

Treading Water: Climate Risk Perception and Institutional Response in Norwegian Salmon Aquaculture

Elísabet Jónsdóttir

Supervisor
Dr. Georgios Pardalis

Thesis for the fulfilment of the
Master of Science in Environmental Management and Policy
Lund, Sweden, May 2025



© You may use the contents of the IIIIEE publications for informational purposes only. You may not copy, lend, hire, transmit or redistribute these materials for commercial purposes or for compensation of any kind without written permission from IIIIEE. When using IIIIEE material you must include the following copyright notice: 'Copyright © Elísabet Jónsdóttir, IIIIEE, Lund University. All rights reserved' in any copy that you make in a clearly visible position. You may not modify the materials without the permission of the author.

Published in 2015 by IIIIEE, Lund University, P.O. Box 196, S-221 00 LUND, Sweden,
Tel: +46 – 46 222 02 00, Fax: +46 – 46 222 02 10, e-mail: iiiee@iiiee.lu.se.

ISSN 1401-9191

Acknowledgements

This thesis is my final assignment to fulfill my master's degree at the IIIEE, Lund University. It also marks the end of my time in Lund, after five years of studying. My stay here in Lund and the writing and completion of this thesis could not have happened without the people in my life, supporting me and cheering me on throughout.

First and foremost, I want to thank my supervisor, Dr. Georgios Pardalis for your endless patience and encouragement. Thank you for your great availability, feedback and for calming me down when I was unsure. You promised to deliver me safely to the finish line and that you did. You made the thesis period, which is known for being entirely too stressful, an (almost) smooth sailing journey.

I would like to express my gratitude to the participants of this study who generously offered their time, perspective and advice. This study would not have been possible without their valuable insights and experience. Through these interviews I gained an enhanced understanding of this complex problem.

I want to thank my coworkers and supervisors at Marsh. For offering me insights, advice and taking an interest in my topic. I would especially like to thank Otto, Sarah and Marieke.

Thank you to my B30. With great food, music, wine, dancing and laughter, you turned this challenging program into an amazing journey. Through thick and thin, we have gone through this together, and with Meijing watching over us I will carry your love with me. The Insti brought me an extended family, for which I will eternally be thankful for.

To Sophie, Otty, Max and Erik, I want to extend a special thank you. Your unwavering support and encouragement, runs, texts, phone calls and dinners, all of it kept me going.

I am forever grateful for my family, my parents and my sisters. I could not have done this without you. Thank you for supporting me and encouraging me when it was difficult to be away. To my mom for always picking up the phone and being the voice of reason, to my dad for his endless patience for reviews and never-ending questions. Thank you for being my biggest supporters and always believing in me. A special thank you to Rannveig for taking me in, and for continuing the godmother role long into my adulthood.

To Lilith, Sarah and Norah, thank you for always being there for me. Your friendship means the world to me, more than I feel that I can express here.

Finally, to Erik, thank you for being by my side. I could not have done this with anyone else.

Abstract

Climate change adaptation (CCA) has become a prominent topic as the global environment changes. Increased extreme weather events, changes in microclimates and local ecosystems necessitate a change in current production methods, particularly within the food industry. Aquaculture, which provides over 50% of the global seafood, is particularly vulnerable to climate change. That includes Norway, the world's largest producer of Atlantic salmon. While the Global North has thus far experienced fewer direct impacts, firms in these regions, will increasingly face climate-related risks. This study investigates how Norwegian sea-based aquaculture firms are addressing CCA and the factors that influence their responses. It explores which risks are prioritized by stakeholders and the tools available for adaptation.

Using semi-structured interviews and document analysis, various stakeholders were interviewed to provide a comprehensive view. The findings are analyzed through the lens of risk management, institutional theory and institutional inertia. Uncertainty emerged as the most significant barrier to CCA implementation. The grow-out phase was found to be particularly vulnerable, where increased sea lice outbreaks are already having significant impact. A lack of data and foresight regarding climate outcomes contributes to firms' reluctance to invest in adaptation efforts. Misaligned time horizons further exacerbate this, as firms focus on short-term operations while governments and researchers adopt a long-term perspective.

This study found that firms are largely focused on immediate risks and day-to-day operations, and holistic enterprise risk management is currently lacking. Stakeholders highlighted coercive and normative pressures as the most influential for surpassing this inertia. To reduce uncertainty knowledge sharing is an essential step, both across the sector and with research institutions. Firms can be incentivized to prioritize CCA through enhanced collaboration with the research community and the establishment of clear regulatory guidelines.

Keywords: Climate Change Adaptation, Sea farm aquaculture, Atlantic Salmon, Norway, Risk management

Executive Summary

Climate change is bringing various challenges on a global scale, across all business sectors. These risks are only expected to increase in the forthcoming years and as a response climate change adaptation (CCA) has become more prominent. Global food consumption is increasingly including more aquatic food, where aquaculture accounts for over 50% of the aquatic food consumed. Ensuring safe and stable aquaculture food production is hence imperative. In Norway, which produces over half of farmed salmon in the world, 97% of the aquaculture production is in sea-based systems. The sector has so far experienced fewer direct impacts due to its northern geography. However, projections indicate a growing vulnerability, emphasizing the need for proactive CCA.

Despite legal requirements for risk management in Norwegian aquaculture, existing research indicates that many firms fall short of compliance, suggesting limited integration of CCA practices as well. Additionally, Norway has a complex regulatory landscape and a policy focus on environmental protection, rather than how climate change impacts firms. This has further halted industry responsiveness. The recently implemented Corporate Sustainability Reporting Directive (CSRD) is a partial response to this gap. It requires large firms in Norway (and across Europe) to report on their environmental risks and impacts, and their CCA. However, the directive has been said to create a more administrative burden rather than incentivizing firms to take action.

Global literature on aquaculture adaptation has largely concentrated on the Global South, leaving a gap in frameworks applicable to high-income, northern contexts like Norway. Moreover, there are geographical variations in local environments, and the fish species grown differ, which require location specific climate predictions. This in turn often makes for CCA solutions that are not easily extrapolated across regions. There is scarce literature on CCA for aquaculture in the Global North and CCA frameworks, to support firms on decision making, are lacking. Case studies and stakeholders' perspectives on CCA in the Global north are needed to ensure tangible and actionable recommendations.

This thesis explores how Norwegian aquaculture firms are approaching climate change adaptation and what factors influence their actions. It investigates key climate-related risks, available adaptation tools, and the institutional dynamics that shape corporate decision-making. The study is guided by the overarching research question: What factors influence Norwegian aquaculture firms' implementation of climate risk assessments? This is supported by two sub-questions: What are the major environmental risks facing aquaculture firms in Norway? And what adaptation tools are available to mitigate these risks?

This research utilizes a qualitative method approach. This is deemed most appropriate as it allows for an in-depth analysis to understand the experience and perspectives of the various stakeholders within the aquaculture sector. While it does not use specific firms as cases, the study is informed by elements of a multiple-case study design. Expert perspectives from internal (firm representatives) and external (industry facing representatives) stakeholders are used to recognize patterns and explanations for firm behaviors within the sector. Semi-structured interviews and a supplementary document analysis provide insights that cannot be captured through quantitative approaches.

Stakeholder groups were identified through a stakeholder analysis and a carefully mandated selection criteria was created before reaching out to potential interviewees. The data was analyzed through the platform Nvivo, through inductive and deductive coding. The inductive codes were derived through literature review where an analytical framework was

constructed, with conceptual themes and concepts based on risk management, institutional theory and institutional inertia. Risk management theory was used to structure the various risks that came up during interviews. Institutional theory identified institutional pressures that can influence firms to implement CCA whereas institutional inertia recognizes five main mechanisms that halt CCA: uncertainty, cost, power, path dependency and legitimacy.

This study found that while stakeholders recognized that climate change had already started impacting firms' operations and would impact them at a greater scale in the future, they prioritize immediate risks and day-to-day operations. Citing uncertainty as a large barrier, stakeholders found that unclear data and lack of knowledge for what to expect makes firms reluctant to invest resources.

Furthermore, a mechanism of inertia not captured within the initial analytical framework was a misalignment in the time horizon. Where firms organize and strategize on a year-to-year basis with a long-term strategy of 3-7 years, climate change research has a time scale of several decades. While external stakeholders proposed financial incentives to surpass this inertia, internal stakeholders did not cite high costs as a barrier. They rather found that unless climate risks start impacting firms financially, such as through stopping operations or increasing disease and mortality rates, firms would continue to focus on day-to-day operations and known risks that are currently impacting them. Meaning, firms are not lacking financial resources, but rather direct them towards other risks and actions. This is contradicting to much of the literature which commonly finds that organizations need financial support and funding for CCA.

Stakeholders highlighted that there is even uncertainty surrounding climate events that have started impacting firms already. Operational risks such as increased sea lice, harmful algal blooms and jellyfish are sporadic and can be caused by other variables than climate change. The grow-out phase was found to be the most vulnerable to climate risks, given its dependency on the natural environment. Operational risks and legislative risks were mentioned frequently, and stakeholders all referenced the same risks of concern, further strengthening the claim of the sectors homogeneity. While aquaculture firms are wary of reputational risks due to their direct consumer relationship, consumers are not viewed to concern themselves with CCA, leading to firms prioritizing it less.

Institutions were frequently cited as impactful to push firms towards CCA. Coercive pressures from the government in form of clear regulation was mentioned by internal stakeholders as the most crucial. Despite finding regulatory pressure important, decision makers also found the CSRD non influential in materializing action for CCA. External stakeholders suggested that insurance firms and financial institutions could play an important role by creating financial incentives for firms that implement CCA. The study further found that in order to bridge the gap of uncertainty, normative pressures play a large role. Sharing knowledge and facilitating interactions between the research community and firms, can be beneficial to both. Firms gain a better understanding of what they should adapt to while the research community learn what solutions are applicable and actionable for firms.

The findings from this study ultimately highlight that firms require more information and certainty on what to expect from climate change. The inertia within the sector appears to stem from the misaligned time horizons, lack of data and uncertainty in climate predictions, all resulting in hesitancy to invest in CCA. To surpass this, knowledge sharing across firms and external institutions is needed. Regulatory changes and a more streamlined administrative burden, both within the governmental bodies and for firms to fill out, is

needed so that regulations result in an overarching view of the sector and actions that benefit both firms and the authorities.

The findings from this research can aid stakeholders. Providing an understanding of how firms view CCA, what they prioritize and what is halting their actions, allows decision makers within firms and political actors to start responding accordingly. This study further lays out a foundation for future studies. Finding a common ground between research and firms so that it benefits both is of high importance. Examining financial tools and applying monetary values to climate risks can further help firms gain understanding of the importance for CCA. This also allows for exploring the operationalization of knowledge sharing and cross-sector collaboration. Finally, the findings point towards a complex regulatory landscape that reinstates the inertia, researching how to design actionable regulations and policies, create coherence and make them so they facilitate change is an important catalyst for CCA.

Ultimately this thesis contributes to understanding how organizational behavior, institutional dynamics, and risk perception affect CCA in a high-income aquaculture context. Its findings offer practical guidance for policymakers, researchers, and industry leaders aiming to strengthen resilience and support sustainable growth in the face of climate change.

Table of Contents

ACKNOWLEDGEMENTS	I
ABSTRACT	II
EXECUTIVE SUMMARY	III
LIST OF FIGURES.....	VIII
LIST OF TABLES.....	IX
ABBREVIATIONS.....	X
1 INTRODUCTION.....	2
1.1 PROBLEM DEFINITION	3
1.2 AIM AND RESEARCH QUESTIONS	5
1.3 SCOPE AND DELIMITATIONS.....	5
1.4 ETHICAL CONSIDERATIONS	6
1.5 AUDIENCE	6
1.6 DISPOSITION.....	7
2 RELEVANT STUDIES	8
2.1 RISK MANAGEMENT.....	8
2.1.1 <i>Risk Management and Aquaculture</i>	10
2.1.2 <i>Risk Categorization</i>	10
2.2 THE RISK LANDSCAPE OF NORWEGIAN AQUACULTURE	10
2.2.1 <i>The Aquaculture Value Chain</i>	10
2.2.2 <i>The Physical Environment of Norway and Climate Change</i>	14
2.2.3 <i>Norwegian Regulatory Landscape</i>	16
2.3 BEST PRACTICES	18
2.4 INFLUENTIAL FACTORS FOR RISK MANAGEMENT AND CLIMATE CHANGE	19
2.4.1 <i>Institutional Theory and Isomorphism</i>	19
2.4.2 <i>Institutional Inertia</i>	20
2.5 ANALYTICAL FRAMEWORK.....	22
3 RESEARCH DESIGN, MATERIALS AND METHODS.....	24
3.1 RESEARCH DESIGN.....	24
3.2 SECTORAL COMPARATIVE APPROACH USING EXPERTS' PERSPECTIVES	25
3.3 DATA COLLECTION METHODS AND RATIONALE.....	26
3.3.1 <i>Stakeholder Mapping and Selection of Case Studies</i>	26
3.3.2 <i>Semi – structured Interviews</i>	28
3.3.3 <i>Document Analysis</i>	29
3.4 DATA ANALYSIS METHODS	30
4 FINDINGS AND ANALYSIS	33
4.1 RISK MANAGEMENT AND CCA.....	33
4.2 CLIMATE RISKS AND THE INDUSTRY RESPONSE.....	34
4.2.1 <i>Climate Risks Faced by Firms</i>	34
4.2.2 <i>Current Response, CCA Tools and Solutions</i>	37
4.3 THE HALT IN CCA – INSTITUTIONAL INERTIA	38
4.3.1 <i>Uncertainty Halting Actions</i>	38
4.3.2 <i>Cost as a Barrier to Adaptation</i>	39
4.3.3 <i>Power and Institutional Influence on CCA</i>	40
4.3.4 <i>Path Dependency and Legitimacy</i>	41
4.3.5 <i>Misaligned Time Horizons: Climate Science vs. Business Strategy</i>	42
4.4 EXTERNAL PRESSURE AND INSTITUTIONAL ISOMORPHISM IN CCA.....	43
4.4.1 <i>Coercive Isomorphism: Regulation and Financial Incentives</i>	43
4.4.2 <i>Normative Isomorphism: Knowledge, Dialogue, and Collaboration</i>	43
4.4.3 <i>Mimetic Isomorphism: Who to Follow</i>	44
5 DISCUSSION	45
5.1 THE FINDINGS IN CONTEXT WITH PREVIOUS RESEARCH.....	45
5.1.1 <i>Identifying Climate Risks and Recognizing the Impact and Solutions</i>	45

5.1.2	<i>The Norwegian Aquaculture Firms and Climate Inertia</i>	47
5.1.3	<i>Drivers of Change – Overcoming Institutional Inertia</i>	48
5.1.4	<i>Synthesis of key discussion points</i>	49
5.2	CRITICAL REFLECTIONS AND LIMITATIONS OF THE STUDY	50
6	CONCLUSIONS	52
6.1	CONCLUSIONS FROM THE RESEARCH	52
6.2	PRACTICAL IMPLICATION AND CONTRIBUTION TO RESEARCH	53
6.3	RECOMMENDATIONS FOR FUTURE RESEARCH	53
	BIBLIOGRAPHY	55
	APPENDIX	67

List of Figures

Figure 2-1 An undefined risk matrix	9
Figure 2-3 The supply chain of an aquaculture sea farm.	12
Figure 2-4 Aquaculture production sites in Norway (includes Trout and Shrimp) ...	15
Figure 2-5 The analytical framework.....	22
Figure 3-1 Structure of the research	25
Figure 3-2 Stakeholder map of external and internal stakeholders	27
Figure 3-3 The coding approach of mixed methods	32
Figure 4-1 Climate risks within the aquaculture value chain.....	35

List of Tables

Table 3-1 Selection criteria for interviewees.....	28
Table 3-2 List of interviewees	29
Table 3-3 List of documents analyzed.....	30
Table 5-1 Summary of key barriers and drivers of CCA in the Norwegian aquaculture sector, categorized by institutional mechanism.....	50

Abbreviations

B2C = Business-to-consumer

CCA = Climate Change Adaptation

COSO = The Committee of Sponsoring Organizations

CSRD = Corporate Sustainability Reporting Directive

ERM = Enterprise Risk Management

ESG = Environmental, social and governance

EU = European Union

FAO = Food and Agriculture Organization

FCR = Feed conversion ratio

GHG = Greenhouse Gas

HAB = Harmful Algal Blooms

IPCC = Intergovernmental Panel of Climate Change

ISO = International Organization for Standardization

KPI = Key performance indicator

RAS = Recirculating aquaculture system

ROI = Return of investment

SMEs = Small and Medium sized Enterprises

TLS = The traffic light system

1 Introduction

A changing climate presents numerous challenges not only for the natural environment and its ecosystems but also for the businesses that rely on these environmental services. Climate-related threats such as rising temperatures, increased storm frequency, shifting precipitation patterns, ocean acidification, and rising sea levels are just a few examples of the disruptions a changing climate will bring worldwide (IPCC, 2022b). These changes are complex and difficult to predict. The timing, scale, and impact on different geographical regions in the coming decades depend on various factors. The continued emission of CO₂, primarily driven by human activities, and on natural climate cycles, the adaptive responses of various organisms, and, most significantly, the actions humans take to adapt or capitalize on environmental changes (Chapin et al., 2011).

One of the most pressing global challenges resulting from climate change is food insecurity. Increased droughts, flooding, and soil nutrient depletion are examples of climate change impacts that are already reducing crop yields and diminishing the availability of animal protein. The Food and Agriculture Organization (FAO) has highlighted that the current global food system fails to consistently provide nutritious, sustainable, and safe food for the world's population (FAO, 2024). In 2022, aquaculture accounted for 51% of global aquatic animal consumption, surpassing wild fisheries for the first time—a trend expected to continue in the coming years (FAO, 2024). The consumption of aquatic animals has been steadily increasing at an annual rate of 3.0% from 1961 to 2021 (FAO, 2024). Given this trajectory, ensuring the sustainability of aquaculture is imperative to securing a stable, nutritious, and resilient food supply for the global population. More importantly, identifying how the sector can adapt to climate change, and to the business risks that are expected to arise from climate change, is crucial.

Aquaculture refers to the farming of aquatic organisms. A typical aquaculture process starts on land before the grow out phase of the fish where they are put into net pens in open bodies of water (Falconer et al., 2022). During the grow-out phase farmers are completely dependent on the natural environmental conditions, conditions which are expected to change significantly in the forthcoming years. The FAO (2021) identified the following climate factors of most concern to aquaculture: sea level rise and extreme water level, change in precipitation pattern, ocean acidification, storms, air temperature, sea temperature, extreme heatwaves and deoxygenation. In a process that is completely reliant on the natural environment for the production of the goods, changes like this are a risk to the business model and the business itself.

Risk management, used by both governmental bodies and private entities - aims to identify potential risks and guide strategic decision-making. Arthur et al. (2009) emphasize that while risk definitions vary by sector. They generally encompass three key elements:

- Uncertainty of outcome
- Probability of an adverse event
- Consequence if the event occurs

Risk analysis, in this context, involves quantifying potential impacts and identifying strategies to reduce the likelihood or severity of adverse outcomes. Climate Change Adaptation (CCA) can be considered a specialized form of risk assessment, where firms evaluate the probability and consequences of climate-related disruptions and take proactive measures in response.

According to the Intergovernmental Panel on Climate Change (IPCC, 2021), CCA is defined as “the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.” For the aquaculture industry, this raises a fundamental challenge: how can firms effectively adapt to future conditions when the exact nature, timing, and intensity of climate impacts remain uncertain?

