SEARCHING FOR SUSTAINABLE AQUACULTURE GOVERNANCE
A focus on ambitions and experience

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Abstract
Aquaculture is one of the most diverse food-producing industries and is suggested as a key solution to a growing global food demand. It has been argued that aquaculture has the potential to expand sustainably in most parts of the world, especially in the EU where consumption far outweighs production. This positive view surrounding aquaculture’s growth emphasizes its positive social and ecological effects. These include the generation of rural employment opportunities and the production of nutrient-dense food with negligible or even beneficial environmental effects (e.g., nutrient sequestration). However, for the industry to fulfil this potential, it needs informed governance structures and policies about social-ecological systems that are sensitive to local issues and conditions but also linked to the wider transnational/global context. This thesis provides empirical insight into how different levels of governance and policy interact and the ‘sustainability aquaculture development’ that different actors advocate. By using the Social-Ecological Systems (SES) approach as the theoretical foundation, combined with discourse and policy analyses, this thesis delves into how sustainability is framed in different aquaculture governance settings to give nuanced insights into varied sustainability discourses. This includes examining some of the most influential governing actors in the global North, ranging from intergovernmental organizations (IGOs) like the EU and UN to states and certification organizations.

Based on academic and international governing goals for expanding aquaculture sustainably through multi-stakeholder engagements, and the rapid expansion of Atlantic salmon production, this thesis analyzes how alternative influential governance regimes, like certification programs, compare in terms of environmental stringency with the national regulatory standards of the largest salmon-producing states. One region of interest in this thesis is the Nordics where aquaculture production is unevenly distributed. Norway is one of the most prominent global aquaculture production countries; other states such as Iceland are growing rapidly while countries around the Baltic Sea have very little production. Aquaculture in the Nordics is mostly centered around resource-intensive species with a high market value like Atlantic salmon. Continuing with the ambition to use multi-stakeholder engagements, this thesis also provides empirical insight into how policies and legislation are formed to promote aquaculture. Finally, based on global and regional recognition that food production needs to decrease its dependence on antibiotics, this thesis looks at how some of the most impactful aquaculture markets globally regulate antibiotics usage in aquaculture operations.

This thesis contributes by developing a conceptual framework to examine how different aspects of sustainability are aspired to and pursued in different aquaculture governance arrangements and settings. Through the application of this framework, the thesis develops critical insights into how governing actors frame sustainable aquaculture, identifying dissonances and synergies between international and
national ambitions and making suggestions for how aquaculture sustainability can be improved.

**Key words:** Aquaculture, policy, environmental governance, Social-Ecological Systems
Acknowledgements

The acknowledgement section of a PhD thesis is similar to an acceptance speech at an award show. Although I have not won an award, this could be my only chance to write an acceptance speech as if I had just won an Oscar. But before I do that I would like to extend my gratitude towards the Foundation for Baltic and East European Studies for financing this project.

And now back to the acceptance speech: A lot has transpired during the course of this PhD. The COVID-19 pandemic shut the world down for two years, making it next to impossible to go anywhere or meet all the great colleagues at the School of Natural Science, Technology and Environmental Studies at Södertörn University. When we finally were able to return to reality, it was as easy of a transition as anyone could have ever hoped for. Thank you all for that and especially Mohannad Abdelgadir, Thérese Janzén and Nikolina Orescovic!

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### Abbreviations and acronyms

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<td>AG</td>
<td>Adaptive Governance</td>
</tr>
<tr>
<td>AMR</td>
<td>Antimicrobial Resistance</td>
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<tr>
<td>ENGO</td>
<td>Environmental Nongovernmental Organization</td>
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<td>IGO</td>
<td>Intergovernmental Organization</td>
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<td>NMSD</td>
<td>Nonstate market-driven</td>
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SEARCHING FOR SUSTAINABLE AQUACULTURE

GOVERNANCE
List of Papers

Papers included in this thesis

Paper I

Paper II

Paper III
**Luthman, O.,** Saunders, F., Skúlasdóttir, K. H., (manuscript). Icelandic salmon run.

Paper IV

Contributions to the papers
For papers I & II, I conceived and developed the idea, performed the research and wrote the manuscripts. For paper III, I co-developed the idea, analyzed the data and wrote most of the paper. The interviews for paper III were conducted by co-author Katrín Helga Skúlasdóttir. For paper IV, I co-developed the idea, performed the research, analyzed the data and wrote the paper. Ultimately, all papers are a result of collective efforts from myself, co-authors as well as my supervisors.

Related papers outside the thesis

Background brief (for the SeaBOS project)
1. Introduction
– Sustainably sourced food for a growing population, how are we going to do it?

Give a man a fish and he’ll eat for a day. Teach a man to fish and he’ll eat for a lifetime…
(Maimonides)

What is overlooked in Maimonides’ famous quote is that if everyone knows how to fish, we will deplete our oceans. With rapidly declining fish stocks globally, there is a world-wide need to sustainably expand the farming of seafood to increase food security, jobs and ensure that our growing population has access to nutritious and sustainably sourced food in the future (FAO, 2022e, Costello et al., 2020, Bennett et al., 2021). However, this widely promoted sustainability path is not without its risks and uncertainties. The governing of this sector must be done with careful scientific and stakeholder engagement to support contextually situated sustainabilities - that justly and judiciously consider the specific mix of goals and ambitions, distributional effects, and environmental values and conditions.

The unpredictability associated with climate- and environmental change has exacerbated the already difficult task of producing food for a growing global population whilst minimizing anthropocentric stressors on our planet (Willett et al., 2019). It is one of the most pressing challenges of our time as showcased by the Sustainable Development Goals (SDGs) (UNDP, 2015b), Intergovernmental Panel on Climate Change (IPCC, 2022), and Farm to Fork Strategy (F2F) set up by the European Union (EC, 2020b). It is apparent that food production is an industry in dire need of transformation, moving away from unsustainable practices that exacerbate climate change and unjust availability of nutritious food (Turnhout et al., 2021, Gordon, 2017). One commonly suggested solution is to expand aquaculture production, as it is perceived to increase the availability of healthy and sustainable food whilst providing jobs and stability in rural areas (EC, 2021b, Froehlich et al., 2018, Costello et al., 2020, UNDP, 2015a). However, aquaculture in Europe has been developing slowly, and there is a huge consumption-production deficit (Guillen et al., 2019, EC, 2021b, Avdelas et al., 2021, Paisley et al., 2010, EUMOFA, 2018). The largest seafood exporter to the EU is Norway, and farmed salmon is the most imported seafood in the region (EC, 2022c). Aquaculture in the other Nordic countries¹ has been much

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¹ The Nordics consist of Denmark, Finland, and Sweden bordering the Baltic Sea and Faroe Islands, Iceland and Norway in the Northeast Atlantic.
slower (Paisley et al., 2010) even with ambitious growth-promoting policies in play (paper I). This is largely due to unfavorable conditions in the Baltic Sea with low salinity and high nutrient retention (Kotta et al., 2023, Almroth-Rosell et al., 2021). The slow development of European aquaculture has been pinpointed to strict environmental regulations and complicated license processes (Falconer et al., 2023). However, this is a simplification, as suitability for aquaculture sites, low profit margins, and cheaper imports are also important aspects (López Mengual et al., 2021, Avdelas et al., 2021). To increase production, the EU incentivized member states to streamline the aquaculture development processes and create action plans (EC, 2009). To date, this has not yielded a significant increase. Other important aspects that are highlighted by the EU are the following: a) diversifying the industry, which could increase food security, resilience, and public health outcomes; and b) obtaining social acceptance of establishing aquaculture operations (EC, 2020a, EC, 2021b). The ambition of European aquaculture is to produce sustainable and healthy food that fights climate change and mitigates its impacts; decarbonize the economy; reduce pollution; contribute to the preservation of ecosystems (EC, 2021a); reduce therapeutic treatments and antibiotic dependency; and significantly increase organically certified production (EC, 2021a, EC, 2021b). A growing body of research advocates for aquaculture’s capacity to succeed in doing all this (Armoškaitė et al., 2021, Kotta et al., 2020, Costello et al., 2020, Torrissen, 2011). However, for aquaculture to achieve the previously stated ambitions, there is a need for policies to have a comprehensive understanding of the complexities of aquaculture production in social-ecological systems (SES). The SES approach emphasizes the intertwined nature of human-environmental development (Folke et al., 2016), embedding the “social”, namely any human dimension, e.g., institutions, societies, economies, politics, cultures, and technologies, with ecological systems, e.g., the biosphere (Berkes, 1998, Folke et al., 2016). This stresses adaptiveness and resilience as key components for sustainability. These conceptual attributes are also stressed in the EU strategies to increase aquaculture production (EC, 2021b). Essentially, they emphasize the need to learn, evolve, and sustain ecological integrity, social justice, and economic welfare in the face of changing environments and climate (Folke et al., 2021, Folke et al., 2005). Both of these serve as crucial elements in achieving the aforementioned SDGs and F2F strategies that emphasize food system transformations, which not only minimize anthropocentric stressors but also reverse inequalities and ecosystem degradation (EC, 2020b, UNDP, 2015b).

This is where governance strategies can have a significant impact – in setting directions, developing strategies, and making decisions about the multidimensional goals of sustainability and how they are expressed in practice. According to the SES framework, governance should highlight the environmental as well as social elements equally when striving towards sustainability (Folke et al., 2005). Environmental governance is “the system of institutions, including rules, laws, regulations, policies, and social norms, and organizations involved in governing environmental resource
use and/or protection[...]” (Chaffin et al., 2014). Another more normative definition of environmental governance is the method of resolving trade-offs and providing visions and directions for sustainability (Boyle et al., 2001). There are three important aspects of just and sound environmental governance: (1) the decisions should have their moorings in scientific information about ecosystem functions (Brunner, 2005); (2) environmental governance needs to account for contextualized issues and large-scale challenges, thus be both adaptive and robust at the same time (Chaffin et al., 2014); and (3) environmental governance needs to consider and consolidate the people who are relying on the system that is being governed (Krause et al., 2015). As a result, there is a need for adaptive governance (AG) that stresses flexible and learning-based collaborations between state and non-state actors at different hierarchical levels to negotiate and coordinate the management of social-ecological systems and ecosystem services (Schultz et al., 2015).

The EU’s ambition to increase organically certified products is shared among member states like Sweden, Denmark, and Finland, which express this goal in their food and aquaculture development policies (paper I). By advocating for eco-certified products, states and Intergovernmental Organizations (IGOs) share some of their governing and monitoring responsibilities with private entities without holding any formal authority accountable. Since these certifications are voluntary and incentivized through price premiums, it puts pressure on producers and consumers to make the “right” choice and has higher price tags than un-certified products (Barkemeyer et al., 2023). However, the COVID-19 pandemic and the following inflation have significantly reduced the consumption of certified products in the EU (Rehder, 2023). This type of market mechanism has also benefited larger, more affluent producers to a higher extent as well as targeted high-value and more environmentally demanding species like salmon or trout (Jonell et al., 2013). Thus, increasing environmental performances of production does not necessarily leading to sustainable production. Atlantic salmon is the most consumed aquaculture product in Europe, especially in the Nordic and Baltic states (Eurofish, 2021a, Eurofish, 2021b, EC, 2022c). It is also, together with trout, the most-produced seafood in the Nordics (Hornborg, 2021). Atlantic salmon is also the fastest growing and most lucrative aquaculture industry in the world (Barasa, 2022). Salmon and trout are associated with rather high inputs of high-grade feed, waste production, energy consumption, and greenhouse gas emissions, even if significant improvements have been made during the last couple of years (Aas et al., 2019, Johansen, 2022). The environmental performance improvements of these species are admirable; however, it can result in Jevon’s paradox. This means that improved efficiency and environmental performances per unit produced are not coupled with a decrease in environmental effects or resource use due to increased production (Sears et al., 2018). Krause et al., (2015) identify the production-orientation in policies as a main hindrance for aquaculture to reach its potential as a sustainable source of food as it creates people-research-policy gaps due to omitting its multiple dimensions (ecological, social, and
economic). This challenge is at the core of this thesis as it delves into how national aquaculture policies and regulations are framed and how these compare to international- and scientific recommendations.

Understanding what governing institutions like states, IGOs, and certification programs are advocating for when proposing sustainable aquaculture development is an important step in analyzing and assessing whether this ambition is reflected in practice. By looking at how aquaculture development is framed by these governing actors, this thesis will further a critical discussion about how states should construct policies and strategies in a more holistically sustainable fashion. In accordance, one of the main ambitions of this thesis is to conceptualize and analyze how aquaculture development is portrayed by leading farmed salmon-producing states who also happen to be among the highest performing countries in terms of achieving the SDGs (SDGINDEX, 2022). The SES approach serves as the theoretical foundation to analyze if and how the states could improve their governance strategies. To do this, I mainly focused on how policies are framed as these documents articulate governance cultures, addressing more than legal requirements as they also drive aims and goals (UTS, 2018). Another ambition is to analyze how their strategies, policies, and regulation match the sustainability narrative around aquaculture and if there are any incongruencies or blind spots.

1.1 Research puzzle

By ratifying the SDGs, each state agreed to contribute to creating a more sustainable, equitable, and healthy planet and population (UNDP, 2015a). To do so, states need to apply and combine a global resource commitment with locally informed and contextualized interventions, policies, and strategies (Crona et al., 2023). One of the most impactful measures to do so, and mitigate the anthropocentric stressors as well as contribute to environmental and public health, would be to transform global food systems (Gordon, 2017). A sustainable expansion of aquaculture to replace some of the less sustainable food-producing industries would indeed contribute to this endeavor (Gephart et al., 2021, Crona et al., 2023). The combination of the three pillars of sustainability – environment, society, and the economy – is a complex and wicked policy challenge (Pullin, 2013, Hopwood et al., 2005). By wicked I mean a challenge that lacks a clear definition or response, where an improvement or solution to one challenge might set off another somewhere else along the production line (Rittel and Webber, 1973, Kerekes, 2021). Most can agree that something should be done; it is the “what” and “how” that separates the main discourses regarding sustainability (Béné, 2005), whether they prioritize safeguarding the environment, social aspects, or the economy. These separated focal points are often referred to as strong sustainability, with environmental emphasis, and weak sustainability, which emphasizes economic growth (Neumayer, 2003). As a result, sustainable aquaculture
development might have significantly different meanings and outcomes depending on what pillar is emphasized the most and by which actor.

One rather broad and usable definition of sustainable aquaculture is, as Tlusty et al., (2019) put it, “production that balances socio-economic benefits while maintaining environmental integrity now and in the future”. The Food and Agricultural Organization of the United Nations (FAO) defines sustainable aquaculture as the enhancement of global food security, nutrition, and poverty eradication as well as contributing to ecosystem resilience and societal well-being (FAO, 2022e). The EU Commission adopted a new guideline for sustainable and competitive aquaculture (EC, 2021b) that connects to the Farm to Fork Strategy, which defines sustainable aquaculture as resilient, and competitive, aiding in the green transition of food production, ensuring social acceptance, and increasing knowledge. A more comprehensive description of how these guidelines and the Farm to Fork strategy articulate goals involves reversing biodiversity loss trends; reducing pollution and antibiotic use in food production in general; increasing food security through diversifying the industry as well as being adaptive and resilient in the face of climate change; and increasing the presence of other stakeholders like certification bodies (EC, 2021d, EC, 2020b). This last description serves as the foundational definition of sustainable aquaculture in this thesis. This definition will be used to compare and examine different conceptions and practices of sustainability across a range of aquaculture contexts.

Aquaculture does have a much smaller ecological footprint than many other animal protein-based industries and should complement or replace some of these industries if the SDGs are to be achieved (Gephart et al., 2021, Willett et al., 2019). However, aquaculture is often scrutinized in news outlets and popular culture, where emphasis is put on risks and negative examples rather than societal and/or ecological benefits (Froehlich et al., 2017, Govaerts, 2021, Olsen and Osmundsen, 2017). These risks revolve around contributions to overfishing, greenwashing through certifications, pollution, mass escapes, and effects on wildlife. The issues raised in the media are not unwarranted but there is a need to be balanced and nuanced in the reporting of aquaculture and in our approach to understanding aquaculture production practices and their effects (Olsen and Osmundsen, 2017). The aquaculture industry in general and especially in the EU is not an unregulated, coastal version of the Wild West (Sullivan, 2022, Abate et al., 2016). However, even if regulations and monitoring systems are in place, it is still important to conduct an informed scrutinization of how the industry is governed and how sustainable aquaculture development is defined by governing agents. In this lies the focal research problem of this thesis, how aquaculture regulations and governance strategies are constructed, what sustainability aspects are central to governing institutions, and how this relates to the previously mentioned definitions of sustainable aquaculture (EC, 2021d, EC, 2020b, Tlusty, 2019).

Furthermore, the contributions and potential of aquaculture vary significantly depending on markets, geographical location, and economic prerequisites (Troell et
al., 2023). This is also reflected in global production and how different national and international policies and strategies aimed at increasing aquaculture production are formulated (Cao, 2015, EC, 2009, FAO, 2020). The ambition might vary too. For example, is it to produce food in an environmentally sustainable way, or are short-term productivism approaches applied that do not fully address the environmental challenges? Is it to maximize resource use or create just distributions? Is it to increase food security? Is it to create new jobs and business opportunities? It is probably a mix of them all as policy goals are usually not one-sided but have multiple ambitions, which can affect how policies and strategies are formulated (Abate et al., 2018). However, in many policy settings, especially in affluent regions like the EU and Nordic countries, sustainability and the SDGs are an underlying prerequisite for development (Sachs, 2019). As a result, in this thesis, I delve deeper into how aquaculture development is framed by different governing institutions in this region and what sustainability aspects are being prioritized. The main emphasis in this thesis is environmental sustainability. However, as sustainability issues are intertwined, the thesis also addresses other sustainability issues, most notably social aspects. The connection between the two is emphasized through governance strategies (paper III) and resource use, more specifically feed ingredients that connect as much to the environment as it does social equity (van Riel et al., 2023, Troell et al., 2014). Furthermore, the thesis uses the SES approach to analyze whether governing institutions advocate for sustainable aquaculture or merely less unsustainable aquaculture.

1.2 Research aim and questions

The issue with sustainable development ambitions in pluralistic governance regimes is, as was touched upon in the introduction and will be discussed in further detail in the next chapter, that they can have different implications depending on the stakeholder or governing level. This in and of itself is not an issue but can lead to sweeping claims and “greenwashing”, which in this thesis refers to making unsubstantiated, false, or misleading claims in a strategy or policy (Berrone et al., 2017). Another problem relating to this is whether a strategy or policy advocates for sustainable or less unsustainable development. What this implies is whether a sustainability challenge is mitigated, improved on, or replaced by a new challenge. To give an example and contemporarily situate this wicked problem, we could look at the suggestion to move aquaculture production onto land, which by many is regarded as a more sustainable production system as the operators have full control over nutrient flows and recycling (Martins et al., 2010, Gardner-Pinfold, 2019). While this would remove some of the issues associated with open net pens in marine environments, it does create new challenges at a time when energy is becoming a scarce resource (Doukas and Nikas, 2022). Thus, understanding and looking at what the issues are represented to be and what solutions are suggested is crucial in order to determine if in fact governing actors are advocating for sustainable aquaculture development. As
a result, the research aim of this thesis is to provide empirical insights into how aquaculture development strategies and policies align with international conceptions of sustainable aquaculture and find possible areas of improvement. To this end, this thesis focused on some of the highest performing states according to the SDGINDEX (2022) as these could be deemed as head of the class, with a special emphasis on Atlantic salmon farming, as it is the fastest growing aquaculture industry (Barasa, 2022). Definitions of sustainability are like the climate; it is dynamic and constantly evolving based on current challenges, which make assessments of when something is sustainable difficult (Seager, 2008). This is in line with resilience thinking, which is embedded in the SES framework. It emphasizes political actors’ anticipation and capacity building to respond to changes (Folke et al., 2021). This evokes the second research question, which focuses on how policies and strategies could aid sustainable aquaculture development. By using SES as the theoretical approach, the second research question also focuses on what is lacking in the current state of policies and strategies in their endeavor to enhance sustainability.

