystem service can help create awareness around alternatives to desirable SES configurations.

On the same topic, another respondent offered some reflections on what the connectivity around food can mean for consumers specifically. In their words:

> *"I find that there is an opinion in the seaweed industry…this kind of esoteric air… but if I look at some of our markets for the products, that is what people are looking for. They are looking for a local connection, or for connection with the land or the ocean, they want to know where their food comes from…they are interested in the story behind it…the seaweeds itself, and seaweed farming, is the perfect match for such a desire...Because it is a story, it can also be so diverse, on so many levels."*

Moreover, De Groot et al. (2003, 196) describe the ecosystem service value of 'existence' as related "to the intangible, intrinsic, and ethical values attributed to nature, stemming from feelings of stewardship on behalf of future generations and for non-human species." Conserving and enriching ecosystems for the sake of nature's intrinsic value is for some motivated by a deep respect for all life and is an ecosystem value that can increase well-being (De Groot et al. 2003). While developing industries that lead to growth and economic opportunity is generally viewed as a positive endeavor, one respondent described the intention behind a collaborative project with their company and the municipality in relation to this value of existence. They stated that the project's had an aim to:

> *"…really understand the long term values that are at stake when using our coastal zone. Maybe right now we want a salmon farm and a seaweed farm here, but in the long term we need natural ecosystems or pristine ecosystems..."*

The respondent describes a need to consider what is at stake when pushing for developments in the coastal zone. Recalling back to chapter 2, around 80% of the Norwegian inhabitants live less than 10 km from the coastline (Directorate of Fisheries 2016), making the intrinsic value of coastal environments a key subject matter for policy agendas. Eventually, it may no longer become possible to enjoy pristine ecosystems for the moral satisfaction linked to the conservation of biodiversity (Schmidt, Sachse, and Walz 2016), or to simply enjoy open and seemingly untouched landscapes, or 'existence' (De Groot et al. 2003).

Beyond the value of 'needing' or simply desiring pristine landscapes, there is also a value worth considering in fostering a connection with these landscapes so that we as a society may become more inclined to protect it. One respondent remarked:

> *"…also the fact that you get more attracted to and have a deeper understanding about the sea…one of the reasons I invited (name removed) up there was also because she adds this kind of knowledge to the totality of the recreational value… she believes that by understanding and knowing more about the sea, you will care more about it. I think the same thing. By being out in nature…people get often a shock but they also get a very strong experience of what nature really is and not just something you see on a film…"*

Another one of the featured respondents from this sub-section had a similar view on this, stating that increasing our knowledge about what exists below the surfaces may also facilitate our ability to communicate better what needs to be prioritized when it comes to ecological and environmental issues in particular. In their words, one necessary consideration is:

> *"…just being in touch with what is happening…not necessarily that we grow all these other species, but that they are part of the communication around the concept of seaweed and seaweed production… when we do these communication or information events we usually complement it with just walking along the shore, collecting and asking the question 'what is seaweed?'… if you put yourself in the shoes of a seaweed there are reasons why certain species grow like they do, or why they taste like they do, why they are perennial or just annual… it is such a fantastic starting point for communicating what this really is."*

Several seaweed enthusiasts who I spoke to throughout my research journey also mentioned the significance regarding this notion of 'being in touch' with the seaweed. Amongst other things, this included how the physical connection with seaweed and the ocean was a positive contributor to their well-being and livelihood. One harvester described what they saw as the benefits of working with seaweed, which included:

> *"From learning how to run your own business, to working with being creative… and to be able to explore our creative sides a little bit more…and yeah, having a lifestyle that allows you to go out and be outside with nature and harvest. Sometimes when you are out here and it is a beautiful day you think 'ah, this is our job'. And that is quite a lovely way to think."*

After many weeks of harvesting, packing, and processing seaweed during my internship, I too found that the act of manual labor was exceptionally rewarding, both physically and mentally. Doing hands-on work is becoming increasingly rare as systems become increasingly automated. Yet, as these respondents describe, the process of kinaesthetic or tactile learning or doing can be an effective way to learn and engage with issues of sustainability. According to one actor, what keeps them sustainable is that:

> *"…we basically touch each piece of seaweed and kiss it and put it in a bag. That is how it is. But, it is not sustainable in any way economically."*

The respondent distinguishes between environmental and economic sustainability here, but still emphasizes the value of proximity for the business overall. This value gained from 'being in touch' with the seaweed was also echoed by another respondent, who remarked:

> *"…you see new things and just from experience you learn a lot by being so close to the seaweed, so you hold each plant or each species in your hand and like you were saying, from one week to the next there is different growth, and then suddenly things look different, the color, the texture, and all these things."*

One respondent also added a remark on their appreciation for the 'mythological imagery' of seaweed, and how this contributed to their attachment and interest in this work:

> *"…I did not know very much about what was underneath the surface of the water and came to think about this kelp forest as something like a hidden treasure or knowledge…seaweed was the first living organism on earth, it is more than 500 million years old, and it contains so much of what was the beginning of us… it became like a mythological imagery…what I then understood after a while was that it was possible to eat a lot of the seaweed that you could find in Norwegian waters."*

This comment also relates to the artistic or aesthetic value of seaweed as an ecosystem service. De Groot et al. (2003, 195) describe aesthetic values under the category of 'amenity values', which are benefits "derived from the aesthetic qualities of a given natural area and the recreative possibilities it offers, such as the appreciation of a pleasant natural scenery, the joy of learning and understanding during nature hikes and naturalist expeditions and the

experience of solitude and contemplation in natural surroundings." In the context of an art project that the respondent was involved with, a free diver describes:

> *"…being drawn through the kelp forest, it was just really fascinating… and we decided to use that as a scenography because we worked a lot with video and sound installations and stuff…it became a very beautiful visual element in the performance."*

Figure 10: Floating sugar kelp. Photo: Troels Rosenkrantz

Although difficult to measure, values binding nature and aesthetics together can offer valuable or even critical contributions to human well-being (De Groot et al. 2003). Seaweed environments appreciated as an ecosystem or object of beauty in itself contributes non-instrumental value. Another respondent described, enthusiastically, how incorporating seaweed into the seascape could in fact augment the value of the landscape. In their words:

> *"And so you have landscape architects that are working on how can they create artificial reefs so that the seaweed can attach itself to reefs, and grow. It is really lovely. So, this is of course something that would cost a lot of money, but the value is added to the reputation of Norway, and attracting people to Oslo."*

I heard mention of several other prospective projects such as this which may contribute to a raising awareness about the broader value of ecosystem services, which I come back to in chapter 6.