Climate change is driven primarily by anthropogenic greenhouse gas (GHG) emissions, particularly CO₂. The scale and character of future impacts will depend heavily on global mitigation efforts, an uncertainty that complicates long-term planning (Yue & Gao, 2018). For aquaculture firms, this introduces not only scientific and environmental unpredictability but also strategic ambiguity in how to design robust adaptation strategies in the face of evolving climate scenarios.

Numerous climate models are available to project possible futures based on different emission scenarios (Hayhoe et al., 2017; Webster et al., 2002). While these models consistently indicate that change is coming, they all vary in terms of timeline, magnitude, and how the different perils will act. They also differ in the types of perils they predict, the level of detail and their geographical specificity (Webster et al., 2002). As a result, uncertainty surrounds the risks posed by climate change, making it challenging for firms to proactively react to it and plan effectively.

The Northern hemisphere has, so far, experienced less severe effects of climate change compared to regions further south (Ketzler et al., 2021). This has resulted in less pressure on firms to take proactive actions or assess climate risks. In Europe, Norway is the second largest exporter of aquatic animals, following China (FAO, 2024). In 2022 it produced 1.6 million tons of aquatic animals, more than the entire output of the European Union (EU) (Marotta, 2025). The aquaculture sector in Norway is largely composed of sea farms, and produces over half of all farmed salmon globally (FAO, 2024). Following oil and gas the aquaculture industry is the second largest exporting industry of Norway and was valued at around 10.6 billion EUR in 2024 (Norwegian Seafood Council, 2025). This makes Norway a particularly relevant geographical focus for examining the impacts of climate change on aquaculture. Additionally, the homogeneity of Norway’s aquaculture industry makes it so that while all firms may be vulnerable to significant environmental changes, they tend to face similar risks. This uniformity allows for more straightforward extrapolation of findings across the sector.

1.1 Problem Definition

Climate change is increasingly recognized as a multidimensional challenge, generating complex risks across sectors and governance levels. The EU introduced the Corporate Sustainability Reporting Directive (CSRD), which Norway adopted in 2024, as a partial response to these risks. This legislation compels businesses to evaluate both the environmental, social and governance (ESG) risks they face and the consequences of their operations. Moreover, it mandates that companies disclose all risks they deem material as well as the adaptation plans in response to those risks (European Commission, 2025). While intended to enhance climate accountability, the directive has been criticized for its administrative complexity. Firms report that significant financial and human resources are being diverted toward compliance rather than actionable CCA. In response, the European Commission proposed an omnibus package aimed at simplifying the directive and narrowing its scope, potentially exempting small and medium sized enterprises (SMEs) and even some large firms (European Commission, 2025).

Despite aquaculture's importance to the global food supply, it is often excluded from national and international CCA plans (Poulain et al, 2018). Climate change will bring new risks that require coordinated adaptation actions at local, national and global level. Pham et al. (2021) found that out of the 155 countries that adopted the Paris agreement in 2015 only 68 included fisheries and aquaculture in their national adaptation strategies. Furthermore, climate change considerations are largely absent in EU's primary regulatory frameworks for fisheries and aquaculture. This omission creates challenges not only for firms attempting to assess climate-related risks but also for researchers and policymakers aiming to develop comprehensive evaluation and adaptation tools.

This issue is particularly pronounced in the Norwegian context. Norway is one of the largest aquaculture producers globally, yet the regulatory and reporting landscape is fragmented, involving multiple agencies with different reporting requirements and structures (Yang et al., 2020). While firms are legally required to conduct risk assessments, studies show that compliance is inconsistent and often superficial (Holmen et al., 2018). One key issue identified is the lack of cross-departmental involvement within firms, which weakens internal control mechanisms and leads to insufficient integration of risk management (Holmen et al., 2018). Literature and frameworks, at large, do not account for emerging risks or long-term risk view, such as is associated with CCA.

Additionally, existing literature predominantly focuses on the Global South, specifically countries with developing economies and governance systems. These include case studies on mangrove restoration or small-scale artisanal fisheries, approaches largely inapplicable to Norway's high-tech, export-driven salmon aquaculture sector (Abu Samah et al., 2021; Galappaththi et al., 2020; Pham et al., 2021; Poulain et al., 2018). In 2018, the FAO published a large synthesis report on adaptation and mitigation options for fisheries and aquaculture. Of the 28 chapters in the report, only four specifically address aquaculture, and close to 70% of the case studies are in Africa and Asia, underscoring a significant gap in both geographic and sectoral representation in adaptation research (Barange et al., 2018). Furthermore, climate models used for adaptation planning often lack the resolution required to inform localized risk management strategies in the North (Falconer et al., 2020).

With the CSRD now in effect, requiring firms to disclose environmental risks, impacts, and opportunities, there is an urgent need for deeper investigation into the Norwegian aquaculture sector's exposure to climate-related risks and the barriers to comprehensive risk assessment. Furthermore, much of the existing adaptation literature remains concentrated on the Global South, making it difficult to apply those findings to high-income, northern contexts like Norway. These regions differ significantly in terms of social structures, political frameworks, and environmental conditions, highlighting the need for context-specific research to inform effective adaptation strategies.

This thesis addresses a research gap situated at the intersection of environmental science, policy, and strategic management. It investigates how Norwegian aquaculture firms interpret and respond to climate risks within a fragmented policy context and amid scientific uncertainty. The problem is inherently interdisciplinary, requiring a blend of climate risk understanding, institutional theory, and business strategy to assess both barriers and enabling conditions for adaptation. In doing so, it contributes to a more context-specific and actionable understanding of CCA in high-income, environmentally dependent industries.

1.2 Aim and Research Questions

The aim of this research is to examine the position of the Norwegian aquaculture industry regarding CCA within the context of risk management. Specifically, the study seeks to identify key climate-related risks and explore the adaptation tools available to mitigate these risks. This thesis will investigate the current practices among aquaculture firms in Norway, mapping both the environmental risks they face, and the strategies employed to adapt to them.

The overarching research question is the following:

RQ: What factors influence Norwegian aquaculture firm's implementation of climate risks assessments?

To support this, two sub-questions are posed:

RQ1: What are major environmental risks facing aquaculture firms in Norway?

RQ2: What are the adaptation tools available to them to mitigate these risks?

This thesis contributes to the fields of management and risk literature by analyzing how Norwegian aquaculture firms are responding to climate-related risks and identifying the factors that shape their approaches to risk assessment and adaptation. The findings aim to offer practical insights for both policymakers and industry stakeholders. For policymakers, the research highlights key environmental risks and relevant adaptation strategies, informing policy development and regulatory frameworks. For business leaders, it provides an overview of prevalent risks and actionable recommendations to strengthen strategic planning. Additionally, this study presents a comprehensive analysis of both current and anticipated climate risks, grounded in a combination of literature review and qualitative data from interviews, offering a foundation for future research.

1.3 Scope and Delimitations

This study focuses exclusively on the sea-based aquaculture firms within the Norwegian aquaculture industry. Six stakeholder groups were identified to provide a comprehensive overview of the sector and capture different perspectives. Among internal stakeholders, the scope is limited to corporate firms, as they are expected to have more resources and in turn knowledge of this topic.

For the geographical focus, Norway was chosen due to the sector's significant contribution to the national GDP and its heavy reliance on the natural marine environment. The homogeneity of the sector in Norway further makes for an optimal research subject. The dependence on the environment leaves sea-based aquaculture particularly vulnerable to climate-related risks. The study limits the research to aquaculture, excluding other sectors within food production and fisheries, to ensure a targeted and in-depth analysis.

This study does not aim to address the current sustainability challenges within the Norwegian aquaculture industry. While it acknowledges issues such as environmental impact, feed use, impact of escapees on the wild salmon population, and disease transmission, they are assumed to be well documented in existing literature. Instead, the research focuses on projected future climate risks and their implications for firm operation. It is presumed that firms are capable of addressing the current sustainability challenges alongside the implementation of CCA strategies.

The research was conducted over a relatively short period. The primary data collection, mostly interviews, reflects the perceptions and practices of stakeholders during a specific

timeframe. The sample size was influenced by the accessibility of industry-facing actors. While a considerable effort was made to ensure a diverse and proportionate representation of various stakeholders, the number of interviewees remained modest. To strengthen the study, the interview data was supplemented with grey literature including industry reports, regulatory documents, and previous academic research. Attention was paid to thematic saturation during interviews, with the objective of identifying whether consistent patterns and responses emerged across participants.

1.4 Ethical considerations

This research was conducted in collaboration with Marsh, an insurance brokering and risk management firm. The collaboration provided general contextual insights into risk management practices but did not influence the formulation of research questions, data interpretation, or reporting of results. Every effort was made to maintain academic independence and objectivity throughout the research process to avoid potential bias arising from the association with a private firm.

All interviews were conducted in accordance with ethical research standards as outlined by the Swedish Ethical Review Authority. Participants were recruited through purposive sampling and contacted via professional online channels. Prior to participation, they received detailed written information outlining the research aims, interview procedures, and their rights as participants. Informed consent was obtained from all interviewees, and their participation was entirely voluntary. To ensure confidentiality and minimize the risk of identification, all participant data were anonymized during transcription and analysis. No identifying information is presented in the final thesis. The collected data are stored securely and will be used exclusively for academic purposes.

The researcher was attentive to power dynamics that may arise in industry-academic collaborations and took precautions to mitigate any undue influence on participants. Participants were assured that their decision to participate or abstain would have no bearing on their professional standing or relationship with the collaborating organization.

At the time of writing, no foreseeable risks to participants, such as reputational harm, psychological distress, or professional disadvantage, have been identified. However, the researcher remains aware that research findings can be misinterpreted or misused. As such, careful consideration has been given to the framing and communication of results, with an emphasis on responsible and transparent dissemination. This research design has been reviewed against the criteria for research requiring an ethics board review at Lund University and has been found to not require a statement from the ethics committee.

1.5 Audience

This research is intended for a diverse set of audiences engaged in the intersection of CCA, risk management, and aquaculture.

First, it is directed toward decision-makers within aquaculture firms who are responsible for integrating sustainability and risk management into business operations. Drawing on stakeholder insights, the study highlights factors that influence firm behavior and offers practical considerations that may support the development of more robust climate risk assessments and adaptation strategies. While the recommendations are not prescriptive, they are grounded in empirical findings and intended to inform strategic planning and long-term resilience building.

Second, it is aimed at policymakers working at national and regional levels. By identifying the current challenges and needs within the Norwegian aquaculture sector, the research offers insights that can inform the development of more targeted and effective regulatory frameworks for CCA.

Finally, the study contributes to the academic community by addressing existing gaps in the literature on climate risk management in aquaculture, particularly in high-income, northern regions such as Norway. The findings reflect broader theoretical discussions within environmental management, organizational adaptation, and climate change science, offering a foundation for future empirical and conceptual research in these areas.

1.6 Disposition

The structure of this thesis is designed to guide the reader through a logical progression from the research background to its conclusions and implications. It unfolds over six chapters, each building on the previous to develop a comprehensive understanding of climate change adaptation in Norwegian aquaculture.

Chapter 1 (Introduction) introduces the topic of this thesis. Laying out the background to the topic, scoping the research problem before setting the aim and research questions. It then clarifies the scope and delimitations of the study. Finally, it discusses ethical considerations, and identifies the target audience.

Chapter 2 (Relevant Studies) provides a review of the academic literature and theoretical foundation. It begins by introducing key concepts in risk management, followed by an overview of the Norwegian aquaculture industry, its exposure to physical risks, and the surrounding regulatory landscape. It then discusses adaptation literature and best practices in aquaculture. The chapter finally presents the theoretical framework, drawing on risk management, institutional theory, and institutional inertia.

Chapter 3 (Research Design, Materials and Methods) lays out the methodological method and the research design. It describes the data collection methods, including stakeholder interviews and document analysis, and outlines the analytical process used to interpret the findings.

Chapter 4 (Findings and Analysis) presents the empirical results and analyzes them through the selected theoretical lenses, identifying key patterns, barriers, and drivers related to CCA in the sector.

Chapter 5 (Discussion) explores the findings in a broader context and compares them to existing, reviewed, literature. It presents considerations and critical reflections of the study.

Chapter 6 (Conclusions) summarizes the main insights of the study, outlines its contributions to research and industry, and provides suggestions for further investigation and policy development.

2 Relevant Studies

This chapter provides an overview of relevant theories and scientific literature related to CCA in the aquaculture sector. It begins by introducing risk management, before exploring the risk landscape specific to Norway, including aquaculture practices, associated environmental risks, and influential factors shaping sectoral responses. Subsequently, examples of CCA strategies from other countries and regions are discussed to provide comparative insights. Finally, it explains key theoretical frameworks and how they can be applied to understand CCA processes within aquaculture. The chapter concludes by presenting the analytical framework that will guide the analysis of the empirical data collected in this study.

2.1 Risk Management

Risk management is widely practiced by both governmental bodies and private firms to identify potential risks and guide decision-making processes. As Arthur et al. (2009) note, risk is sector dependent and definition can vary across sectors; they generally share three core components: the uncertainty of outcomes, the probability or likelihood of an undesirable event occurring, and the consequences or impacts should such an event take place.

Historically, corporate risk management was focused on insurable and financial risks, such as fluctuations in foreign exchange rates and interest rates. Risk managers were primarily tasked with purchasing insurance and financial officers were responsible for edging strategies (Nocco & Stulz, 2022; Smith, 1995). Over the past decade, risk management has significantly expanded to encompass a wider range of risks, including operational, strategic, legislative and reputational risks (Nocco & Stulz, 2022). These broader risk categories differ across sectors, organizational types and geographies, and require context-specific assessments. Effectively identifying, assessing, and addressing these risks can provide firms with a competitive advantage in their market environment (Gatzert & Schmit, 2016; Mishra et al., 2019; Schulte & Hallstedt, 2018).

This holistic approach to risk has evolved into what is now named Enterprise Risk Management (ERM). Unlike traditional risk management, which often isolates risks into individual categories, ERM emphasizes an integrated framework in which all risk types are assessed in relation to the firm's overarching strategy and internal context (Green, 2016; Olson & Wu, 2023). The Committee of Sponsoring Organizations (COSO, 2017) developed a widely used ERM framework, which asserts that well-implemented ERM not only enhances operational performance but also strengthens governance, improves decision-making, and aligns risk management with strategic objectives.

However, ERM is not a one-size-fits-all approach. Its design and execution vary based on organizational culture, financial capacity, and managerial priorities (Jankensgård, 2021). A central concept within ERM is risk appetite, which refers to the degree of risk a company is willing to accept in pursuit of its objectives. Because there is no universal standard for defining risk appetite, firms must tailor their assessments to reflect not only anticipated benefits and expected returns, but also their financial resilience, ethical values, and long-term strategic goals (Green, 2016; Jankensgård, 2021). The process of assessing risk typically involves three key stages: identifying potential risks and their sources, analyzing their likelihood and consequences, and evaluating the outcomes against predefined criteria (Green, 2016; International Organization for Standardization, 2018).

ISO 31000:2018, a global standard for risk management, from the International Organization for Standardization (ISO) outlines that both quantitative and qualitative methods may be

employed in risk analysis (ISO, 2018). Quantitative assessments can be appealing due to their use of measurable data—often assigning numerical probabilities and monetary values. However, even these estimates are subject to uncertainty, especially in dynamic business landscapes, affected by political, environmental, and social variables (Emblemsvåg & Endre Kjølstad, 2006; Jankensgård, 2021).

Qualitative methods, while inherently more subjective, allow firms to evaluate less tangible risks – such as reputational, strategic or legislative threats – that are difficult to quantify. These methods are often preferred by firms, where the assessments rely on expert judgement. Professional experience, managerial intuition, or “gut feeling” are an inherent part of a qualitative approach. Albeit more susceptible to bias, the qualitative approaches enable firms to assess and navigate more complex and abstract risk domains where hard data may be lacking (Emblemsvåg & Endre Kjølstad, 2006).

Once the risks have been analyzed, firms must evaluate them by comparing the results to their internal risk appetite and established criteria. This evaluation informs decision-makers whether mitigation actions should be implemented, ongoing monitoring is sufficient, or if further information is required (International Organization for Standardization, 2018). A common tool used in this process is the risk matrix (see Figure 2-1) which helps firms prioritize risks by plotting their likelihood against the severity of their potential consequences. The matrix provides a visual overview that aids in identifying which risks warrant immediate action (Green, 2016; ISO, 2018).

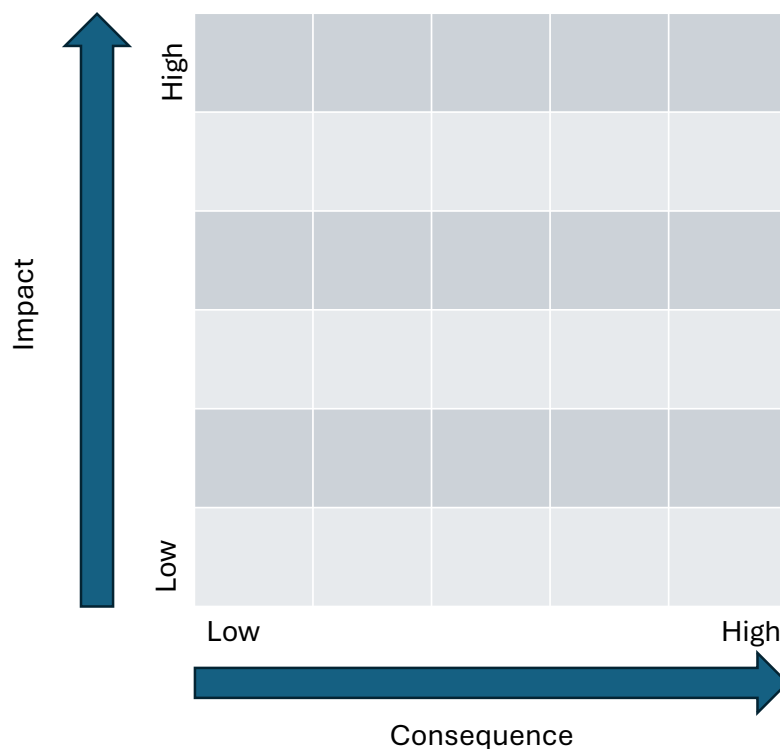


Figure 2-1 An undefined risk matrix. (Source: Author's own illustration. Developed from Green (2016))

Despite its potential benefits, ERM does not come without challenges. Critics argue that formal frameworks such as ISO 31000 and COSO ERM provide vague guidance, particularly around risk appetite, which can result in an oversimplified or inconsistent implementation (Jankensgård, 2021). Further, there is a danger of the ERM giving a false

sense of security, where it is reduced to a checklist exercise rather than a dynamic and strategic guidance tool. Firms can overlook emerging risks or fail to adapt their strategies accordingly. Moreover, the promotion of short-term targets or Key Performance Indicators (KPIs) within some ERM models, can inadvertently lead to firms prioritizing immediate goals at the expense of long-term resilience. The KPIs can, in some cases, become a risk themselves, where resources are diverted from more strategically aligned objectives (Jankensgård, 2021).