The aim is framed through the following two overarching research questions:

- How do leading salmon farming states and the Nordics position their aquaculture development strategies and regulations compared to recommendations by the UN, EU, and the leading aquaculture certification program?
- How could policies and strategies be improved to come closer to achieving “sustainable” aquaculture?

Table 1. Overview of which research question corresponds to each paper.

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I will respond to these questions by discussing some of the implicit assumptions associated with development, sustainability, and aquaculture through policy analysis. This then allows for a comparison between the different governing institutions and their policies, strategies, and standards to see what sustainability issues they address related to aquaculture. Furthermore, I will critically analyze how environmental
sustainability as a term is used and what it means in the context of aquaculture policy and practice. This is then compared to the scientific understanding of what sustainable aquaculture entails. This is to some extent a normative approach, as I used a scientific foundation to compare and suggest pathways for increased sustainability, most notably emphasizing environmental sustainability (Osmundsen et al., 2020). As our interdependent and connected world consists of intertwined environmental and social systems, I include perspectives from different institutional and hierarchical settings as well as geographical locations. Furthermore, I analyze how different governance mechanisms are applied to reach different sustainability goals defined by the research community and the actors themselves.

1.3 Scope of the thesis

The aim and research questions in this thesis are examined and answered through four different papers. **Paper I** focuses on the operationalization of environmentally sustainable aquaculture development in the Nordic countries (Denmark, Faroe Islands, Finland, Iceland, Norway, and Sweden). It corresponds to the first RQ. In **paper II**, we analyzed the additionality\(^2\) of one of the most stringent and renowned aquaculture certification standards, the Aquaculture Stewardship Council (ASC), and compared it to national legislation in the four largest salmon-producing regions (Norway, Chile, Scotland, and British Columbia in Canada). It links to the first and second RQs. **Paper III** analyzes the emergence and development of Icelandic aquaculture governance. Furthermore, the paper analyzed stakeholder participation in and perceptions of the new regulation and the expanding industry. This paper contributes to responding to the first and second RQs. Finally, **Paper IV** maps and analyzes antibiotic regulations in 17 of the largest aquaculture-producing countries/regions in the world. It corresponds to the second overarching RQ. Whilst quite different in terms of research focus, each paper examines different elements in response to the previously defined EU version of sustainable aquaculture development as well as the previously stated research aims and overarching questions. The first two papers focus on environmental sustainability and how it is operationalized by governing institutions such as states and a leading certification scheme. The third paper focuses on a governance landscape in transition and social acceptance, as well as aspects of sustainability, by looking at participation in governance and perceptions of new regulations related to aquaculture in Iceland. The final paper focuses on public health issues related to aquaculture production, which encompasses all pillars of sustainable development.

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Table 2. Description of papers.

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<th>Paper</th>
<th>Title</th>
<th>Research questions</th>
<th>Research design</th>
<th>Scale</th>
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<th>Sustainability focus</th>
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| Paper I | Strong and weak sustainability in Nordic aquaculture policies | - What characterizes different levels of sustainability in aquaculture?  
- How is ‘sustainable aquaculture’ framed in Nordic aquaculture policies and strategies?  
- How do the policies and strategies relate to environmental discourses on weak and strong sustainability? | Policy analysis, discourse analysis | Regional, Nordic countries | Published in Aquaculture | Environment |
| Paper II | Governing the salmon farming industry: Comparison between national regulations and the ASC salmon standard | How much does an eco-certification scheme add to national/regional environmental regulations?  
What environmental benefits come with a certification? | Policy analysis and measuring additionality | Global | Published in Marine Policy | Environment |
| Paper III | Icelandic salmon run | What are the key drivers for enacting the ‘new’ aquaculture legislation?  
How are the new legislation and policies perceived by the affected stakeholders?  
What do they see as the future of aquaculture development in Iceland? | Semi-structured interviews and policy evaluation | Iceland | Manuscript | Social |
| Paper IV | Global overview of national regulations for antibiotic use in aquaculture production. | How has the presence of AMR been translated into international steering documents and how does it relate to aquaculture? How do the antibiotic regulations in 17 of the largest aquaculture-producing countries/regions compare to the recommendations by the WHO and two leading aquaculture certification programs? | Policy mapping | Global | Manuscript (submitted to Marine Policy) | Public health (environment/public health) |
2. Background
– Aquaculture and sustainability initiatives

In the background section, I give a quick description of why aquaculture is regarded as a more sustainable food-producing industry than others as well as situate key aspects for the thesis. These aspects will be recurring throughout the thesis itself as well as in the different papers.

2.1 Why aquaculture?

Since the green revolution in the 1950s-60s, global food production has increased food availability but has also resulted in significant global socio-environmental problems (Gordon, 2017, Steffen, 2015). Some of the most pressing issues with terrestrial food production are that approximately 40 percent of terrestrial land is cultivated or grazed (Froehlich et al., 2018) combined with unsustainable fresh-water use (Mekonnen and Hoekstra, 2012), pollution and substantial greenhouse gas emission (Bouwman et al., 2013, Tilman and Clark, 2014). Mitigating the negative environmental consequences associated with food production is widely seen as key to supporting the future well-being of the planet and its inhabitants (Willett et al., 2019). Apart from pushing the planetary boundaries on a local and global scale (Rockström, 2009, Steffen, 2015), the food sector is also associated with public health issues through malnutrition and the spreading of antimicrobial resistant bacteria (AMR) (Popkin et al., 2020, Murphy, 2017) as well as uneven and inequitable resource management (Friedmann, 2009, Hiç et al., 2016). As a result, there is a need to transition food production to increase availability, resilience, and public health outcomes.

Seafood, and especially aquaculture, is often overlooked in national food policies and strategies (Crona et al., 2023) but has gained much greater attention from academia and IGOs as a possible solution to these issues (Costello et al., 2020, Gephart et al., 2020, Willett et al., 2019, FAO, 2017, EC, 2017, Torrissen, 2011). Numerous commentators have argued that eating more seafood would lead to healthier diets and a healthier planet as its environmental footprint often is much smaller than terrestrial animal proteins (Gephart et al., 2020, Willett et al., 2019, Hornborg, 2019). However, due to unsustainable harvests and overfishing, there is a consensus among researchers and intergovernmental organizations that the wild-caught fisheries cannot expand further (FAO, 2022e, Boonstra and Österblom, 2014). This has led to an increasing interest in aquaculture. Aquaculture can even be seen as a mitigation strategy for climate and environmental change and degradation through carbon and nutrient sequestration (Gentry et al., 2020, Myers and Subban, 2022). However, the efficiency
of carbon sequestration has been questioned (Troell et al., 2022b). The potential environmental benefits of aquaculture are part of the rhetoric in the EU’s aquaculture strategy (EC, 2021d). However, the sustainability of aquaculture is not a given; it can also have detrimental effects on ecosystems through pollution or impacts on wildlife and create or perpetuate social injustices (Hansen, 2019, Krause et al., 2015, Cao, 2015, Gephart et al., 2021, Béné, 2005). As a result, aquaculture eludes a simple “good or bad” categorization and instead poses both potential benefits and risks to social-ecological systems (Rickard et al., 2021).

Aquaculture is defined as the breeding and cultivation of fish, crustaceans, mollusks, algae, and other organisms in all types of water environments (FAO, 1988). Cultivating seafood is nothing new; it dates back to the Neolithic age (4,000 B.C.) when trapping marine animals in lagoons and ponds was a method to ensure its availability (EC, 2019). Historical traces of seafood husbandry have been found all over the globe, in China, Australia, Europe, and Latin America (Nash, 2011). The scalability was quite small up until the 1960s when the discovery of specific feed and health requirements as well as the floating cage was developed (EC, 2019). Since then, the commercial interest in aquaculture has increased significantly, and today it is the fastest-growing food-producing industry in the world, and over 500 species are cultivated (FAO, 2022e, Hambrey, 2017, Troell, 2017). Aquaculture can be very diverse, in terms of production size, species, and actors (Troell et al., 2023). Diversity is incremental for the resilience and sustainability of any food-producing industry (Rockström et al., 2023) and aquaculture is no different. Currently, salmonids are the fastest-growing aquaculture industry, increasing at an annual rate of 7 percent (Barasa, 2022).

Aquaculture takes place in all types of water environments and can be conducted all over the globe. What is produced varies depending on food cultures and markets. In Asia, where most aquaculture takes place, algae, carp, tilapia, and shrimp make up the lion’s share (FAO, 2022e). European production, on the other hand, tends to concentrate on mussels, salmon, trout, and oysters (EC, 2021c). Norway, which is not a member of the EU but a close associate through the European Economic Area (EEA), is the largest producer of farmed salmon (1.5 million tons) in the world (Fiskeridirektoratet, 2022), but this number has been rather stagnant for the last couple of years (Hersoug et al., 2019, Barasa, 2022). The Norwegian stagnation has increased the incentives for actors to produce in other countries, e.g., Iceland (StatIcf, 2021) and Sweden (Larsson, 2022). In the Americas, salmon has also become the most important species together with shrimp in South America and trout, oysters, clams, and mussels in North America (FAO, 2022e, NOAA, 2021, DFO, 2021). African production is centered around indigenous freshwater species like tilapia and catfish (Adeleke et al., 2021). Mussels, oysters, barramundi, bluefin tuna, and salmon are the dominant species in Australia and New Zealand (FAO, 2022a, ABARES, 2022). Global production in 2018 reached 32 million tons of algae, and 82 million tons of aquatic animals, out of which 54 million tons were finfish (FAO, 2022e). Freshwater
aquaculture is especially important in the global south where it contributes to poverty alleviation and food security (Belton et al., 2018, Filipski and Belton, 2018). Marine aquaculture is the main production form in the global north with salmon farming being the most important species of production (Naylor et al., 2021). The social impacts of marine aquaculture in the global north are usually overlooked in many instances as environmental and technical aspects have been central to justifying expansion and intensification (Krause et al., 2020).

The environmental footprint of aquaculture operations depends on its governing institutional arrangements, geographical location, what species are produced, and production methods. For instance, filter feeders that require no input, such as macroalgae and blue mussels, have a rather low environmental impact and could even have positive effects on the environment through nutrient and potentially carbon uptake (Liu et al., 2016, Kotta et al., 2020, Myers and Subban, 2022, Petersen et al., 2014). These species have gained more attention lately from researchers and IGOs like the EU, which strive to kick-start a market and industry to not only increase food security and socio-economic benefits in coastal regions but also mitigate eutrophication and carbon storage (EC, 2022b, Armoškaitė et al., 2021, van den Burg et al., 2020, Troell et al., 2022b). However, large-scale systems can also have impacts on water flows and changes in the sedimentation rate as well as compete over nutrients with naturally occurring users and change the structure of local flora and fauna (Campbell et al., 2019). Furthermore, it can take up pollutants that affect its use for human consumption (Camarena-Gómez et al., 2022). However, this is debated as previous research indicated that the risks of negative health impacts from eating seafood from polluted oceans are rather small (Tuomisto et al., 2020). The Baltic Sea, one the most polluted oceans in the world (Almroth-Rosell et al., 2021), could benefit from an aquaculture expansion of filter feeders as the high levels of nutrients would not offset a system due to increased competition for nutrients (Kotta et al., 2022, Kotta et al., 2020)(see Text box 1). Due to the low salinity levels in the Baltic Sea, blue mussels do not grow to be bigger than three centimeters (Kautsky, 1982), which is too small for human consumption. However, it can be used for mussel meal as a replacement for fishmeal in animal feeds (Jönsson and Elwinger, 2009, Sicuro et al., 2023), which could alleviate one of the most pressing issues for fed aquaculture, that is, the usage of high-grade food resources in feed (Johansen, 2022, Cashion, 2017).
The Baltic Sea has limited aquaculture production. Largely due to low salinity levels, high levels of dioxins, and eutrophication, with 97% of the Sea considered degraded due to eutrophication (Kotta et al., 2022, Tuomisto et al., 2020). Furthermore, consumer perception of the health risks and benefits of eating Baltic fish varies significantly between countries (Pihlajamäki et al., 2019), which makes production less intriguing. As a result, expanding aquaculture practices that add to emissions is unlikely. However, more research suggests that the riches of nutrients and political sway towards cleaning European Oceans make the Baltic an attractive Sea in which to increase macroalgae and blue mussel production, which could contribute to nutrient uptakes and the reduction of Nitrogen and Phosphorous (Petersen et al., 2014, Kotta et al., 2022, Armoškaitė et al., 2021, EC, 2022b).

Fed species, both piscivorous species such as salmon, trout, zander, and tuna, as well as omnivorous species like catfish and tilapia, are all dependent on feed inputs as well as to variable degrees, therapeutic treatments (Pelletier et al., 2009, Cashion, 2017, Burridge et al., 2010). The challenges surrounding feed are centered around the health of the animals, impacts on ecosystems and high-grade food ingredients that compete with human consumption (van Riel et al., 2023, Cashion, 2017) as well as deforestation associated with soy production (Hansen, 2019). As a result, feed becomes a matter of both ecological sustainability and social equity. Another is the use of therapeutic and antibiotic treatments in intensive farming systems and how that affects Antimicrobial Resistance (AMR) (Rector et al., 2023, Han et al., 2019, Henriksson et al., 2018, Schar et al., 2020). Furthermore, the production method also has its environmental impacts. For example, open net pens, which is the most common production method of marine fed aquaculture, have issues with pollution and eutrophication through excess nutrients from uneaten food and feces (Quiñones et al., 2019); as well as impacts on wildlife through escapees (Forseth, 2017) and pathogen interactions between wild and farmed fish (Teixeira Alves and Taylor, 2020). High-technological, land-based solutions such as Recirculating Aquaculture Systems (RAS) are associated with high energy consumption (Badiola et al., 2018), and for some species, disease outbreaks (Xue et al., 2017). There is a considerable amount of research and development invested in making the industry more sustainable, which has to some extent been successful (Kok et al., 2020, Smith et al., 2010). The environmental impacts from fed species have decreased significantly in the last two decades (Naylor et al., 2021, Torrissen, 2011); however, some of the impacts mentioned are not fully addressed, and therefore there are lingering doubts about the industry’s environmental performance (Naylor et al., 2021, Choi et al., 2020, Olausussen, 2018). In general, much the aquaculture development decisions have been driven by revenue generation and have failed to account for the interactions...
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with ecosystems and the potential environmental benefits of aquaculture (Schmitt and Brugere, 2013).

2.2 Sustainable + development

Sustainability is a contested term; it is cited in numerous international, national, and private policies and strategies, yet there is a lack of specificity regarding the concept (Stirling, 2009, Rossberg et al., 2017). There are many definitions depending on experiences and the disciplines in which they have been developed. Furthermore, the variances regarding the feasibility of concepts such as sustainability, development, and/or resilience differ depending on the theoretical approach and application context. This differentiation in perceptions is at the core of its fuzziness as it leaves room for interpretation that benefits the person or institution that uses it, i.e., it aids or extends the inclusivity of those who can engage with sustainability thereby enacting different platforms and pathways for change. At its core, sustainable development is built on three pillars: the environmental, social, and economic. As Fischer et al. (2007) and Hopwood et al. (2005) argue, for economies to thrive, you need just and inclusive societies, and for societies to thrive, you need a healthy biosphere. These three pillars are also the basis of most commitments regarding sustainable development. In combination, their operationalization is seen as the ability to meet the present needs without compromising the future capacity to meet them (WCED, 1987). This definition, also known as the Brundtland definition, refers to the well-being of people living now as well as conserving nature, cultures, and economic stability for future generations to enable them to thrive (Neumayer, 2012). This rather vague definition is often coupled with other concepts such as development, technological advancements, and resilience (Stirling, 2009, Tendall et al., 2015).

Development is also a highly contested term that has had many faces throughout history depending on who is using it. Critics view it as a Western (Euro-Atlantic) hegemonic concept used to define economic prosperity and resource accumulation (Sachs, 2010). As a result, development is often associated with production, the ability for people everywhere to be able to produce more food, more materials for their housing, and more mechanical and technological advancements (Robert, 2011b). Furthermore, equity is an often-cited argument for pro-development, with related arguments that equality can be achieved, or at least that inequality can be reduced through accelerated accumulation of economic growth and resources (Lummis, 2011). The term development has been coupled with sustainability, which according to critics could be perceived as the “sustaining of development” (Esteva, 2010) rather than transmogrifying or usurping the current politico-economic agenda. Strong arguments have been made that with the dwindling of global resources and the erosion of life-support systems upon which human well-being depends, there is a need to rethink development, moving away from resource-intensive activities and an emphasis on technological efficiency (Freeman et al., 2016). This ties into ecological
economist Herman Daly’s definition of sustainable development as “development without growth” (Daly, 1996). This version of development has become more prominent in recent years with the growing interest in degrowth (Kallis et al., 2018, Hickel et al., 2022). The concept of development without growth or degrowth refers to Sustainable Development (SD) as qualitative improvements, e.g., higher human well-being, increased equality, and better goods and services rather than perpetuating economic growth that drives climate change and ecological breakdowns (Demaria et al., 2013, Hickel et al., 2022). The current narrative around economic growth leads to quantitative increases through more material and energy use (Kallis et al., 2018). This type of economic- and production growth orientation is prevalent in aquaculture policies, too, and has been criticized (Krause et al., 2015, Brugere et al., 2021). An example of development rather than growth relevant for this thesis would be emphasizing food distribution, resource use, and altering political ambitions and policies to highlight food systems with a smaller environmental impact (Farmery et al., 2021, Hiç et al., 2016, Gephart et al., 2021).

A commonly suggested strategy to achieve sustainable aquaculture development from states and IGOs is to increase certified production (paper I) (Ababouch, 2011). However, this is not without its controversies as will be described in further detail later, as certification programs tend to focus on resource-intensive species (Jonell et al., 2013), to accentuate environmental and governance goals over social and economic sustainability (Osmundsen et al., 2020), and moreover leave a large portion of smaller producers out of the loop through high evaluation costs (Marschke and Wilkings, 2014, Gulbrandsen, 2009). There are programs, however, that enable smaller producers to pool their certification applications to share the benefits and split the costs (ASC, 2022d).

2.3 The presence of certification programs

During the 1970s, the perception of our oceans as plentiful and infinite was shattered, which resulted in the UNCLOS (UN, 1982), a convention on how to better care for our marine resources. Since then, several conventions, regulations, and policies have been deployed. Ranging from the global – Code of Conduct for Responsible Fisheries (FAO, 1995); regional – Common Fisheries Policy (EC, 1983, 1992, 2002, 2013); and private governance bodies such as certification schemes. Some noteworthy certifications for fisheries are the Marine Stewardship Council (MSC), Friends of the Sea for Aquaculture GlobalG.A.P, Best Aquaculture Practice (BAP), and Aquaculture Stewardship Council (ASC).