The actors featured in this section described that they generally felt lonely in their approach, which included recognizing the social and cultural aspects to a much greater extent than is currently the custom. One respondent also stated specifically that they found this to be problematic, expressing:

> *"…it feels very lonely with this approach…I find there is an understanding of this thinking, but not in this industry…not in aquaculture, and not in the maritime sector…I see it for example in organic agriculture or local food production… [but this industry] is dominated by this thinking of 'bigger, larger, more, faster'…discussing business theory or business concepts from the very top down…talking to other people in aquaculture, or shareholders, you still have this more traditional understanding of what business is and what we have to do to survive as a company…"*

The respondent describes organic agriculture or local food production systems as reflecting this kind of holistic mental model. Biggs, Schlüter, and Schoon (2015, 148) confirm this association, citing more traditional ecological knowledge systems as systems that fundamentally integrate CAS thinking in their management approach. Moreover, what the respondent describes as a thinking of '*bigger, larger, more, faster'* in the last quote alludes to what I refer to as the 'myth of efficiency', which I return to in the discussion soon to follow.

On a similar note, one smaller-scale producer also expressed a difficulty in finding the 'right' kind of investors for their venture amongst this 'trend' of green investors that was described in 5.3 (slow variables and feedbacks). They explain:

> *"…we are desperately looking for green investors who also understand and believe in non-growth, which is really a difficult. There is hardly any investors who will believe in long-term changes and who see value as anything other than money and growth…All the other ones are just normal investors, but they will put their money into green tech…which is basically investment that will make money on devices that clean up the mess. What I am working on is actually to try and prevent people to make more mess…"*

This last respondent confirmed that the larger societal trends or transformations towards a 'green society' was indeed a significant slow variable facilitating the prospects for working with something like seaweed. Yet, when speaking about 'green investment', the respondent made a point to distinguish between investment leading to 'green economic growth' and investment that aligns with non-growth. Reflecting the respondents remark, Moriarty and Honnery (2018, 53) distinguish between these possible futures respectively, describing green economic growth as the "diversion option…doomed to failure" compared to the vision of "ecological sustainability…the only viable future, but will require unprecedented social and economic changes". How these values impact management objectives and priorities remains unclear. However, with an increasing cluster of scholars including Moriarty and Honnery (2018) recognizing that true ecological sustainability will require unprecedented social and economic changes, these view are worth deliberating.

In the following chapter I turn the focus to the second part of the central research question. I engage more specifically with the findings in a way that reveals the impact of these objectives and priorities on the delivery of ecosystem services specifically, as an element of resilience. The key findings from this chapter are also brought into conversation with the theoretical framework presented in chapter 3.

6 DISCUSSION

The accounts I have presented in chapter 5 provide compelling evidence in favor of integrating the resilience and cultural landscape approach, as suggested by Plieninger and Bieling 2012). The social-ecological resilience approach did ultimately offer a good framework to better understand how the key stakeholders and social actors that dominate the seaweed industry think and act, and where this reflects resilience thinking. However, recalling Bitektine's (2008) PCS design, I found the explanatory power of the framework to be limiting in two ways: 1) recognizing the underlying political and power structures inherent to the system, and 2) recognizing the broader social and cultural benefits as a critical factor for building resilience. The implications for future scholarship on SES include the need for more profound social analyses. Combining resilience and the cultural landscape approach can advance the literature on social-ecological systems in this respect and "ensure that the ecosystems and social-ecological systems of interest are being considered more realistically as embedded in complex regional and global contexts" (Kinzig 2012, 319).

The first part of this chapter (6.1) will discuss how integrating the two frameworks can provide deeper insights into why the social realm behaves the way it does and the societal and scholarly implications of this. Recalling that a central objective of this study is to deepen the social analyses in the resilience framework, this fusion can strengthen the explanatory power of resilience and is a strong fit when taking the spatial and social context of the study into consideration. I then proceed to critically analyze the two areas where I encountered explanatory limitations of the social-ecological resilience framework. In 6.2 I will examine a selection of political and power dimensions identified in relation to each resilience-building principle in turn. These underlying configurations arguably influence the control that stakeholders have on the delivery or valuation of ecosystem services in the system, and are therefore crucial to recognize. Finally, 6.3 will examine the wider deliberation of the social and cultural values of ecosystem services, a process that was initiated in the final section of chapter 5 (5.8). These deliberations can not only contribute to greater awareness and transparency regarding the prospect of wider societal goals for SES, in this study being the emerging seaweed industry, but can strengthen efforts towards sustainability.

6.1 Integrating the Resilience and Cultural Landscape Approach

In chapter 3 I presented the background and evolving discourse of social-ecological systems and resilience. The framework is rooted in the field of ecology, where it emerged in the 1970s, and is now being adopted by researchers in social and interdisciplinary sciences to understand complex social or coupled social-ecological issues. As demonstrated in chapter 5, the approach has demonstrated good potential as a starting point to identify certain elements that foster or compromise resilience in the system. Still, "resilience would be better served if more of its scholars examined political ecology, economic geography and other perspectives in the field of the cultural landscape" Kinzig (2012, 319). This includes recognizing that landscapes are complex and contested, and there exist many, sometimes contradicting, perspectives on what a system could or should offer.

With this in mind, the integration of the resilience and cultural landscape approach is useful when trying to explain how social systems behave. To demonstrate, I re-visit the conceptualization of the adaptive cycles and panarchy described in chapter 3. Holling's (1973) work has proven particularly useful to describe ecological examples such as the phase transitions in boreal forests. However, this adaptive cycle metaphor falls short in many ways as soon as it is applied to social systems (Kinzig 2012). For example, one could try to explain the social dynamics of the emerging seaweed industry as moving from the r-phase (small-scale wild harvesters) through to increasingly inflexible and complex large-scale cultivation systems (assuming a similar progression to that of other aquaculture industries), until high levels of vulnerability such as increasing temperatures lead to the sudden disappearance of certain species and ultimately a collapse, or partial collapse, of the system. Following disturbance, the system would then move into a state of reorganization, and potentially a new growth phase in a new cycle. Yet, such as depiction is far too simplistic, and "allow no capacity for societies to recognize the ways in which they might be vulnerable, and ameliorate those vulnerabilities through strategies that have nothing to do with the larger system collapsing" (Kinzig 2012, 321).

Kinzig (2012) suggests that societies, or systems in the social domain, can introduce innovations and other forms of learning that allow fluctuation between the growth-phase (r) and the conservation-phase (k). The concept of adaptability, defined as "the capacity of the actors in a system to manage resilience" Walker et al. (2006, 3) can help clarify this notion.

Westley et al. (2002, cited in Walker et al. 2006, 3) note that compared to ecological systems, humans or social systems are capable of deliberate action and foresight, which in turn affects the potential for self-organization. Walker et al. (2006, 3) add that "because human actions dominate social-ecological systems, the adaptability of such systems is mainly a function of the individuals and groups managing them". Rather than solely identifying resilience through an analysis of interconnections within and between the system, it is therefore critical to demonstrate how actors demonstrate adaptability, such as collaborating to buy seaweed off one another in times of shortage, as was mentioned by one actor. These reflections help explain how this fluctuation between the r-phase and k-phase may function in practice.