2.1.1 Risk Management and Aquaculture

Luna et al. (2023) explore how the aquaculture sector lags behind other industries in terms of risk management. Due to how diverse the industry itself is in terms of production methods, species and physical environment, it makes it difficult to apply a general risk model. As a result, individual risk assessments must often be conducted for each case (Luna et al., 2023). This claim is further supported by an analysis done by the FAO in 2009 (Arthur et al., 2009), which highlights that while risk management frameworks have broad applicability in aquaculture, they are most commonly used to assess societal risks and the environmental impact of aquaculture development. Consequently, these frameworks are rarely used to evaluate the risks faced by the aquaculture firms themselves, particularly those posed by the physical, social and economic environments. Addressing these risks could help firms develop more sustainable practices within the sector (Arthur et al., 2009). Moreover, the focus tends to be on the risks the aquaculture firms pose to the external environment, rather than the risks they face themselves.

2.1.2 Risk Categorization

There are several risk categories that frequently appear in management literature, including financial risk, in particular operational risks, and compliance or legislative risks (Hopkin, 2018). However, neither ISO 31000 (2018) nor COSO (2017) provide specific categories, leaving it up to firms to determine the relevant classification for their business context. Risk categorization can be tailored to sector-specific frameworks or even to the needs of individual firms (Jankensgård, 2021). When deciding on risk categories industry specific knowledge, consultants and stakeholders are commonly used. The same goes when identifying the risks themselves, albeit scientific literature can be used as well. Jankensgård (2021) found that when registering risks, firms sort them into overarching categories as they find appropriate. Categorizing the risks aids in making sense of them but is not a necessary part of the process.

In aquaculture some key risks to explore include financial, operational, biological, social and environmental risks (Luna et al., 2023; Pham et al., 2021; Yang et al., 2020). While there are few publications that focus specifically on CCA frameworks for aquaculture, the majority of studies, except for those by Luna et al. (2023) and Yang et al. (2020), do not specify risk categories (Arthur et al., 2009; IFAD, 2014; Lindegren & Brander, 2018; Luna et al., 2023; Marvin et al., 2020; Yang et al., 2020).

2.2 The Risk Landscape of Norwegian Aquaculture

2.2.1 The Aquaculture Value Chain

Sea farmed aquaculture does not come without its set of environmental risks and sustainability challenges, where the farming practices impact the natural environment. In aquaculture corporate firms typically control most of their value chain, in some cases even producing their own feed (Asche et al., 2018; Vlachos & Malindretos, 2023). From hatchery to processing, production is often managed within the same firm. This gives firms control

over a large part of their value chain, offering opportunities to analyze and respond to risks directly, rather than relying on suppliers for information and responses.

A report conducted from a project named the Aquarius project mapped out the supply chain of salmon farming, using a comprehensive literature review, expert interviews and an online questionnaire (Marvin et al., 2020). Due to the extensive research done for the Aquarius project it will serve as the primary source in this thesis to explain the value chain and its process (See Figure 2-2). For the climate risks, Falconer et al. (2022) compiled a comprehensive overview of climate risks posed to aquaculture in Norway. This review is referred to in a working document from the EU on CCA in aquaculture and will henceforth be used as a main source for the climate risks posed to aquaculture.

During breeding, eggs from the broodstock – adult salmon kept specifically for breeding purposes – are fertilized. Broodstock fish are either kept in land-based cages or in sea cages until they are ready to spawn, after which they are transported to the hatchery (Falconer et al., 2022). The eggs, and later the alevins (the first stage after hatching) are kept in tanks in the hatchery. There are two common systems used: flow through tanks where the water is exchanged at a defined rate from a water source, and a recirculating aquaculture system where the water is cleaned before being returned to the tanks (Bregnballe, 2015). Hatchery is a long and delicate process where environmental variables such as oxygen levels in the water, temperature and light are closely monitored and controlled in closed facilities (Benchmark Genetics, 2019). Bio security is of high importance in the breeding phase, as it is a delicate process (Marvin et al., 2019).

Once the eggs hatch the alevins are transferred into other tanks and feeding begins, depending on the husbandry practices. During the juvenile stage the fish are kept on land in tanks using the same systems as in the hatchery. This can be within the same facilities, or the fish are transported to another location. During this stage the fish undergo smoltification, where the salmon adapt from freshwater to saltwater (Falconer et al., 2022). When using freshwater, it is not only important to ensure access to a high-quality water source, but the wastewater from the facilities must be considered. Both breeding and juvenile stage of the value chain can be impacted by increased storms, flooding and other weather damage to infrastructure. Furthermore, dependent on inlet water, the quality of it must be pristine to ensure biosecurity, and there must be consistent water availability (Falconer et al., 2022).

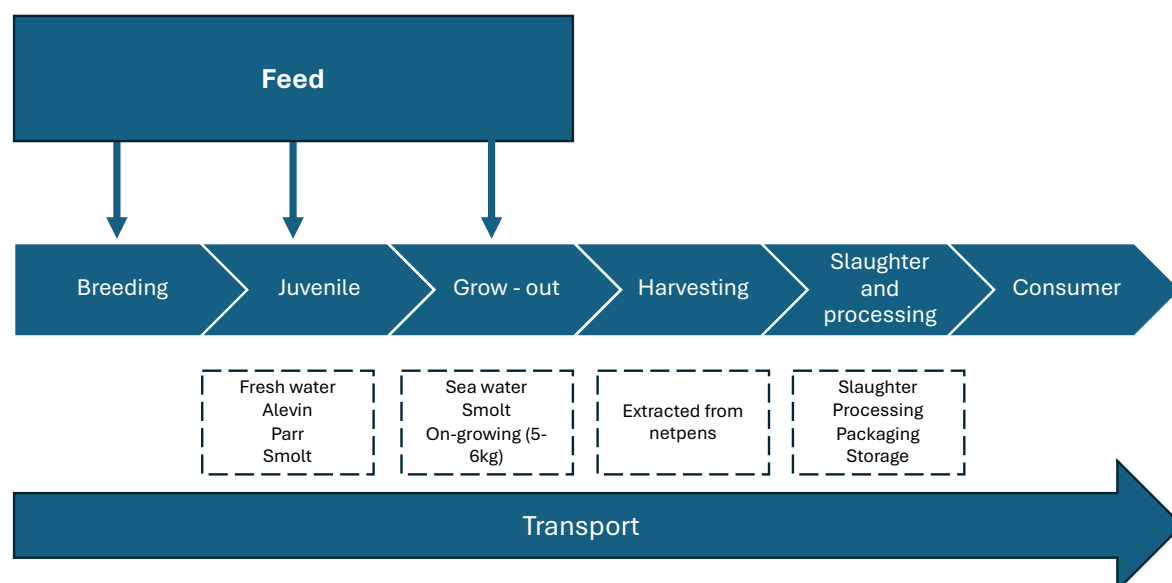


Figure 2-2 The supply chain of an aquaculture sea farm. (Source: Author's own illustration. Developed from Marvin et al., (2020) & Falconer et al.,(2019))

Once juveniles have reached sufficient size they are transferred to the ocean and placed in net pens, where they grow to market weight. This grow-out phase is the longest and most environmentally exposed stage of the production cycle. In open water, salmon are vulnerable to a range of biological threats, including pathogens, bacteria, and parasites (Marvin et al., 2020). In addition, environmental changes such as oxygen depletion, temperature fluctuations, and the introduction of invasive species present significant operational challenges (Falconer et al., 2022).

Climate change is expected to increase ocean temperatures along the Norwegian coast, potentially triggering cascading effects on marine environmental conditions. Increased water temperatures are associated with reduced availability of oxygen, which can lead to hypoxia and stress among farmed fish. Warmer conditions also encourage the proliferation of harmful algal blooms, which can lead to eutrophication and compound oxygen-related challenges. Moreover, there is well-established evidence linking increased temperatures to a rise in viral and bacterial disease prevalence, which may intensify in future climate scenarios (Falconer et al., 2022).

Another emerging concern is the increase in jellyfish blooms, which have been observed with greater frequency in recent years. Jellyfish can cause gill damage and other fish welfare issues when present in high concentrations (Baxter et al., 2011; Bosch-Belmar et al., 2021). However, the relationship between increased jellyfish blooms and climate change is not completely understood, with limited research on causality and long-term trends (Falconer et al., 2022).

Several parasites currently affect salmon aquaculture in Norway, with salmon lice (*Lepeophtheirus salmonis*) and amoebic gill disease (AGD) identified as the most serious. Temperature and salinity are considered key environmental variables influencing these infections. AGD was first observed in Norway in 2006, in conjunction with elevated sea temperatures and reoccurred in 2012 (Falconer et al., 2022). Since then, it has become a persistent challenge for the industry (Lillehammer et al., 2019). The disease impairs gill function, making salmon more vulnerable to low-oxygen conditions, which are also

increasingly common due to warming waters and eutrophication (Falconer et al., 2022; Lillehammer et al., 2019). Sea lice remain one of the most prominent threats. These parasites attach to the salmon's skin, creating lesions that weaken the immune system and increase mortality (Finstad et al., 2010). Warmer sea temperatures not only accelerate lice reproduction but also enhance the dispersal of larvae through ocean currents, affecting both farmed and wild salmon populations (Finstad et al., 2010; Vollset et al., 2018). This creates not only operational and fish welfare risks, but also ecological and reputational concerns due to impacts on wild species.

While the harvesting and processing phases are generally less directly exposed to climate variability, some indirect risks exist. During harvesting, fish are pumped into well boats and transported to shore for slaughter. This operation is dependent on reliable infrastructure and weather conditions and can be disrupted by extreme weather events such as storms. Increased air temperatures may also create new challenges for food safety and energy use. Higher temperatures can promote the growth of foodborne pathogens and increase the need for cooling systems within processing plants, raising both hygiene risks and energy costs (Falconer et al., 2022).

Feeding is an integral part of salmon farming, occurring throughout most of the production cycle. Salmon require different nutrient levels at various stages of their life, and environmental conditions, cage system and feed type all influence feed uptake and distribution (Marvin et al., 2019). Farmers monitor feed intake closely, aiming to maintain a low feed conversion ratio (FCR), the amount of feed required to produce one kilogram of fish biomass (Kg feed/Kg fish). Atlantic salmon is one of the most efficient aquaculture species, with an average FCR of approximately 1.3 (T. S. Aas et al., 2022). The appetite and growth of Atlantic salmon is seasonal, influenced by both temperature and photoperiod (Imsland et al., 2014; Nordgarden et al., 2003). While increased temperatures and the photoperiod may accelerate growth rates, especially in land-based freshwater phases, they can induce early sexual maturation. This affects the quality of the flesh and the overall growth performance (Marvin et al., 2019). During the early stages of production, these factors are more easily controlled through artificial lighting and temperature regulation in tanks.

Atlantic Salmon is typically fed feed pellets which are composed largely of soy and wild caught small pelagic fish, both of which raise environmental concerns. Soybeans are not part of the salmon's natural diet and while selective breeding has produced phenotypes that are able to easily digest it, this practice has drawn criticism from animal welfare advocates who consider it unnatural (Salin et al., 2018). Furthermore, soy and grains used in aquafeed are grown on land, exposing the supply chain to the vulnerabilities of agriculture. Climate change is expected to amplify risks such as drought, crop failure, and yield volatility, increasing the operational and financial risks associated with feed production (IPCC, 2022b).

The high soy content in the feed is, in part, a response to another major sustainability challenge: the overexploitation of wild fish stocks. These stocks, traditionally used as a protein source in aquafeed, are under immense pressure and are depleting rapidly. The stocks are not recovering fast enough to match the fishing rate, making the long-term availability of marine ingredients highly uncertain (Bregnballe, 2015; Tocher, 2015). Moreover, rising sea temperatures and shifting oceanic conditions are already contributing to the migration and depletion of fish stocks, further complicating sustainable sourcing (Falconer et al., 2024).

The transportation of the fish also raises concerns. Live fish are transported between facilities by road, making the industry susceptible to disruptions caused by extreme weather events (Gephart et al., 2017). Transportation of the finished product relies on air, road, train and ship, all of which will be impacted differently by the changing climate (Gephart et al., 2017). Industry examples of delayed shipping due to climate events have already been noted (Ho, 2022). Damaged infrastructure, storm-related flight delays and cancellations, along with rising fuel costs from taxation and environmental regulations, are posing both logistical and financial challenges (Falconer et al., 2022).

Although literature on consumer-related climate risks in aquaculture is limited, existing research shows that fish welfare is a major concern for consumers, particularly in salmon markets (Olsen et al., 2021). As a business-to-consumer (B2C) product, salmon farming is especially sensitive to reputational risk. Firms must maintain a positive public image to ensure continued market demand. Public concerns often center on the environmental impact of farming practices and the use of shared natural resources, such as coastal waters (Olsen et al., 2021, 2023; Tiller & Richards, 2018). Failure to adapt to climate change and mitigate its effects, especially those impacting animal welfare, may negatively influence consumer preferences, thereby increasing reputational exposure. As such, proactive CCA and transparent sustainability practices are increasingly essential not only for operational resilience but also for consumer trust and brand reputation (Negri et al., 2021).

2.2.2 The Physical Environment of Norway and Climate Change

Norway is located in Northern Europe, where it reaches from 57°58'N to 71°11'N, a large part of the Scandinavian peninsula. The country extends to the northwest, bordering the North Sea. With a long coastline filled with fjords and island, the country has five climate zones according to the Köppen classification system (Ketzler et al., 2021). Atlantic salmon has high oxygen requirements, specific temperature requirements, and is sensitive to pollution. These factors limit its farming to particular geographic locations. In Norway, the Atlantic Ocean current brings in warm water to the fjords, which have low pollution and oxygen rich waters, making the conditions ideal for farming this species (Hermansen & Heen, 2012).

Salmon farms in Norway are distributed across the coastline, with highest concentration of farms to the southwest of the country between latitudes of 62°N-66°N (see Figure 2-3). Over the past two decades, Norway's average air temperature has increased by 1.1°C. Given the hundreds of fjords in the country, each with its own microclimate, oceanic conditions such as oxygen levels, water temperature, as well as weather conditions, will differ across locations (Hermansen & Heen, 2012). This variation underscores the importance of localized climate change projections for both short term and long-term scenarios.



Figure 2-3 Aquaculture production sites in Norway (includes Trout and Shrimp) (Source: Author's own illustration. Data source: Norwegian Directorate of Fisheries (2024))

Climate change projections attempt to predict the change in the climate and frequency of extreme weather events, depending on several variables. Models vary by temporal scope, with near-term (today-2040), medium-term (2041-2060) and long-term (2081-2100) projections (IPCC, 2021). Not all models have near or medium-term projections, and regional averages are often used (Falconer et al., 2020). These projections are further dependent on the representative concentration pathways (RCPs) and the shared socio-economic pathways (SSPs). There are four RCP scenarios, each representing different future global GHG emission trajectories, depending on societal changes. These are modeled in five different SSP scenarios, which each account for different socio-economic developments and how they align with the respective RCPs (IPCC, 2021). There are over 100 models available for climate modeling, varying in granularity, perils and SSP pathways. Some models are region-specific and consider local geographical factors (IPCC, 2022a). Their results vary significantly and the difference in granularity and perils makes them difficult to compare (Falconer et al., 2022).

It is common to combine various models to decrease uncertainty and get more robust results (IPCC, 2021). These projections are further dependent on the representative concentration pathways (RCPs) and the shared socio-economic pathways (SSPs). Falconer et al. (2024) highlight that there are few climate models available specifically for Norway, and those that

do exist often have low spatial resolution, rendering them relatively generic. As a result, there are significant limitations in making meaningful comparisons between models or generating specific, location-based predictions. In addition to the inherent uncertainties related to future emission scenarios, the limited accuracy and resolution of the available models present further challenges for climate risk assessment in Norway.

A fundamental challenge associated with using different SSP scenarios in strategic industry planning lies in the inherent uncertainty. While it is possible to make an educated guess about the future global socio-economic landscape and the general direction of societal development, these trajectories are highly dynamic and unpredictable. Forecasting decades into the future can never be fully accurate, making the selection of a specific SSP scenario for corporate adaptation planning highly challenging, even for near-term horizons (Yang & Cui, 2019).

Despite the emergence of regulatory and voluntary reporting frameworks, such as the Task Force on Climate-related Financial Disclosures (TCFD), which require firms to assess and disclose climate-related risks, the private sector has made only limited progress in advancing CCA strategies (Hennes et al., 2024). Moreover, academic literature exploring the reasons behind this slow progress remains scarce. A comprehensive literature review by Hennes et al. (2024) found that there is limited literature on the outcomes of strategic corporate adaptation and resilience along with its drivers. These findings align with an earlier study by Linnenluecke et al. (2013), which highlighted the persistent gap between insights generated by the natural sciences and their application in business and management studies. Much of the existing literature remains focused on the physical impacts of climate change, with even less attention given to transition risks, regulatory shifts, or liability issues.

For Norwegian aquaculture firms, the application of SSP pathways and RCP scenarios presents considerable uncertainties. Conducting localized climate projections and interpreting model outputs requires both significant resources and specialized expertise. Firms would typically need to acquire external competence to carry out these tasks, which are often both time-consuming and costly. Moreover, the coarse spatial resolution of most available climate models fails to adequately capture the specific local conditions that individual farms experience. As Falconer et al. (2020) note, projections at such generalized scales can be misleading, and adaptation measures for aquaculture must often be tailored to the specific conditions of individual farms.

This indicates that, while the Norwegian aquaculture industry may appear relatively homogenous at a sectoral level, CCA priorities can differ substantially at the farm level, depending on site-specific vulnerabilities and environmental exposures.

2.2.3 Norwegian Regulatory Landscape

The Norwegian government has implemented several control mechanisms for aquaculture throughout the decades (Hersoug, 2022). There are six different ministries and authorities involved in various administrative monitoring such as fish farm licensing, environmental protection, management of coastal area, fish welfare and site planning (Holmen et al., 2018). While the specificities of each authority or legislation will not be explained in this thesis, a general overview of relevant regulations will be provided.

The regulatory landscape in Norway is extensive and often perceived as complex and difficult to navigate (Hersoug, 2022). Norway is renowned for having some of the strictest aquaculture regulations globally, with a strong emphasis on environmental protection and

fish welfare (Olaussen, 2018). The six governing bodies are responsible for granting licenses to aquaculture firms, a process that can be particularly challenging for newcomers. The standard costs for a new license range between 12.6 million and 16.8 million euros (Hersoug, 2022), creating a significant financial barrier to entry.

The Institute of Marine Research publishes an annual risk report assessing Norwegian aquaculture practices. The 2025 report focused on nine key risks, eight of which occur within the grow-out phase of the aquaculture value chain (Grefsrud et al., 2025). Notably, the top two risks identified in the report have direct operational consequences for firms and can influence licensing decisions (Grefsrud et al., 2025).

One important regulatory tool introduced in 2017 is the Traffic Light System (TLS) (Regulation FOR-2023-12-14-2087). Under this framework, the Norwegian coastline is divided into thirteen production areas. Firms are required to monitor and report the number of female sea lice per fish. Based on the levels of lice and their impact on wild salmon populations, authorities can mandate a reduction in production for affected areas in the subsequent year. The system uses a color-coding mechanism, red, yellow, and green, to determine whether production may increase, remain stable, or must be reduced (Regulation FOR-2023-12-14-2087).

TLS functions as a form of environmental risk management, linking farm operations directly to ecological monitoring and requiring firms to adapt based on environmental outcomes. Despite its intentions, the TLS has faced scientific criticism. Some researchers argue that it is an ineffective tool for protecting wild salmon populations, citing issues with enforcement and biological assumptions (Eliassen et al., 2021; Jensen et al., 2024). In addition to standard licensing, Norway offers development licenses for innovation and special-purpose licenses for research and development (Hersoug, 2022), which often involve partnerships between research institutions and established farms.