Environmental certifications started with the Forest Stewardship Council (FSC) in the 1990s, and were quickly applied to other industries as well, e.g., fisheries and the Marine Stewardship Council (MSC) (Gulbrandsen, 2014, Hysing, 2009). The strategy grew out of the frustration of the public and NGOs regarding what was seen as the ineffectiveness of international and national governmental organizations in
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Redressing unsustainable practices (Ababouch, 2011, Gulbrandsen, 2014). Initially, the idea of having private actors governing common resources (‘commons’ (Hardin, 1968)) such as fish was unpopular, especially in the Scandinavian countries (Foley, 2013). Since then, there has been a rapid increase in the importance and acceptance of certifications (Gulbrandsen, 2014). Especially in Scandinavia and the Baltic states, which have some of the highest consumption of certified products in Europe (Barkemeyer et al., 2023). Increasing organically or sustainably certified food production is something that many states and IGOs are in favor of as policies and strategies are pushing for cooperative, cross-sectoral, and multi-stakeholder approaches (Okamuro et al., 2019, FAO, 2017). The explicit mention of increasing certified aquaculture products is prevalent in both state- and IGO policies (Ababouch, 2011). In 2021, more than half of all farmed salmon was ASC certified (ASC, 2022b), which is also the leading aquaculture certification program (Blasiak et al., 2021). With the growing importance of certification schemes, it is important to know what they contribute to and how they operate to make the aquaculture industry more environmentally sustainable. In this thesis, aquaculture certification programs are analyzed to see if and what elements they improve on compared to national legislations and thus, what IGOs and states want the aquaculture industry to look like but do not regulate to achieve.
3. Theoretical framework

In this chapter, I will describe the theoretical foundations of the thesis. The theoretical approach in this thesis is based on Social-Ecological Systems (SES) thinking. SES is a rather large theoretical framework, and some aspects are used more than others. Key concepts from SES thinking that are used in this thesis are adaptive governance and resilience. The SES approach is used to convey what important considerations governance strategies and policies should incorporate and compare to how existing governance strategies and policies are constructed. The governance aspect of that framework is based on adaptiveness, that emphasizes the need for governing actors to be adaptive and responsive. As a result, SES is used to analyze the second research question of this thesis “How could policies and strategies be improved to come closer to achieving ‘sustainable’ aquaculture?”. I have also used the strong versus weak sustainability dichotomy and coupled it with John Dryzek’s (2013) astute environmental discourse definitions to highlight how operationalizations of sustainability are applied to policies and strategies as well as to analyze how aquaculture governance is structured in private institutions as well as on country, regional and global scales (see Figure 1). This approach relates more to the first overarching research question of the thesis: “How do leading salmon farming states and the Nordics position their aquaculture development strategies and regulations compared to recommendations by the UN, EU, and the leading aquaculture certification program?”. These operationalizations are then applied to SES thinking to highlight potential areas of improvement.

Figure 1. Theoretical approach to analyzing governing actors.
3.1 Social-Ecological Systems

In this thesis, I argue that there are some ontological (i.e., how the world works) truths, one of which is that people and societies are dependent on the functioning of ecological systems (Berkes, 1998). Furthermore, SES proponents argue that societies and ecological systems are interdependent and intertwined, part of the same system and not separated, thus constantly feeding back into one another (Carpenter and Folke, 2006, Rebecca et al., 2017, Folke et al., 2016, Turner, 2014). This line of thinking is the essence of Social-Ecological Systems (SES), which serves as an overarching theory throughout the thesis. Another axiological basis is that we need to keep within the biophysical limits and stay within the planetary boundaries (Steffen, 2015, Rockström, 2009). This is in line with Giddings’ nested sustainability definition that situates societies and economies within the limits of the environment (Giddings et al., 2002). Thus, any governance strategy and policy needs to mind the boundaries and limits of our planet (Steffen, 2015). What this comes down to is that people are part of the biosphere, which in turn affects the ecological services that we rely on, and this in turn affects living conditions for people (Fischer et al., 2015). For people to thrive long-term, we need to preserve our environment and fit-for-purpose governance arrangements and mechanisms to do that. SES emphasizes the interconnectedness of social-ecological systems on a global scale, arguing that production, consumption, and well-being stretch out of ecosystems, which also depend on other regions’ ecosystems to sustain them (Folke, 2006). This means that we have to consider how production and consumption affect not only people connected to the local system but also how it affects ecosystems in other regions (Brugere et al., 2021), thus highlighting the need to think globally even in contextualized situations (Chaffin et al., 2014). For this to happen in a meaningful way, policies and governance structures need to advocate resilience and adaptiveness (Folke et al., 2005). Social-ecological resilience concerns the capacity for social agents (ranging from institutions, societies, policies, regulations, and technologies) to withstand and develop in the face of changes, both predicted and unpredicted (Folke et al., 2021). From a biosphere perspective, resilience is about the capacity of ecosystems to absorb and provide ecosystem functions and services even in a changing climate (Folke, 2016). Social-ecological resilience is not about bouncing back and remaining exactly the same but rather adapting and reorganizing, changing and sustaining certain functions (Rockström et al., 2023, Walker, 2020). As a result, policies and governance strategies need to be based on a deepened scientific understanding of the biosphere as well as adaptive and equitable, meaning that they need to be forward-looking and learning-based with several stakeholders across sectors, regions, and hierarchical scales to incorporate knowledge and experience to best be able to persist, adapt and transform (Rockström et al., 2023, Folke et al., 2021). This evokes being modular, that is, no
over- or under-connectedness between systems, which ties back to the idea of having guiding principles or collaborations between actors rather than a top-down steering of one or a few strong actors and diversity, both in governing actors and production lines (Walker, 2020).

Criticism of the SES approach emphasizes that it focuses merely on organized social units that miss power dynamics and social diversity (Fabinyi et al., 2014). However, I would argue that even though SES emphasizes organized social units which might overlook power relations and individuals, it still contributes to diversification as it gives voice to stakeholders other than states and IGOs (Ostrom, 2009). Furthermore, changing governance structures to a more polycentric and adaptive governance system would ensure that agency and power are distributed in an inclusive, and regionally and culturally appropriate, way (Wood et al., 2023). An important contribution from critical theorists when analyzing the governance of social-ecological systems is encapsulated by Castree’s (2002) statement: “Policy is too political – too much about power and values – to be simply passed off as a domain of technical judgments and practices.” This implies that there is a need to move beyond the limits set up by the natural sciences and include consideration of the perceptions and social effects of human-nature interactions when making policies. The construction of social and environmental challenges and possible responses are influenced by situated cultural and historical norms and values (Hastings, 1998, Kooiman, 2013). As a result, it is important to critically analyze how sustainability is conceptualized and realized in policy settings, as sustainability in and of itself can mean very different things depending on your experiences, values, and perspectives.

This ties back to the wickedness of sustainability, about which most can agree that something should be done, although what and how varies significantly. From what angle should the challenges be mitigated? To unravel the knot, one must start by defining what the challenges are or represented to be (Bacchi, 2009). One issue related to sustainability in policy settings that has been raised by researchers at both ends of the spectrum is the emphasis on efficiency and pushing technological advancements (Loos et al., 2014, Nyström et al., 2019, Bouzarovski, 2022). The criticism raised by SES and the resilience approach towards efficiency is that it removes diversity, creating more homogenous systems, which in turn are more susceptible and less adaptive and transformative to shocks (Walker, 2020).

To spread the wealth of this thesis and to critically examine how sustainability is portrayed in political settings – like policies, strategies, and standards – I borrow kernels from critical theorists, asking questions generated through an explicitly political lens, such as: For whom is it sustainable (Escobar, 1996)? What is to be sustained and why (Dryzek, 2013, Barr, 2008)? Is it actually sustainable or is it just less unsustainable (Hediger, 1999)? What is taken for granted in the dominating discourses (Benjaminsen and Svarstad, 2019)? These questions are also present in the theoretical sustainability debate between weak and strong sustainability (Neumayer, 2003, Neumayer, 2012). I use and apply these questions to the ongoing debate between
strong and weak sustainability to highlight how sustainability is portrayed and operationalized in aquaculture policies and strategies. This is done by drawing and expanding on Dryzek’s differentiations of environmental discourses (Dryzek, 2013) to analyze how notions of sustainability are engaged within various aquaculture production settings.

The relevance of the SES approach in this thesis is connected to the unpredictability associated with climate change, which calls for governing actors to adopt a resilience line of thinking (Naylor et al., 2023). They need to be able to anticipate and cope with different shocks to preserve ecosystem functions, societal well-being, and economic stability (Folke et al., 2021, Cao et al., 2023). This ties back to resilience thinking, which involves five attributes, diversity, redundancy, connectivity, inclusiveness, and equity and adaptive learning (Rockström et al., 2023). Aquaculture is not exempt from this as marine aquaculture operations are experiencing issues associated with a human-induced temperature rise in the oceans, which has resulted in mass die-offs in the Patagonian archipelago (Navedo and Vargas-Chacoff, 2021). A similar risk with increased ocean temperatures is prevalent along the Norwegian coast (Falconer et al., 2020), which has called for moving production further north (Hersoug et al., 2021). The increased temperature issue has been experienced in freshwater aquaculture as well contributed to decreased levels of dissolved oxygen and increased toxicity of pollutants (Ficke et al., 2007). Increased water temperatures can also affect disease profiles and subsequently make vaccines less successful (Mugwanya et al., 2022). Finally, fed aquaculture’s dependence on terrestrial ingredients and wild-caught fish decreases its resilience as competition for these resources rises (Troell et al., 2014), especially as resource availability might change as the climate and environments change (Reid et al., 2019). As a result, policymakers need to consider how climate change will affect productivity and resource availability when planning for sustainable aquaculture development. One of the first things to address, as argued by SES researchers focusing on food availability and sustainability, is to diversify the industry, making better use of low-trophic species with smaller environmental impacts (Troell et al., 2014, Bullock et al., 2017). Diversification of the aquaculture industry is also a stated ambition in the EU sustainable aquaculture strategy, as its definition of sustainable aquaculture serves as the foundational description of sustainable aquaculture in this thesis (EC, 2021a).

SES aims to address the middle ground between social sciences and natural sciences (Young et al., 2019) where the exchanges between the systems and governing interactions take place (Jentoft, 2015). Furthermore, SES and adaptive governance (AG) want to increase decision-making processes between state and non-state actors in governing arrangements of different sizes and hierarchical levels at the negotiation table (Folke et al., 2005).
3.1.1 Governing Social-Ecological Systems

Regardless of the way sustainable development is perceived, there is a need to have some form of governance or social institution establishing rules and engendering norms that influence the way that aquaculture is conducted. Governance can be defined as social, political, and economic, comprising “interactions taken to solve societal problems and to create societal opportunities; including the formulation and application of principles guiding those interactions and care for institutions that enable and control them.” (Kooiman, 2005). This definition can be connected to the more normative definition of environmental governance stated in the introduction, where emphasis is put on providing a pathway for sustainability (Boyle et al., 2001).

Environmental governance has historically been managed through administrative rationalism; in other words, a problem-solving-driven discourse that accentuates the role of “experts” (Dryzek, 2013). However, top-down, state-centered governance systems or command and control policies rarely provide solutions for contextualized challenges and often fail to coordinate governance across large-scale ecosystems or sustainability challenges that cross international jurisdictions (Lemos and Agrawal, 2006). Due to the difficulties in matching the relevant scale and the uncertainties associated with climate and environmental change, this governance strategy is arguably changing (Cumming et al., 2006, Young, 2002). To encompass the scale and complexity of ecosystems and environmental change, a new and more adaptive governance (AG) regime is called upon; this type of multi-stakeholder engagement is called for by governing institutions in their policies and researchers (ICAT, 2020, UNDESA, 2020, Kooiman, 2013, Ostrov, 1999, Österblom, 2013).

Institutions play a key role in governance. Institutions are ubiquitous, and the term can be described as “humanly devised constraints that structure political, economic, and social interactions” (North, 1991). It is an integrated system of rules that structure social interactions and create clarifications of said rules and values in social settings (Hodgson, 2006, Crawford and Ostrom, 1995). Within the SES approach, institutional fit plays a key role. There are three types of fits. Ecological fit (1) emphasizes whether an institution matches the ecological or biophysical issue they are meant to address, this approach is quite technical. Social fit (2) concerns the congruence of institutions and human actor’s preferences, values, and needs. Finally, the SES fit (3) emphasizes context-specific institutional solutions to increase the sustainability of Social-Ecological systems (Epstein et al., 2015). To measure the institutional fit, the constraints, or rules that are set up by institutions, must be codifiable so that breaches can be discussed and subjected to discourse (Hodgson, 2018). An institution creates the norms and rules that act as a governing framework for societies (Ostrom, 2000). Their ability to create ecological and or biophysical norms and rules must be shared and used or must have the potential to be shared and used by social actors to increase the institution’s legitimacy (Ostrom, 1990, Suchman, 1995). Thus, an institution can be informal (taboos, customs, tradition) or formal (laws and constitutions) (North, 1991). This also means that organizations, whether they are public or private, should be categorized as
institutions (Hodgson, 2018). A governing institution is therefore any social platform where rules and norms that either are followed or have the potential to be followed are created. In this thesis, the emphasis is on governing institutions that are deemed to be legitimate – both in terms of broader democratic representation and legitimacy (regarding government institutions) – and recognition by aquaculture producers and consumers in the case of certification schemes. These institutions will serve as the main sources for the data collection throughout this thesis.

To make institutions better equipped to solve social-ecological challenges, there has been a change in international and national governance strategies towards “rolling rule regimes”, where IGOs such as the EU and UN create policy frameworks that apply to its member states and their domestic industries, e.g., fisheries and aquaculture industries (Young, 2007, Dryzek, 2013). To increase the legitimacy and compliance of policies and governing documents, these documents and frameworks are to be co-developed through multi-stakeholder collaborations (UNDESA, 2020, Koppell, 2008, Ostrom, 2007a, Österblom, 2013, Schouten and Glasbergen, 2011). Each state is responsible for fitting the overarching goals and ambitions by creating its strategies within that framework, and in many cases, they more or less duplicate the international framework and delegate the governing responsibilities to local governments, NGOs, or certification schemes, who establish voluntary guidelines that exercise soft law within the scope of the frameworks set up by IGOs and states (Gulbrandsen, 2014, Ababouch, 2011, Young, 2007, Dryzek, 2013). This pluralistic approach is regarded as preferable as opposed to a top-down structure that is inefficient, unjust, and unrealistic (Ostrom, 2007b). The geographical and temporal variances and unpredictability of sustainability challenges stress the need to incorporate local and multi-stakeholder engagements when governing a system as complex as the interaction between societies and the environment (Foley and Havice, 2016, Berkes, 1998, Folke et al., 1998, Folke, 2006). Therefore, proponents argue that governance mechanisms need to be flexible and adaptive, which calls for pluralism rather than a prescriptively uniform rule or policy (Kooiman, 2013). A move towards a pluralistic, rolling rule regime with several actors and stakeholders and a decentralized governance strategy seems to be increasing, which should, thus, theoretically include stakeholders at all hierarchical levels, scales, and governance nodes (Dryzek, 2013).

One such system that is central to this thesis is the interactions between societies and marine environments. In recent years, there has been a push towards Blue Growth, that is the sustainable exploitation of our oceans (FAO, 2013, EC, 2017). The idea is to better govern and use ocean resources in a way that supports economic development, energy production, and food security (EC, 2014). Stakeholder engagement is explicitly mentioned as a tool for Blue Growth initiatives by IGOs such as the UN and EU, as it promises to improve compliance and facilitate complementary governance arrangements, e.g., voluntary standards (EC, 2016, UNDESA, 2020). Arguably, this evokes transdisciplinary or democratic pragmatism as an important governance strategy, i.e., including knowledge and perceptions from stakeholders in a range of sectors, not only
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governmental institutions and experts, something referred to as administrative rationalism (International Ocean Institute - Canada, 2018, Dryzek, 2013). However, the current emphasis within blue growth is on production growth rather than equitable distributions, which could result in “blind spots” in policies geared towards increasing the sustainability of the aquaculture sector (Farmery et al., 2021).

Whatever lens is applied to give practical meaning to sustainability, it is important to know how it is used in policies and standards, as steering documents have tremendous impacts on the direction an industry takes and market demands (Esteva, 2010, Schipanski et al., 2016).

3.1.2 Adaptive governance

Connected to institutional fit is the adaptiveness of institutions to evaluate and learn from practice. Understanding the Social Ecological changes in the Anthropocentric world is increasingly challenging. Globalization has increased the interdependence of not only people and institutions but also the impacts on ecological systems (Figge et al., 2017). Furthermore, globalization has increased the speed at which changes, both political and ecological, take place (Pahl-Wostl, 2009). Policymakers, researchers, and civil society organizations must be able to collaborate and understand the dynamic interactions between nature and society, which requires a deepened understanding of ecological systems as well as social systems to create sustainable, reflexive, and adaptive governance (Folke et al., 2016, Rika et al., 2018, Johnson, 2013). Furthermore, they need to do it at different geographical and temporal scales, understanding how to balance local challenges and global issues and their interdependence (Epstein et al., 2015, Rockström et al., 2018). The idea of multiple-stakeholder engagement is not a new governance approach; it has been on the agenda and recommended by researchers for several decades (Ostrom, 1999, Ostrom, 2007a, Dietz et al., 2003, Gunderson, 1999, Folke et al., 2005). Adaptive governance (AG) is perhaps the most proliferated and promoted governance ambition these days as it stresses the need to share power by adding multiple stakeholders in the planning and strategizing phases of policy-making of resource management (Folke et al., 2005, ICAT, 2020, Ostrom, 2005). This does not necessarily mean having as many stakeholders as possible in the mix, as these collaborations need to be inclusive enough to be legitimate and valid yet small enough for mutual understanding and respect to develop (Tengö and Andersson, 2022). AG is defined as “flexible and learning-based collaborations and decision-making processes involving state and non-state actors, often at multiple levels, with the aim to adaptively negotiate and coordinate management of social-ecological systems and ecosystem services across landscapes and seascapes” (Schultz et al., 2015).

The ambition of adaptive governance is to improve the coordination and collaboration of resource management in the face of uncertainties associated with climate- and environmental change (Chaffin et al., 2014). An incremental part of AG is adaptive management, which focuses on learning-based policies to update and
better address challenges for resource use to improve ecosystem functions (Carpenter and Gunderson, 2001). AG, however, goes beyond adaptive management’s emphasis on resource management as it focuses extensively on ecological outcomes and less on social resilience (Folke et al., 2005). As a result, adaptive governance further emphasizes knowledge generation and learning, organizational learning, collaboration and power sharing, participation, trust, social memory, organizational flexibility, and forming stakeholder groups (Chaffin et al., 2014, Folke et al., 2005). The inclusion of other actors and increasing participation could lead to policies and a scientific understanding of other previously unaddressed issues (Turnhout, 2018).