Another concept that can help clarify this variability in social systems is transformability, defined as the "the capacity to create a fundamentally new system when the existing system is untenable" Walker et al. (2006). Because the emergence of a seaweed industry is so new, it can be more helpful to consider the context and landscape that opened a window of opportunity for this transformation to manifest in the first place. As we have seen, one landscape development that has significantly shaped and both positively and negatively impacted the advancement of a seaweed industry is the already existing fishery industry. Global changes in the environment and changing preferences towards more plant-based foods were also described by respondents as significant variables that both opened a window of opportunity for the industry to emerge and which continues to attract investment and interest from the public.

Berkes (2015, 66) confirms several drivers related to globalization and global changes in the environment that have opened a window of opportunity for aquaculture to develop when it did, three of which agree specifically with the findings from this study that are more specific to seaweed. These are: 1) a 'globalization of tastes', such as the increasing popularity of sushi, 2) global environmental change, which is leading to the scarcity of some products and the opening up of niche markets for other products, and 3) developing technology and aquaculture 'know-how'. Many smaller and larger factors existing on local to global scales, combined with the ability of social actors to practice deliberate action and foresight, can indeed lead to the creation or emergence of a new system such as a seaweed industry in Norway.

Moreover, it is also worth considering how the system has the potential to exist in many different phases of the adaptive cycle, in addition to oscillating between the r- and k-phases.

For example, as was described by one respondent in 5.8, the system can provide a diversity of applications in conjunction with the landscape. This extends beyond the diversity in applications detailed in section 5.1, which described a function of diversity that can foster resilience in relation to already harvested biomass. Several respondents specifically recognized different values, technologies, connections, and innovations that could contribute to diversification in the function of seaweed production in itself. Although most designs were still in the early stages of development, I heard mention of many captivating landscape development projects that involved seaweed cultivation, including: artificial reefs to increase biodiversity, seaweed farms that can contribute to reviving the highly contaminated water in the Oslo fjord, integrated multi-trophic aquaculture (IMTA) systems that can tackle some of the issues with pollution in fisheries, and 'maritime allotments' (maritime nyttehaver in Norwegian), a form of urban aquaculture which amongst other things has an aim to make use of a diversity of edible foods from the sea[9].

Recalling the comment in 5.8 about artificial reefs contributing to the reputation of Oslo and the landscape, the respondent was very pleased about the motivation to invest in diversity when it involved using the potential of seaweed for more than just harvestable biomass. Worth noting is that value can be added to the landscape in this regard, rather than seeing the emergence of a seaweed industry as something external to society, or as existing solely in a single phase of the adaptive cycle. Coupling management goals with visions to broaden ecosystem services and their benefits is a noteworthy demonstration of how resilience thinking in a cultural landscape framework can reimagine the value of seaweed to more widely deliver the ecosystem service benefits it has the potential to offer.

Moreover, recalling from chapter 2 that the cultural identity and heritage of Norway have been built on the studies of landscapes, folk-tales, and customs (Grimseth 1998), broadening these perspectives in SES is also important for the country's cultural identity and heritage. For example, the remark in 5.6 on the experience of the Northern part of Norway being marginalized from the rest of the country, also in matters of a developing seaweed industry, speaks to complex issues of national identity, regional marginalization, and concerns regarding centralization. Indeed, the Norwegian coastline carries with it a unique land-use

9 For more information (Norwegian) see: https://info.ostfoldfk.no/om-marint-grenseforum-skagerrak?hsCtaTracking=a4d0758e-1c35-487a-9509-1466b8849632%7Ce170bd8f-a3f1-46ce-b19a-480fe4e61201

history, stakeholder perspectives, landscape values, economic realities, and policy frameworks. The development of a new industry is both shaped by the cultural landscape and will continue to shape the collective identity of Norwegian culture and values. Thus, developments or debates regarding the cultural landscape that builds on or shape this collective identity are intrinsically important to recognize as they may impact place and identity in both its positive and negative aspects, as described by the respondent in 5.6. Contextualizing these issues pertaining to the SES as embedded in a cultural landscape offers a much richer description of how these systems do or can work, rather than making assumptions about how they should work (Kinzig 2012).

Plieninger and Bieling (2012, 8) confirm that "among their many important values and functions, cultural landscapes are, in particular, appreciated for allowing sustainable use of natural resources; serving as wildlife habitats; providing economic benefits, scenery and open spaces; and possessing cultural heritage". The multiplicity of narratives described throughout chapter 5 reflects the notion that cultural landscapes carry many important and diverse values and functions, which are necessary to gain a profound recognition that such values are embedded in the cultural landscape. Amongst other important considerations, participation from multiple stakeholders understood in the context of the cultural landscape in which they exist can help ensure that this multiplicity of values and functions does not go unnoticed. A broadened recognition and deliberation around perspectives that merit recognition, including the broader social and cultural values that the industry has the potential to offer, can in itself contribute to, or foster, resilience.

To summarize, Kjærgård, Land, and Pedersen (2014) suggest that "links between resilience and cultural landscape may help recapture landscapes as the primary carriers of social values, which are place based and contextual". Emphasizing the social in social-ecological systems is a tangible way to overcome criticism that this theoretical framework has met for conceptual vagueness (Plieninger and Bieling 2012, 19) and for falling short of adequately addressing the value of broader, often competing value systems (Cote and Nightingale 2012, 476).

6.2 Principles, Politics and the Resilience of Ecosystem Services

Discussing ecosystem services priorities in the context of resilience thinking raises an immediate concern if, for example, it is assumed that a system is considered desirable if it

provides a certain bundle of ecosystem services (Beymer-Farris, Bassett, and Bryceson 2012). As has been noted, different societies require and desire different ecosystem services. What society values at any given time will also vary. Still, the concept of ecosystem services recognizes the social and cultural values *by definition* (MEA 2005a). However, it is not possible to increase resilience amongst all ecosystem services simultaneously, thus trade-offs are inevitable. These trade-offs are inherently political, where politics in this context is defined by the authoritative allocation of values for society (Biggs, Schlüter, and Schoon 2015, 32).

Based on the data collected, the management objectives for seaweed harvest and cultivation amongst the more established and dominant producers representing the industry can be divided into two general categories; one being the provisioning of profitable biomass production (for various provisioning ecosystem services, including food, feed, and eventually energy), and the second being the provisioning of primarily regulating ecosystem services (particularly providing wildlife habitats and climate regulation). This is similar to the conclusions drawn in other European-based projects looking at the development of a seaweed industry, such as in Sweden (Hasselström et al. 2018). While all respondents recognize that these services were something the industry delivered or had the potential to deliver, some actors also remarked the lack of conclusive evidence with regards to the provisioning or actual impact of regulating services in particular (see 5.4), noting the lack of evidence-based claims.