While Norway's TLS is widely considered the most robust legislative framework for managing sea lice impacts compared to other European countries (Vormedal & Larsen, 2021), it is not the only example of environmental legislation targeting the sector. In 2024, the government introduced a new pollution regulation, and in mid-April 2025, it published a white paper outlining the future direction for Norwegian aquaculture (Norwegian Ministry of Foreign Affairs, 2022). The white paper emphasizes the need to lower the industry's environmental impact and improve fish welfare, setting forth a long-term strategic roadmap.

The white paper has received mixed reviews from decision makers within firms. Some are frustrated by the lack of concrete action within the plan and the focus on conducting further assessments before implementing changes. Others welcomed the emphasis on stricter environmental regulations and fish welfare (Negrete, 2025). Key proposals in the white paper include the introduction of a quota-based system for managing lice, auctioning of new licenses to facilitate market entry for newcomers, the establishment of an integrated database for site selection, and a move toward technological neutrality, allowing firms greater flexibility to choose farming systems best suited to their operational needs. These proposed reforms aim to stimulate innovation while maintaining regulatory oversight (Department of Trade, Industry and Fisheries, 2025).

2.3 Best Practices

Climate change has already begun to affect various regions and industry sectors, including aquaculture. While some of the challenges facing Norwegian aquaculture may be relatively new to Norway, they are not necessarily unfamiliar within the global aquaculture sector. However, extrapolating adaptation tools or knowledge from other regions to the Norwegian context is challenging. Asia accounts for approximately 70% of all farmed aquatic animal production (FAO, 2022), but significant differences in species, climate, market structures, and political frameworks make direct comparisons difficult.

Literature reviews and public reports from international organizations often offer broad, sector-wide recommendations, which tend to lack geographic or operational specificity. As a result, their case studies and recommendations may be of limited relevance to Norwegian conditions (Galappaththi et al., 2020). Additionally, aquaculture is often grouped together with fisheries in policy and guidance documents from institutions such as the FAO and the EU. For example, in a major FAO report on CCA, only 22% of the featured case studies focused specifically on aquaculture (Poulain et al., 2018). Multiple reviews have shown that most case studies, sometimes all, were conducted in the Global South, often led or supported by institutions in the Global North (Ahmed et al., 2019; Galappaththi et al., 2020; Poulain et al., 2018).

Falconer et al. (2022) identified 101 adaptation tools and responses applicable to the Norwegian aquaculture sector, derived from an extensive literature review. However, the study did not include interviews with industry representatives, which limits understanding of how relevant or feasible these tools are in practice. Of the 101 responses identified, 39 were technological and 32 were biological, meaning that approximately 70% focused on adjusting salmon phenotypes, improving handling, or enhancing production technology. These types of interventions, technological upgrades and shifts in farming practices, are commonly cited across global literature as effective adaptation measures (Abu Samah et al., 2021; Ahmed et al., 2019; Galappaththi et al., 2020; Lebel et al., 2021; Poulain et al., 2018).

Examples of such practices include diversifying farmed species, modifying production cycles (e.g., keeping smolts on land longer), and selective breeding for heat or disease tolerance (Falconer et al., 2022; Lebel et al., 2021; Poulain et al., 2018). However, implementing these measures requires alignment with site-specific environmental conditions, farm-level decision-making, and regulatory flexibility, which limits their direct transferability across regions.

In addition to technical solutions, several studies highlight the importance of knowledge sharing and institutional support in advancing CCA. Increasing internal knowledge within firms about climate risks and improving capacity to interpret climate data are crucial steps toward proactive adaptation. Government support for research and development also plays a critical role, particularly in generating localized climate data and improving modeling accuracy. Furthermore, institutional mechanisms such as policy reforms, regulatory frameworks, and financial incentives are frequently cited as key drivers of adaptation, both at the firm and governmental levels (Abu Samah et al., 2021; Galappaththi et al., 2020; Poulain et al., 2018). Nevertheless, due to the context-specific nature of regulatory regimes and firm-level needs, no single policy approach or adaptation measure can be universally applied to the Norwegian aquaculture industry. This emphasizes the need for localized, sector-specific approaches informed by empirical insight.

2.4 Influential Factors for Risk Management and Climate Change

Management and organization theories seek to explain the behavior and rationale behind decision-making within organizations. While no single theory is able to fully encompass nor explain all aspects of organizational behavior, combining and utilizing them to analyze the data can be valuable. Appropriate theories can guide the analysis and explain and conceptualize the findings (Podsakoff et al., 2016; Shepherd & Suddaby, 2017). For this study, institutional theory, institutional inertia, which is derived from institutional theory, and a risk management framework are used to guide the analytical framework. Although climate change is not a new topic, literature on its impact has been found to be more concentrated in business and management journals compared to natural sciences (Daddi et al., 2018).

2.4.1 Institutional Theory and Isomorphism

Institutional theory is one of the more prominent frameworks in management literature when studying organizational responses to climate change (Daddi et al., 2018). In particular, neo-institutional theory emphasizes the role of external institutional pressures in shaping how organizations behave. The theory poses that organizations within the same sector often adopt similar structures and practices. This is not primarily due to efficiency or competition, but as a response to institutional pressures (DiMaggio & Powell, 1983). These pressures drive conformity, a process referred to as institutional isomorphism, wherein firms become increasingly alike over time (Daddi et al., 2020).

Institutions are regulatory, normative or cognitive systems that structure social behavior and societal functions (Bag et al., 2023). This can be formal institutions such as governmental agencies, firms, or informal ones like societal groups, culture, and values (Hodgson, 2006). Organizations respond to these systems to gain and maintain legitimacy, which is essential for their survival and acceptance in society. Legitimacy refers to the perception that a firm's existence and actions are appropriate, desirable, or acceptable within a socially constructed system of norms, values, and beliefs (Lammers & Garcia, 2013; Sminia, 2024). Firms must go beyond mere operational efficiency – they must contribute to societal expectations and uphold social norms. Maintaining legitimacy can serve as a source of competitive advantage (Sminia, 2024).

Institutional isomorphism is typically categorized into three mechanisms: regulatory, normative and coercive (Daddi et al., 2020; DiMaggio & Powell, 1983).

- **Coercive isomorphism** arises from formal and informal pressures exerted by stakeholders upon whom organizations depend. These include political mandates, regulatory requirements, and expectations from actors such as employees, communities, and governments (Daddi et al., 2020; Kauppi, 2013). This form of pressure is closely linked with maintaining legitimacy (Kauppi, 2013).
- **Normative isomorphism** results from professionalization, whereby norms, standards, and best practices are disseminated through education, professional training, industry associations, and the mobility of employees between organizations (Daddi et al., 2020).
- **Mimetic isomorphism** occurs when firms imitate strategies and practices of other successful or established peers. It is usually driven by uncertainty. When goals or processes are ambiguous, firms may adopt the practices of others perceived as legitimate or effective (Daddi et al., 2020; DiMaggio & Powell, 1983).

Together, these mechanisms explain why firms within the same field often converge in structure and behavior, particularly when responding to complex challenges like climate change.

By implementing CCA, firms maintain their legitimacy, where external demands from society expect actions to the changing climate (Bag et al., 2023). This is accompanied by the assumption that the institutions are demanding firms to respond to. Several studies have concluded that different pressures influence different sectors and geographical locations (Daddi et al., 2020). Aquaculture firms, like any other firm, are influenced by these pressures. There is scarce literature on overarching institutional pressures for the case of aquaculture firms in Norway, but some scientific articles on legislation and stakeholder perception, particularly local community perception, were found (Bjørkan & Eilertsen, 2020; Krøvel et al., 2019; Lindland et al., 2019; Olsen et al., 2023). Finding which pressures are perceived by the industry as influential, how they impact the decision making, and if they external institutions are exerting any pressure at all for CCA, aids in further understanding the sector and its actions.

2.4.2 Institutional Inertia

Institutional inertia refers to the resistance of institutions or organizations to change (Munck Af Rosenschöld et al., 2014). Originating from new institutionalist scholars, this concept is often described using the term “stickiness”, the tendency of established structures and norms to persist even in the face of external pressures or environmental shifts (Samadi et al., 2024). This inertia can manifest as delayed responses to emerging problems, unwillingness to explore new approaches, or a general rigidity that inhibits adaptation at both local and global levels (Aksom, 2022; Samadi et al., 2024).

This resistance to change is perhaps unsurprising given the foundational traits of institutions. Institutions are designed to provide stability, predictability, and consistency, often reinforced through mechanisms of institutional isomorphism. While these characteristics support legitimacy and coordination, they can also hinder flexibility and responsiveness (Aksom & Tymchenko, 2020), especially in the context of rapidly evolving challenges such as climate change.

Munck Af Rosenschöld et al. (2014) found a lag between the advancement of climate change science and the implementation of corresponding policies. They attributed this delay, in part, to systemic inertia within institutions. The complexity of the climate system, with delayed feedback loops, long-term stocks and opaque causal links, contributes to a slower institutional response. Their study identified five key mechanisms that reinforce institutional inertia within climate policy: cost, uncertainty, path dependency, power and legitimacy. While additional factors may contribute, these five are consistently highlighted in the literature as central to understanding inertia in climate governance (Samadi & Afroozeh, 2024).

2.4.2.1 The Five Mechanisms of Inertia

Climate change presents significant costs for organizations, contributing to institutional inertia. It is widely posed as a problem of public good provision, where the benefits of action are diffuse, and the consequences of inaction are delayed. Because climate change does not always present an immediate threat to institutional objectives, there is often limited motivation for individuals or organizations to bear the costs of proactive actions (Munck Af Rosenschöld et al., 2014).

There are two primary types of cost-related barriers that have been identified: transaction costs and free rider costs (Munck Af Rosenschöld et al., 2014). Transaction costs refer to the administrative, financial and organizational burdens involved in coordinating climate action, particularly in the face of long-term and uncertain outcomes. If these costs are not addressed early, they can escalate over time, becoming significant obstacles to adaptation (Samadi et al., 2024). These costs are often exacerbated by inefficient communication and negotiation processes among stakeholders.

In parallel, free rider costs emerge when actors benefit from the CCA efforts of others without contributing themselves. This collective action problem results in widespread inaction, as organizations are reluctant to move independently without guarantees of reciprocal effort (Munck Af Rosenschöld et al., 2014; Samadi et al., 2024). This persistence of economically efficient but unsustainable practices reinforces the status quo. While these practices may be optimal from a short-term or private-interest standpoint, they are misaligned with long-term societal and environmental goals.

Beyond the issue of cost, uncertainty is another mechanism contributing to inertia. This uncertainty often delays institutional responses. When information is incomplete or ambiguous, decision-makers can delay action out of concern for regret potential, the risk of investing in adaptation strategies or technologies that may later prove to be unnecessary or ineffective (Munck Af Rosenschöld et al., 2014). Uncertainty thus reinforces a preference for the known and stable over new and experimental. Institutions, particularly those that are well-established and risk-averse, tend to favor strategies that have historically been proven effective, even when those strategies may not be adequate for future climate conditions (Samadi et al., 2024). This dynamic is shaped by an organization's risk appetite; lower tolerance for risk encourages a reliance on familiar systems rather than pursuing adaptive innovations based on uncertain forecasts (Samadi et al., 2024).

The third mechanism of inertia is path dependency, the tendency of past decisions and established trajectories to shape and constrain future organizational choices. In this context, institutions and firms often remain locked into existing practices, not necessarily because they are most effective, but because prior investments, infrastructures, and policies make deviation costly or complex (Munck Af Rosenschöld et al., 2014). Large capital investments in technology, long-standing regulatory frameworks and deep-rooted political interest can reinforce the status quo (Argyriou & Barry, 2021). An example is aquaculture firms which have invested heavily in infrastructure suited to stable environmental conditions might be reluctant to adopt new, climate-resilient technologies, even when emerging risks make them more appropriate. Similarly, policy regimes that favor existing production models may discourage experimentation with adaptive methods, such as offshore alternatives or use of biotechnology for genetic altering.

Power dynamics represent the fourth mechanism contributing to institutional inertia and are closely intertwined with path dependency. Fixed social structures not only reflect historical choices but also concentrate power among actors who benefit from the existing system. These actors, whether political leaders, corporate executives, or media influencers, may resist change when it threatens their interest, reinforcing the status quo (Aksom, 2022). In the context of climate change, this resistance can hinder the implementation of adaptation strategies, even when there is strong scientific consensus or economic rationale for change. Power dynamics are particularly influential when they align with institutional legitimacy; as long as dominant actors perceive current practices as legitimate, and no credible pressure exists to challenge them, there is little incentive to pursue alternative approaches (Munck Af Rosenschöld et al., 2014). New policies or innovations that lack endorsement from powerful

stakeholders, risk being dismissed or delegitimized, further delaying necessary adaptation. Thus, power not only sustains existing institutional paths but also actively shapes what is considered acceptable or possible within the CCA discourse.

2.5 Analytical Framework

The scope and context of this study are outlined in chapter 1, where climate risks are defined as the main criteria for this analysis. To answer the overarching research question, what factors influence the implementation of CCA assessment in the Norwegian aquaculture sector, this study draws on two complementary theoretical lenses: institutional theory and risk assessment framework, specifically ERM (see Figure 2-4).

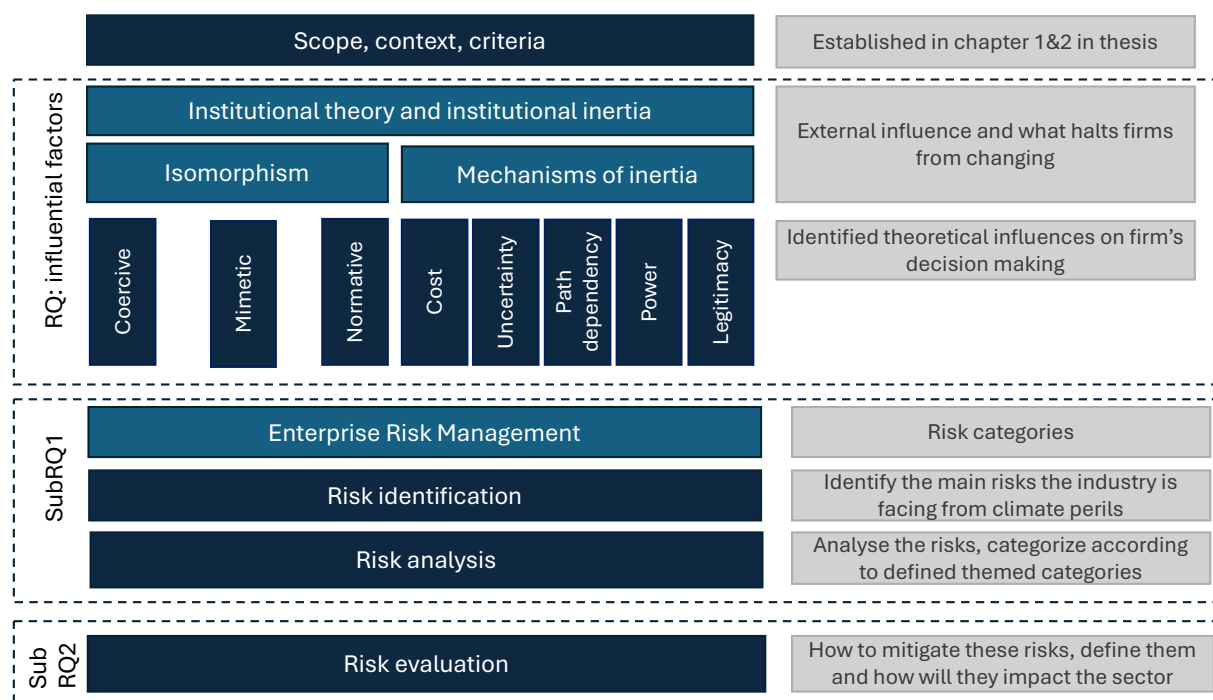


Figure 2-4 The analytical framework (Source: Author's own illustration)

Institutional theory provides a foundation for understanding how external pressures shape organizational behavior. The theory emphasizes three forms of isomorphism, coercive, mimetic, and normative, that drive convergence in organizational practices across sectors (DiMaggio & Powell, 1983). At the same time, institutional theory highlights mechanisms of inertia, such as cost, uncertainty, path dependency, power, and legitimacy, that inhibit change. By exploring both drivers and barriers of change, this framework helps identify why aquaculture firms may either pursue or resist implementing climate risk assessments.

In parallel, CCA requires the identification and prioritization of risks that are materially relevant to firms. For that, the study adopts the ERM framework to structure and categorize the risks identified through interviews. ERM facilitates a systematic approach to risk by organizing them into defined categories, assessing their potential impacts, and identifying mitigation strategies. This enables a more nuanced understanding of how climate risks are perceived, managed, and potentially adapted to within the aquaculture sector.

Together, these two frameworks offer an integrated perspective: Institutional Theory captures the broader external and internal forces influencing firm behavior, while ERM provides a practical model for how risks are understood and addressed at the organizational

level. This dual lens enables a more comprehensive analysis of the barriers and drivers affecting the implementation of CCA practices.

The literature reviewed in preceding sections highlights several critical gaps. While climate change presents both direct and indirect risks across the aquaculture value chain, firms in Norway appear to deprioritize CCA amid complex regulatory environments and more immediate operational challenges. Moreover, existing adaptation frameworks are often based on case studies from the Global South and lack contextual relevance for Norway's high-capacity, export-driven aquaculture sector. These shortcomings point to the need for localized, empirically grounded research into how adaptation is approached in practice. Accordingly, this study is guided by the following research question: What factors influence Norwegian aquaculture firms' implementation of climate risk assessments? Two sub-questions support this aim: (1) What are the major environmental risks facing aquaculture firms in Norway? and (2) What adaptation tools are available to mitigate these risks?

By linking theoretical insights with practical tools for risk identification and decision-making, this analytical framework positions the study to examine both the institutional context and the internal processes that shape CCA within the Norwegian aquaculture industry.

3 Research Design, Materials and Methods

This section presents the methodological approach used in this study, which explores how the Norwegian aquaculture sector manages climate-related risks and what influences a firm's decision-making processes regarding CCA. The aim is to investigate which climate risks are prioritized, how they are assessed and managed, and the factors that shape these responses. To achieve this, a qualitative research strategy was adopted, enabling an in-depth exploration of practices, perceptions and contextual influences. The chapter presents and justifies the research design, including the chosen data collection and analysis methods. Each method is described in detail, along with its relevance to the research objectives and questions. Additionally, the chapter addresses potential methodological limitations and discusses how these were mitigated during the research process.

3.1 Research Design

In order to assess what climate risks are of concern to aquaculture firms and how they are responding, this study follows a qualitative design with semi-structured interviews and a multiple case study approach. Qualitative research is particularly well-suited for exploring complex phenomena where the objective is to understand the meanings, experiences, and perspectives of individuals and organizations (Creswell & Creswell, 2018). This approach enables the researcher to examine both theoretical frameworks and real-world applications of climate risk management in detail. By employing qualitative methods, the study aims to uncover the nuanced decision-making processes involved in CCA, providing insights that are not easily captured through quantitative approaches.

The chosen methods – document analysis and semi-structured interviews – will be employed to gather both secondary and primary data to provide a holistic view of the subject. These data sources will triangulate the findings, which enhances the validity of the findings by enabling cross-verification across multiple perspectives (Creswell & Creswell, 2018). Together they provide a comprehensive understanding of how climate risks are perceived, evaluated, and acted upon in the aquaculture sector.