One of the most prominent examples of adaptive governance that is already in place is the One Health Approach, which stretches over several sectors and stakeholders to create and implement knowledge, policies, and regulations on, amongst other things, antibiotic use in food production (WHO, 2017). The One Health approach aims to design and implement policies, programs, regulations, and research in which several actors and disciplines meet and collaborate to increase human health (WHO, 2017). The inclusion of how antibiotics and Antimicrobial Resistance (AMR) might affect the aquaculture industry in international steering documents has increased significantly since the One Health approach was applied (paper IV). Largely due to an understanding of the interconnectedness and interdependence of human, animal, plant, and environmental health, the One Health approach aims to incorporate different actors to generate and share knowledge to improve the well-being of these systems (Collignon and McEwen, 2019). Its relevance for food security is perhaps most apparent in its aims to control zoonoses (diseases that spread from animals to humans, e.g., influenza or COVID-19) and antibiotic resistance (AMR). AMR occurs when viruses, bacteria, parasites, and fungi evolve and no longer respond to medicines (WHO, 2021a). In aquaculture, antibiotic use is expected to increase by 33 percent by 2030 due to expansion and intensification (Schar et al., 2020). Climate change is another contributor to this estimate as uncertainties regarding its effects on pathogens, parasites, and pests persist (Naylor et al., 2021). What exacerbates matters further is that with aquaculture production, residues of antibiotic treatments spread into the surrounding waterbody and are very difficult to control (Choi et al., 2020, Bondad-Reantaso et al., 2023). As a result, it affects wildlife, plants, drinking water, and subsequently people, making AMR in aquaculture a truly multi-faceted issue.

With the unpredictability of climate and environmental change, governance structures must be able to facilitate adaptation to shocks and changes as well as evolve (Craig, 2019). In this sense, it is much like the resilience of ecosystems in that it should enable changes when necessary. Thus, the importance of knowledge sharing between stakeholders and sectors becomes an integral part of this governance regime. This includes, but is not limited to, scientific recommendations that set the premise for how ecosystems and human institutions interact (Cvitanovic et al., 2015). The marine systems in which many aquaculture practices take place, especially in Europe and the
Nordic countries, are amenable to adaptive governance. This is due to the high level of uncertainty regarding marine ecosystem responses to environmental stressors (Grafton and Kompas, 2005, Rodrigues Garcia et al., 2017) as well as human interactions with these ecosystems (de la Mare, 2005).

One area that is not studied enough in polycentric governance research is the power dimension. All governance involves power, and powerful actors receive more favorable outcomes than less powerful ones (Morrison et al., 2019). However, since monocentric, that is, top-down governance has become a contested and unwanted form of governance regime, key institutions have developed, designed, and deployed more polycentric governance regimes that enable other actors to influence the directions of governance (Abbott and Bernstein, 2015, Abbott, 2017, Cox et al., 2016). This is where different types of power take place, ranging from “power over” (coercion and manipulation) to “power to” (resistance and empowerment) and “power with” (learning and cooperation) (Partzsch, 2017). In a “power over” regime, controlling the narrative becomes instrumental (Ingram et al., 2013) as it gives legitimacy to goals, actions, and policies within the polycentric governance regime. In this type of governance regime, power is relative, meaning that for one actor to increase its power it has to decrease someone else’s (Fuchs et al., 2016). “Power to” is an actor’s capacity to get things done by themselves (Barnett, 2004). It could be a certification program that creates its own strategy to increase environmental performance, a company deciding to become more eco-friendly, or even an individual taking the bike to work or buying organically certified products (Partzsch, 2017). “Power with” is the type of governance form that is advocated for by SES scholars and IGOs. This type of power implies that learning and self-questioning about predefined norms is key for increasing understanding and awareness about complex issues associated with earth system governance (Eyben et al., 2006). This is distinctive from a power over-, top-down approach where a leader enforces their self-interest over others. Instead, this type of power empowers and enacts collective action on environmental issues (Partzsch, 2017). The power dynamic in policies and governance regimes is important to consider as it can shed light on how mobilizations of power can perpetuate political ambitions by denying, distorting, or cherry-picking facts or science to legitimize a desired outcome (Morrison et al., 2019). This criticism does not discredit adaptive governance but rather highlights that this is a process and that more work is needed to increase fairness, representation, and subsequently knowledge sharing within governance regimes. With this in mind, having a critical perspective on how policies are formulated, what assumptions or facts that are used to legitimate a course of action, and who has been involved in the policy-making process becomes important. As a result, in this thesis, I have compared what stakeholders and academia recommend to what states, IGOs, and NGOs propose to achieve sustainable aquaculture development.

Meaningful advancements in sustainable development practices would arguably have a better chance of being advanced if these governance strategies are employed,
even if it may seem like an oxymoron to combine environmental sustainability with development (Kooiman and Jentoft, 2009). However, there is a pressing need in today’s society to safeguard legitimacy and justice, combining the multiple dimensions of sustainability through combining and generating sound scientific and experiential knowledge (Bäckstrand et al., 2010). Thus, to move towards a sustainable aquaculture policy, we need adaptive governance that allows for changes and flexibility within the institutional boundaries that safeguard societal progression.

3.2 Weak versus strong environmental sustainability discourse

Much like the Brundtland definition of sustainability, the debate between strong and weak sustainability has its moorings in anthropocentric perspectives that emphasize intergenerational justice (Barr, 2008, Dresner, 2003, Neumayer, 2003). Both conceptions of sustainability strive towards increasing the well-being of mankind and apply a sustainability rhetoric (Dryzek, 2013). What this sustainability entails varies depending on who is using it and in what circumstances. Weak sustainability is a technocentric theory that argues for a cornucopian development progression and that the ingenuity of mankind will steer away from disasters (Barr, 2008). Furthermore, natural capital and human-made capital are regarded as interchangeable (Ang, 2012). However, it would be wrong to state that weak sustainability is merely a green-washing ideology that perpetuates anti-ecological capitalism (Castree, 2002). Instead, it should be seen as a growth-promoting discourse that puts considerable faith in the ingenuity of mankind and that by having a laissez-faire policy approach market mechanisms will increase incentives and the willingness of industries to make necessary changes (Dryzek, 2013). Strong sustainability, on the other hand, advocates for the value of nature and that we need healthy environments to thrive in the long run (Dasgupta, 2001, Neumayer, 2003). Here nature has intrinsic value, and natural capital must be preserved and protected from human interactions to stay clear of planetary boundaries (Barr, 2008, Clapp, 2011). Again, one should not jump to conclusions about this discourse; it too has layers and nuances that could be accentuated. To do this, I have divided the two discourses into four to make them more applicable and give a more nuanced and precise representation of the way they are expressed in aquaculture. The four different discourses are based on Dryzek’s (2013) main environmental discourse definitions and have their moorings in either the preconceived political-economic rules set up by industrialism (prosaic vs imaginative), whether the suggestions involve a complete overhaul of the industry or if sufficient changes can be made in a moderate fashion (radical vs. reformist). In this thesis, I applied this taxonomy of discourses to the weak and strong sustainability dichotomy and made it case-specific for aquaculture. To simplify, the discourses have been renamed to very weak (prosaic reformism)-, weak (imaginative reformism)-, strong (prosaic radicalism)- and very strong sustainability (imaginative radicalism). These four different
Table 3. Applying Dryzek’s discourse definitions to aquaculture policies and the theoretical debate between strong and weak sustainability.

<table>
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<th></th>
<th>Reformist</th>
<th>Radical</th>
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<td><strong>Prosaic</strong></td>
<td><strong>Very weak</strong>: Environmental problems can be solved within the current political-economic system. Putting price tags on environmental harms and enforcing the end of pipeline solutions to mitigate environmental degradation is advocated for. This could be done either by letting the market fix itself, incentivizing towards using better practices, or by enforcing restrictions and laws to prevent people or companies from cheating. Production should be based on demand, i.e., if there is a demand for resource-intensive species, these should be produced albeit with the best available technology to safeguard the environment. Efficiency and productivity are the core of environmental improvements, less damage per produced kg leads to an increase in production rather than a decrease in pollution.</td>
<td><strong>Strong</strong>: There is a need to stay clear of the environmental limits/boundaries. The precautionary principle should be applied and use risk assessments as well as measurements around aquaculture farms to ensure the well-being of the environment. The capacity for aquaculture is limited to natural boundaries and no degradation of the ecosystem should be allowed beyond resilience. Renewable resources should be advocated for, and non-renewable can only be used if renewable resources are developed at the same pace as they are used. High-grade food ingredients should be certified and must not push ecological boundaries. Using trimmings or resources that otherwise would have been lost is okay for feed production. Transforming the system towards more sustainable practices does not solely refer to technological advancements, but rather towards promoting and increasing the production of less damaging species.</td>
</tr>
<tr>
<td><strong>Imaginative</strong></td>
<td><strong>Weak</strong>: The limits discourse is insufficient as economic growth and environmental protection can be combined and will incorporate social sustainability. While recognizing that there are limits or boundaries to the environment, these can be stretched if smart policies are developed that ensure the perpetuity of economic growth. The exploitation of resources, the direction of investments, technological development, and institutional reforms harmonize to enhance current and future needs and aspirations. Non-renewable resources can be used if renewable resources are developed. Using high-grade food is okay if certified, including fish. Emphasis on turning challenges into opportunities.</td>
<td><strong>Very strong</strong>: There is a need for radical reforms to safeguard environments and justice between people. The focus must change from growth and technological advancements to safeguarding social-ecological well-being. The division between developed and under-developed has created vast injustices, both monetarily and by environmental degradation. Nature has intrinsic value, and development should not be at the expense of ecosystems. Furthermore, using high-grade food as feed is insufficient and a gross misconduct when striving towards ending global hunger and malnutrition. Detrimental use of life-support systems such as clean water is unsustainable. Unfed fish, algae, and mussels are currently the only species groups that could be expanded sustainably.</td>
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3.3 Certifications – a legitimate governing body?

A common misconception about private governing institutions like certifications is that they are decoupled from the state and solely based on market demands (Ababouch, 2011). This used to be the case, especially when certifications started to grow in the 1990s, but things have changed, and today states and international organizations support certifications and are even framing policy goals and ambitions around the notion that more production should be sustainably certified (Gulbrandsen, 2006) (paper I). Thus, one could argue that this constitutes a new governance system where the state has shared its policy-making authority with private organizations (Cashore, 2002). According to Dryzek (2013), the main ambition of a state operating in a capitalistic system is to maintain economic growth. Thus, advocating for non-state market-driven (NSMD) governance systems to improve environmental performances where governmental organizations previously failed is a win-win-win (Cashore, 2002). It cuts costs for the state to delegate governing responsibilities to other institutions; it creates a competitive incentive for producers to become certified as certifications are associated with price premiums (Asche et al., 2021); and it increases environmental performances (paper II). For any organization to be successful, they need to have some sort of legitimacy. There are several forms of legitimacy; the most obvious is output legitimacy, which refers to the ability to deliver and perform as advertised (Backstrand, 2006). That is, are they doing what they set out to do? Are certified products sustainable or more sustainable than un-certified? Another definition of legitimacy is a more procedural version, which can be defined as “a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed systems of norms, values, beliefs and definition” (Suchman, 1995). Another usable conception of how an institution obtains legitimacy is, as Koppell (2008) puts it:

- **Representation**: Those governed need to have a voice in decision-making and the right to be represented.
- **Participation**: Those governed need to have the opportunity to observe and comment on the activities of the governance initiative.
- **Neutrality**: All stakeholders involved need to be treated equally and consistently.
- **Procedural regularity**: Decision-making processes need to take place according to a set of general procedures: Decisions need to be transparent, and open for public scrutiny, and there needs to be a right of appeal.

Even if a certification program has legitimacy, there are other issues with the NSMD governance system (Schouten and Glasbergen, 2011). One of which is the governing over “commons” issue, and another is the cost issue. Is paying for certifications reasonable for small-scale producers? Are there price premiums for certified products (Blomquist et al., 2015)? The legitimacy issue is a complex one for environmental
certification programs, but the ambition to enhance the environmental performances of actors, institutions, and organizations voluntarily is a good one. However, the fact that no one is coerced to abide by the rules, which leads to a lack of traditional state accountability, makes it difficult. To some extent, this is solved by certification programs by increasing the procedural transparency of the governing process as well as the outcome transparency through e.g., audit reports (Auld and Gulbrandsen, 2010).

While desirable, legitimacy is not always obtained by certification schemes (Schouten and Glasbergen, 2011). Sustainability policies are primarily framed around preconceived criteria that implicitly reinforce the primacy of the environment over social and economic aspects (Rector et al., 2023, Belton et al., 2009). The decisions are not generally open for public scrutiny or appeal. However, we are seeing a shift in the unilateral focus on biophysical elements as certification schemes are now including social aspects in their standards through collaborations with Fair Trade USA, another sustainability certification better equipped to handle social issues (ASC, 2019a). This type of collaboration across sectors and actors is pivotal for certifications to address their major blind spots as well as increase their legitimacy. Furthermore, the ASC is working to increase the presence of other actors through consultations (ASC, 2022c). This also increases their legitimacy and fulfills the representation and participation criteria. Increasing collaborations with other programs better positioned to address social issues and use public consultations adds to the multi-stakeholder engagement goal set up by international standards and steering documents (ICAT, 2020). Balancing public input with scientific knowledge about the ecosystems could render standards and regulations “responsible” rather than “sustainable” (Belton et al., 2009), and this could diminish a certification’s legitimacy as changing the environmental performance demands from scientific to stakeholder knowledge could be perceived as greenwashing. Thus, to avoid washing out the legitimacy of a certification’s rules, it must adhere to technological biophysical criteria, which the stakeholders could agree ought to be obeyed (Hurd, 1999).

The combination of governments advocating for certifications, with the certification’s drive to create legitimacy by, e.g., market benefits and the prioritization of environmental issues leads to complex issues related to legitimacy both from a social standpoint and an environmental one. As has been noted before, food demand is heavily influenced by policies (Schipanski et al., 2016), and some policies are phrased to be market-sensitive and produce after demand (paper I). Rather than pushing for less resource-intensive species, this strategy favors aquaculture industries producing high-demand species. These high-demand species are also targeted to a higher extent by certification firms and retailers (Jonell et al., 2013, Vormedal, 2016). This combination creates a risk of policies and certifications being geared towards increasing the demand and thus a market for less environmentally sustainable species that need technological biophysical criteria to determine their sustainability, which, in turn, could perpetuate the primacy of the environment over social, and economic sustainability.
3.4 Theoretical summary

The analysis of this thesis is built on Social-Ecological Systems thinking and strong versus weak sustainability. Within SES thinking, adaptive governance is key to increasing the institutional fit as they stress the need for learning-based, equitable, and flexible governance that enhances the role of different actors to contribute to the sustainable development of aquaculture (Rockström et al., 2023). Knowing about the ecological system is crucial to avoiding risks and pushing boundaries beyond resilience (Folke et al., 2021). That is a system’s ability to provide ecosystem services and opportunities for co-existence between social, economic, and environmental well-being. However, operative norms are not going to increase sustainability without compliance from stakeholders (Birnbaum, 2016). Involving stakeholders across sectors increases the holistic understanding of a system or challenge, not just from a biotechnical standpoint but also experiential knowledge (Turnhout, 2018), which should lead to fairer outcomes and increase compliance (Österblom et al., 2015). However, one still needs to keep a critical mind when analyzing the narratives in governance regimes and policies. Thus, in this thesis, I critically analyze what is in the words “sustainable” and “development” in aquaculture policies and strategies. To get to the bottom of how sustainable development is expressed in aquaculture strategies and policies, I have deployed critical questions where the emphasis is on what, how, and why some aspects of sustainable development are dominant in policies and strategies (Escobar, 1996). This critical perspective ties in well with the discourse analysis that is used in paper I and will be described further in the next chapter. Social-Ecological Systems highlight the interdependencies of societies and ecological systems as well as how policies need to be adaptive and inclusive of different actors at different hierarchical levels (Kooiman, 2013, Johnson, 2013, Ostrom, 1990).

The strong versus weak sustainability dichotomy also helps in operationalizing how sustainable development of the aquaculture industry is constructed by states (Neumayer, 2003). The strong and weak sustainability discourse represents two opposing sides of the mainstream definition of sustainability: economic versus environmental. The strong versus weak sustainability dichotomy is complemented by the more critical questions posed earlier, to get to the bottom of what elements are prioritized by whom and why. This is to a large extent an unaddressed aspect in the strong versus weak sustainability debate. This is something that will be given more room and detail in the results and discussion section of this thesis that ties back to different actors in a governance system.

Finally, in this thesis, I look at how alternate governance systems differ from the traditional, top-down administrative rationalism governance (Dryzek, 2013). As states and intergovernmental organizations have shared their policy-making authorities with private entities, it becomes important to discuss if and how they differ and how these alternate institutions fit into the adaptive governance realm. This is done
by looking at how a certification program differs from states in its ambitions and practices to improve the environmental performance of the aquaculture industry.
4. Methodological approach and materials

Most of our contemporary issues and challenges are complex and in need of multifaceted and integrated approaches across disciplines and through engagement with societal actors (Aldrich, 2014, Ledford, 2015). This insight is apparent in governing institutions and academia alike (Okamura, 2019, Wernli, 2017). As a result, this thesis is based on an interdisciplinary approach that integrates theories, information, perspectives, and concepts from academic disciplines such as economics, political science, and natural sciences (NSF, 2022). In doing so, it applies these varying perspectives to different empirical aquacultural-related contexts to ascertain actors’ knowledge, experiences, and perspectives. The ontological premise in this thesis is that nature or the environment sets the premises of human and societal well-being (Folke et al., 2016, Rockström, 2009). However, how these premises are translated into policies and development strategies is regarded as socially constructed (Castree, 2002). The research is therefore based on the notion that political actions, thoughts, and knowledge are shaped by language and discourse (Moses, 2019). Thus, the epistemological (i.e., how we can generate knowledge about how the world works) outset of this thesis is that “facts” regarding sustainability in policies, strategies, and standards are not independent of the social, political, or cultural contexts (Glynos, 2007). That does not mean that environmental change processes are not real: the climate is changing, ecosystems are stressed, and species are going extinct (Dryzek, 2013). However, what we do and how we interpret these facts are through social interpretations and constructions. As a result, I have analyzed how sustainable aquaculture is discursively constructed and how facts are used. I therefore have not tried to redefine a true definition of what sustainable aquaculture is myself but refer to the previously stated EU definition of sustainable aquaculture (EC, 2021d, EC, 2020b) and tried to deconstruct and question what the terminology and discourse entails in other institutional settings (Torfing, 2005).

In doing so, I adopted a mixed-method approach. The papers vary in their scale of analysis and reliance on empirical data. Overall, the papers rely on a qualitative approach; however, there are traces of quantitative methods too, most notably in paper II. One common denominator in all of them is that I have conducted a policy analysis and/or mapping. Analyzing policies generates insights into the direction and ambition of a governance regime as it can make ambitions and goals intelligible. Following is a more precise description of the methods and materials.
4.1 Materials

To muddle through the waters to find important sustainability aspects regarding aquaculture, I have used different databases, most notably PubMed, ScienceDirect, Wiley Online Library, Web of Science, Springer Link, searching words to gain a firm grasp of what science, states, and NGOs state as the most pressing sustainability challenges and foci. Consequently, the process of finding the relevant information for all papers included in this thesis started by reading through research papers relevant to the topics. From there, I defined the most stated sustainability impact categories and compared them to gray literature, e.g., information from states and NGOs. Based on this, I found that the most cited impact categories ranged from *feed inclusion*, *therapeutic treatments*, *nutrient offloads*, and *pollution*, as well as *interactions with wildlife* (papers I & II).