Still, what I found when enquiring about what the industry could and should offer is that the majority of stakeholders from interviews and elsewhere during my investigation were primarily concerned with seaweed delivering either regulating or provisioning services and prioritized cultural or social services to a lesser extent. This suggests one of the following scenarios: a) the explanatory power of SES and resilience as a framework falls short in capturing a complete understanding of what ecosystem service benefits entail, or b) stakeholders do not reflect resilience thinking when it comes to recognizing a broad range of ecosystem services, and particularly the social and cultural values.

Considering that I used the same interview guide for all my respondents, the initial thought is that my findings reflect the latter, option b). Yet, a crucial point to consider, is that there is no reason to expect that individuals in a system *should* embrace the principles of resilience for 'the greater good'. Kinzig (2012, 324) asserts that "to oversimply a rich literature greatly,

societies in the past have collapsed not because people were unwise or lacked sufficient foresight (although these attributes can contribute), but because it was in the interest of those in power (those whose actions could impact the society as a whole) to continue to push social-ecological systems in directions that introduced increasing vulnerabilities". In the face of such power dynamics, ensuring that all pillars of the ecosystem services paradigm are recognized is no simple task (Kinzig 2012). Rather than fixating on whether or not stakeholders reflect resilience thinking, therefore, a deeper social analysis of the conceptual framework can help identify the more important "political and power dimensions inherent in the governance of SES and the implicit or explicit societal choices about which sets of ecosystem services to build resilience of, and try to sustain" (Biggs, Schlüter, and Schoon 2015, 33). Kinzig (2012), for example, is particularly concerned with the ways in which globalization dynamics may, in fact, limit the control and influence that local managers and stakeholders have to prioritize or value different ecosystem services in a particular system. I will attempt to tease out some of these key political and power dimensions that emerged from engagement with each of the seven principles, in turn, next.

To begin, the seaweed industry in Norway remains in the early stages of development. From what I gathered, the first wild harvester started in 2009, while the first permits for cultivation were not distributed until 2014. The scale of harvest and production, therefore, remains relatively small in comparison to other regions in the world. Still, the question of scalability remains highly relevant when considering where the line goes between sustainability and profit, which was discussed with several respondents. Campbell et al. (2019, 1) regard small-scale cultivation projects as 'low-risk', while "an expansion of the industry that includes 'large-scale' cultivation will necessitate a more complete understanding of the scale dependent changes in order to balance environmental risks with the benefits that seaweed cultivation projects can offer".

On one hand, transitions towards more productive and industrial-scale food production, both in terms of intensification and expansion of land use, have been significant for economic development in all parts of the world (Plieninger and Bieling 2012). As described in chapter 2, an industrial-scale seaweed industry can contribute to a broken food system and plays a significant role in contributing to the nutritional status of communities (FAO 2018). The potential contribution in the fight against climate change is also significant. In an e-mail correspondence with a producer on their status following the emergence of COVID-19, they

also remarked that automation and mechanization of processing may be more relevant than ever before; the sudden drop in access to foreign and more cost-effective labor meant that this company, and very many others, had to switch to Norwegian labor at a much higher cost. All respondents, regardless of scale, described the need for larger-scale, more mechanized or industrial levels of farming in order to meet the more ambitious goals of contributing to bettering a broken food system and more generally uncovering the untapped potential of a valuable resource.

At the same time, Plieninger and Bieling (2012, 9) raise the concern that "most productivity increases in agriculture have brought forward a market decline of the diversity and complexity of localised farming systems, with a standardisation of crop varieties and livestock breeds, a sharp increase in mechanisation, an intensification of matter inputs and farm specialisation and an increase in farm sizes". While there are of course differences between agriculture and aquaculture, it is worth deliberating on how the ideal of efficiency – or the language of 'bigger, larger, more, faster', presented as the myth of efficiency in 5.8 – functions in practice. Indeed, efficiency has become an ideal in capitalist systems and can be positive when an actor knows exactly what they are going to need, and how to get there. Yet, once you accept that there is some inherent uncertainty in the system, you also must accept that there is a need for slack in the system. This is fundamental to resilience thinking. In this way, when the unexpected occurs, you have multiple resources or a toolbox to work with to deal with that uncertainty. Reflection around resilience can teach us to confront the fact that as a society we are so focused on efficiency, and are so devoted to its principles, that it is discounting resilience from the system. By falling into this trap of efficiency thinking we increasingly distance ourselves from the reality that there are always going to be surprises.

Additionally, according to one of the three respondents featured in section 5.8, this also ties into an expectation as a producer to make money first before having surplus energy to consider sustainability issues, in the name of efficiency. This was something the respondent felt should be turned on its head, and saw the investment in sustainability issues as something that could be both efficient and economically sustainable in itself.

Moreover, in section 5.2 one key finding was how stakeholders thought about the connection with the dominant salmon industry in relation to the emerging seaweed industry. Environmental regulations were described as adapted from salmon farming from the very beginning of the seaweed venture and continues to define development today, despite some

producers observing that regulations and guidelines were gradually changing and becoming more appropriate. From the perspective of political economy, which "views human relations with nature as fundamentally rooted within the process of capitalist production and associated power asymmetries" (Plieninger and Bieling 2012, 286), it is possible to critically examine why space allocation for salmon aquaculture is still prioritized over seaweed despite the many environmental limitations of salmon aquaculture as pointed out by several respondents.

Indeed, the Norwegian aquaculture industry has since its emergence in the 1970s developed into a 67 million NOK industry based on coastal resources and area (SSB 2019b). Yet, what has become a leading sector in the Norwegian economy is in fact first and foremost defined by salmon as a single species, generating 64.5 NOK billion in first-hand value in 2018, which makes up close to 95% (Ibid.). The fisheries industry, and particularly salmon aquaculture, continues to dominate the economic realities, stakeholder perspectives, and policy frameworks currently in place. This helps explain the context in which social actors, the county officer respondent in this case, is making decisions. The 'pretty clear guidelines that we should develop the salmon industry' are based on values grounded in capitalist production systems and fundamentally embedded and prioritized in the decision-making processes on multiple levels. Such agendas must be transparent to recognize how the connectivity, in this case between two industries, may impact the resilience in SES.