This study is guided by an "interpretivist worldview", which seeks to understand how decision-makers identify and respond to climate risks. Interpretivism recognizes that these perceptions may differ from those presented in scientific literature. This approach aims to uncover the reasons behind decision-making processes, which can be shaped by culture, history, and personal experiences (Chen et al., 2011; Creswell & Creswell, 2018). This is particularly relevant, for the context of climate risk, as risks are often subjective, uncertain, and difficult to quantify (Jankensgård, 2021). Understanding how decision-makers interpret and respond to these climate risks is essential for explaining the variability in risk management practices across firms.

This research is exploratory in nature and content-driven, where there is not a predetermined hypothesis or an outcome. Instead, the research aims to identify emerging themes and trends to inform the analysis and guide the development of relevant insights (Chen et al., 2011; Creswell & Creswell, 2018). The research design process is seen in Figure 3-1.

The initial literature review allowed for identification of the research gap and guided the formulation of the research questions and analytical framework. The analytical framework was formulated from literature, through books on risk management, and published standards. The literature review also allowed for setting the scope, deciding on Norway and sea farm aquaculture for Atlantic salmon. For data collection, primary data was gathered through semi-structured interviews and secondary data to supplement it was gathered through

document analysis. All data analysis was done through content coding prior to discussing the findings.

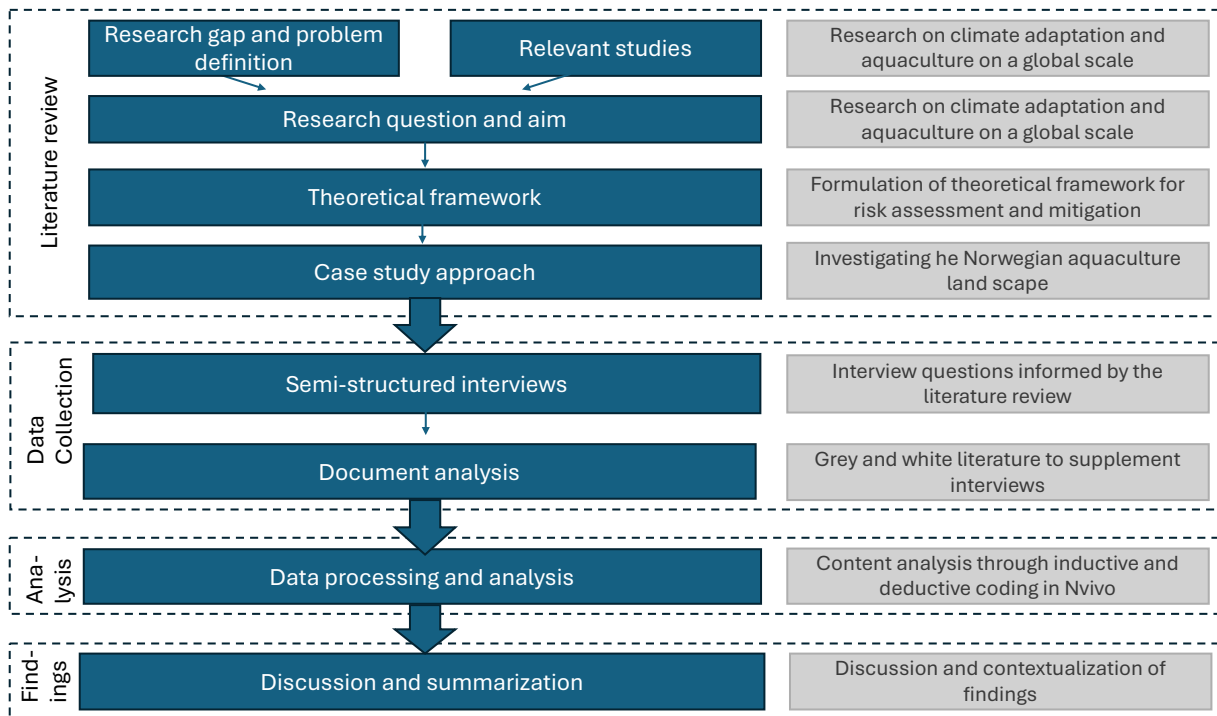


Figure 3-1 Structure of the research (Source: Author's own illustration)

3.2 Sectoral Comparative Approach using Experts' Perspectives

While this research is informed by elements of a multiple-case study design, it does not examine specific firms as bounded cases. Instead, it draws on expert perspectives across the aquaculture industry to explore patterns and explanations for CCA behavior. The "cases," in this context, are represented by different functional roles and institutional perspectives (e.g., private-sector actors, policy advisors, industry consultants), rather than individual companies. This more thematic and sectoral approach enables the study to identify factors influencing adaptation across a range of organizational contexts (Döringer, 2021).

Although Yin (2014) defines case studies as inquiries into contemporary phenomena within real-life settings, he also emphasizes that flexibility exists in how "cases" can be conceptualized, particularly when the objective is to understand complex social processes. In this study, the focus is on the broader dynamics of CCA inertia, making a comparative, expert-informed design more appropriate than a traditional firm-level case study.

The research adopts an explanatory orientation, aiming to uncover causal and structural factors that shape how and why aquaculture firms engage (or fail to engage) in CCA. The use of multiple expert interviews, supplemented by document analysis (e.g., industry reports, white papers), enables a multi-source triangulation of findings. This method enhances both the credibility and transferability of the insights, even without the formal bounding of individual organizational cases (Priya, 2021; Yin, 2014).

By analyzing themes across diverse professional perspectives within the aquaculture sector, the study is able to capture differences, patterns, and tensions in adaptation practices. This approach allows for a rich and contextualized understanding of institutional inertia without requiring a strict case study format.

3.3 Data Collection Methods and Rationale

The research design integrates two complementary data collection methods: document analysis, and semi-structured interviews. Each method offers unique yet interconnected insights into CCA in the aquaculture sector. The document analysis provides contextual information offering a foundation for understanding the formal discourse around risk and adaptation. Semi-structured interviews, in contrast, offer access to in-depth, experience-based perspectives from industry professionals, allowing for the exploration of how adaptation strategies are understood, interpreted, and implemented in practice. By triangulating these two sources, the research aims to develop a comprehensive understanding of climate-related risk management, identify cross-cutting themes, and present a robust account of how adaptation is perceived and approached within the sector.

3.3.1 Stakeholder Mapping and Selection of Case Studies

In qualitative research, participants and documents are selected based on their relevance and potential to provide insights into the research questions (Creswell & Creswell, 2018). To ensure a transparent and theoretically grounded selection process, criteria were created and developed for both interviewees and selected documents, aligning with the study's objective of understanding decision making around CCA in aquaculture.

For selecting case studies, a stakeholder analysis or mapping was done. A stakeholder analysis is a systematic review of relevant actors that influence decision making and strategic management within an organization (Schmeer, 1999). For the purpose of this paper a stakeholder mapping was performed to identify relevant actors to contact for interviews. Identifying the relevant stakeholders and their salience aids in getting a multi-perspective understanding of the aquaculture firms, what influences their decision making and how they are adapting.

The stakeholder groups were informed by Pham et al (2021), who developed a stakeholder framework for CCA in fisheries and aquaculture. They categorized stakeholders into four primary groups: industry actors, advisory bodies, policy makers, and scientific institutions. This categorization was used as a basis for identifying suitable participants. To refine the list of stakeholders, the sustainability reports of three leading Norwegian aquaculture firms, Austevoll Seafood ASA (2023), MOWI (2023), and SalMar (2023), were reviewed. The purpose was to identify stakeholders who directly influence climate-related decision-making within the firms.

Based on this analysis, the scope was narrowed to stakeholders involved in processes within the direct control of aquaculture firms, excluding actors such as NGOs, suppliers, and customers. Although NGOs play an important role in shaping public discourse and environmental accountability, they were considered outside the scope of this study, which focuses on industry facing, internal, views of climate risk assessment and adaptation. Suppliers and customers were also excluded, as they are less likely to possess a holistic view of internal risk management strategies or firm-wide adaptation planning. The final selection of interview participants aimed to include individuals with operational, advisory, or strategic roles within the industry. See Figure 3-2 for an overview of the stakeholder mapping results.

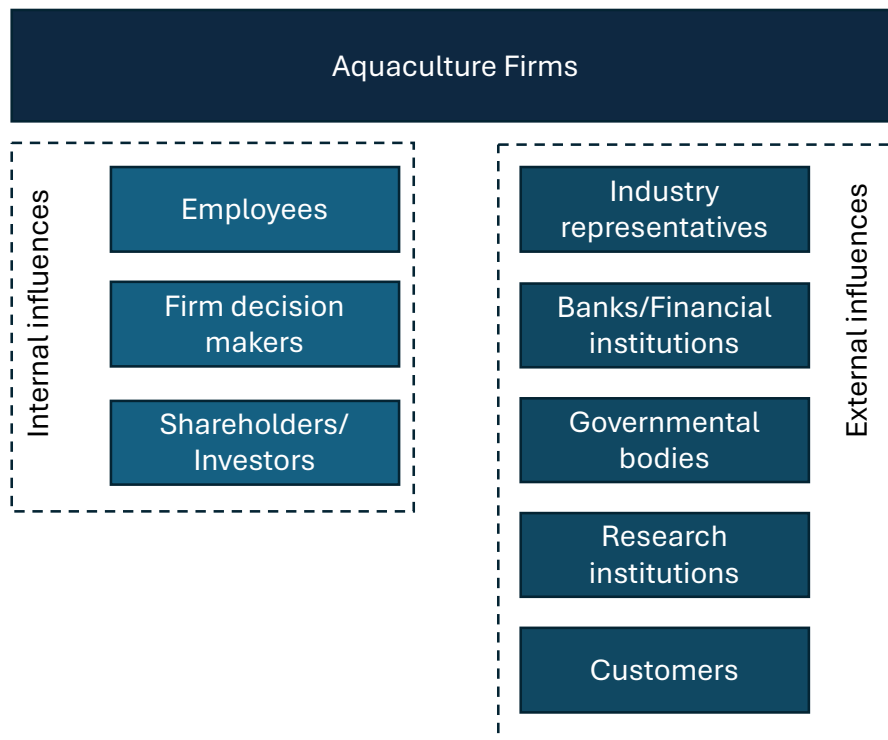


Figure 3-2 Stakeholder map of external and internal stakeholders (source: Author's own illustration)

To further define appropriate interview participants, a set of criteria was developed for both internal and external stakeholders (See Table 3-1). As the study was focused on Norway, it was essential that all interviewees had first-hand experience with the Norwegian aquaculture sector. Insights from the literature review suggested that CCA practices within the industry remain limited. Consequently, the scope was narrowed to focus on corporations subject to the Corporate Sustainability Reporting Directive (CSRD). These firms were considered more likely to possess knowledge of climate-related risks and to engage in structured risk management and strategic planning activities. Including SMEs could have introduced inconsistencies, as organizational responses and capacities may differ significantly by firm size. Therefore, to ensure comparability and internal coherence, the study focused exclusively on corporate entities.

For external, industry-facing stakeholders, an additional criterion was applied: participants were required to have not only relevant expertise in aquaculture, but also a demonstrated focus on climate change, environmental risk, or sustainability strategy. This included individuals whose professional roles involve climate risk management, environmental policy, or research directly related to adaptation in aquaculture. These criteria ensured that selected participants could provide informed, relevant perspectives aligned with the study's objectives.

Table 3-1 Selection criteria for interviewees

Actors	Selection criteria
Firm representatives	• Seafarm – salmon • Norwegian headquarters • Falls within the scope of CSRD (before omnibus) • Is a board member, in a decision leading role or works with sustainability or risk management
Industry facing actors/representatives	• Based in Norway • Research or occupation focused on aquaculture • Extensive knowledge on climate change and/or risks, determined either through published papers or a defined position with an organization

3.3.2 Semi – structured Interviews

For the purpose of this research paper qualitative semi-structured interviews were deemed most appropriate for collecting primary data. Semi structured interviews are open ended and allow the interviewer to ask follow-up questions and the interview setting is more of a conversation (Roulston & Choi, 2018; Yin, 2014). In qualitative research, and particularly in exploratory or case-informed studies, interviews are among the most valuable sources of insight, providing perspectives that may not be available in scientific literature or public policy documents (Creswell & Creswell, 2018; Yin, 2014)

In this study, interviews served to complement the findings from the literature review and document analysis. While the literature highlighted the climate risks facing the Norwegian aquaculture industry and documented relevant regulations (e.g., CSRD), it offered limited insight into how these risks and frameworks are actually understood and applied by industry actors. Semi-structured interviews with key stakeholders thus enabled a deeper examination of how adaptation is interpreted and operationalized within the sector.

To mitigate the risk of bias, careful attention was given to the design of the interview guide. Interview questions were developed in alignment with the analytical framework and grouped into five core themes. These themes provided structure while still allowing respondents the freedom to share their experiences and reflections. In line with Creswell and Creswell's (2018) recommendations, the interview protocol and information sheet were shared with participants in advance. The full interview guide can be found in the appendix. A total of eight interviews were conducted between March 18 and April 8, 2025 (see Table 3-2), with each interview lasting between 30 to 50 minutes. Interviews were conducted online, two via Zoom and six via Microsoft Teams. Before each interview, participants were asked to provide verbal consent for audio recording, and all signed a consent form. The consent form can be found in the appendix.

Table 3-2 List of interviewees

Stakeholder Group #	Interviewee #	Stakeholder group	Position/expertise	Date of interview
S1	F1	Firm level decision maker	Board member, Aquaculture business consultant, former CEO	18.03.2025
S1	F2	Firm level decision maker	CEO	31.03.2025
S2	F3	Firm representative	Fish health and environment	04.04.2025
S2	F4	Firm representative	ESG and environment	14.04.2025
S3	E1	Norwegian governmental agency	Climate change impact on fisheries and aquaculture	08.04.2025
S4	E2	Insurance sector	Head of aquaculture insurance	25.03.2025
S5	E3	Industry representative	Head of environmental department	27.03.2025
S6	E4	Research/academia	Research in aquaculture and climate adaptation	08.04.2025

There are limitations to be considered when using semi-structured interviews as data. The participants are influenced by their personal experience and may interpret questions in varied ways (Creswell & Creswell, 2018). Further, interviewees could display reflexivity, answering what they believe the researcher wants to hear, potentially affecting the authenticity of the data (Yin, 2014). For a case study, the researcher must also be aware of their own biases, particularly in a case-informed study, where they have pre-existing knowledge of the problem and can inadvertently shape the direction of the conversation (Yin, 2014). To navigate these potential risks, several strategies were employed. The interview guide was structured so that key questions were repeated across themes, allowing respondents to revisit topics from different angles. Moreover, a document analysis was used to enhance reliability and cross-check emergent themes (Creswell & Creswell, 2018).

3.3.3 Document Analysis

The document analysis was used as a complementary qualitative method to support the triangulation of findings and contextualize the data gathered through interviews. It is defined as a systematic procedure for reviewing or evaluating documents, enabling the researcher to extract meaningful content from various kinds of textual materials such as reports, policy briefs, press releases, and internal publications (Bowen, 2009). Within qualitative research, and particularly in case-informed designs, document analysis serves as a critical tool for corroborating data, identifying themes, and generating new insights (Creswell & Creswell, 2018; Yin, 2014).

Documents offer several advantages as a data source. They are time-efficient for analyzing, generally accessible and often contain precise factual details such as names, locations and dates (Bowen, 2009). Furthermore, they are unobtrusive, meaning they are not created in response to the research itself, and as such are less susceptible to observer effects or reactivity (Yin, 2014).

However, documents are not free from bias. As with all research, documents contain an inherent bias of the author. The worldview, assumptions, or strategic goals of the document's author can shape the content, particularly in the case of corporate communications or public

relations materials (Bowen, 2009; Creswell & Creswell, 2018). Furthermore, the researcher's selection criteria can be biased, if documents are chosen selectively or in a manner that reinforces pre-existing assumptions (Bowen, 2009). To minimize this risk, the selection criteria were clearly defined to ensure a balanced presentation of perspectives and document types.

The selection criteria for documents was guided by both relevance and source diversity. For corporate annual reports, only those from firms whose stakeholders participated in the interview process were included. This resulted in four annual reports. Additional documents were sourced to represent each stakeholder group identified through the stakeholder mapping process. In total twelve documents were selected based on the following criteria:

- The document must be directly related to aquaculture, climate change, CCA, and/or Norwegian policy or industry
- Preference was given to material produced by organizations involved in the aquaculture sector, including industry actors, regulatory bodies, advisory groups, and scientific institutions.

The full list of analyzed documents can be found in Table 3-3.

Table 3-3 List of documents analyzed

Reference number	Stakeholder group	Type of paper	Title	Date of publication
R1	Firm	Sustainability report	Intergrated annual report 2024	2025
R2	Firm	Sustainability report	Annual report 2024	2025
R3	Firm	Sustainability report	Intergrated annual report 2023	2024
R4	Firm	Sustainability report	Intergrated annual report 2023	2024
R5	Government (EU)	Commission staff working document	Implementing the Strategic Guidelines on EU Aquaculture Climate-change Adaptation in the Aquaculture Sector	2024
R6	Consulting firm	Position paper	The Norwegian aquaculture analysis 2024	2025
R7	Aquaculture assosiation	White paper	Seafood 2030 A blue change of pace	2017
R8	Industry facing research institution	Press release	Climate change adaptation for aquaculture discussed	2024
R9	Consulting firm	Press release	Climate risks in Norwegian aquaculture	2025
R10	Government (NO)	Strategy	A sea of opportunities	2021
R11	Government (NO)	Report	Norway's second Adaptation Communication	2024
R12	Government (NO)	Report	Barriers to Climate Adaptation on the Local and Regional Level	2022

3.4 Data Analysis Methods

For a qualitative study the researcher must go through the information gathered and analyze the findings. It is important to have an analytical strategy when starting work on the data (Yin, 2014). For the strategy, a structure from Guest et al. (2012) was used. First the analytical objectives were set, before doing an analytical plan. The analytical plan for this research was an explanatory analysis, where a mixed approach of inductive and deductive

methods allowed the researcher to identify emerging themes in the data (Guest et al., 2012). The analysis was further a thematic analysis. A thematic analysis enables the identification of patterns within and across data without the bounds of a theoretical framework (Clarke & Braun, 2017). This form of analysis was deemed the most appropriate for this research due to its flexibility, where emerging themes and reoccurring patterns can be identified.

Each interview was recorded and later transcribed. Two interviews were transcribed through Microsoft Word and the rest were transcribed through Microsoft Teams. Each transcript was manually reviewed after, where the audio recording was replayed to review errors and eliminate repeated words. For analyzing the data itself, the qualitative data analysis software NVivo was used. The analytical framework created, based on the theoretical propositions, was used as guidance when starting the analysis (see Figure 3-3). The mixed approach involved starting off with without predefined codes, using an inductive approach. The data was then coded again, with predefined codes gathered from the analytical framework and the literature review, which was the deductive part of the coding process. Using the inductive approach ensures that all aspects and themes of the data are captured (Azungah, 2018). The codes from both reviews were later compared, emerging themes and new codes not captured by the framework were categorized appropriately. This ensured rigid and thorough coding. The coding structure can be found in the appendix. Having coded the data, the final step was framing the findings and to present them along with a discussion.

Part of the objective of this research was to identify the main risks that are posed to the aquaculture firms in Norway. A mixed analytical approach was used to categorize these risks, as it was not known in advance which types of risks stakeholders would consider material. The risk categories were decided upon through an inductive approach, but respondents were asked to identify risks within the value chain. The risks were hence categorized within the value chain (see Figure 2-1) and from there they were viewed, and overarching categories were developed to describe commonalities. This form of coding is common practice as described by Jankensgård (2021). The final coding structure can be found in the appendix (thematic coding structure).