Policies and strategies articulate the governing culture; they address more than just the legal framework as they also drive ambitions and objectives. Thus, to understand, conceptualize, and ultimately analyze how sustainable aquaculture is portrayed, I needed to start with policies, strategies, and regulations. There is a plethora of policies related to sustainability from most institutions analyzed in this thesis. However, in most of the cases chosen for this study, there is a limited amount of aquaculture policies. Another important aspect of finding the relevant documents was that aquaculture is practiced differently depending on geographical characteristics, e.g., marine aquaculture in countries with long coastlines and land-based aquaculture in countries with limited coastlines. As a result, the search words to find the relevant documents ranged from aquaculture, marine development, bioeconomy, blue growth, and food policies (see Appendix A in paper I, Appendix B in paper II, and Appendix I in the thesis). Furthermore, the policies needed to be contemporary and relevant; thus, the most recent version of the different policies and strategies were used. Policies and standards related to aquaculture were collected through government web pages and personal communication with administrative officials in the cases included in this study (papers I, II, III). The certification scheme, Aquaculture Stewardship Council (ASC), was selected based on its reputation as the most comprehensive and stringent aquaculture certification scheme and its importance for the salmon farming industry (SeafoodWatch, 2017, GSI, 2019) (paper II). To assess the environmental additionality of the ASC certification, we examined their salmon standard and feed standard (grey paper) and compared them to national regulations and practices.

To retrieve information about antibiotic regulations for paper IV, I had to, in some instances, write to researchers in the country I was interested in to ask for the relevant document and ask them to double-check the translations. Thus, some of the information was based on personal communications but can be traced back and referenced to the correct official document.
4.2 Study area and selection of cases

As part of the Baltic and Eastern European Graduate School (BEEGS) at Södertörn University, this thesis primarily focuses on aquaculture in the Nordic countries (this includes the Baltic Sea, see picture 1) and Northeast Atlantic, or what the FAO (2022b) calls, region 27 (paper I). Furthermore, paper IV reviews antibiotic use regulations in the EU and Russia among other countries, thus adding to the Baltic and Eastern European connection. A common denominator for the first three papers is that Atlantic salmon is the central species of production. Atlantic salmon is interesting to study as it is the most profitable- and fastest-growing aquaculture industry (Barasa, 2022, Asche et al., 2018). Furthermore, the narrative around salmon farming in academia (Ellis et al., 2016, Torrissen, 2011, Asche and Smith, 2018), government agencies (paper I), and certification programs (ASC, 2019b, BAP, 2021) often refers to it as a sustainable source of animal proteins. It is also the most traded seafood in the EU, including in the Nordic- and Baltic countries (EUMOFA, 2018). Another important aspect was that the cases chosen in this thesis are all associated with high sustainability performances and reputation (SDGINDEX, 2022, Sachs, 2019), and I wanted to see how these well-performing countries have defined the trajectory for aquaculture development and whether this was in line sustainability challenges associated with aquaculture. This eventually led to paper IV, which looks at one of the most pressing challenges for sustainable aquaculture worldwide. Here I wanted to distinguish if and how countries separated themselves from one another and how well aligned their regulations were to scientific and international recommendations.
Picture 1. FAO region 27.
Picture 2. Countries included in the papers.
This thesis used two different types of case studies: traditional case studies and cross-case methodology. A case study is an in-depth examination of a case, e.g., a policy. Cross-case methodology is aimed at observing several cases for the same thing (paper IV), whereas a case study is more in-depth and looks at all the ins and outs of a specific case (Gerring, 2006).

In paper I, we analyzed how the Nordic countries operationalize sustainable aquaculture and how that fits into the dichotomy of strong versus weak sustainability. The cases were chosen as the Nordic countries all are frontrunners in sustainable development (Sachs, 2019) and all have an expressed desire to increase their aquaculture production (paper I).

For paper II, we chose to compare the national strategies and policies in the largest salmon-producing countries of the world, namely Norway, Chile, Canada, and Scotland. This is because we wanted to analyze how big of an environmental difference a certified salmon had against non-certified salmon in the countries with the largest production. We chose to compare national legislations to the Aquaculture Stewardship Council (ASC) salmon standard over other certification organizations after reviewing the WWF’s fish guide and the Monterey Bay Seafood Watch guide, both of which recommended ASC-certified salmon but no other organization (WWF, 2022, SeafoodWatch, 2017).

We gathered primary data from stakeholders in Iceland (paper III). Iceland was chosen as a case study for paper III as it is a country in transition, forming its foundation for a burgeoning aquaculture industry. Thus, analyzing their strategy and their updated policies just after they were developed and implemented provided an opportunity to study the dynamics of aquaculture governance as it is unfolding in real-time.

The idea for paper IV was spurred by collaborations with the SeaBOS initiative and focused on the countries in which 10 of the largest 13 seafood companies operate (Österblom et al., 2022). The data consist of information from 17 countries spread all over the world and among them are the largest aquaculture-producing countries in the world (see picture 2). Some among the 17 are world-leading due to their size, whereas others have a leading position in the market as large importers of seafood.

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3 SeaBOS is a collaboration between 10 of the largest seafood-producing companies and their 600 subsidiaries and researchers from the Stockholm Resilience Centre at Stockholm University with key scientific partners from the Beijer Institute of Ecological Economics at the Royal Swedish Academy of Science, the University of Lancaster, and the Stanford Center for Ocean Solutions.
Picture 3. Countries included in paper IV.
4.3 Methodology

Throughout this thesis, I have differentiated between methodology and method. Methodology is the subjective strategy in which I look at a research question and relate it to theory. In turn, methods are the tools used to collect data and find the information necessary for me to analyze the research question (Moses, 2019). I do agree with naturalists who argue that there is a “Real World” out there that can be observed and recorded. Examples of this are biophysical limits and ecosystem-carrying capacities (Dryzek, 2013). However, we live in an anthropocentric era and the real world is not decoupled from humanity; thus, most if not all areas of knowledge are affected or constructed by human endeavors (Moses, 2019). What knowledge we choose to act upon and include in strategies, policies, and standards is not self-evident – it is based on deliberate actions and choices (Weber, 1949). We are constructing interpretations of what the problems are and how we can solve them (Bacchi, 2009). Thus, the knowledge that states, IGOs, and NGOs base their policies and recommendations on is not exogenous, but rather a result of political will and ambitions. It is part of the value rationality that emphasizes the ends rather than the means of social action (Kallio et al., 2007). As a result, in this thesis, I have critically analyzed how sustainable aquaculture development is framed and constructed and what the outcomes of these definitions mean in practice. In doing so, I take a soft constructivist view – not denying reality but insisting it can only be accessed through our conceptions, positions, and experiences – about many of which we have either explicit or implied social conventions.

4.4 Methods

There are a few common threads in the methodology: one is the policy analysis, which will be described in greater detail further on, and the other two are comparative case studies and document analysis. A comparative case study covers two or more cases that can illustrate differences and how or why a policy is formulated (Goodrick, 2014). A document analysis is a systematic review or evaluation of a document, e.g., a policy. The data are examined and interpreted to elicit meaning and construct empirical findings. The analytic process involves finding, selecting, assessing, and synthesizing data contained in documents (Bowen, 2009).

In some cases, I have had to rely on personal communications to back up the translations I have used. This has been done through communications with researchers working with aquaculture in the countries observed in the papers and with FAO officials. Most of the papers are based on qualitative research, such as policy analysis, policy mapping, and document analysis. However, in paper II we additionally used a rough quantifying measuring tool to see what environmental elements are improved by applying the standards of a certification scheme on top of national/regional policies and practices. This thesis has used both cross-case methodology, where several cases have been observed with the same focus (paper IV), and a case
4. METHODOLOGICAL APPROACH AND MATERIALS

4.4.1 Policy analysis

Policy analysis was used in all papers of the thesis. A policy analysis is an analysis “designed to supply information about complex social and economic problems and to assess the processes by which a policy or program is formulated and implemented” (Fischer, 1995). The policy analysis could either emphasize the intended outcomes or the actual results. In this thesis, it is often used in combination with a comparative approach, where the intended outcomes are central for the comparison. A policy analysis could either be positive (looking at what is actually said in the policy) or normative (looking at what ought to be) (Robert, 2011a). Throughout the papers that compose this thesis, I have used both. The normative approach relates to the theoretical foundation of this thesis, looking at how policies and strategies could be improved based on SES thinking. Another divide within the method of policy analysis is whether it is mainstream (focusing on values, actors, and political rationality) (Browne et al., 2019) or meanings (interpretations) (Yanow and Colebatch, 2004, Bacchi, 2009). Again, I have used both versions of policy analysis in this thesis. Interpretive policy analysis focuses on the meaning and the presupposed ontological, epistemological, and auxological information that underlies the policies (Yanow, 2007). It is intended to identify artifacts (language, objects, or acts) that have significant meaning; meanings or interpretations; the discourses; and finally potential areas of conflict (Yanow, 2007). Thus, it holds great promise in the endeavor to discuss implicit assumptions that motivate policy goals. This type of analysis has been applied to standards and strategies as well. Standards and strategies differ from policies in the sense that a strategy is the overarching goal, whereas a policy is more specific on how to obtain that goal. However, it is still only an intent, whereas a standard is a set of rules on how to achieve the intent.

4.4.2 Policy-mapping

Policy-mapping is similar to content analysis in that it refers to systematically examining the contents and meanings of texts in policies (Bowen, 2020, Krippendorff, 2013). In this thesis, it is applied as a means to retrieve information from policies and regulations regarding antibiotic use in aquaculture operations and compare the results between countries, IGOs, and certification programs. Thus, in combination with a comparative approach, policy-mapping was used to conduct rigorous and reproducible policy analysis that helped us pinpoint gaps or shortcomings in regulations and policies that advocates can address (Bowen et al., 2022). Part of the policy-mapping process is choosing a research question, describing what type of documents to include and exclude, and defining categories for coding the available information (Bowen et al., 2022). For paper IV, we chose 17 of the largest aquaculture-producing...
countries and analyzed their regulations on antibiotic use (see Appendix I), specifically for aquaculture operations where it was available, or in the case of Russian animal husbandry in general. The categories we decided to look for were based on scientific recommendations for the prudent use of antibiotics in aquaculture as well as the recommendations set up by the One Health approach and FAO documents related to aquaculture operations (FAO/WHO/OIE/UNEP, 2022, WHO, 2017, Bondad-Reantaso, 2020). We used five different questions to define the categories used in the analysis:

1. Can antibiotics only be used if prescribed by a veterinarian or fish health expert?
2. Is prophylactic use banned?
3. Is using antibiotics as growth enhancers banned?
4. a) What antibiotics are allowed?/b) Are highest-priority antibiotics allowed?
5. Is there a limitation to the number of antibiotic treatments during each production cycle?

4.4.3 Discourse approach

Discourse is defined as “a particular way of talking about and understanding the world (or an aspect of the world)” (Jørgensen, 2002). A discourse helps construct meanings and relationships that help us define and legitimate knowledge (Dryzek, 2013). It creates a shared understanding of problems and how to solve them. Discourses are based on values and perceptions that perpetuate power and political practices (Hajer and Versteeg, 2005). To understand why we have conditioned and defined a challenge, a solution, or knowledge, we must look at the discourse that situates it all. It is important to consider the way that power is imbued in dominant discourses and shapes the challenges, solutions, and suggested outcomes (Dryzek, 2013). To retrieve information about how sustainability is framed in policies and strategies, it is important to consider the facts that underlie its goals and ambitions; thus, using a discourse approach as a research tool allows the researcher to treat these goals and ambitions as empirical questions rather than preconceived facts, thereby questioning what the goals are, what they actually mean, and who came up with them. In paper I, we conducted a discourse analysis based on John Dryzek’s (2013) astute descriptions of environmental discourses. These are (I) problem-solving, (II) Sustainability, (III) Limits, and (IV) Green radicalism. The discourse analysis was complemented by the strong and weak sustainability debate to better clarify which discourses were dominant in the policies and strategies. To identify and categorize a dominant discourse, one must start by defining the key elements of each discourse (see Table 3).
4.4.4 Quantifying the potential additionality

The additionality of a certification scheme is defined as “the benefits of certifications beyond the outcomes of current policies and practices” (Garrett et al., 2016). It enables researchers to make a rough quantifiable differentiation between regulations and certifications. In paper II we used a positive policy analysis to establish the minimum national/regional requirements for salmon farming industries. The method did not look at actual performances from different farms or regions but only at the minimum requirements set up by national legislation referred to as the business-as-usual metric (BAU). We identified 18 impact categories from the ASC standard that were compared with national/regional standards, referred to as the relative stringency of the certification (S). The (S) metric had a constant value of one. The positive policy analysis (p) metric received a value of 0 if it was as stringent as the ASC standard and 1 if it was less rigorous. The (p) values were added together and then subtracted through the number of variables. The potential additional stringency (A) was calculated by subtracting BAU through S. If (A) was close to 1, it meant that the ASC standard has high potential additionality compared to the national/regional legislation and policies.

$$\text{BAU} = \frac{\text{number of variables}}{p}$$

We then calculated the potential additionality (A) by subtracting the business as usual (BAU) relative stringency of the certification schemes (S).

$$A = S - \text{BAU}$$

4.4.5 Semi-structured interviews

Article III is based on semi-structured interviews with aquaculture producers, environmental NGOs, administrative officers at national authorities, and local people in western Iceland. The study intended to obtain a holistic view of how the amended aquaculture regulations and new policies were perceived by people working with and directly affected by aquaculture. Therefore, we tried to choose as diverse a group as possible, with people in areas with aquaculture operations, as well as aquaculture producers, NGOs, and people in a governing context. The aquaculture producers we talked to farmed Atlantic salmon in open net cages on different sites along the Icelandic coast.

Using semi-structured interviews with end users encompasses the opportunity to steer the interview, without limiting the respondent too much (Gläser, 2009, Warren, 2001). Semi-structured interviews set an agenda for the discussion with the respondents and allow for nuances and follow-up questions that may help create a more holistic picture. Due to COVID-19, we had to be flexible with the respondents; some answered via telephone and others via Zoom or had face-to-face meetings with a co-author residing in Iceland. The respondents were chosen based on their participation.
in the policy-making processes, their role in aquaculture development and production in Iceland, or on their work or place of residence. The latter two were interesting as the Icelandic government has allowed for production in areas where it was previously banned. One of the co-authors had previous knowledge about whom to interview and had been in contact with several respondents for her master’s thesis project (Skúladóttir, 2022). The interviewees were informed about how the data would be used, given an option to not participate or give their answers anonymously, that they could withdraw their answers at any time. Initially, the interviewees only gave verbal informed consent that we then had to back up with a written consent form in accordance with the General Data Protection Regulation (GDPR). Our data-coll ecting co-author informed the respondents how the data would be used, i.e., translated, transcribed and shared with the other authors of the paper, as well as what the purpose of the study was. The interviews were conducted in Icelandic and then translated and transcribed before being sent to me for analysis. The interviews were not financially compensated.

4.5 Limitations of the method, methodology, and material

As is the case with all research, there are limitations to the methodology. All papers have some form of policy analysis as its basis, and whether policies are representative of actual performances is contested (Abbott, 2009). However, countries with strong environmental regulations and economic stability tend to achieve higher environmental performances (Esty and Porter, 2005). This is relevant for this thesis as most studies focus on countries with rigorous government controls and economic stability. According to SES and adaptive governance theory, having stakeholders involved in the policy and regulation-making process incentivizes them to comply with the regulations, hence a carrot rather than a whip is used to obtain the desired outcomes (Österblom, 2013). However, in paper IV we studied several countries that do not have a strong compliance or enforcement of their regulations, as regulations deter actors from using certain antibiotics, which are still widely used in their practices (Lulijwa et al., 2020)(paper IV). This could be perceived as a limitation; however, the paper does not claim to examine actual performances but rather how regulations are framed.

The replicability of papers II and III is perhaps the most apparent limitation. The analysis of paper II is based on a rough quantification of additionality that in turn is based on policy analysis and a literature review that defines what elements of sustainability that should be analyzed. The issue with this is that important elements could be overlooked, as the definition of sustainability challenges is based on previous research and not defined by our study.

There is always a risk of missing key actors when conducting interviews as we did for paper III. The respondents were chosen based on their visibility in the public debate and their role in the policy-making processes or where they lived. Further-
more, we were unable to talk to as many salmon farming companies as we would have liked. This was in some cases due to a drop off in respondents when the interviews were supposed to take place. Due to the COVID-19 pandemic, I could not participate in the collection of data for paper III as traveling was limited during this time. Furthermore, our co-author in Iceland had other obligations, which limited her possibilities to travel around the country to collect data. As a result, we had to rely on email correspondence, phone calls, and Zoom meetings, which also limited the number of people we were able to talk to. Arguably, if the geographical focus of this thesis had been limited further to a smaller sample size in the Nordic region, more in-depth studies and policy tracing could have been conducted. However, as I mentioned earlier, the pandemic made traveling to even the neighboring countries in the Nordic region impossible. Which resulted in this thesis mostly being based on desk studies.

For paper IV, there was an issue concerning the availability of documents. Some important aquaculture-producing countries, e.g., Egypt and Bangladesh, were not included in the study due to a lack of publicly available documents regarding antibiotic use in aquaculture. Neither aquaculture producers, veterinary organizations, NGOs, IGOs, researchers working with antibiotic use in aquaculture in the countries nor government officials could provide information about the regulations or what antibiotics were authorized for aquaculture. I was in contact with representatives from their General Organization for Veterinary Services, World Fish, and with researchers working with antibiotics in Egyptian aquaculture but no one knew where to find, or if there were any, regulations regarding antibiotic use for aquaculture in Egypt. Similarly, I contacted several organizations and researchers in Bangladesh without any luck. As a result, the paper is missing two important pieces of mapping antibiotic regulations in major aquaculture-producing countries.

It is impossible to take the person out of the research, and there is always going to be some subjectivity in the research. As was mentioned in the methodology section, my methodological approach is based on a mix of naturalism and constructivism. If someone with another methodological approach had conducted this research, they might have seen things differently or interpreted the findings in another way. This bias or subjectivity is not always a bad thing, however, if the researcher is aware of the risk and uses subjectivity to fulfill the research aim (Bumbuc, 2016).

Sweden updated its strategy for aquaculture development in the midst of my writing paper I. I had the pleasure to read and comment on the new strategy as part of the research community but refrained from using it in paper I as the document was not official at the time of submission.

To conclude, the largest limitation of this thesis is that I have not been able to study how policies and regulations are enforced or practiced in reality.
4.6 Ethical aspects of the work

Research ethics was a significant consideration in conducting this thesis. First, the overarching thesis topic with its central focus on sustainability required careful and considered handling of contested views and positionalities on what should be prioritized in pursuing sustainable aquaculture and how this should be done. The idea of sustainable development is intrinsically normative (Schmieg et al., 2018). As a result, it is important to consider the implications one area of emphasis has on the other two, whether it is environmental, social, or economic. Thus, in this thesis, I try to present different perspectives of sustainability with careful consideration. More specifically, in paper III we interviewed different stakeholders and actors on their perspectives and experiences regarding aquaculture development in Iceland. Prior to conducting interviews, respondents were provided with an overview description of the project and the purpose of this particular study. We also assured the interviewees of their anonymity and confidentiality in dealing with their answers to our interview questions, as well as allowed them to withdraw their answers from the study at any point. The interviewees gave their permission to record conversations and were made aware that interview data would be translated and transcribed to be used in the research paper and the Ph.D. thesis work more broadly. Furthermore, following the General Data Protection Regulation (GDPR), we did not collect more information about the recipients than necessary (EP/CEU, 2016). We only registered their place of work, and then their name, gender, and age if they wanted to share this voluntarily. The interviewees gave oral consent at the time of the interviews and subsequently signed a written consent form. As a researcher, I was reflective that interview ethics starts with the design of the study and goes on throughout the research process (Sanjari et al., 2014). In our study, while using semi-structured interviews, we planned to give the interviewees the scope to answer questions freely. In doing so, while we steered interviews with questions, we also allowed interviewees to raise issues that were of importance to them.
5. Summary of papers and findings

As mentioned earlier, the thesis consists of four separate articles. Each article contributes to the holistic picture of understanding how aquaculture development is proposed and applied in different institutional settings, how sustainable aquaculture is operationalized, how aligned different institutions are in their operationalization of sustainable aquaculture, why some aspects are prioritized, and unresolved elements.