Furthermore, also on the topic of connectivity, one respondent remarked that "*everybody has now found out that you cannot do anything without naming the sustainable development goals, or sustainability*". This was discussed in the context of taken-for-granted assumptions around sustainability. A key finding presented in 5.2 was related to sustainability having become a buzzword also within the seaweed industry. However, it is not just individual people who make sustainability claims on behalf of their businesses, but rather there seems to be a collective narrative that is upheld by individuals as well as institutions. Fægri et al. (2017, 7) note that "the Nordic countries market themselves as drivers in the pursuit of a sustainable existence characterized by unspoiled nature, clean water and air, natural raw materials and responsible resource management". This narrative was repeatedly heard during my investigation, both when speaking to respondents during interviews as well as at conferences and talks. Comments indicating that Norway has a particularly ideal and pristine landscape for seaweed production were common. Coupling the vision of what can be described as the 'Nordic brand' with sustainability may be fair in some respects, such as the

extent to which strict regulation and integrated coastal management are highly valued compared to many other countries, as was pointed out by one respondent. However, taken-for-granted sustainability assumptions are also something to be aware of.

It is worth considering to what extent the notion of Nordic standards, or the Nordic Brand, a "known brand of 'clearness and purity'" (Nikolajsen and Bech 2014, 18), is circulating within the industry. This particular mainstreaming strategy has been recommended by Nordic Innovation (Ibid.), a Nordic organization working amongst other things to promote innovation and cross-border trade. On one hand, the Nordic Brand may indeed be a useful tool to meet market expectations in Norway. On the other hand, it may be exploited without sufficient evidence with an aim to attain faster acceptance from consumers, and in part legitimize the actions as well as impacts of the industry. In addition to exploring the opportunities that Nordic branding offers in terms of mainstreaming and commercialization, assessing what dilemmas or paradoxes may be overlooked in the process merits further consideration.

Similarly, it is often assumed that "innovation can redirect production towards environmental goals, and decouple economic growth from environmental degradation" (Smith, Voß, and Grin 2010, 2010, 436). As Fægri et al. (2017, 8) point out, there is reason to be critical if and when the "interest in 'the Nordic phenomenon' and eagerness to market the Nordic countries as a global brand create an ideal where positive features are grouped somewhat randomly, while interesting dilemmas and paradoxes are overlooked". In particular, the assumption that the industry engages solely in sustainable and 'clean' practice, implied through the interchangeable use of the concept of sustainability with the Nordic landscape features, is concerning. Particularly striking is that there is, in fact, lacking information, and no standard laws or regulations, for production of seaweed offshore (Nikolajsen and Bech 2014), as was also pointed out by some respondents. It remains unclear how the industry is connected to the landscape, ecosystem and local societies, which are necessary considerations to make before such claims on environmental impacts can be made.

Moreover, on the topic of slow variables (5.3), Wong-Parodi and Fischhoff (2015) describe how extreme events and systemic changes will have implications for decisions made by businesses, governments, and individuals. For example, for businesses it may be relevant to consider what crops, or in this case seaweed species, to grow in the face of a globally changing environment. More specifically, it may become increasingly less suitable to cultivate and harvest seaweed from southern regions compared to northern regions, which

may lead to issues with the distribution of available areas, as well as impact the livelihoods of communities located further south. However, identifying the information that will be most critical for decision-makers in this respect, and then coherently communicating this, is a challenge and remains understudied (Wong-Parodi and Fischhoff 2015).

There are critical limits to how much change an SES can withstand before it enters into a new regime where it serves to produce a new bundle of ecosystem services (Biggs, Schlüter, and Schoon 2015, 113). Rising sea temperatures are an example of a key slow variable that is already having an impact on ecosystems and ecosystem services around the world (Biggs, Schlüter, and Schoon 2015; Svolsbru 2013). Such variables often lead to unexpected changes in the systems due to the difficulty in observing changes in real-time. Several researchers in Norway, including ones I spoke to in my investigation, have already identified and characterized certain traits that are a direct outcome of rising sea temperatures, including the displacement of farmed organisms that may be better adapted to grow in cold water (Stévant, Rebours, and Chapman 2017). Yet, embracing variables that are inherently 'slow' into management is perhaps an incommensurable task due to the short-sightedness in politics described in 5.2, making this resilience-building principle one that is particularly difficult to translate into practice.

On the topic of CAS (5.4), I discussed some stakeholder reflections on matching institutions to CAS processes in order to foster CAS thinking. This also applies to research institutions, as was pointed out by one respondent in 5.6, who describes the research community as being relatively closed. Investigating this further, I came across a SINTEF report charting the 'measurers for development of biologically based marine industries towards 2050'(Almås and Ratvik 2017). Although their recommendations are based primarily on the more established fisheries that dominate aquaculture in Norway, the leading research organization indicate two concerns deemed relevant for securing coastal development: 1) Coastal development should be at the top of the list of priorities, and 2) Issuing fees paid to the municipality for access to land will strengthen the 'goodwill' and understanding that is advantageous to have aquaculture farms in the municipality (Almås and Ratvik 2017, 22).

Regarding the recommendation to prioritize coastal development, the report views current management, comprised of many public agencies with partial responsibilities for aquaculture, as leading to "loss of efficiency for both business and management" (Almås and Ratvik 2017, 21, my translation). They identify large transaction costs associated with public regulation,

monitoring, and control of the industry as key problem areas. Yet, as has been described already, deprioritizing coastal management in order to achieve a more cohesive coastal development agenda is problematic for various reasons. While the report refers particularly to salmon farming, any growth or development in one industry will have a direct impact on the development of neighboring industries as well. One obvious issue is that of available space as was pointed out by one respondent, where "*aquaculture is associated both with environmental problems but also just taking up space in the sea*". Although Norway has one of the longest coastlines in the world, with 'enough' available space per se, it is also worth considering what other value we can gain from the sea and how space should be managed accordingly. One example is conserving ecosystems as they are for the moral satisfaction of doing so, related to the intrinsic value of nature described in section 5.8.

Reaching a consensus on what restrictions are necessary for environmental protection and sustainable ocean governance is both political and complex, and any regulation will inevitably affect some groups more than others. This leads me to discuss the second point addressed in the report by Almås and Ratvik (2017) regarding issuing fees to strengthen goodwill around the industry. As alluded to in chapter 5.3, this again raises an immediate concern linked to the topic of short-sightedness in policy. Although this recommendation was put forward in the context of fisheries, one respondent mentioned that this was a potential issue emerging in the context of seaweed as well. As mentioned in chapter 5.3, the county governor perceived the introduction of a new guarantee fee as having disproportionately affected smaller-scale seaweed actors. While "issuing fees to be paid to the municipality for access to land" may strengthen 'goodwill' and will not necessarily cause any significant barriers for the larger businesses, they are likely to discourage smaller producers from applying for licenses. Indeed, the county governor representative expressed that it was their impression that this was already happening.