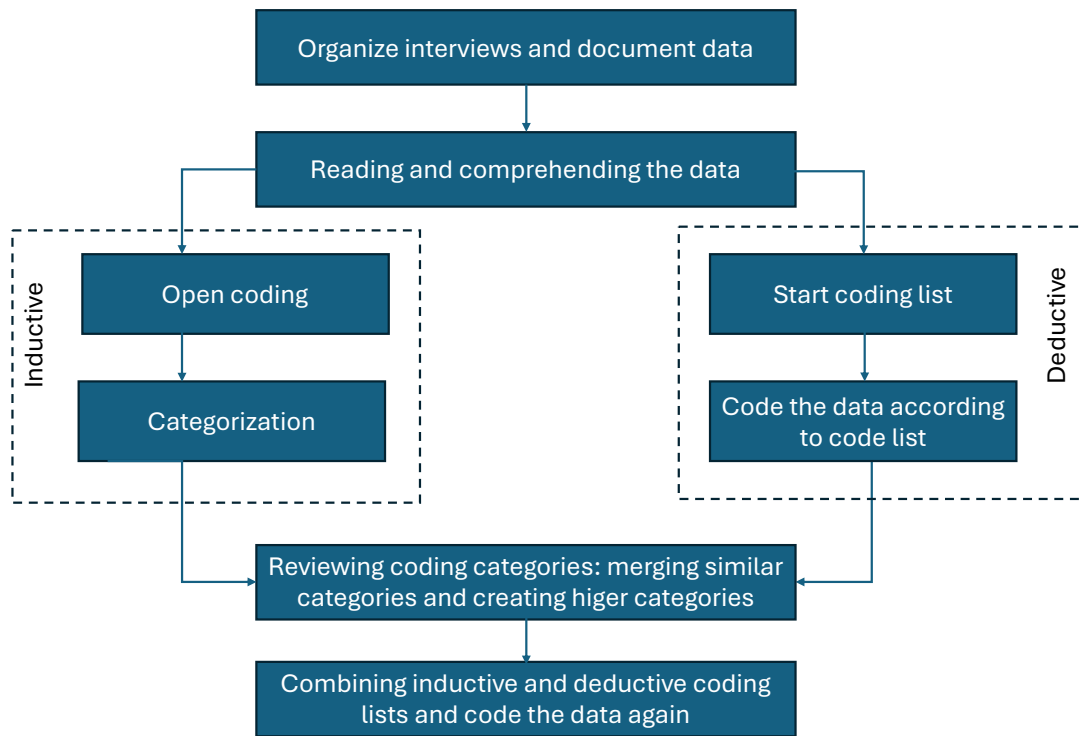


Figure 3-3 The coding approach of mixed methods (Source: Author's own illustration. Developed from Azungah (2018))

4 Findings and Analysis

This chapter presents the findings from the semi-structured interviews and document analysis, structured around the three research questions. Firstly, the larger climate risks of concern to the industry and adaptation tools will be explained from the perspectives of the stakeholders, and the analyzed documents. Secondly, the factors influencing the implementation of climate risk assessment and adaptation strategies to these risks in the Norwegian aquaculture sector are presented.

Throughout the analysis, the interviewees will be referred to by shorthand (see Table 3-2 & Table 3-3), internal firm stakeholders have a numbered shorthand “F” and external stakeholders will be referred to by “E”, followed by their reference number. When referring to firm decision makers, firm representatives or the entirety of stakeholders a shorthand “S” along with a number, is used.

4.1 Risk Management and CCA

Risk management is present to varying degrees across the Norwegian aquaculture sector. Firm representatives and decision makers stated that “day to day risks” were documented and contingency plans generally in place (S1, S2, E3). However, S1, S2 and E4 noted that the concept and application of risk management vary depending on the role and perspective. Risk management encompasses many things and depending on who is asked the answer might differ on its definition and how it should be implemented. As noted by E4, risk is often perceived in relation to an individual’s responsibilities, meaning that definitions and practices differ not only between stakeholders, but also among employees within the same organization.

F4 observed that while most firms maintain an overarching risk management system, its implementation at the operational level remains limited. S1, S3, and S4 described risk management as largely existing “on paper”, with little evidence of systematic action across the enterprise. Although basic mitigation plans were common, these were typically focused on immediate, operational concerns rather than long-term strategic risks.

A recurring theme was the lack of training and awareness among staff. F4 emphasized that employees may follow risk procedures without fully understanding their purpose or rationale. This results in what F4 described as a “box-ticking” approach, where compliance is prioritized over proactive risk prevention. E2 and F3 further noted that even when climate-related events result in financial losses, firms often treat them as isolated incidents rather than triggers for broader adaptation planning. As E2 put it, any heightened awareness that follows such events tends to diminish over time, with focus reverting back to routine operations and frequently occurring risks.

Risk management in Norway appears to be more integrated at a managerial and regulatory level, particularly due to national legislative frameworks (F4, E4). E4 highlighted the role of regulatory mechanisms such as the risk management requirement and the TLS, which embed risk considerations more deeply than other countries. E4 also remarked that risk is an inherent component of business but is not always labeled or formalized as part of a standard risk assessment framework, such as ISO or COSO.

While most salmon farming companies have a general risk policy, and risk is reportedly discussed frequently in board meetings (F1), few have implemented a comprehensive ERM framework. All interview participants (S1–S6) indicated that formal ERM structures, particularly those addressing CCA, are rarely in place.

4.2 Climate Risks and the Industry Response

Three categories of climate risks emerged through the interviews: operational risks, legislative risks and reputational risks. Operational risks are perceived as any risks that impact the day-to-day operations. These risks are inherently linked to financial impact and that was not lost on interviewees. Operational risks are, by some, categorized as a type of financial risk. However, other subcategories within financial risks such as capital structure, liquidity, and credit risk were not touched upon during the interviews. Hence, operational risks were used as a main category, acknowledging that they carry with them various costs. Legislative risks are a category for any compliance risks or challenges that were mentioned. The final category, reputational risks, encompasses any risks that could influence stakeholders' perception of aquaculture firms.

4.2.1 Climate Risks Faced by Firms

All interviewees identified the grow-out phase as the most vulnerable stage of the aquaculture value chain in terms of exposure to climate risks (S1-S6; see Figure 4-1). This finding is consistent with sustainability reports from major firms, which also emphasize the grow-out phase as both a point of high climate exposure and a significant contributor to environmental impacts (R1-R4). Sea-based farms are particularly dependent on natural environmental conditions during this stage, making them highly susceptible to the effects of climate change (R6). When interviewees were asked to categorize the types of climate risks their firms faced, operational risks emerged as the most prominent, both in terms of perceived severity and number of identified risks. Following were legislative risks, frequently cited as well. These findings underscore the dual exposure of the sector: to direct environmental hazards and to evolving regulatory expectations in response to those hazards.

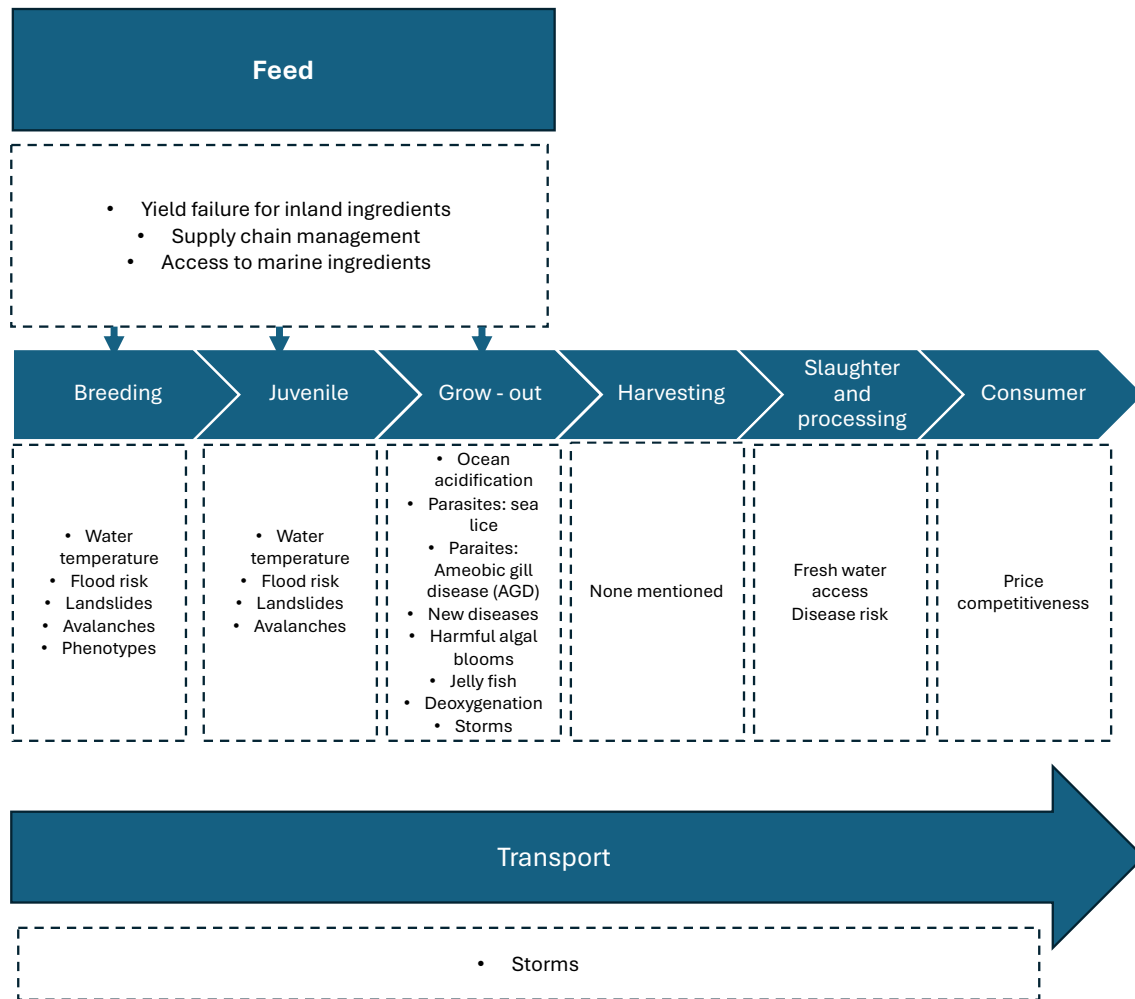


Figure 4-1 Climate risks within the aquaculture value chain (Source: Author's own illustration)

4.2.1.1 The Grow-out Phase

As previously mentioned, the grow-out phase was identified by all interviewees as the stage most vulnerable to climate-related risks (S1–S6). This is echoed in corporate sustainability reports, where climate impacts and environmental pressures are also most frequently associated with this phase (R1–R4). Given its dependency on natural environmental conditions, the sea-based grow-out phase is particularly exposed to changes such as rising temperatures, oxygen depletion, and biological threats (R6).

Sea surface temperature increase was the most commonly cited climate risk. Nearly all identified risks, aside from storms and ocean acidification, were linked in some way to warmer waters (S1–S6). Ocean acidification, mentioned only by F1 and F4, was not perceived as an immediate threat. F1 discussed it in relation to fish feed availability, where wild fish stocks could decrease or migrate due to change in oceanic conditions. F4 described it as a distant and poorly understood risk.

Rising temperatures are directly linked to declining oxygen levels in the water, resulting in both financial risks (e.g., increased mortality) and operational challenges (e.g., altered fish behavior, reduced feed conversion ratio) (E2, E3, F1, F3, R5). Warmer waters also interact with nutrient levels to create favorable conditions for HABs, an emerging and already impactful risk in Norwegian aquaculture (E2, E3, E4, F1, F3, F4).

Sea lice outbreaks were also highlighted as a critical concern. This issue has historically been concentrated in southern Norway but is now increasing in the north as well (S1–S6). A notable outbreak in 2024 revealed a lack of well boat capacity to manage widespread delousing (F2, F3). In 2023, sea lice and other parasitic diseases were the leading cause of mortality in salmon farming (R5). The risk is multifaceted: it affects fish welfare, prompts consumer concerns, carries reputational risks, and incurs significant operational costs. Treatments are expensive, stressful for the fish, and can lead to secondary infections or death (F1). Climate change exacerbates this risk, as higher water temperatures accelerate lice reproduction cycles (F1, E2). The TLS further heightens the stakes by regulating production volumes based on lice prevalence, making sea lice both an environmental and legislative risk (R10, F3).

After sea lice, harmful algal blooms were the second most frequently mentioned concern. These blooms involve toxic algal species that typically kill fish through asphyxiation (E2, E4). Furthermore, mitigation strategies for these blooms (such as aeration or water column mixing) can, in some cases, unintentionally exacerbate the problem by spreading the algae further or stimulating additional blooms (E4). Sustainability reports from R1, R2, and R4 identified HABs as material risks. These events pose operational, financial, and welfare concerns, with mitigation methods often dependent on algal type (E4).

Interviewees also noted the increased presence of jellyfish species capable of stinging and killing Atlantic salmon (E2, E3, F2, F3). Though not new to Norwegian waters, this species has become more prevalent during recent summers. Two sustainability reports (R1, R4) listed jellyfish as a material risk under double materiality assessments. In addition to operational losses (mortality), the issue carries reputational risks linked to public concern over fish welfare (E2, E3, E4, F1, F3, F4, R2).

Finally, a key emerging risk in the grow-out phase is the spread of new and unknown diseases. Higher sea temperatures can increase the prevalence and virulence of pathogens, some of which may originate in warmer regions and spread northward with warming currents (E2, E3, F1, F3). These diseases can cause financial losses through mortality and treatment costs, and reputational damage due to fish welfare concerns. Compounding this, existing stressors such as heat and lice treatments may weaken fish immunity, making them more susceptible to new bacterial or viral threats (E1, E2, E3, F1, F3, R9).

4.2.1.2 Value Chain Climate Risks Beyond the Grow-out Phase

While the grow-out phase presents the highest concentration of climate-related risks, other stages of the aquaculture value chain also face growing challenges. One major concern raised by interviewees was related to feed (E2, E3, E4, F1, F2). This aligns with findings in industry reports, which identify feed-related risks such as supply chain disruptions, soy yield failures, and limited availability of marine ingredients as significant issues (R5, R9). Feed represents the largest cost in salmon farming (E2), since it is composed of both terrestrial and marine ingredients, many of which are sourced from the Global South. Climate-related disruptions such as drought, flooding, and shifting fish stock distributions can compromise ingredient availability, resulting in both operational and financial risks due to price volatility (E2, E3, E4, F1, F2).

In addition, feed sourcing carries both reputational and legislative risks. As consumer awareness of environmental sustainability increases, firms face growing scrutiny over the carbon footprint of their feed, the use of unsustainable marine ingredients, and broader concerns about overfishing (E3). Failing to address these issues may affect public perception and regulatory compliance.

Hatchery and juvenile phases were generally considered to be of lower concern, with most farms reportedly equipped with the necessary tools to manage operational risks (E2, E3, E4, F2, F3). However, some region-specific risks have been identified. A consultancy report using climate modeling and spatial analytics found that major production areas in Norway are at increasing risk of flooding and storms (R5). E2 specifically mentioned a 20% increased flood risk in western Norway, and avalanche hazards were identified in mountainous regions. Additionally, systems drawing water directly from natural sources may require cooling or aeration as temperatures rise (E3, E4). Nevertheless, land-based hatcheries were generally seen as less exposed to climate risks than sea-based grow-out sites (F2, F3).

At the processing stage, interviewees mentioned existing risks such as listeria, which are already addressed through standard operating procedures (F1). F4 added that water scarcity in processing plants located outside Norway could become a future bottleneck, limiting capacity even if farms maintain production volumes. In the transportation phase, storms were noted as a risk factor that could delay shipments and disrupt delivery schedules (F2). Longer-term, economic shifts due to climate change could lead to reduced consumer spending power, making salmon, a premium product, vulnerable to substitution by cheaper protein sources (F2).

Overall, the risks identified across these phases are interconnected. For example, legislative changes responding to environmental degradation can create financial burdens, which in turn require operational adjustments. This interdependence is especially evident in the grow-out phase, but it also affects upstream and downstream processes. Farms remain primarily focused on immediate and already-materializing risks, while emerging or long-term risks are often deprioritized.

4.2.2 Current Response, CCA Tools and Solutions

While few farms appear to be systematically monitoring emerging climate risks, many have begun to implement adaptation measures targeting risks that are already affecting daily operations (S1–S6). Among these, sea lice have prompted the most immediate responses. Outbreaks in recent years have disrupted operations and damaged the industry's reputation, prompting firms to invest in sustainable delousing technologies that minimize harm to fish. Examples include laser-based delousing systems (e.g., Stingray technology), submersible cages that access cooler water at greater depths, and larger well boats to improve treatment capacity (E1, E2, F1, F3). Although such technologies are expensive and constrained by production cycles, meaning implementation may be delayed, they are considered a high priority by most firms and are being pursued despite cost (E3).

Importantly, these tools are primarily reactive rather than preventive (F1). They treat the symptoms of environmental stress rather than addressing its root causes, such as long-term temperature increases or ecological imbalance. Nevertheless, interviewees noted that innovation within the sector is rapid and remains a central part of CCA strategies.

In addition to sea lice mitigation, farms are investing in technologies to address low oxygen levels and harmful algal blooms. These include deep water intake systems, aeration equipment, and further investment in mobile treatment infrastructure such as well boats (E2, E3, F1, F2). Rising sea temperatures have also encouraged some firms to explore more transformative strategies, including relocation of operations, land-based farming using Recirculating Aquaculture Systems (RAS), and even a shift in species. For example, some

smaller firms have begun growing trout instead of Atlantic salmon, citing trout's greater resistance to temperature fluctuations, albeit with lower market value (E2, E3, F4).

Another long-term solution discussed was selective breeding for more resilient phenotypes. By developing broodstock with improved tolerance to higher temperatures or emerging pathogens, farms aim to enhance biological resilience to environmental change (E2, E3, F4). F4 noted that such breeding strategies are already underway in their organization, guided by climate models and projections that help identify desirable traits for future conditions.

Across all these strategies, the availability of accurate climate data and localized predictions was cited as a critical enabler. Firms must understand future environmental conditions in order to make informed investment decisions, particularly when adapting biology or infrastructure. Collaboration was repeatedly highlighted as a key facilitator of adaptation, both within firms and across stakeholder groups (S1–S6). F4 emphasized the need for stronger internal coordination, noting that an ESG related strategy often depends on a few individuals pushing the agenda forward within firms.

From the research perspective, E4 stressed the importance of long-term partnerships between researchers and industry, especially given that climate change unfolds over timeframes much longer than typical research project cycles. Due to site-specific environmental differences, case study results are often difficult to generalize. As such, sustained collaboration and data sharing are essential for improving predictive models and tailoring solutions to local contexts.

4.3 The Halt in CCA – Institutional Inertia

All interviewees provided recent examples of climate-related events that had directly impacted aquaculture operations. Notably, all but two incidents occurred during the grow-out phase, highlighting the particular vulnerability of this stage in the production cycle. While various CCA tools, some of which are already available and in use, were mentioned, all participants agreed that CCA is not currently a strategic priority for most firms.