5.1 Strong and weak sustainability in Nordic aquaculture policies

In this paper, we analyzed how the Nordic countries; Denmark, Faroe Islands, Finland, Iceland, Norway, and Sweden have constructed their aquaculture development strategies in their endeavor to increase national production. Each state has an expressed ambition to increase production and is regarded as a frontrunner in environmental sustainability (Sachs, 2019). The emphasis of the paper was on environmental sustainability. It is regarded as a first steppingstone in theorizing about strong and weak sustainability in food governance, where future emphasis should be put on social and economic aspects that could add to the discourse definitions.

Sustainably intensifying the aquaculture industry is and has been part of IGOs’ strategies, including the EU, European Economic Area (EEA), and UN for the last decade or two (EC, 2009, NACA/FAO, 2000). To illustrate how development is advocated for in the steering documents, we used the theoretical dichotomy between strong and weak sustainability that also situates the environmental sustainability ambitions of the Nordic aquaculture policies and strategies. In the paper, we applied modified versions of John Dryzek’s definitions and descriptions of environmental discourses to better highlight which theory is dominant in the policies and strategies. The different discourses were defined as very weak, weak, strong, and very strong (see Table 3). The very weak sustainability discourse emphasized economic growth and technological development; this discourse was defined as one that advocates for species that make the most fiscal sense to produce, e.g., salmon. The weak and strong discourses try to bridge some of the polarizing aspects of the dichotomy by advancing and illustrating synergies between different species of production. Their emphasis on the economy or environment varies significantly, however, with strong sustainability arguing for a more austere resource use, especially regarding non-renewable resources. Finally, very strong sustainability focuses almost exclusively on environmental well-being and resource use, arguing for an industry that has zero inputs that either negatively impact the environment or could be used for human consumption, e.g., blue mussels and algae. By using discourse analysis and the strong versus weak discourse dichotomy, we critically analyzed what type of aquaculture development
the Nordic countries advocate and how sustainability is operationalized in the aquaculture governing context. The strong versus weak sustainability concepts were used to define and clarify what sustainability aspects are central to each state.

Our findings show that weak sustainability is dominant in the strategies and policies. The environment plays a significant role in the documents but is subordinate to prospects of growth and technological advancements. What environmental aspects are prioritized differ between the countries. Denmark, Finland, and Sweden, all of which border the Baltic Sea, prioritize effluents such as nitrogen and phosphorus. Norway’s environmental focus is mainly on sea lice and their effects on wild salmon stocks. The Faroe Islands also prioritize fish health through the minimization of therapeutic treatments but also effluents, while the Icelandic emphasis is mainly on how salmon farming might affect the genetic composition of wild salmon. The ambition is to produce high-value species but with a smaller environmental impact than current practices. The policies and strategies argue that this ought to be done through technological development, which will enhance the environmental performance per kilo produced. Low-trophic species like blue mussels and algae are advocated for too; however, these are regarded as compensation for emissions from high-trophic species like salmon and trout or as feed.

This paper adds to the theorization of food governance in general and aquaculture in particular. It defines how aquaculture development is portrayed by one of the main governing actors: states. It also contributes to the theorization of sustainability in environmental discourses and the application to aquaculture specifically. In this study, we found that species with high economic value are prioritized and that high-technological solutions were suggested as a main solution to environmental challenges. Our study found that this emphasis on technology left important challenges unresolved, e.g., high-grade food resource use and energy consumption.

5.2 Governing the salmon farming industry – A comparison between national regulations and the ASC salmon standard

Farmed salmon has become an important export commodity for many countries and regions. The expanding salmon aquaculture industry has, due to its rapid increase, resulted in environmental concerns, most notably relating to the interaction with wildlife, effects of effluents and discharges in local ecosystems, and in some regions overuse of antibiotics and the development of Antimicrobial Resistance (AMR), as well as high dependence on high-quality food in feeds. As a response to these concerns, the industry has strengthened its efforts to improve practices, and privately led sustainability initiatives have become increasingly important; this includes certification and eco-labeling. This study examines the differences between salmon farming governance policies in the four largest salmon-producing regions: Norway, Chile, Scotland (UK), and British Columbia (Canada). The purpose of the study was to analyze how environmental aspects of a certification scheme differ from national
minimum requirements. To do this, we used a rough quantifiable version of additionality to see how much the certification scheme adds to environmental performances in comparison to legislations in the four main producing regions. The certification scheme was chosen based on its reputation as the most comprehensive and stringent aquaculture certification scheme (SeafoodWatch, 2017). We analyzed the Aquaculture Stewardship Council’s (ASC) salmon standard. The ASC is not only deemed to be comprehensive and stringent but one of the leading industry interest groups has expressed a desire to make 100 percent of their member farms certified by the ASC; thus, it is regarded as a legitimate program by producers as well as by non-partisan organizations like the Monterey Bay Aquarium (GSI, 2019).

The paper concludes that the ASC salmon standard has some additionality over existing regional/national standards in all countries, in some more than in others. The main elements of additionality in all countries are escape numbers allowed, antibiotic usage, and fish resources in feed. Incorporating these three requirements into national/regional regulations would significantly improve key sustainability practices of uncertified salmon farming. The study also finds that the potential additionality of the ASC standard differs between the cases, with the highest additionality in Chile and the lowest in Norway. Besides looking at how different governing institutions enact sustainable aquaculture; this paper also raises the issue regarding antibiotic-resistant bacteria and how the regulation in each state falls behind the ASC standard in combating this issue. The Norwegian salmon farming industry has managed to successfully remove almost all antibiotic treatments through vaccination programs. The issue lies in what compounds Norway uses (amphenicols and quinolones), both of which are listed by the WHO as important for human health (TNVI, 2016, WHO, 2018). As a result, there is room for improvement, even for Norway, in aligning with the One Health approach set up by the UN.

In this paper, we delved into how different governing actors construct sustainability standards for the aquaculture industry, specifically for salmon farming. As was noted before in this thesis and in paper I, many states and IGOs argue for an increase in certified aquaculture. This means that their relevance is likely to increase. Thus, seeing how a well-established certification program differentiates itself from national legislation constitutes an important contribution to evaluating the actual environmental benefits. Furthermore, the promotion of certification programs by states and IGOs adds to the theoretical framework of adaptive and multi-stakeholder governance as it illustrates how multiple actors complement each other and how aligned these actors are regarding what elements are central for the environmental sustainability of the salmon farming industry.

5.3 Icelandic salmon run

After gathering the data for the first paper, I realized that Iceland was in the midst of a governance transition for its aquaculture industry. Several amendments have been
made to regulations that have benefited the industry. The general rhetoric in policies, strategies, and public statements has been very pro-aquaculture, particularly regarding salmon farming. Aquaculture is often seen as a means to increase financial and employment stability in rural areas (Krause et al., 2020). Rural development of this sort is something that has been an ongoing ambition in Iceland since the introduction of individual fishing quotas (ITQs) in the 1990s and the 2008 financial depression (Eythorsson, 2000, Ólafsson, 2013). In the last three years, Iceland has seen enormous growth in its aquaculture production, especially the salmon farming industry (WorldBank, 2022). With stagnating production growth in the other major salmon-producing countries and with growing global demand, this expansion can improve the livelihoods of many in rural areas of the country. The emphasis on improved livelihoods is also how expansion and intensification of aquaculture often are portrayed in national policies and strategies (Bailey and Eggereide, 2020). The major investors in the new aquaculture sector in Iceland are Norwegian companies with the know-how and financial capacity to expand salmon farming (paper III). This also makes sense from their perspective as the Norwegian government just introduced a new resource rent tax of 40% (Regjeringen, 2022). However, for the industry to reach its full potential, it needs legitimacy (Koppell, 2008) and social acceptance, something that marine finfish expansion has had difficulty with in Europe (Ertör and Ortega-Cerdà, 2015). As the FAO (2022c) argues, to avoid social resistance it is important to take different stakeholders’ perceptions into account when building an aquaculture development strategy.

In this paper, we analyzed an expanding industry and a governance landscape in transition. We delved into how and why changes were made to the governing of the aquaculture industry in Iceland, who was involved in the process, and how they were included. Furthermore, we looked at how different stakeholders perceived the changes and how they saw the progression of Icelandic aquaculture in the future. Our analysis is focused on how power, participation, and influence interacted in forming aquaculture strategy and governance. By investigating how the regulations and policies were formulated and by looking at who had a seat at the negotiating table, we were able to create a picture of how and why changes were made. Furthermore, by talking to different stakeholders, we were able to discern the extent to which their knowledge and viewpoints were included in the policy-making processes and if the different stakeholders had similar outlooks as well as views on how the Icelandic aquaculture industry should develop.

In the paper, we found that there is a large discrepancy in perception about the industry and its potential growth between government officials, NGOs, and members of the industry. The environmental (E)NGOs and local people of the Icelandic East Coast are critical and skeptical of how the industry is growing and how the state has promoted it. Others, such as people on the West Coast (with less diverse industries), industry members, and government officials have a more optimistic outlook. Stakeholders with a more critical outlook are less represented in the different govern-
ing contexts, and there is a dissonance in the perception of how many metric tons the Icelandic fjords could handle. For instance, the Marine and Freshwater Research Institute (MFRI), which is an active governing actor, argues for much less than the Ministry of Food, Agriculture and Fisheries (MFRI, 2020b, MII, 2019). We conclude that pro-aquaculture actors have tended to be more influential in the development of aquaculture up until now and that there is still a sizable degree of fragmentation in the views on how it should be promoted moving forward.

5.4 Global overview of national regulations for antibiotic use in aquaculture production

This article is part of the Seafood Business for Ocean Stewardship (SeaBOS) project, initiated by researchers at Stockholm Resilience Center and the Beijer Institute of Ecological Economics at the Royal Swedish Academy of Science and partnering with researchers at the University of Lancaster and the Stanford Center for Ocean Solutions. The SeaBOS project gathers researchers and wild capture fisheries, feed producers, and aquaculture businesses all over the world. One of the tasks of the project is to decrease the usage of antibiotics in aquaculture. The initiating step of the project was to conduct a global overview of antibiotic regulations in some of the main aquaculture-producing countries. This paper looks into how antibiotic-resistant bacteria (AMR) and the One Health Approach became integral parts of the global sustainability dichotomy. Furthermore, it looks at and compares what antibiotic compounds are authorized in 17 of the largest aquaculture-producing countries. We also look at the standards of two certification programs (Aquaculture Stewardship Council, ASC & Best Aquaculture Practice, BAP) and what the tripartite agreement between the Food and Agriculture Organization (FAO) of the UN, the World Health Organization (WHO), and World Organization for Animal Health (WOAH4) suggests (WHO, 2005).

The One Health Approach is aimed at increasing the awareness and effectiveness of policies related to human, animal, and ecosystem health by combining the knowledge of several actors from academia, practitioners, and NGOs to see how ecosystem health, public health, and animal health interconnect (FAO/WHO/OIE/UNEP, 2022). One of the main issues that the One Health Approach is working against is AMR (WHO, 2021b). In this paper, we have gathered, analyzed, and synthesized information about antibiotic use regulations for aquaculture specifically. In the paper, we look at what compounds are allowed, what regulations there are regarding veterinarian or fish health expert prescriptions, if it is allowed to use antibiotics as a growth enhancer or prophylactically, if there is a limit to how many treatments each production cycle could have, and if there are bans on antibiotics listed as critical for human health by the UN.

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4 Previously OIE
From our research, we found that each country has regulations that abide by the recommendation to have a veterinarian or fish health expert write prescriptions before usage. Furthermore, each state has banned the use of antibiotics as a growth enhancer; however, prophylactic use is still practiced in some places. No state has any restrictions on the number of treatments, although the ASC and BAP have some. Finally, antibiotic compounds listed as critical or important to human health by the WHO are only banned from usage in Canada, Ecuador, the UK & the US. Some countries differ in that they do not have official lists, but rather a specific regulation that allows for veterinarians to prescribe whatever antibiotic they see as necessary. In practice, this system risks a decrease in transparency and could not be regarded as abiding by the recommendations of the WHO.

Ultimately, each state comes up short in its ambition to abide by the WHO code of practice but seems to be adopting different measures to work with AMR prevention through a more holistic approach that aligns with One Health.

This paper looks at how different institutional actors align or differ in their operationalization of sustainable aquaculture and what elements remain unresolved. It uses certification programs and the One Health approach as a comparative tool and adaptive governance aspect to highlight how collective and multi-stakeholder engagement and compliance are necessary to solve local challenges that can become global issues (Rockström et al., 2018).
6. Analysis

In this section, I apply the thesis’ theoretical concepts to key findings and tie these insights to the research aim and overarching research questions.

**RQ1: How do leading salmon farming states and the Nordics position their aquaculture development strategies and regulations compared to recommendations by the UN, EU, and the leading aquaculture certification program?**

The EU’s Farm to Fork and Aquaculture strategy emphasize sustainability and resilience (EC, 2021d, EC, 2020b). In these strategies, the EU highlights the significance of diversifying the industry to promote resilience and abundance; the need to reduce the use of antibiotics; ‘really’ contributing to the welfare of ecosystems rather than just reducing environmental consequences; and increasing societal acceptance through inclusiveness. These defined goals are very much in line with the SES approach that stresses diversification and abundance, inclusiveness, and equity combined with a strong knowledge of biophysical elements (Rockström et al., 2023, Folke et al., 2021).

If we were to generalize all the studied countries in this thesis, the key element of sustainable aquaculture is centered around minimizing effluents while increasing production. The prioritized species and production methods are quite homogenous between the countries and quite different from the prioritized species in the IGO policies and strategies. The states prioritize high-value species, like salmon and trout, whereas the IGOs prioritize low trophic species to a higher extent. The states often couple production with high-technological solutions to increase efficiency and profitability. From an SES perspective, this type of monocultural prioritization that advocates for efficiency decreases the resilience of the food production system (Nyström et al., 2019). It does not lead to increased diversification or abundance, which are key elements in food production resilience (Rockström et al., 2023, Troell et al., 2023). While improvements have been made to the feed composition, these species are still dependent on high-grade food resources that are consumed by people and other livestock animals, which increases the competition for these resources and adds to production costs (Troell et al., 2014, van Riel et al., 2023). This affects the equity of food production globally as considerations of global food production’s interconnectedness are lacking in the policies and strategies (Folke, 2006). Furthermore, these species are mostly traded in more affluent countries like Sweden, the US, Denmark, France, Poland, and the UK (ITC, 2022). However, much emphasis is put on researching new feed and technologies in all studied policies, which could be crucial for improving the equity and sustainability of the aquaculture industry (van Riel et al., 2023). New feed ingredients such as mussels, insects, and algae could...
replace some of the high-grade food resources used in today’s feed and be produced locally to a greater extent (Goglio et al., 2022, Sicuro et al., 2023).

The prioritized effluents vary to a much higher extent than the prioritized species, e.g., nitrogen and phosphorus in the states surrounding the Baltic Sea, pathogens in Canada, or copper, AMR bacteria and feed by the ASC and BAP (papers I, II & IV). However, all actors raise other challenges, such as inputs (e.g., feed, therapeutic treatments) or energy consumption. These are not prioritized by states in general but are emphasized heavily in IGO and NGO strategies and standards. Herein lies perhaps the largest discrepancy in the operationalization of sustainable aquaculture: states are, perhaps not surprisingly, emphasizing local conditions and impacts that mostly center around effluents. Thus, from a state’s perspective, sustainable aquaculture is achieved when the effluents are kept at a minimum, or as it is defined in a Baltic Sea context, “kept at a natural level” (HELCOM, 2007). An often-mentioned mitigation strategy, which could increase the resilience of the production system, is to produce other low-trophic species in the proximity, which could serve as cleaners of the resource-intensive species, an ingredient in feed or even a means to produce clean energy or fertilizers (paper I). Advocating for low-trophic, filter-feeding species like mussels and macroalgae could be beneficial for the Baltic Sea states as it could generate a new industry that produces feed ingredients for animal husbandry whilst reducing eutrophication (Sicuro et al., 2023, Jönsson and Elwinger, 2009, Kotta et al., 2022, Kotta et al., 2020). On a global scale, this type of multi-trophic aquaculture system could be an important stepping-stone to some of the most pressing sustainability challenges associated with marine-based, fed aquaculture as it would reduce dependence on other feeds and diversify the aquaculture industry (Troell et al., 2014, Troell et al., 2009, Rockström et al., 2023); however, it is not yet practiced on a large scale (Sickander and Filgueira, 2022).

The suggested solution to solve environmental challenges through technological development lacks consideration of whether producers are willing to make investments in new technologies (Xuan and Sandorf, 2020). The other solution to use low-trophic species as cleaners lacks an understanding of the scale and suitability of filter feeders to clean the effluents from farms (Troell et al., 2022a). It is assumed by many formulating aquacultural policy that updated technologies to produce high-value species will increase revenues and efficiency as well as reduce environmental impacts, making it somewhat of a silver bullet for sustainable aquaculture (paper I). The issues with the technocentric, intensification emphasis in the national policies and strategies have been exacerbated due to the COVID-19 pandemic and the war in Ukraine. That is, raw materials and energy prices have increased significantly, which high-value species in high-tech production systems like recirculating aquaculture systems are dependent on (Badiola et al., 2018, EC, 2022a, TheFishSite, 2022). These contemporary global challenges have highlighted the need for policies to reboot their prioritizations away from efficiency and optimization towards abundance and equity.
to increase social and environmental capacities to cope with unpredictable shocks and uncertainty (Rockström et al., 2023).

Unpredictability is also part of the future as climate change effects become more pronounced, and this could affect resource supplies, pathogens, therapeutic treatments, and suitable areas for production (Navedo and Vargas-Chacoff, 2021, Sheshadri et al., 2021, Maulu et al., 2021, Hersoug et al., 2021). Another challenge related to climate change is the spreading of pathogens, parasites, and pests, which could have devastating consequences for intensification plans in marine environments (Naylor et al., 2021). This would then increase the risks of having to use antibiotics to a higher extent, which would reverse one of the core goals of the EU’s aquaculture strategy, namely to minimize antibiotic use and dependence (EC, 2020a).