Even more problematic is that this kind of restriction on licensing does not necessarily mean that there will be less farming and production with potential implications for natural environments or coastal ecosystems. Rather than creating a barrier for growth, this allotted guarantee fee actually creates a barrier for diversity (principle 1 - diversity) in production and scales by limiting smaller-scale producers or those with limited funds from being able to compete with the larger businesses. If there are only a select number of producers that can afford to cultivate with their selection of seaweed species, this also runs the risk of limiting

genetic diversification and contributes to more at-risk monoculture systems. Such a monetary barrier may therefore be highly problematic and seems to have already made an impact on the diversity of newcomers applying for concessions (principle 6 - participation), as was mentioned in 5.4. This negative feedback configuration has the potential to generate marked consequences for the appropriate management of ecosystem services, as well as potential consequences for human well-being and the country's trajectory for development.

As was endorsed by all respondents, the sustainable success of the industry will require good collaboration (principle 2 - connectivity) between industry actors and authorities. The SINTEF report (Almås and Ratvik 2017) aligns with this claim, suggesting recommendations to ensure this collaborative spirit, including rewarding high levels of innovation. The recommendation to reward innovation, however, is contradictory to the decision to issue fees that will have the biggest impact on the small-scale producers and start-ups which are fundamentally characterized by innovation (principle 5 - learning).

What this dilemma also demonstrates is that the short-sightedness in management and politics that was referred to by several respondents relates to several of the principles on multiple levels. It is also unpopular for politicians to take action on something that may or may not happen 50 years down the line. Biggs, Schlüter, and Schoon (2015, 127) confirm that "government institutions are often structured to operate on shorter timescales than the timescale over which important changes in controlling slow variables may occur". The implication of this is that the slow variables that need to be addressed often end up ignored or sidelined.

Moreover, based on the findings presented in 5.5 on how stakeholders described learning and experimentation in relation to food systems, I perceived the politics and trade-offs to be highly complex. In many political strategies, food is simply a matter of nutrition, and the primary concern is how to feed a population in accordance with nutritional guidelines. There is also a tendency to emphasize production systems and consumption patterns in their own right, without sufficient understanding of smaller and larger factors interconnect across the value chain. Yet, there is more to a food system than just the provisioning element, which was described in section 5.8. For example, food production and consumption are linked to health and well-being in the population as well as for the planet. Food can also be a critical way to approach issues of sustainability both locally and globally, as it connects to fundamentally to people's culture and practices. Integrating these wider perspectives on food into political

strategies can thus impact the extent to which these benefits are prioritized in management within the industry. Food systems are shaped by political frameworks, and in turn, impact how and what we eat.

Furthermore, on the principle of broadening participation (5.6), I found particularly noteworthy reflections regarding community participation. Recalling the fact that "ecosystem-service governance outcomes are a result of balancing competing 'desires' of different groups; however they are influenced by various asymmetries, leading some groups to get closer to their desired goals than others" (Biggs, Schlüter, and Schoon 2015, 41), it is critical to validate the participation and desires of multiple groups to allocate the flow of ecosystem services in a more fair and just manner. Based on several remarks in 5.8, the participation of the local community has the potential to be very positive for the social cohesion of the community. These accounts also reinforce the importance of community participation for strengthening agency, building collective identities, and providing the communities with a sense of ownership and connection with the coastal developments that impact their lives in one way or another. Integrating the concept of agency or other socially-loaded concepts has also been flagged as an area where the resilience approach falls short (Welsh 2014; Cretney 2014; Cote and Nightingale 2012). Participation from multiple stakeholders to address different issues that are of relevance to both the industry *and* the community can strengthen legitimacy as well as build a common knowledge pool pertaining to the SES. Participation from multiple stakeholders can also help detect and interpret perturbations (Biggs, Schlüter, and Schoon 2015, 204), such as deliberating on what ecosystem services are actually being provided in a social-ecological system, as was described in section 5.4.

Lastly, on the topic of polycentric governance (5.7), all my respondents were in favor of a more inclusive system. Yet, this view was not shared by all stakeholders in the system, as was noted at one of the conferences I attended. The respondent quoted in 5.7 who remarked being very provoked by the idea of having a single governing body went on to describe this kind of thinking as a 'danger to democracy'. A much more sensible approach, and to which the framework of resilience agrees, is to work on strengthening communication between these various authorities in order to build knowledge and ensure that those who have something to say can announce their interests freely.

Aligning with the current state of polycentric governance that characterizes the emerging seaweed industry, Biggs, Schlüter, and Schoon (2015) outline the arguably more extensive list

of benefits with a broadly inclusive system where governance occurs at multiple levels. Referencing the work of Olsson and colleagues (2004, cited in Biggs, Schlüter, and Schoon 2015, 234), the authors describe how "a polycentric system can capitalize on scale-specific knowledge (e.g. traditional and local knowledge) to aid learning through sharing information, experience, and knowledge across cultures and scales, while also providing an opportunity for broader participation". Fostering principles as well as institutions that allow individuals and communities to express their views openly, and deliberate on the issues that inevitably impact their society and landscape, is inherently political. Recognizing how broadening values and perspectives on ecosystem services can be significant both for the resilience of the SES, and by extension for the well-being and livelihoods of future generations, is particularly critical. I elaborate specifically on this last point in the next section.

Before moving on to 6.3 I wish to underline that assessing what components foster or compromise resilience is not a means to establish whether the system *is* or *isn't* resilient (Kinzig 2012). Rather, the principles used for this case study and all future studies of SES serve best as a conceptual framework or guide to uncovering which functions are the most resilient and in what circumstance. With this is mind, "one must always ask 'the resilience of what to what?' (Carpenter et al. 2001) and 'how much resilience'" (Kinzig 2012, 316). Raising awareness about the political dimensions underlying how actors think and act with regards to resilience-building initiatives and ecosystem-service choices is in itself an integral component to understanding SES (Biggs, Schlüter, and Schoon 2015).

6.3 Deliberating on Wider Ecosystem Service Benefits

As I have shown, integrating the resilience framework with a cultural landscapes approach invites a socially-focused examination of the multiplicity of perspectives that exist in any one landscape (Kinzig 2012). Biggs et al. (2015, 44) remind us that "more fully deliberating on which ecosystem services should be the focus of resilience-building initiatives in SES can not only help balance competing conceptualizations of which ecosystem services society desires to sustain, but can build further benefits towards sustainability". Through my investigation, and especially as an insider, I came to appreciate how the case I studied can be a vehicle for other positive effects and notions of sustainability that extend beyond producing and distributing seaweed as raw material. This includes increasing self-possibilities in a meaningful way, bridging the disconnect between producers and consumers in relation to

food systems and the landscape more generally, and enhancing health and wellbeing through connection with the ocean and with our natural environments. In the following section, I deliberate more specifically on the wider perspectives on what the landscape could or should offer, including the benefits for society and for sustainability principles.