Although elements of risk management are integrated into operations, often informally or without a formalized framework, CCA remains largely absent from long-term planning processes. Interviewees noted that industry conferences and strategic discussions rarely address adaptation explicitly, suggesting a broader lack of engagement with the issue at the organizational and sectoral levels. As one participant described it, firms appear to be "pushing the issue ahead of them," delaying proactive responses in favor of addressing more immediate, operational concerns.

4.3.1 Uncertainty Halting Actions

A recent workshop hosted by the research institute Nofima in 2024 brought together over 70 industry actors from the Norwegian aquaculture sector to discuss CCA, with another workshop planned for April 2025 (R8). At the event, 85% of participants reported that the industry is already experiencing the effects of climate change, yet only 12% believed the sector possesses sufficient information to respond effectively (R8).

These perceptions were reflected in the interviews conducted for this study. All interviewees acknowledged that climate change had impacted the sector, most commonly citing the heatwave in northern Norway as a recent and tangible example (S1–S6). Additional events mentioned included HABs in 2019 (E3) and a more recent bloom in southern Norway in April 2025 (F3). Jellyfish bloom was also raised as an emerging issue across various regions,

with F4 detailing a 2024 event in which jellyfish caused widespread mortality (E2–E4, F1, F3, F4). While five interviewees expressed concerns about a possible increase in jellyfish events, none were confident that this trend could be definitively attributed to climate change, citing a lack of conclusive research (E2–E4, F2, F3). These incidents were seen as risks, but not necessarily as climate driven.

Interviewees emphasized the complexity of the marine environment, where interacting variables, such as water temperature, storm events, oxygen levels, feeding schedules, harvest cycles, and disease treatments, make it challenging to predict how one factor will influence another (E4). The system's inherent unpredictability, coupled with gaps in scientific knowledge, presents a significant barrier to long-term planning. As noted by E3, "every year, we are seeing unprecedented things" such as record-breaking temperatures, shifting sea currents, and the emergence of new species. This trend reinforces the need to rely on forward-looking climate projections, as historical baselines are becoming less reliable. Yet, as both E3 and E4 pointed out, efforts to forecast future conditions are hampered by insufficient data resolution, systemic complexity, and uncertainty about climate models.

For firms, this uncertainty is not merely scientific, it is financial. As E4 explained, when businesses are asked to make large, long-term investments, they require a certain level of confidence in the data and projections informing those decisions. Striking the right balance between providing actionable insights and avoiding over-prediction is difficult, particularly when corporate capital is at stake.

Moreover, the uncertainty extends beyond attribution, i.e., whether a given event is climate-related, to questions of what will happen, when, and how severely. This was frequently cited as a constraint on adaptation planning (E2–E4, S1, S2). E2 noted that past climate projections from a decade ago have not fully materialized, further undermining confidence in the predictive tools currently available. Others highlighted year-to-year variability, where one year might bring extreme ocean surface warming and the next may revert to "normal" conditions (E2, F1). Temperature data from aquaculture sites reflect this inconsistency, showing no consistent warming trend across the country, except for locations in the far north (R4).

Due to this sporadic and unpredictable pattern, many firms continue with a business-as-usual approach, reacting to events as they occur rather than investing in structural adaptation (E2, F3). E2 described this as a potential "transition period", where climate-driven events are becoming more frequent but are spaced over a long enough timeline that they do not yet compel widespread changes in insurance policies or adaptation practices.

4.3.2 Cost as a Barrier to Adaptation

Transaction cost was frequently cited as a significant factor influencing whether firms pursue CCA measures. F3 provided an example in which a catastrophic sea lice outbreak occurred in northern Norway in 2024. Despite the severity of the event, the firm's decision-makers chose to adopt a "wait-and-see" approach, opting not to invest in preventive measures unless the issue reoccurred. This example underscores a common pattern: unless a climate-related risk is perceived as recurring and financially damaging, firms are hesitant to invest in long-term adaptation.

That said, many firms are actively investing in mitigation measures for certain pressing and recurrent risks, particularly sea lice. Stakeholders (S1–S6) and supporting literature (R1–R4) consistently identified sea lice as an ongoing and worsening problem, potentially

exacerbated by climate change. Some firms, especially larger or more proactive ones, have invested heavily in technological adaptations, including well boats, closed containment systems, and specialized lice treatments (E2, F1). However, investment capacity and willingness differ significantly between firms. For instance, while well boats are recognized as an effective solution, E1 and F3 noted that the high costs involved make them inaccessible for many firms. As a result, some companies are pursuing joint investments or leasing arrangements, while the well boat providers themselves are expanding their capacity to meet growing demand (F3).

In contrast, for risks that are emerging, less well-understood, or infrequent, interviewees reported that few resources are allocated toward adaptation (E1–E4, F1–F3). In all interviews, participants expressed the view that without sustained direct financial impacts from climate-related events, firms are unlikely to act proactively (S1–S6). As E2 explained, the cost of implementing structural adaptations for rare events such as extreme weather is high, and most farms instead prefer to rely on insurance mechanisms. In many cases, firms do not assess or plan for these risks until they have already materialized, a pattern consistent with the broader industry attitude toward CCA (S1–S6).

This reveals a key challenge: the economic calculus of adaptation is reactive rather than anticipatory. Firms are more willing to invest in well-documented, short-term risks with clear financial consequences, while longer-term or uncertain risks, no matter how potentially significant, are deprioritized unless immediate loss is experienced.

4.3.3 Power and Institutional Influence on CCA

Legislation and government action, or inaction, were frequently cited as central to the industry's limited progress on CCA. Interviewees pointed to a dual challenge: on one hand, stringent regulation can constrain innovation; on the other, a lack of targeted regulation allows firms to deprioritize adaptation (E1, E3, E4, F2, F4). While larger firms may employ staff dedicated to ESG and environmental compliance, these roles can be siloed within organizations and lack influence over broader strategy (F4). Without strong internal leadership or external pressure, adaptation efforts often remain superficial—reduced to "box-checking" exercises rather than substantive change (E1, F1, F2, F4).

The recently implemented CSRD was cited as a catalyst for awareness, prompting firms to begin assessing climate-related risks. However, interviewees expressed concern that this momentum was short-lived. F2 noted that although CSRD initially drove firms to examine their risk profiles, few concrete actions followed. F4 added that the anticipated omnibus revision, which may significantly reduce the number of firms covered under the CSRD, could result in firms removing climate risk from their strategic agendas altogether. Moreover, F1 and E1 warned that other, separate, excessive administrative burdens, such as separate reporting requirements on feed inputs, lice levels, and emissions, risk obscuring meaningful action beneath layers of compliance.

Institutional support for research and knowledge sharing was also seen as lacking. While some national efforts have emerged, interviewees stated that research is insufficiently coordinated, slow to materialize, or lacking in practical application (E1, F4). A 2024 governmental report acknowledged these gaps, citing a lack of understanding of climate change impacts on aquaculture and fisheries (R11). Though it noted that initiatives had begun, more specifically on a national level (R10, R11), no concrete examples were provided. A white paper from the government was expected in April 2025 to address the sector's adaptation strategy (F1) but had not yet been published at the time of the interview.

Regulatory fragmentation across government agencies was viewed as another barrier to progress (E1, E3). Multiple agencies oversee aspects such as licensing, environmental assessments, fish health, and food safety. This division of responsibilities makes it difficult for the government to formulate a comprehensive and coherent long-term adaptation strategy, and this disorganization is mirrored in the sector itself. Firms perceive government responses as slow and reactive, focusing primarily on existing issues like sea lice, rather than emerging climate risks (S1, S2).

The challenge is further compounded by the interaction between EU and national regulations. F1 remarked that Norway implements all EU directives, sometimes more rigorously than the EU itself. However, the EU's adaptation guidance for aquaculture (R5) remains broad and too generalized to address the specific needs of Norwegian salmon farming. Interviewees emphasized that local knowledge and ecological conditions are critical, making generic EU recommendations difficult to translate into effective policy or practice on the ground (F1, E4).

Some interviewees highlighted what appears to be a contradictory barrier to adaptation: overly restrictive legislation. Firms reported being locked into sites that are becoming increasingly difficult to operate due to environmental pressures yet face significant challenges in relocating or establishing new sites due to regulatory constraints (E1, E3). Additionally, testing and approval for new technologies, particularly in areas like feed innovation and biotechnology, was described as slow and overly restrictive. Expanding definitions of acceptable feed components, allowing more flexible experimental use of unsuitable sites, and accelerating the approval of new technologies were seen as ways to catalyze adaptation (E3, E4).

Finally, several interviewees noted the economic importance of the aquaculture industry to the Norwegian state as a potential reason for political hesitation. Through licenses, taxes, and related schemes, the government benefits financially from aquaculture. E1 and F2 suggested that pressuring the industry to undertake costly changes could have economic repercussions, creating a disincentive for regulators to push aggressive adaptation requirements on a sector that currently contributes significantly to national revenue.

4.3.4 Path Dependency and Legitimacy

The structure of the aquaculture production cycle, typically around two years from hatchery to harvest, can slow the uptake of new technologies or practices, as firms prefer to complete the cycle before introducing innovation (E4). However, the sector appears generally receptive to innovation, particularly when it supports operational efficiency or fish welfare. This suggests that path dependency, while present, may not be the primary barrier to CCA. Instead, path dependency appears more relevant in terms of systemic inertia and market entry barriers, rather than outright resistance to change.

One such barrier is the high cost and limited availability of licenses, which restricts market entry for new firms. As noted by F1, this licensing system favors established actors with greater financial capital, reinforcing the dominance of incumbent firms and limiting sectoral diversification. In this way, historical structures and regulatory design reinforce existing industry configurations, a classic feature of path dependency.

The concept of legitimacy emerged as a more powerful force influencing firm behavior. Across all interviews (S1–S6), social acceptance and stakeholder trust, particularly in

relation to fish welfare, were emphasized as core priorities. Norway has strong regulatory frameworks for animal welfare, and firms frequently highlight their compliance in annual reports and stakeholder communications (R1–R4). Maintaining legitimacy in the eyes of consumers, investors, and regulators depends on upholding these welfare standards (E3, F2).

This focus on legitimacy may inadvertently discourage innovation if new technologies are perceived to pose any risk to fish welfare. Even in the absence of regulatory barriers, farmers may be reluctant to test unfamiliar systems out of concern for fish welfare. While this caution is both justifiable and essential, it may also slow the pace of innovation, particularly in cases where adaptation strategies remain under-researched or unproven. This dynamic reflects a form of normative isomorphism, where firms adhere to widely accepted norms and expectations to maintain legitimacy, even when those norms are not legally mandated.

Interestingly, despite the importance of maintaining legitimacy, CCA is not currently a salient part of stakeholder expectations (S1-6). Interviewees noted that insurers prefer historical data over forward-looking climate projections, reinforcing a business-as-usual approach (E2). S1 and S2 reported that consumers have not yet expressed concern over CCA, and while some investors have begun requesting climate risk disclosures, this was not seen as a decisive factor influencing operational decisions.

In summary, firms are highly responsive to issues that affect their legitimacy, particularly fish welfare, but CCA has not yet become a legitimacy concern. This limited external pressure allows firms to maintain current practices without facing the reputational risks that would typically catalyze institutional change. Unless CCA becomes integrated into the industry's legitimacy narrative, through regulatory requirements, shifting investor expectations, or rising consumer awareness, its adoption is likely to remain incremental and inconsistent.

4.3.5 Misaligned Time Horizons: Climate Science vs. Business Strategy

A recurring theme that emerged from interviews, but was not originally captured within the analytical framework, was the challenge of time scale mismatch. While this issue overlaps with uncertainty, it represents a more specific barrier to adaptation: the discrepancy between long-term projections of climate science and the short-term planning cycles of aquaculture firms.

All interviewees agreed that climate-related events have already impacted the industry, particularly during the grow-out phase. However, the risks most frequently mentioned were those that had either already begun to affect operations or were expected to do so within the next five to ten years. For example, sea lice, harmful algal blooms, and rising sea temperatures were widely recognized and monitored (S1–S6). In contrast, only two interviewees (F3 and F4) briefly referenced emerging long-term risks such as ocean acidification and water scarcity, and even then, mostly in the context of international, not domestic, operations. Firms appear to prioritize day-to-day risks or frequent, observable events. One-off, low-probability events, such as a “100-year flood”, are typically not integrated into strategic planning, even when insurable. Instead, these are either ignored or treated as residual risks to be managed reactively (E2, F1).

This pattern reflects a deeper structural misalignment: climate change projections often operate on decadal to century-long timelines, while most firms plan within three- to five-year horizons. Insurance is renewed on a yearly basis, making the financial logic of CCA difficult to reconcile with scientific models that project changes on much longer timescales

(E2, E3, E4, F1, F4). As a result, firms find it challenging to translate global or national climate forecasts into actionable business strategies. Climate scenarios may be seen as too broad or too distant to inform site-level decisions, and the lack of granular, localized projections exacerbates this disconnect. Thus, even when firms acknowledge climate risks, the temporal gap between science and business practice acts as a significant barrier to adaptation planning.

4.4 External Pressure and Institutional Isomorphism in CCA

Across all interviews, there was strong consensus that external pressure is a critical driver for firms to engage in CCA (S1–S6). Although regulatory frameworks such as the CSRD have introduced some level of obligation, participants emphasized that these pressures are currently insufficient to prompt systemic change. When asked about what forms of external influence might be most effective, respondents most frequently pointed to legislative mandates, financial institutions, and insurance mechanisms.

4.4.1 Coercive Isomorphism: Regulation and Financial Incentives

Coercive isomorphism is visible in the role that insurance and financial institutions could play in advancing CCA. F4 noted that as climate events become more frequent, insurance coverage may become conditional on adaptation efforts, or even unavailable for high-risk, unmitigated operations. E4 suggested that financial incentives, such as reduced premiums for farms implementing CCA measures, could be more effective and faster acting than policy mandates.

Financial institutions were also identified as emerging sources of pressure. Banks and investors are increasingly requiring firms to report on climate-related risks through frameworks such as the EU Taxonomy and TNFD. E1 observed that banks are starting to request evidence of risk mitigation, which can incentivize firms to take a closer look at long-term threats and strategies.

At the same time, interviewees emphasized the need for more cohesive and targeted government regulation. E1 argued that fragmented oversight by multiple regulatory agencies creates confusion and weakens strategic coordination. While E3 called for relaxing regulations to enable innovation, others (E4) insisted that direct regulatory mandates for CCA are necessary to ensure firm compliance. However, both E1 and E4 acknowledged the difficulty of designing effective adaptation policies, citing concerns over maladaptation and the complexity of anticipating unintended consequences.

Pressure from the EU regulatory system is beginning to influence national agendas. Government reports and white papers are increasingly addressing CCA in aquaculture (R5, R9, R11, R12). However, participants noted that regulatory change is slow, and tangible sector-level adaptation remains limited in the absence of binding requirements (F1).

4.4.2 Normative Isomorphism: Knowledge, Dialogue, and Collaboration

Normative isomorphism, driven by professional standards, shared expertise, and collaboration, also plays a key role in shaping firm behavior. A central theme across interviews was the lack of coordinated knowledge sharing within the aquaculture sector. E4 reflected on the past decade, observing that while dialogue around CCA has increased much more remains to be done (E4, R8, R9).

Respondents consistently cited the absence of communication among firms, even those operating within the same fjords and subject to the same environmental changes (E1, E3,

F3). F3 highlighted that companies often participate in the same research projects without knowing it, a missed opportunity for cross-learning and efficiency. E3 and E4 emphasized that firms hold valuable datasets, such as temperature, oxygen levels, and feed inputs, which are often underutilized, despite their potential to enhance predictive models and adaptation strategies.

While many firms take pride in their in-house expertise and innovations, this individualism may hinder progress in the face of complex, systemic climate risks (E3). E3 advocated for increased reliance on formal research collaboration, noting that well-designed partnerships between firms and research institutions could significantly improve sectoral resilience. For example, long-term research cooperation and access to farm-specific climate models helped one firm understand site-level vulnerabilities and to take action (F4).

Interviewees stressed the importance of integrating interdisciplinary expertise, including marine biology, oceanography, and climate science, to effectively manage the multifaceted nature of climate risks (E3, E4). E4 explained that even researchers specialized in aquaculture often struggle with climate terminology, underscoring the value of cross-disciplinary partnerships.

Finally, the role of government research agencies was widely acknowledged. Institutions such as Nofima and the Institute of Marine Research were identified as key actors in supporting knowledge transfer and adaptation planning (F4). F1 argued that research is not only critical for firm-level planning, but also for informing regulatory change, asserting that CCA in the industry will only occur through a combination of research and regulation.

4.4.3 Mimetic Isomorphism: Who to Follow

Aquaculture firms in Norway appear to be prioritizing immediate operational risks, with sea lice frequently cited as the most pressing concern. Interviewees described solutions to this issue as industry standard, indicating that firms often adopt proven practices rather than experimenting independently. This behavior aligns with the concept of mimetic isomorphism, which occurs when organizations, facing uncertainty, imitate the strategies and actions of their peers. However, this form of isomorphism was not frequently mentioned during interviews or found prominently in the reviewed documents.

Larger firms in the sector are investing in research and development to address pressing risks and explore innovative practices (F1). These actors may be considered frontrunners, introducing new technologies and approaches. Yet, there is limited evidence that other firms are actively following their lead. Given the high degree of homogeneity within the Norwegian aquaculture sector, these early adopters have the potential to set new standards that others may eventually adopt. In an industry where operational practices vary little, it is likely that successful innovations, once validated, will diffuse across the sector.

Although stakeholders emphasized the importance of localized climate predictions and firm-level risk assessments to determine the materiality of specific risks, there was broad consensus among interviewees about which environmental risks are most concerning. Similarly, the same adaptation tools and strategies were frequently mentioned across interviews. This not only reinforces the sector's current uniformity but also underscores the importance of fostering innovation and reducing informational uncertainty. If new knowledge and adaptation practices become more accessible, and a few firms begin to implement them, it is likely that mimetic behavior will facilitate wider adoption across the industry.

5 Discussion

This chapter puts the study's findings into a broader academic context, interprets their significance through the lens of institutional theory and risk management, and reflects on their implications for CCA in the Norwegian aquaculture sector. The discussion is organized in three parts. First, it contextualizes the sector's understanding of climate risks and adaptation strategies. Second, it analyzes mechanisms contributing to institutional inertia. Finally, it explores the role of institutional pressures in driving change, followed by a reflection on the study's limitations.

5.1 The Findings in Context with Previous Research

5.1.1 Identifying Climate Risks and Recognizing the Impact and Solutions

The climate risks and perils identified by interviewees closely aligned with those documented in existing literature. Most risks were concentrated in the grow-out phase of production. This reflects findings by Falconer et al. (2022), who concluded that the grow-out phase is most vulnerable to climate-related disruptions. Stakeholders, both internal and external, demonstrated awareness of these risks. However, several interviewees highlighted the challenge of attributing specific environmental changes to climate change, as opposed to other natural variability or anthropogenic influences such as agricultural runoff triggering eutrophication.

This uncertainty reflects a broader challenge in CCA research; actors are more likely to respond once they have experienced climate impacts firsthand and can clearly attribute them to climate change (Blennow et al., 2012). All interviewees had examples of events they connected, partly or completely, to climate change. However, they further explained that the events were sporadic and difficult to predict, making firms more reluctant to take action and invest resources. Rather than a lack of awareness, previously identified in the literature as a barrier to action (Marshall et al., 2013), this study points to a knowledge gap in impact attribution as the key constraint.