Much like the suggestions by IGOs such as the UN and EU, the states analyzed in this thesis also emphasize the need to apply a “power with” approach that empowers different actors in governing the industry. Whereas the state enables a “power with” approach that empowers different actors to participate in governing the industry, including, e.g., academia, NGOs, and aquaculture producers set out a best practice approach (paper III) (Partzsch, 2017). However, the findings of paper III indicate that at least in the Icelandic context there was a selectiveness concerning who was allowed to participate in the policy formation and governing of the industry, which increases risks of greenwashing and making biased policy recommendations and legislative amendments. Thus, this approach could be characterized as the state applying “power over” rather than “power with” (Partzsch, 2017). Furthermore, having a selective group to set the trajectory of development also perpetuates the role of experts and administrative rationalism (Dryzek, 2013), which can result in lower social acceptance, and subsequently lower legitimacy of the expansion plans in areas where the understanding of its biophysical implications is limited (Folke et al., 2021, Epstein et al., 2015). This issue has been illustrated by research conducted by Bäckstrand (2010), which suggested that new forms of collaborative networked governance remain dominated by state and corporate actors. Thus, development plans are still connected to who has the means or who has been invited to sit at the negotiation table (paper III), and subsequently fails to increase situated knowledge and an understanding of local ecosystems (Folke et al., 2016, Turnhout, 2018) or social concerns. Thus, in effect, this becomes a “power over” situation with a “power with” rhetoric (Partzsch, 2017). In one instance relevant to this thesis, “power to” has transformed into a “power over”. This example is from Norway, where a large salmon-producing company with environmental performances higher than mandated state regulations managed to influence national policies to increase environmental performance demands on the aquaculture industry in general (Vormedal, 2016). While positive from an environmental perspective, it does not necessarily increase the social sustainability of the aquaculture industry. An example of how “power to” has influenced “power over” is the emphasis in national strategies on having market-sensitive industries (Näringsdepartementet, 2017) (paper I), meaning
that demand should regulate what aquaculture is being developed (paper I). This also ties back to IGOs advocating for a significant increase of sustainably certified products. By doing so, legitimacy becomes a factor as these institutions are private, and thus no enforcement measures can be put into play other than removing the certification.

In contrast, aquaculture development is given a much different emphasis by international institutions like the UN and EU. One of the main ambitions of the UN is to empower and aid small-scale actors (FAO, 2022d). The EU also emphasizes the importance of smaller producers with extensive systems as a means to increase food security and reduce negative environmental trends (EC, 2021d). The species that are central for this type of development are macroalgae and mollusks (EC, 2022b, EC, 2021b). Technological innovation is not seen as a goal in and of itself in these institutional settings but rather as a means to help people launch and facilitate their aquaculture operations (FAO, 2022d, EC, 2021b). High-value species are not disregarded in these settings but receive less attention. Arguably, this makes sense from a sustainability perspective as species like salmon have high demand already, whereas other aquaculture products like macroalgae have a smaller market, especially in fiscally resourceful areas like Europe and North America (EC, 2021a, FAO, 2022e, NOAA, 2021, DFO, 2021). Thus, to diversify and make the industry more sustainable and resilient, it is a logical emphasis in a policy or strategy to advocate for cultivating species that generate less environmental impacts, require less inputs, and generate new markets. Furthermore, this policy goal combined with the already existing market for high-value species creates avenues for increased abundance, which is key for a resilient aquaculture industry (Rockström et al., 2023). As I have noted previously in the thesis, policies have a strong influencing power on markets and demands (Schipanski et al., 2016).

Not surprisingly, IGOs and NGOs who act and govern on an international scale highlight global challenges associated with the whole production chain, ranging from feed ingredients to the introduction of non-native species, therapeutic treatments and public health concerns. Most of these issues are mentioned in national strategies and policies as well; however, they are not addressed in any other form than through sweeping technocentric claims. What is deemed sustainable is subject to wide interpretation because numerous UN guidelines on sustainable aquaculture emphasize various criteria. The role of smaller producers is not prevalent in the national strategies and policies analyzed in this thesis. On the contrary, most argue for high-tech, high-value, and intensive farming, which is typically associated with larger corporations (Asche et al., 2013). Norway’s new resource rent tax is groundbreaking in this regard as smaller producers (< 4 000 tons per annum) are exempt from the new tax (Regjeringen, 2022) (paper III).5

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5 This tax was introduced after paper I was written, which is why it is not mentioned in the paper or included in its summary.
International organizations like the UN have to be wider in their governing of sustainability to include as many countries and actors as possible. A global strategy needs to allow wiggle room for regional and local differentiations and prioritizations (Kooiman, 2013), allowing management strategies to be adaptive and flexible depending on the scale of the system (Walker, 2020). However, there also needs to be an alignment in the goals and practices in order to allow people and businesses to know what to expect and not incentivize a race to the bottom (FAO/WHO/OIE, 2010). The EU is narrower in its definitions; apart from viewing aquaculture as an effective vehicle for carbon sequestration and nutrient uptake through algae and mollusks, they state resilience as a key factor with a special emphasis on human and animal health in a changing climate (EC, 2021b, EC, 2021d).

Environmental NGOs like the ASC have the most clearly defined version of what they deem as environmentally sustainable aquaculture with a focus on the following aspects: (1) the fauna and flora around aquaculture farms defines good ecological quality as “The level of diversity and abundance of invertebrate taxa is slightly outside the range associated with the type-specific conditions. Most of the sensitive taxa of the type-specific communities are present”; (2) escape numbers from, e.g., a salmon farm must not exceed 300 individuals; (3) therapeutic treatments must always be prescribed by a veterinarian and critically important antibiotics are completely banned; (4) effluents must be controlled and kept at a minimum from inputs by comparing surveys upstream and downstream to ensure good ecological quality, and the infrastructure itself should have as little impact as possible by having fallow periods and the infrastructure removed for cleaning; and (5) the marine contents of the feed should derive from ISEAL-certified fisheries, and non-marine ingredients such as soy should come from certified farms (ASC, 2019b).

Finally, NGOs similar to certifying organizations or environmental organizations have variables different from what they advocate for. They do not have a strategy or policy that is all-encompassing for aquaculture development but rather make assessments of scientific and social aspects of the industry and come up with suggestions and criteria for areas of improvement. These criteria and suggestions are strongly linked to public consultations as well as scientific findings (ASC, 2022c) (paper II). There has been a stronger presence of high-value and resource-intensive species in aquaculture certification schemes (Jonell et al., 2013). This correlates to the market sensitivity that is advocated for by the Nordic states as conscious consumers in more affluent countries are looking for food they are used to (paper I). To mitigate this and to increase the inclusiveness of other species, the ASC is developing an Aligned Standard that will move away from the species-specific requirements, which in theory will lead to an increase in species and production systems that could be certified (ASC, 2022a). This could be an important step from a diversification point of view if states and producers follow suit. Certifying organizations are also part of suggested

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6 International Social & Environmental Accreditation & Labelling
solutions by both states and IGOs as a means to monitor and control the industry and have market mechanisms pushing the industry toward better environmental performance (paper I). As a result, they are important actors in the future development of aquaculture.

It is possible to find an alignment with how sustainable aquaculture development is defined between the different governing actors and academia. Since the IGOs and academia have an immense arsenal of documents and papers that define different aspects of sustainability within aquaculture development, it is easy to find one that matches with what the NGOs and states advocate for. An example of this is to cut effluents and improve resource use; these are all important aspects of sustainable aquaculture development in all governing institutions and academia. However, if you reverse it, it is difficult to see that what the states advocate for as sustainable would suffice in the IGO or academic setting. This is mostly due to selective, but still warranted, criteria of sustainability challenges that are deemed most pressing (papers I & III). Furthermore, the reliance on sustainable aquaculture through technological solutions is becoming less attainable with the current energy crisis (Doukas and Nikas, 2022). In paper IV, we also found that most countries did not live up to the same stringent standards on antibiotic use that NGOs and IGOs advocated for.

Academic, intergovernmental, and non-governmental operationalizations of environmentally sustainable aquaculture are similar and quite comprehensive. The ASC standards, for instance, were built on recommendations and collaboration with researchers (ASC, 2011). Furthermore, whenever a new ASC standard is under process, there is always a public consultation, where stakeholders are allowed to voice their opinions on what is important, thus combining the societal definition of goals and ambitions with a more scientific basis.

RQ2: How could policies and strategies be improved to come closer to achieving sustainable aquaculture?

The main sustainability issue with the national policies and strategies analyzed in this thesis is monocultural prioritization coupled with high reliance on technological development and intensification emphasis. By advocating for monoculture with higher efficiency and productivity, the policies lack two substantial elements of resilience, diversity, and abundance (Rockström et al., 2023). Furthermore, as was mentioned earlier, advocating for resource-intensive species that are mainly produced by large corporations (Asche et al., 2018) decreases the inclusiveness of the industry and contributes to competition over resources that could be used by people and other food-producing industries (Troell et al., 2014). A clearer vision of a diversified aquaculture industry would indeed create incentives and markets for less resource-intensive species (Schipanski et al., 2016). This would increase the resilience of ecosystems as well as increase food security (Folke, 2016, Gephart et al., 2020). A diversification of aquaculture species would also spur diversity among actors
involved in the industry, which subsequently would increase the social sustainability of the industry.

The prioritization of certain elements of sustainability over others can be explained by drawing on this thesis’ theories and relating them to the various empirical studies addressed in the thesis. As was noted by Dryzek (2013) and Escobar (1996), a state within the capitalist market system will first and foremost promote economic growth. This also relates to the strong versus weak sustainability dichotomy, where the states have a clear emphasis on weak sustainability over strong ones as their ambition is to incentivize the development of high-value species in high-technological systems. This is prevalent in papers I and III as each state has a clear economic growth and technological development incentive underlying its aquaculture development strategy. In the Icelandic case, the growth of an industry that could increase employment opportunities in rural areas has been categorized as a main driver for the development of aquaculture laws and policies (paper III). The rhetoric is to improve social well-being and sustainability in these areas but as our results show, without the proper support of the people it intends to help. The selectiveness of who is involved in the policy and regulation processes and the selectiveness of environmental concerns is not in line with SES and the adaptive governance approach it advocates for (Folke et al., 2005). From a sustainability standpoint, both social and environmental, having a more inclusive policy and regulation-making process leads to increased compliance, which in turn would lead to a more sustainable industry going forward (Österblom, 2013, Abbott, 2009).

The prioritization of high-value species and economic growth has thus far been associated with intensive farming from fewer larger corporations (Asche et al., 2018). Intensive farming comes with a higher risk of disease outbreaks, which could lead to a higher reliance on therapeutic treatments and subsequently contribute to the spreading of AMR (paper IV) (Lulijwa et al., 2020, Bergqvist and Gunnarsson, 2013). These challenges are highlighted by Canada, Chile, and the Faroe Islands (papers II & I) but not in other national aquaculture strategies or policies (papers I & III). However, most states are adhering to international commitments and are as a result working towards and minimizing the use of antibiotics (paper IV). One area that is receiving more attention in policies and strategies to minimize antibiotic use is to increase animal welfare as this would lead to healthier animals and subsequently decrease the need for therapeutic treatments (Herrera et al., 2022, Pinillos et al., 2016). This is especially true in the Norwegian and EU documents as they both highlight the importance of treating animals humanely (Regjeringen, 2009, EC, 2021d).

Which environmental considerations take precedence in the national policies and strategies is based on local conditions and the scientific prioritizations of the local environments (paper I). For the states bordering the Baltic Sea, this is mostly phosphorus and nitrogen effluents; this is due to the high levels of pollution and eutrophication in the Baltic Sea (Armoškaitė et al., 2021). In Norway and Scotland, it
is sea lice, due to the significant impact sea lice have on wild stocks (Forseth, 2017, Peel and Lloyd, 2008). The most pressing concern in Iceland revolves around the genetic composition of wild stocks if and when farmed salmon escape (MFRI, 2020a). In Canada, the main emphasis is put on the effects on wildlife, more specifically health issues for wild populations (VanderZwaag, 2002, Milewski and Smith, 2019). Finally, the Chilean priority is effluents and disease control, and this is due to their previous outbreak of infectious salmon anemia virus (ISA) (Tecklin, 2016, SERNAPESCA, 2015). In all cases, the environmental concerns are closely linked to resource-intensive species like salmon and trout and relate to effects on local ecosystems. The national policies and strategies analyzed in this thesis lack a deepened understanding of how interconnected ecosystems are and how production and resource use in one area affect other ecosystems, which is crucial for the long-term sustainability and resilience of the aquaculture industry (Chaffin et al., 2014, Folke, 2006). Furthermore, intensifying the industry without having thorough impact assessments is another issue in some current policies and strategies, as has been highlighted in both Iceland and Norway (paper I & III). Several environmental concerns raised by ENGOs and researchers are not included in their assessments, most notably the effects on benthic environments. This could be remedied through a more inclusive policy-making strategy that would allow different stakeholder groups to raise their concerns, which would increase knowledge sharing and subsequently social- as well as environmental sustainability (Schultz et al., 2015). Another solution would be to apply the precautionary principle as advocated for by the UN. The precautionary principle stresses the need to provide proof that something will not hurt the environment before launching (Garcia, 2005). From a business and resilience perspective, applying the precautionary principle would be beneficial long term, as thorough site selection assessment would benefit not just the present but also the future as climate change could disrupt and prevent successful aquaculture operations (Falconer et al., 2020, Oyinlola et al., 2018, Skogen et al., 2018).

Social implications of aquaculture development are mentioned as beneficial through employment opportunities and economic stability to rural regions in almost all national and international strategies and policies. Indeed, these benefits were highlighted by people and stakeholders on the Icelandic West Coast in paper III. However, we also found a lack of participation and representation in the policy and regulation-making processes, indicating that other industries and local concerns regarding salmon farming were unaccounted for in the policy and regulation-making processes. Environmental NGOs in Iceland criticized the expansion process as they deemed the aquaculture consultation committee too biased towards pro-aquaculture (paper III), stating that other industries and actors that are more skeptical towards the expansion were left out of the decision-making process even after consultations with these actors. Furthermore, they had several environmental concerns that were not addressed in the new risk assessment law, e.g., sea lice, and effects in local environments in previously unexploited fjords (paper III). This type of selectiveness
of assessing projects against environmental criteria can also be found in the Norwegian traffic light system. The traffic light system is based on regional assessments of whether salmon farms can increase, continue, or decrease production volumes (Havsforskningsinstituttet, 2020). The assessments are based on the perceived risk of sea lice-induced deaths in wild stocks (Havsforskningsinstituttet, 2020). This lack of inclusiveness increases the risks of using “power over” and thus decreases the legitimacy and social acceptance of the industry (Partzsch, 2017, Epstein et al., 2015). This negatively affects the legitimacy of the industry and power structures within the governing institution as stakeholders feel unrepresented and unheard in the policy or legislation-making processes (Koppell, 2008).

It is apparent that national strategies and policies lack a global perspective of resource use and the interconnectedness of industries. To some extent, this is expected as a nation-state will protect its interests first and foremost. However, with the knowledge and all the international commitments, it is surprising that there is not more attention on how certain aspects of the domestic aquaculture industry might affect ecosystems elsewhere, thus indirectly having global impacts (Rockström et al., 2018). The emphasis on controlling outputs rather than inputs is an indication of this as unsustainable outputs are more tangible in the producing country than unsustainably sourced inputs, which are usually a composition of materials from several places, e.g., fry, feed, and pesticides. The importance of institutional fit in a time of uncertainties associated with climate and environmental change as well as resource availability in adverse political landscapes is pressing (Epstein et al., 2015). Policies and strategies must be more context-specific to contribute to the sustainable development of SESs. That does not mean that they should be less concerned with how production affects global ecosystems, but rather a deepened understanding of how the aquaculture sector could benefit social and environmental sustainability (Epstein et al., 2015). One important aspect of doing this is to use adaptive and learning-based governance across sectors and scales (Moore et al., 2018). Emphasis should be put on finding a balance between biophysical and social governance to increase the equity, inclusiveness, and abundance in their food policies if these are to increase the resilience and sustainability of the aquaculture sector as is advocated for in the Farm to Fork strategy (Rockström et al., 2023, EC, 2021a, EC, 2020a).

6.1 Section summary

The research aim of this thesis was to provide empirical insights into how aquaculture development strategies and policies align with international conceptions of sustainable aquaculture and find possible areas of improvement.

Several shortcomings in the policies and strategies to achieve sustainable aquaculture development have been highlighted in this thesis, most notably in national contexts. These are closely linked to the SES approach that emphasizes a contextualized and yet global perspective of social and ecological systems that requires a
deeper scientific understanding of the biosphere (Folke et al., 2021) as well as learning-based adaptivity in governance settings that involve meaningful contributions from several stakeholders across sectors. For the aquaculture industry to become more sustainable there is a need for policymakers and governing institutions to apply a more holistic approach and streamline the process to produce less resource-intensive aquaculture species. This does not mean an obstruction for other aquaculture practices but rather increasing incentives to diversify the industry, which would increase its resilience and sustainability. Furthermore, the Icelandic paper highlights the importance of cross-sectoral collaborations when constructing new policies and law amendments related to aquaculture to obtain social acceptance for the industry.

The national versus international governing institutions’ conceptualization of aquaculture development and their compatibility with sustainability challenges indicates that there is quite a large discrepancy in that states’ advocacy for aquaculture development does not solve the sustainability challenges associated with aquaculture. The issues regarding feed, therapeutic treatments, and emissions from farms are not solved by the suggested development strategies. Furthermore, acting on opportunities to make positive contributions to the environment and society is not fully comprehended. The most notable case is how the Nordic countries bordering the Baltic Sea fail to fully seize the opportunity to advocate in their policies for an industry that could have positive impacts on the Baltic Sea through filter feeders (Armoškaitė et al., 2021). Moreover, from the Icelandic case study, we found indications that the governing institutions and amended legislations are based on a selective group of pro-salmon farming actors that have highlighted some environmental challenges but disregarded others. This type of selectiveness in representation and what sustainability challenges are addressed deviates from international organizations and research recommendations, moving away from a top-down administrative rationalism approach towards a more inclusive, equitable, and adaptive governance approach (Turnhout, 2018, Dryzek, 2013, Ostrom, 2005, Kooiman, 2013). Furthermore, this negatively impacts the legitimacy and social acceptance of the industry, which is key for long-term sustainability (Bailey and Eggereide, 2020, Koppell, 2008). The legitimacy issue is a constant in the national policies and strategies for this thesis. For the policies to become more equitable and promote sustainability to a higher degree, it is important to increase the scientific understanding of how food production affects local and global ecosystems (Folke et al., 2016) as well as include actors from different sectors and expertise to ensure that other types of knowledge are being picked up when constructing these policies (Turnhout et al., 2021).

International organizations like the EU and UN are addressing the environmental sustainability challenges to a much higher degree as they advocate for a more diverse development, both in terms of actors and aquaculture systems. This approach is key to remedy the environmental challenges associated with aquaculture and to increase the long-term sustainability and resilience of the industry. Thus, throughout this
compilation thesis, I find that recommendations from IGOs and the research community are not addressed properly in national aquaculture development strategies as they lack a clear ambition to diversify the industry and fail to incorporate smaller actors and other stakeholders in the governing of the industry.
SEARCHING FOR SUSTAINABLE AQUACULTURE

GOVERNANCE
7. Discussion and contributions to the field

In this section, I situate my research in the field of sustainable aquaculture governance and where it fits in the larger context of food governance theory. I do so by outlining the thesis’ contributions to the field and state future avenues of research.

The theoretical foundation of this thesis and its contribution to food governance is similar to what many IGOs and SES researchers emphasize, as it mainly argues for a diversification of actors, institutions, and species produced to increase social and environmental performances and sustainability (Folke, 2006, Nyström et al., 2019, Chaffin et al., 2014). To that end, this thesis added to the field by stressing the importance of having a collaborative, adaptive, and resilient aquaculture sector. Two important initiatives have been used in this thesis to highlight the importance of collaboration across sectors and knowledge areas, namely, the One Health approach and the ASC’s collaboration with Fair Trade USA to increase the social sustainability aspect of their standards (WHO, 2017, ASC, 2019a).

The idea for this thesis was spurred from an interest and hankering to see if governing actors actually advocate for sustainable aquaculture in their policies and strategies or if it is merely less unsustainable. To this end, this thesis builds on and contributes to existing research on governance strategies to increase the sustainability of aquaculture production worldwide. In what follows, I present the main contributions of this thesis.