Indeed, efforts to reverse unsustainable trends "reflect unique combinations of local imperatives, recognized interconnections and engaged players" (Gibson 2013, 4). The challenge that remains is "using the knowledge local actors have on the conditions for change of the social systems and not least tap in on tacit knowledge" (Kjærgård, Land, and Pedersen 2014, 566). The reflections of social and cultural values of seaweed harvest and production presented in chapter 5.8 do not necessarily reflect the shared view of all smaller-scale producers. Nor do these featured reflections suggest that larger-scale producers or farmers do not align with a broadened view of ecosystem service benefits. Still, I found that the reflections that these three respondents made on topics such as aesthetic values and community participation to be particularly critical for the holistic view or shift in perspective aimed at reconnecting people and nature as interdependent social-ecological systems (Folke et al. 2011). Deliberating on wider social and cultural benefits within social-ecological systems research can ultimately allow for a better understanding of how ecosystem services relate to human well-being and sustainability more generally (Schmidt, Sachse, and Walz 2016).

The three respondents featured in 5.8 described their approach to management with words such as 'holistic', 'circularity' or with values aligned with 'non-growth. In the Western world's capitalist economy, dependent on the accumulation of wealth, smaller-scale producers or business models are not necessarily models for the mainstream. However, they serve as reminders of what is possible and can offer perspectives worth studying in order to broaden our views and perceptions around success and the importance of embracing a wider range of ecosystem services. Gibson (2013, 4) discusses the important role of small-scale functions in epitomizing "serious efforts to reverse unsustainable trends and deliver multiple, mutually reinforcing, fairly distributed and lasting positive contributions to sustainability".

While these marginalized perspectives are largely well out of the mainstream and seemingly insignificant in the fight against structural issues (Gibson 2013, 4), they remain valuable, and increasingly necessary reminders of what is possible and the lessons we should bring with us forward in the fight against climate change, destruction of the oceans, and degrading health and food systems. To use the words of Smith (2007, 428, citing Vale and Vale 1975) "[o]ne

live, working experiment, however impractical if it were applied universally, will transmit an idea far better than a shelf full of theoretical reports. Something that can be seen and touched and shown to work to some degree arouses curiosity, and curiosity in turn leads to solutions".

Still, I wish to reiterate that the diversity in actor management priorities within the industry may overall be a positive contributor to resilience and for the sustainable success of the industry. Although this diversity was not necessarily deliberately organized as such, as clarified by one actor, all respondents seemed positive about the fact that there existed actors at multiple different scales with different motivations and functions. As briefly mentioned in chapter 5.3, facilitating industrial scale-production to produce profitable large-scale biomass on the one hand, while at the same time promoting the development of producers that seemingly prioritize delivering a wider range of specific and more localized social and cultural ecosystem services benefits on the other hand, could be a key to sustainability and for a functioning and resilient SES. Again, what is perhaps the most important for a resilient SES is recognizing that "power and competing value systems are not external to, but rather integral to the development and functioning of SES" (Cote and Nightingale 2012, 476).

Biggs, Schlüter, and Schoon (2015, 16) brings up an important consideration which is that "many ecosystem services remain undervalued and underappreciated, especially where they are produced in distant locations or where they contribute only indirectly to the benefits experienced by consumers". The ecosystem services benefits described by respondents in the quoted reflections in 5.8 are indeed localized and produced in distant locations. Their value may thus remain undervalued and underappreciated. However, strengthening the collective narrative on these benefits by bringing these perspectives together can promote greater awareness. Broadening values and perspective on ES is a condition which not only increases recognition but which may also strengthen the access to these ecosystem services overall.

It is worth highlighting efforts that contribute to raising awareness and changing perceptions on our relationship with nature. Mee et al. (2008) highlight the importance of the social element in ensuring effective management of marine environments, including a need to address the cognitive distance to these environments that results in marine issues often being hard to witness and therefore hard to address or even recognize. When 80% of sugar kelp disappeared from the Skagerrak strait on the southeast coast of Norway, it went largely unnoticed (Svolsbru 2013). Despite significant consequences of this disappearance for biodiversity and other ecosystem services that benefit us humans few people had heard about

this adversity, or about the importance of kelp forests for planetary health for that matter. Kim et al. (2017) confirm that "[t]he ecosystem services role provided by seaweed aquaculture often falls unnoticed by coastal managers, partly because the seaweeds are hidden underwater, and partly because the services themselves are not yet accurately valued by markets."

How we value nature, including the relationship between society and the natural world, will ultimately impact how we govern, manage, and develop these same systems. The concept of mental models, or 'habits of the mind', can help explain this thought. For example, is the ocean viewed as an untapped or overused resource? If the answer to the question is the former, and we understand our oceans and coastal regions to be vast empty spaces with unlimited options for development, then resource management and decision making are likely to prioritize large-scale development over conservation. However, if the answer to the question is that the ocean is understood as an overused or exploited resource, then the 'cluster of cognitive behavior leading to action' is more likely to be primarily concerned with conservation. This is, of course, a highly simplistic generalization of an inherently complex and more nuanced issue. From my investigation, I found that seaweed and seaweed cultivation was reflected upon as both an untapped opportunity and as a development that demanded a precautionary approach.

Still, the out-of-mainstream narratives presented in 5.8 strengthen the notion of seaweed and the ocean carrying non-instrumental value (Efstathiou and Myskja 2019), which is worth weighing in when discussing policy framework and priorities for the development of a new industry. With regards to the landscape, this will contribute to a better understanding of how the ecosystems and wildlife that are embedded within these same systems should be governed or cared for. Again, the narrative of what the ocean represents is ultimately a product of a collective perspective and should include the combined viewpoints of researchers, producers, and other industry stakeholders at different scales, as well as lay members of society.

Lastly, while "ecosystem services [are] a key emergent outcome of social-ecological interactions, and a central connector and mediator between social and ecological systems…they are only an ecosystem service if they are valued by people" Biggs, Schlüter, and Schoon (2015, 15). For example, seaweed environments require time and investment to establish (in the case of a seaweed farm) or regulations and policies to protect them (both for

cultivated and wild environments), but they only provide recreational, social or cultural benefits once people recognize or gain access to these environments, goods, and services.

Plieninger and Bieling (2012, 114) state that "in line with the ecosystem goods and services paradigm, we claim that cultural landscapes show resilient behavior, if the goods and services provided remain within a certain range during a specific period of time". Recognizing that stakeholders reflected around the difficulty in assessing the tangible benefits of ecosystem services, whether they are regulating or cultural services, this suggestion offers a concrete approach to engage with resilience thinking and SES both analytically and in practice. Such an empirical analysis of ecosystem services can also help strengthen the explanatory power of the resilience framework and challenge the lack of emphasis on cultural and social benefits.