7.1 New conceptualization of what “sustainability” entails in aquaculture policies

As was mentioned in the background, aquaculture eludes the “good or bad” categorization by contributing both benefits and risks to social-ecological systems (Rickard et al., 2021). It is perceived as a reliable and sustainable food source that could contribute to food security globally (FAO, 2022e). However, it is also subjected to market demands, which has incentivized more resource-intensive species like salmon and trout (Barasa, 2022) that do not necessarily contribute to the stated benefits of aquaculture. One of the main contributions of this thesis to the field of sustainable governance strategies for aquaculture highlights how different governing actors implement sustainability strategies and policies to increase the environmental performance of aquaculture operations. By combining Dryzek’s environmental discourses with the strong versus weak sustainability dichotomy, this thesis illustrated different nuances in how sustainability is portrayed in aquaculture development policies. Sustainability is complex and the papers of this thesis added to the literature
by deciphering what sweeping claims about sustainability means and put these claims in a larger context.

Paper I & II analyzed how the environment is accounted for by some of the most sustainable governing actors like the Nordic states and a leading certification scheme (Naylor et al., 2023). They illustrate how governing bodies prioritize environmental aspects differently and to various degrees. Paper I highlights how states prioritize economic over environmental sustainability in their difficult task of designing aquaculture policies to advance both. One of the ambitions of states and IGOs is to increase the amount of certified food as a means to increase the environmental performances of the industry, which theoretically could do both, but it does not address the abundance and resilience aspects of sustainability. Paper II highlights that the ASC indeed increases environmental performances compared to business as usual as defined by the environmental regulations for aquaculture production in leading salmon-producing countries. This is an important contribution as the debate regarding the legitimacy and actual impacts of certification programs has been contested (Bernstein and Cashore, 2007, Marin-Burgos et al., 2015). In this thesis, however, I have been able to illustrate how environmental performances, at least on paper, are enhanced by certification programs and that they can serve as an important contributor to increasing the environmental performance of an industry.

7.2 Clarifying if and how international recommendations on sustainable aquaculture translate to national policies and regulations

Another contribution from this thesis is the policy mapping of how international steering documents are implemented in national contexts. This relates to papers I, III & IV, especially as they all look at how different measures and recommendations by IGOs like the UN and EU, which increase the sustainability of the aquaculture sector, are implemented in these cases. These range from how to construct policies and regulations based on multi-stakeholder participation to increasing food security, resilience and mitigating global risks such as the spreading of AMR. To achieve sustainability and increase compliance among producers, most governing institutions agree that cross-sectoral, multi-stakeholder engagements are a necessity (Österblom, 2013, Folke et al., 2005, Ostrom, 2000, EC, 2014, FAO, 2017, Bailey and Eggereide, 2020). By looking at how the Icelandic policy and regulation development was conducted, paper III shed light on the difficulty of incorporating this in practice and highlighted how sharing policy-making responsibilities across a wider set of stakeholders could improve the understanding of the biosphere and how other industries will be affected, which subsequently would increase the social acceptance and legitimacy of an emerging industry. By using a wider array of knowledge, the policies would be better equipped to not only increase legitimacy but also add resilience to the industry as experiential knowledge could be addressed to minimize
effects on other industries (Turnhout, 2018, Folke et al., 2016). This is central for AG as stakeholder groups need to be identified and included to increase social sustainability rather than just focusing on ecosystem functions (Folke et al., 2005, Chaffin et al., 2014). Another aspect of making the aquaculture sector more sustainable as defined by IGOs is to diversify the industry. In paper I of this thesis, we illustrated how this recommendation is overlooked to a high extent in some of the most sustainable countries in the world (SDGINDEX, 2022). Finally, in paper IV, we conducted novel research on mapping how antibiotic use regulations in aquaculture differ between countries. Furthermore, by comparing these regulations to the recommendations in the One Health approach by FAO/WOAH/WHO to mitigate and combat the spreading of AMR by reducing the use of critically important antibiotics, we were able to illustrate how far this is from being implemented in most countries. Accordingly, there is considerable work to be done by policymakers in ensuring the sustainable trajectory of the aquaculture industry, even in countries that are perceived to be high performers in the pursuit of achieving the SDGs.

7.3 Avenues for Future Research

In this section, I discuss possible avenues for future research. Analyzing policies and regulations gives an understanding of what an institution is aiming toward and how it intends to get there (UTS, 2018). However, there is usually a plethora of aspects, overarching goals, and aims that each institution needs to consider. In this thesis, I had one study looking at how stakeholders perceive their role in policy-making processes, but there is still significant room to look at how power dynamics affect these processes and how giving certification programs like the ASC a larger role is perceived by other stakeholders. Consequently, some of the most intriguing avenues for future research are to see how policies and strategies on an international and national level affect the daily operations of producers and/or other stakeholders and how power is expressed and practiced in the policy-making processes. Tracing policies all the way to producers would further increase the awareness of how sustainability is practiced and how steering documents actually affect the outcomes of the aquaculture industry. This too could shed light on experiential knowledge that often is overlooked by researchers and policymakers (Turnhout, 2018). Furthermore, it would be interesting to see how experiential knowledge compares to the scientific and policy recommendations regarding sustainable aquaculture. This would especially be interesting for paper IV, where there is a huge difference in how stringently the policies and regulations are followed in different countries (Schar et al., 2018, Iskandar et al., 2020, Chokshi et al., 2019). Is that a result of experiential knowledge, or are there other factors at play? Another interesting area of research is to see if compliance with environmental regulations is higher in countries where stakeholders have had a larger say in the policy and regulation-making process, as is argued by adaptive governance theory and SES (Österblom, 2013, Folke et al., 2005, Ostrom,
Finally, looking at how to implement the overarching aquaculture goals set up by the UN and EU in the Nordic countries surrounding the Baltic Sea would be an interesting feat. Aquaculture in the Baltic Sea is not very prevalent due to low salinity levels, which affects the growth rate of, e.g., blue mussels; its high levels of toxins; and its sensitivity to pollution through its semi-enclosed nature (Kotta et al., 2023, Armoškaitė et al., 2021). However, there is still potential to use filter feeders to combat eutrophication and produce energy or fertilizers for terrestrial agriculture (Spangberg et al., 2013). One interesting case study would examine how combining wind farms with low-trophic aquaculture could be expanded in the Baltic, as this combination would improve energy production in the region as well as help decrease eutrophication. Currently, there is an interesting pilot project between OX2 windfarm and Nemo sea farms, a macro-algae producing company based in Finland, on how to better utilize and combine the two industries (Lind, 2023).
8. Concluding remarks

This thesis aimed to prove empirical insights into how aquaculture development strategies and policies align with international conceptions of sustainable aquaculture and find possible areas of improvement. To do this, I answered two overarching research questions in four different papers. The first research question looks at how some of the highest performing states in terms of achieving the SDGs define and strategize around aquaculture development: How do leading salmon farming states and the Nordics position their aquaculture development strategies and regulations compared to recommendations by the UN, EU and the leading aquaculture certification program? The comprised answer to that question is that the Nordics and leading salmon farming states advocate for the development of high-value resource species like salmon and trout. These species are associated with costs and revenues and tend to be produced by larger corporations (Asche et al., 2013). The research conducted in this thesis also found that, in the policy-making processes, stakeholders that are pro-aquaculture development, especially salmon farmers, are better represented at the policy development stage. IGOs, on the other hand, emphasize less resource-intense, smaller, and inexpensive aquaculture development. One common denominator between states and IGOs, however, is their emphasis on expanding ecologically certified aquaculture products. Using certifications to govern the aquaculture sector is also a way to align practices regardless of their geographical origin if it refers to the same certification scheme. Otherwise, it runs the risk of confusing people and businesses more, which in turn could undermine the positive impacts these certifications have (Roheim, 2018). The observed certification programs in this thesis, most notably the ASC, have a more clearly defined and stringent environmental performance demand on production than do states. This output-legitimacy combined with procedural transparency increases certification programs’ legitimacy as governing actors of the aquaculture industry.

The second research question was How could policies and strategies be improved to come closer to achieving “sustainable” aquaculture? The short answer to this question is to increase the diversity of the industry, both in terms of producers and species. This would increase resilience, abundance, and arguably social acceptance of aquaculture operations. That does not necessarily mean a reduction of high-value species or putting up obstacles for these operations but rather gives stability and nuance to an industry with a large potential. A stronger focus on low-trophic, filter-feeding species like macroalgae and mussels could even replace some of the issues surrounding competition for high-grade food resources by using feed ingredients deemed unfit for human consumption (Sicuro et al., 2023). In the Baltic Sea case,
mussels and algae aquaculture could reduce eutrophication whilst providing feed for other animal husbandry industries.

Climate and environmental change cause concern about how monocultures might fare in the future (Balogh, 2021, Maulu et al., 2021). This issue is true for all food production industries that strive towards efficacy through monocultures (Willett et al., 2019). Another challenge associated with changing climates is that successful tools like vaccines might not cope with higher temperatures and subsequently new disease profiles, which could limit supply and create issues in the future (Mugwanya et al., 2022). This could lead to increased use of antibiotics, which in turn could result in an exacerbation of the spreading of AMRs. Furthermore, climate and environmental change affect resource availability, which aquaculture operations depend upon worldwide (Reid et al., 2019). As a result, adaptivity and the reflexivity of policies and governance strategies are key (Folke et al., 2005). This also includes working with a wider array of actors across sectors and geographical areas to increase awareness in designing and implementing policies and legislation to achieve better outcomes (Dryzek and Pickering, 2017).

Globally, aquaculture is a diverse industry with over 500 species cultivated and a large variety of production methods in all corners of the world (FAO, 2020). It has the potential to supply people with healthy food while having a smaller environmental impact than most other animal protein industries (Gephart et al., 2021). In some instances, it can even have positive impacts on ecosystems through nutrient and carbon sequestration (Gentry et al., 2020, Armoškaitė et al., 2021, Myers and Subban, 2022). It contributes to employment opportunities and expanded livelihoods for people in rural areas and increases food availability (Krause et al., 2020, FAO, 2022e). However, aquaculture can also have detrimental effects on ecosystems, value chains, and public health (Henriksson et al., 2018, Choi et al., 2020, Forseth, 2017). Thus, how it is managed and governed determines whether it will contribute to positive societal and environmental development (Roheim, 2018). As has been pointed out in this thesis, the governing strategies set up by international organizations and states tend to highlight the importance of multi-stakeholder governance that involves several stakeholders and actors from both public and private sectors in the governing processes. This public-private governance strategy has thus far struggled to incorporate the diversity of the industry, both geographically, in terms of aquaculture systems (Naylor et al., 2021) and in some instances with regard to actors (paper III). The market-sensitive strategy where demand sets the trajectory of the industry has also failed to capitalize on the opportunities to create a diverse aquaculture industry, e.g., the emphasis on salmonids in Nordic aquaculture strategies (papers I & III).

The scientific contribution generated by the collective work in the papers in this thesis illustrates that the private initiatives observed set a higher standard for environmental performances than states and international organizations (papers II & IV). Furthermore, the observations in this thesis have pointed towards the fact that the states’ prioritization of expanding fed, high-value, and resource-intensive aqua-
culture with a larger environmental footprint than other aquaculture systems lead to a less unsustainable aquaculture industry rather than a sustainable one. These species already have a high-demand and are already well established on international markets. They are moreover in less need of state sponsorship than aquaculture with a lesser impact and smaller markets. International organizations like the EU and UN are, on the other hand, trying to highlight and emphasize aquaculture with a lesser environmental impact and a smaller market, thus using its governing power (Schipanski et al., 2016) to initiate a diversified aquaculture sector (EC, 2022b, FAO, 2022d).

Since governance, policy goals, and ambitions are based on socially constructed assumptions, I wanted to highlight what constitutes the core of the aquaculture development in international and national settings. Throughout this thesis, I have exemplified how states are taking on sustainability issues by outsourcing some of their governing responsibilities to certification organizations whilst advocating for an expansion of aquaculture with a higher environmental performance. This is to some extent contradictive, but it does increase the environmental performance of the high-impact aquaculture practices. Furthermore, I have shown through paper IV that governing institutions are collaborating on some challenges and managing to create uniform ambitions to mitigate issues associated with food sectors such as aquaculture. Thus, it is possible to co-create policies and goals across sectors and hierarchical levels, which should be practiced more, on larger and smaller scales.
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## Appendix I

<table>
<thead>
<tr>
<th>Country</th>
<th>Documents</th>
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</table>
| Australia      | Australian One Health Antimicrobial Resistance Colloquium Background Paper July 2013 (AG, 2013)  
QuanTity of antimicrobial products sold for veterinary use in australia (APVMA, 2014) |
| Canada         | List of Veterinary Drugs that are authorized for sale by health canada for use in food-producing aquatic animals – health canada (GC, 2010)  
Antimicrobials requiring a veterinary prescription as of december 1, 2018 (CAHI, 2018) |
| Chile          | Manual of good practices in the use of antimicrobials and antiparasitics in chilean salmon farming (SERNAPESCA, 2015) |
| China          | Please keep this list of prohibited drugs for aquatic products and the correct use of fishing drugs (CAPIN, 2018)  
Bulletin no. 194/2019 (MARAPRC, 2020) |
National sanitary control plan for aquaculture and fishing (2020)(MPCEIP, 2020)  
Regulation to aquaculture and Fisheries Organic Act (2022)(PCDLR, 2022) |
| EU             | Authorised fish products: situation in europe (EMA, 2021)  
A European one health action plan against antimicrobial resistance (AMR)(EC, 2021) |
| Faroe Islands  | Same as EU                                                                |
| India          | National policy for containment of antimicrobial resistance india (MHFW, 2017) |
| Indonesia      | Regulation minister of marine and fisheries of the republic of indonesia number 1/perm-en-kp/2019 about fish medicine by the grace of god almighty minister of marine and fisheries of the republic of indonesia (MMFRI, 2019) |
| Japan          | Records regarding the use of marine medicines and handling of antibacterial agents for marine products (MAFF, 2020) |
| Norway         | Use of antibiotics in norwegian aquaculture (TNVI, 2016)  
Forskrift om produksjonsområder for akvakultur av matfisk i sjø av laks, ørret og regnbueørret (produksjonsområdeforskriften) (Lovdata, 2017) |
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<th>Country</th>
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| Thailand   | GAP Standard Compliance Manual 7436–2020 for aquaculture farms for consumption (DFMAC, 2020)  
Guidelines for the Prudent Use of Antimicrobials in Aquaculture (FDA, 2012) |
| UK         | UK Veterinary Antibiotic Resistance and Sales Surveillance Report (VMD, 2021)  
Currently authorised products from Veterinary Medicines Directorate (DEFRA, 2023) |
| USA        | Approved Aquaculture Drugs (FDA, 2022)  
Where Resistance Spreads: Food Supply (CDC, 2022)  
Approved Drugs for Use in Aquaculture (FSW, 2020) |
| Viet Nam   | LIST OF VETERINARY DRUG ACTIVE INGREDIENTS SUBJECT TO CRITICALLY IMPORTANT ANTIBIOTIC GROUP ACCORDING TO THE RECOMMENDATIONS OF WHO (MARD, 2020)  
LISTS OF PERMISSIBLE ANTIBIOTICS AS GROWTH STIMULANTS IN LIVESTOCK AND POULTRY FEEDS IN VIETNAM AND CONTENTS THEREOF (MARD, 2016a)  
ON VETERINARY DRUG MANAGEMENT (MARD, 2016b) |
| Russia     | Register of pharmaceutical substances (MA, 2022)                           |
| South Korea| Korean food standard codex, 10-5-89 (KFDA, 2011)  
Notice No. 2009-173 (KFDA, 2009)  
Notice No. 1992-13 (MAF, 1992)  


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Appendix II

Respondents from the governmental agencies:

<table>
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<tr>
<th>Agency</th>
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<tbody>
<tr>
<td>Food and Veterinary Authority (MAST)</td>
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<tr>
<td>Ministry of Food, Agriculture and Fish (MFAF)</td>
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Respondent from Aquaculture Consultation Committee:

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<th>Committee</th>
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<tr>
<td>River Association (Skúladóttir, 2022)</td>
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Respondents from environmental NGOs:

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<th>NGO</th>
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<td>Icelandic Wildlife Fund</td>
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<td>Landvernd</td>
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Respondents from the industry:

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<th>Company</th>
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<td>LAXAR</td>
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<td>Arnarlax (Skúladóttir, 2022)</td>
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Survey:


Utifrån akademiska rekommendationer samt nationella och internationella styrningsmål om hållbar expansion av vattenbruket genom certifieringar samt samarbeten med flertalet intressenter, analyserar denna avhandling hur alternativa inflytelserika styrningsaktörer, såsom certifieringsföretag, jämförs med nationella riktlinjer för miljökrav för vattenbruk. En region som är särskilt intressant i avhandlingen är Norden, där vattenbruksproduktionen skiljer sig åt i storlek. Norge är en av de mest inflytelserika och betydelsefulla aktörerna inom vattenbruk, medan Island och Färöarna har en växande produktion och länderna runt Östersjön fortfarande har en relativt låg produktion. Vattenbruket i Norden fokuserar huvudsakligen på resurskrävande arter med hög ekonomisk omsättning, som lax. Av den anledningen, samt laxens framför som den snabbast växande vattenbrukssektorn, fokuserar den här avhandlingen även på andra stora laxproducerande länder. Dessutom ger denna avhandling empirisk insikt i hur styrdokument och lagar konstrueras och förändras för att överensstämma med de tidigare nämnda målen om
samarbete med flera aktörer. Slutligen granskas i avhandlingen hur stora vattenbruksproducerande länder reglerar användningen av antibiotika inom vattenbruket. Detta eftersom överanvändning av antibiotika har blivit en av de mest akuta folkhälsoutmaningarna inom matproduktionsindustrin idag.

Denna avhandling bidrar till utvecklingen av konceptuella ramar för granskning av hur olika aspekter av hållbarhet framställs och efterlevs inom olika styrningssammaenheter kopplade till vattenbruksproduktion. Genom detta ramverk har den här avhandlingen skapat kritisk insikt i hur olika styrningsaktörer definierar hållbart vattenbruk samt identifierar motsättningar och synergier mellan internationella och nationella ambitioner. Slutligen bidrar avhandlingen med rekommendationer om hur aspekter av hållbarhet kan förbättras i styrningsdokument.

Nyckelord: Vattenbruk, policy, miljöstyrning, Social-Ecological Systems (SES)
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221. Ola Luthman, *Searching for sustainable aquaculture governance – A focus on ambitions and experience*, 2023
Ensuring food supplies for a growing population with expanding needs in a time of adverse environmental and climatic change is an epically difficult and uncertain task. Aquaculture development is widely promoted and institutionalized as a key sustainable and reliable option to meet this challenge. But are plans for the expansion of a sustainable aquaculture sector credible or are there flaws?

This thesis examines how aquaculture development policies and strategies are framed and analyzes their implications for the overall sustainability of the industry, with a focus on the Nordic region. The thesis delves into how governing actors ranging from states to IGOs and certification programs strategize to handle some of the most pressing sustainability challenges associated with aquaculture. Drawing on Social-Ecological Systems thinking as the theoretical foundation, this thesis highlights the importance of incorporating global challenges with contextualized knowledge when planning for a sustainable expansion of aquaculture.

Ola Luthman carries out research in the field of environmental social science. He specializes in how sustainability is framed in governance contexts with a special emphasis on aquaculture and food production.

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