While my investigation initially pursued a desire to understand how stakeholders reflect upon and engage with resilience-building principles, my research also led me to uncover a lack of engagement with social and cultural ecosystem service benefits amongst the larger and more established actors in particular. What would strengthen these findings even further is establishing the percentage of stakeholders in a large sample that acknowledges each ecosystem service in the three realms, including provisioning, regulating, and cultural services. In addition to compromising resilience in the system, a lack of adequate representation of all relevant services can have consequences for society and governance more generally. A discussion around how actors reflect upon these issues is critical, as the implications will ultimately reflect back onto these same actors in society.

Figure 11: Kelp in the North-Atlantic ocean. Photo: Troels Rosenkrantz

7 CONCLUSION

> *"Managing for resilience enhances the likelihood of sustaining desirable pathways for development in changing environments where the future is unpredictable and surprise is likely" (Folke 2006, citing Walker er al. (2004) and Adger er al. (2005)).*

I presented the outset for this research in the introductory chapter, which is the understanding that ecosystems do not exist without human influence and no society exists that does not depend on ecosystems and the services they provide; they are intertwined to create social-ecological systems (Folke et al. 2011). This is especially true as societies, and ecosystems, becomes increasingly globalized. The complexity and uncertainty that characterizes social-ecological systems may be viewed as a drawback or liability when it comes to creating effective policy guidelines and management strategies, as well as when it comes to conducting research at all. On the other hand, "the shift from people and nature as separated parts to interdependent social-ecological systems provides exciting opportunities for societal development in tune with the biosphere; a global sustainability agenda for humanity" (Folke et al. 2011, 719).

Investigating how and why industry stakeholders make and respond to decisions concerning the management of ecosystem services has opened up for a discussion around priorities of the seaweed industry more generally, and how this may impact resilience. However, in employing the social-ecological resilience framework to study how stakeholders in the emerging industry think and act it has not been my intention to suggest that stakeholders *should* adopt resilience thinking in their management. My working title for this thesis '*…towards a social-ecological understanding of management objectives and ecosystem service benefits'*, may allude to this often taken-for-granted assumption that actors ought to align their practices with what a social-ecological systems approach would expect from them. Kinzig (2012, 325) reminds us that ignoring these assumptions as academics "includes a tendency to assert that the landscapes or resource management strategies we prefer (from our comfortable, academic, largely urban lives, where we want to experience these landscapes only occasionally or from afar) are somehow the 'right' ones for everyone - more resilient, more beneficial, more pleasing".

Still, what viewing the emerging seaweed industry as an SES has contributed is building an awareness and transparency of the current trajectory of development, and particularly how

these dynamics are embedded in the cultural landscape. Although industry is often seen as an enemy of the environment (Efstathiou and Myskja 2019), this investigation has emphasized the promising potential of industrialization to contribute to reimagining the food system and tackling environmental pressures as well as the unique qualities and non-instrumental value of seaweed in benefitting societies and ecosystems also beyond the provisioning of quantifiable ecosystem services. The recognition of a multiplicity of perspectives and sometimes competing value systems is, in fact, integral to the ability of a complex system to deliver life-supporting ecosystem services and can also be critical for resilience-building.

With regards to the implications for scholarship, combining resilience and the cultural landscape approach can ensure that the social analysis often missing from studies on resilience is addressed. Analyzing governance structures and management approaches through the lens of resilience must consider how the past, present, and future elements of both social and ecological dynamics are interconnected. This includes deliberating on wider social and cultural elements as well as political and power dynamics, which are fundamentally embedded in any complex system. Only with such reflections does it then become possible to evaluate where the resilience approach can be part of a larger solution, and where it may fall short.

As a new industry, and as part of a growing global expansion in seaweed production, it is important to assess and revise knowledge and knowledge-systems regarding the current state of production as well as future goals, so that management and policy guidelines can be aligned accordingly. Once humans move beyond seeing nature as something that can be managed or controlled, we as a society can more adequately prepare for developments in the cultural landscape *where the future is unpredictable and surprise is likely*.

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Appendix

Appendix A: Interview Guide – Seaweed producers in Norway

Interview Guide – Seaweed producers in Norway

Background:

1. Can you tell me a little bit about the company you work for and the kind of production you do?
    - Farming/wild harvest, scale, size of company, established in?
    - Your role? (position, daily responsibilities)
2. Why did you get involved with producing seaweed in Norway?

Principle 1: Maintain diversity and redundancy

3. What would you say are the main objectives of the company you started/work for?
    - If mainstreaming is not a primary goal, what alternative goals are of priority?
4. In what ways do you find that your objectives are different/similar from other companies that farm/harvest seaweed in Norway? Social, environmental, economic?
    - Scale, mode of production, different species, different goods and services?
    - How do these objectives compare to the objectives of the industry as a whole?
5. Is your approach scalable or transferrable?
6. Are your objectives the same now as when you started? Why/why not?

Principle 2: Manage connectivity

7. To what extent do you find that the industry is interconnected?
8. Do you collaborate or exchange knowledge with other producers in Norway?
9. Do you collaborate or exchange knowledge with other producers abroad?
10. Do you collaborate or exchange knowledge with other industries in Norway?
    - E.g. fisheries
11. Do you find this connectivity is always positive?

Principle 3: Manage slow variables and feedbacks

12. What are the main opportunities of this work?
13. What are the main challenges or barriers at this stage?
14. How does this compare to the challenges or opportunities of the industry?
15. To what extent do you consider the following external factors in the decision making of your company?
    a. Legal system
    b. Regulatory authorities
    c. Cultural/social/traditional values, in relation to demand
    d. Climate change?
16. What would you say are the most important benefits/costs to the environment?
17. What would you say are the most important social benefits/costs?

Principle 4: Foster CAS (complex adaptive systems) thinking

18. Is there a lot of change, uncertainty or unexpected findings as your company and the industry develops?
19. How do you deal with this uncertainty and change?

Principle 5: Encourage learning and experimentation

20. To what extent does this influence your potential and willingness for innovation?
21. Do you find that learning and experimentation are encouraged in your field?

Principle 6: Broadening participation

22. What would you say are the most important arenas for participation and collaboration amongst actors? (How does participation take place?)
23. Who are the main stakeholders, other than producers, that are important to this industry?
24. Who participates the most / who should participate more?
25. Do you find that there is transparency and trust amongst stakeholders and actors?
26. Other than consumers, do you see other groups benefitting from you working with seaweed?

Principle 7: Promote polycentric governance systems

27. Do you find that the involvement of various stakeholders is effective as the industry develops?
28. Do you find it necessary to have so many different stakeholders involved?
29. Do you find that there is good communication between parts?
30. Is there any way this could be done differently?

Additional questions:

1. To what extent, if any, is the provision of ecosystem services a priority in your management approach?
2. What distinguishes your approach from other actors abroad?

CONCLUSION

Finally, is there anything else you would like to add in terms of what
the sustainable success of the industry looks like? Are there any factors that you find would be particularly important to achieve this success?