When discussing adaptation tools, stakeholders placed less emphasis on physical infrastructure and more on the biological and operational impacts of climate change, particularly fish health. While literature identifies various risks to infrastructure and logistics (Falconer et al., 2022), interviewees considered these manageable through established tools like insurance and physical reinforcements. The general perception among firms is that infrastructure-related risks, while real, are not a priority relative to biological threats—an outlook also seen in other sectors, where physical climate risks are often viewed as manageable, and not a material risk to their business (WEF, 2023).

Innovative insurance products, such as parametric insurance, are emerging to address such risks. These instruments provide payouts when predefined thresholds (e.g., wind speed or flood level) are reached, bypassing the need to assess actual loss. While increasingly discussed in the insurance literature (Marsh, 2025; Swiss Re, 2023), interviewees had limited awareness or use of these tools within the Norwegian aquaculture sector.

CCA solutions that came up for the grow-out phase revolved more around emerging technologies, changing regulations, and even relocation of farms. Two key barriers were identified: first, the high market value of Atlantic salmon, which makes species diversification economically unappealing (Falconer et al., 2024); and second, the lack of mature technologies that can reliably address these risks. The combination of high uncertainty and limited practical solutions halts action.

This uncertainty and limited proactive adaptation are not unique to Norway. Similar patterns are seen in other high-income, cold-water aquaculture regions such as Scotland, Canada, and Ireland. Interviewees referenced climate-related events in these countries, but no best practices or lessons learned were cited. This suggests a shared challenge among industrial aquaculture systems in temperate climates: translating risk awareness into structured adaptation strategies. In contrast, aquaculture sectors in the Global South often integrate adaptation into existing policy and community frameworks, including actions like species diversification or habitat restoration (Galappaththi et al., 2020; Poulain et al., 2018). However, such measures are context-dependent and largely unsuitable for Norway due to its specific species focus, technological systems, and institutional and natural environment. The Norwegian sector's homogeneity, centered on sea-based Atlantic salmon farming, reduces ecological and operational flexibility, making it more vulnerable to systemic disruptions. This reinforces the need for tailored, context-specific adaptation strategies that reflect the biological, regulatory, and economic realities of cold-water aquaculture in high-income nations.

Concerns on operational and reputational risks were most frequently mentioned. Operational risks are directly linked to financial performance and are prioritized both in practice and in the literature (Holmen et al., 2018; Marvin et al., 2020; Yang et al., 2020). However, both interviewees and scholarly sources tend to focus on short-term, day-to-day threats rather than long-term strategic risks. Materialized adaptation measures were only mentioned in relation to risks that had already caused visible impacts.

Reputational risks are especially salient in this sector, given its consumer-facing nature. Norwegian salmon enjoys a global reputation for quality and sustainability, and firms are highly sensitive to threats that could undermine this image. Animal welfare issues were often mentioned as climate-related concerns, particularly as increased disease or mortality could erode consumer trust. However, literature suggests reputational risks may extend further. If communities perceive aquaculture operations as harming to local ecosystems or failing to adapt responsibly, this could threaten firms' social license to operate (Olsen et al., 2023). Interestingly, none of the interviewees perceived current consumer concern around CCA as significant, potentially overlooking an emerging area of reputational vulnerability.

The regulatory landscape within Norway was described among interviewees as complicated and with stringent regulations, but not necessarily a direct risk. Rather, regulation was seen as a barrier to adaptation, especially when it creates inefficiencies or delays. Nonetheless, regulations on pollution, energy usage, carbon emittance could pose material risks as regulatory scrutiny increases (Kouloukoui et al., 2023). While Atlantic salmon has one of the lowest carbon footprints among animal proteins (Johansen et al., 2022), this advantage may diminish if climate-related mortality increases or if feed and transport systems become more carbon-intensive (Falconer et al., 2022).

Despite the logistical risks outlined in the literature, such as transport disruptions due to extreme weather or carbon regulations, these were mentioned infrequently by interviewees. This may reflect a perceived manageability of such risks, with many firms already maintaining contingency plans (Choi et al., 2016). Nonetheless, rising costs or restrictions on air freight, for example, could significantly impact export-reliant firms.

Feed availability was one area of concern where literature and interviews converged. Interviewees acknowledged the risk of climate-related disruptions to key feed ingredients

like soy and wheat. Innovation in alternative feed sources, including algae and insect-based protein, is underway but not yet widespread (Falconer et al., 2022).

To conclude, this study that Norwegian aquaculture firms are aware of the climate risks identified in the literature, and they acknowledge the tools available to address them. However, action remains limited. The challenge is not one of ignorance, but of ambiguity, firms are caught between recognition of climate risks and uncertainty about how best to respond.

5.1.2 The Norwegian Aquaculture Firms and Climate Inertia

Despite widespread awareness of climate risks among stakeholders, this study found that CCA remains a low strategic priority for Norwegian aquaculture firms. Interviewees consistently emphasized that while risks are recognized, concrete actions are limited. This observation aligns with broader trends across Norwegian industry: a recent survey of over 1,000 companies in Norway found that more than 80% had not implemented any form of CCA, and only about a third had conducted climate-related risk assessments (Henke et al., 2024).

Through the data analysis some mechanisms within the theory appear to be of greater influence for the inertia present in the sector. The most frequently cited was uncertainty, not about climate change in general, but about its specific, localized impacts. Firms were reluctant to commit resources when the return on investment was unclear or unquantifiable. While literature often frames cost as a primary barrier to adaptation (Finke et al., 2016; Herrmann & Guenther, 2017; Sakhel, 2017), this study suggests a more nuanced interpretation: Norwegian aquaculture firms are not hindered by a lack of financial capacity, but rather by a lack of confidence in where and how to invest.

Interviewees made clear that financing CCA action is most likely when climate risks are already impacting business operations or when regulation imposes financial consequences (e.g., fines or production limits). Otherwise, the perceived benefit of adaptation remains speculative. External stakeholders proposed financial incentives, such as insurance premium reductions or green financing, as potential motivators, but these ideas were not raised by internal stakeholders. This gap suggests that the issue is less about affordability and more about informational and strategic uncertainty.

Another factor reinforcing inertia is the knowledge gap regarding how to interpret and operationalize scientific climate data at the firm level. Risk managers noted that climate models often lack the spatial resolution or sectoral relevance needed for farm-level decision-making. As a result, CCA is not fully integrated into enterprise risk management strategies. These findings mirror other studies that highlight the lack of tools, metrics, and guidance for assessing climate materiality in the private sector (Kouloukoui et al., 2023; Malik & Ford, 2024; WEF, 2023).

A particularly novel insight emerging from this study is the misalignment of time horizons between science, policy, and business. Climate science models forecast decades into the future, while firms typically plan on 1–3-year operational cycles and 3–10-year strategic cycles. Policies and regulations also move slowly, often taking years to materialize. This divergence creates a fundamental disconnect, climate risks are perceived as “real,” but not “immediate,” weakening their relevance to business decisions today. This gap is underexplored in existing literature and represents an important area for further research.

Power dynamics also reinforce inertia. Norwegian aquaculture firms operate in a heavily regulated industry, and when government bodies themselves express uncertainty or delay decisive action, as noted by one interviewee from the public sector, firms are unlikely to move ahead independently. This reflects a mutual deferral of responsibility: firms wait for clearer policy signals, while regulators delay mandates in the absence of clear vision of the path forward. When both institutional actors default to the status quo, inertia becomes self-reinforcing.

Finally, the institutional goals of actors involved differ significantly. Climate science seeks long-term planetary stability; government policy balances environmental protection with socio-economic development; firms, by contrast, prioritize financial performance and shareholder returns (DiMaggio & Powell, 1983). These different institutional logics contribute to misaligned expectations and hinder collaboration for adaptation.

In summary, the inertia observed within Norwegian aquaculture firms stems not from a lack of interest or denial of climate change, but from a complex interplay of uncertainty, knowledge gaps, short-term business horizons, and systemic misalignment between institutions. Recognizing these factors is essential for designing more effective interventions that translate awareness into action

5.1.3 Drivers of Change – Overcoming Institutional Inertia

While institutional inertia was evident across the firms interviewed, the study also identified specific external pressures that can push aquaculture firms toward CCA. The most influential among these was coercive pressure, particularly in the form of governmental regulation and financial accountability. Both internal and external stakeholders agreed that legislative mandates, fines, or formal reporting obligations were among the few mechanisms likely to compel firms to act. This is consistent with literature that identifies coercive isomorphism, top-down institutional pressure from state and financial institutions, as a key driver of corporate CCA (Abu Samah et al., 2021; Bag et al., 2023; Galappaththi et al., 2020; Henke et al., 2024).

Internal stakeholders repeatedly emphasized that clearer regulation, rather than voluntary frameworks, would likely be more effective in triggering firm-level change. Despite the perception of Norway's regulatory landscape as fragmented and administratively complex, firms expressed a willingness to comply with adaptation-focused legislation, provided it is predictable and actionable. This is commonly cited across literature as well, private firms ask for clear legislation and frameworks to aid and navigate CCA actions (Henke et al., 2024; Herrmann & Guenther, 2017; WEF, 2023). This somewhat contradicts the global narrative that vague or excessive regulation is a barrier to adaptation (WEF, 2023). A key example discussed was the EU's CSRD, which has introduced mandatory climate risk disclosures. Interviewees acknowledged that the CSRD has increased awareness of climate-related risks, but they also described it as overly burdensome and bureaucratic. As a result, while it has improved visibility, it has not catalyzed meaningful action.

Beyond regulatory influence, normative pressures also play a role in driving CCA. Interviewees and supporting documents frequently pointed to the importance of knowledge sharing, collaboration, and guidance from government agencies and research institutions (Henke et al., 2024; WEF, 2023). This aligns with the concept of normative isomorphism, where actors conform to the expectations of professional networks and expert communities. These networks are particularly important in addressing the knowledge gap identified earlier.

Firms noted a lack of in-house expertise to translate scientific forecasts into business decisions, and called for more guidance, templates, and best practices.

The role of financial institutions and insurance providers emerged as another potential driver of adaptation. Although innovative tools such as parametric insurance are available internationally, their uptake within Norwegian aquaculture remains limited. Still, external stakeholders suggested that if climate risk premiums begin to rise, or coverage becomes more conditional, firms may be more motivated to engage with adaptation planning. Given an insurance's role in managing operational risk (Gatzert & Kolb, 2014), this sector could be a potentially important influence on pushing firms towards CCA.

Reputational risk also surfaced as a relevant, though currently underutilized, source of pressure. Consumers are not yet demanding CCA from aquaculture producers, but stakeholders recognized that perceptions could shift rapidly, especially if fish welfare issues or environmental impacts become more visible. Literature suggests that reputational concerns, especially in consumer-facing sectors, can drive firms to change (Olsen et al., 2023). However, firms in this study did not yet perceive CCA as a reputational issue, perhaps reflecting the sector's current emphasis on immediate, observable risks.

Finally, while mimetic isomorphism was not identified as a current driver, it may become more influential as adaptation becomes more visible and standardized. Several interviewees noted that once frontrunners in the industry begin to implement CCA effectively, others are likely to follow. This could lead to a positive feedback loop, especially in a sector as homogenous as Norwegian aquaculture.

In conclusion, coercive isomorphism is a key enabler in surpassing the climate inertia within the aquaculture sector. Normative influence in form of knowledge sharing can further aid in surpassing the main mechanism of uncertainty. Finally, given the sectors homogeneity, mimetic isomorphism will likely play a role later on. When front runners and a larger part of the sector starts implementing CCA, other actors are likely to follow.

5.1.4 Synthesis of key discussion points

The findings reveal a sector that is aware of climate-related risks but remains hesitant to act due to uncertainty, knowledge gaps, and misaligned institutional timelines. While adaptation tools and strategies are recognized in principle, implementation is largely reactive and dependent on external pressure, particularly regulatory mandates. Institutional inertia is reinforced by sectoral homogeneity, short-term business cycles, and fragmented regulatory bodies. However, the presence of enabling conditions, such as strong reputational sensitivity, emerging financial tools, and willingness to follow regulatory signals, suggests that targeted interventions could unlock more proactive adaptation. These dynamics underline the complexity of translating climate awareness into action and highlight the importance of multi-level, coordinated responses across institutions, the sector, and policies. Table 5-1 summarizes the key barriers and drivers of CCA in the Norwegian aquaculture sector, along with their corresponding institutional mechanisms.

Table 5-1 Summary of key barriers and drivers of CCA in the Norwegian aquaculture sector, categorized by institutional mechanism

Category	Barrier/Enabler	Institutional Mechanism	Notes
Awareness	High awareness, but uncertainty about attribution	Normative / Cognitive	Firms recognize climate change but struggle to localize its impacts
Costs	Not a primary barrier in large firms	Strategic logic (aligned with inertia)	Financial capacity exists, but action is delayed due to unclear ROI
Time Horizons	Business planning cycles misaligned with climate timelines	Institutional misalignment	A systemic barrier not well captured in existing frameworks
Regulation	Seen as the strongest driver if clear and enforceable	Coercive Isomorphism	Firms support more prescriptive CCA requirements
Knowledge sharing	Lack of internal expertise to act on climate data	Normative Isomorphism	Collaboration with research institutions is critical for enabling action
Reputation	Latent risk, currently under-recognized	Social Legitimacy / Coercive (potential)	Could become a major driver if consumer sentiment shifts
Insurance/Finance	Underutilized; potential lever via premiums or product innovation	Coercive Isomorphism (market-driven)	Parametric insurance not yet applied in aquaculture
Peer Learning	Sector may follow frontrunners in future	Mimetic Isomorphism	Especially likely in homogenous, risk-averse industries

5.2 Critical Reflections and Limitations of the Study

The analytical framework developed in this study was derived from existing theories and reviewed literature. The findings are inevitably shaped by this framework and selecting other theories or different criteria might result in a different outcome. The framework emphasizes business and institutional perspectives and does not capture the views of other potentially relevant actors, such as local communities, smaller producers, or environmental organizations. Including these perspectives in future research could uncover additional drivers, barriers, or forms of adaptation that fall outside formal governance or corporate strategy. This exclusion does not weaken the study's findings but rather reflects its deliberate focus on institutional responses within a defined segment of the aquaculture sector.

The study has a strong emphasis on external pressures and institutional barriers. This is accentuated through the analytical framework and the structure of the interview guide. It must be recognized that answers of the interviewees could be influenced by the set-up and thematical approach despite all interviewees being encouraged to offer additional insights through open-ended questions. To mitigate this potential bias, the analysis was initially conducted inductively to allow themes to emerge outside the predefined framework, and only later structured using theory-driven categories.

The use of semi-structured interviews introduces further methodological limitations. The responses reflect the subjective experiences and perceptions of each participant and may be influenced by social desirability or assumptions about the researcher's intentions. Moreover, the interpretation of these responses is shaped by the researcher's own background and worldview. Although care was taken to ensure transparency in coding and analysis, some degree of interpretive bias is unavoidable in qualitative research.

The number of participants of this study was limited, where one representative from each external stakeholder group was interviewed and two from each internal stakeholder group. While this is a relatively small number the homogeneity of the Norwegian aquaculture sector, in terms of species, production methods, and regulatory context, supports the relevance of the findings. The consistency of responses across different stakeholders further strengthens the reliability of the insights, which were also triangulated through document analysis.

The choice of the sector and geographical area was influenced by the author's academic interest in aquaculture, and an internship with Marsh in Oslo during the summer of 2024. This provided useful contextual knowledge and access to topic specialists within risk management. Additionally, the researcher is not a native speaker and lacks operational experience in aquaculture production. These factors may have introduced challenges in understanding or interpreting certain sector-specific concepts. To address this, Norwegian-language documents were translated using AI tools, and any uncertainties related to operations were clarified with industry professionals.

This study specifically examines large, corporate aquaculture firms, which typically have greater financial, technical, and administrative capacity than SMEs. As a result, cost-related barriers may be underrepresented in the findings. While external stakeholders spoke broadly about the Norwegian aquaculture sector, the absence of SME voices limits the transferability of conclusions across firm sizes. Future research could address this by incorporating perspectives from smaller producers, who may face distinct constraints and adaptation dynamics.

The generalizability of the findings to other countries or sectors is also limited. Climate risks, regulatory environments, and institutional configurations vary significantly between contexts. While the analytical framework itself is flexible and could be applied elsewhere, the specific empirical insights, particularly those related to institutional inertia, sectoral awareness, and regulatory responses, are most applicable to high-income, cold-water aquaculture systems like Norway's. Nonetheless, the broader mechanisms explored, such as uncertainty, external pressure, and institutional alignment, are likely to resonate in other sectors facing complex CCA challenges

6 Conclusions

This section highlights the main findings of this study and contextualizes them for practical implication before it concludes with ideas for future studies.

6.1 Conclusions From the Research

Climate change presents a range of direct and indirect risks for the aquaculture sector. These include operational disruptions, shifts in the regulatory landscape, and consequential risks such as financial losses or reputational damage. Although Norwegian aquaculture firms are legally required to conduct risk assessments, these assessments are often limited in scope and rarely account for long-term climate-related risks. The current regulatory environment is highly complex, involving multiple agencies and overlapping reporting obligations. The implementation of the CSRD further adds to the administrative burden, requiring firms to assess and disclose ESG risks, as well as their adaptation plans. Yet, CCA actions on firm level appear to be lacking. Additionally, CCA tools and frameworks remain fragmented, vague, and often lack geographic or sector-specific guidance. This study set out to explore the factors influencing how Norwegian aquaculture firms engage in climate risk assessment and adaptation planning. Specifically, it examined which environmental risks are considered most pressing and what tools are available to mitigate them, aiming to address the limited research on CCA in high-income aquaculture contexts.

In regard to the overarching research question on what influences Norwegian aquaculture firms' implementation of CCA, this study found evidence of significant organizational inertia within the sector. While such inertia is not unique to this sector, several specific barriers were identified. Namely, uncertainty: firms lack access to reliable, localized climate projections and thus hesitate to invest in long-term adaptation strategies. The uncertainty surrounding climate change, particularly regarding what changes to expect, results in firms not prioritizing CCA. In addition, many firms lack specialized human resources capable of interpreting climate data or developing tailored adaptation plans. As a result, even when climate risks are acknowledged, they are not prioritized unless they translate into immediate financial consequences.

The fragmented and overlapping regulatory environment was also cited as a contributing factor to this inertia. Firms are often more focused on meeting compliance requirements than on taking proactive adaptation measures. In this context, coercive institutional pressures, particularly from government agencies, were seen as essential for driving change. Stakeholders emphasized that without clear regulatory mandates or economic incentives, firms are unlikely to allocate resources toward CCA.

The sub-questions of the study, (1) What are the major environmental risks facing the sector? and (2) What adaptation tools are available? were also addressed. Industry actors consistently identified key threats such as rising sea temperatures, ocean acidification, hypoxia, extreme weather events, and increased disease pressure. These risks are particularly acute during the grow-out phase at sea and were identified as mainly operational. While reputational risks are acknowledged as part of broader risk management, they are not viewed as urgent in the context of CCA, largely due to limited consumer concern. Regarding adaptation tools, interviewees mentioned emerging technologies, insurance mechanisms, policy reforms, and even potential farm relocation. However, most of these remain underutilized, primarily due to uncertainty about their effectiveness, high implementation costs, and a lack of clear policy direction.

The study ultimately finds that while awareness of climate risks is high, structured adaptation remains limited. A complex mix of uncertainty, short-term business planning, fragmented regulation, and limited internal expertise continues to delay action at the firm level.

6.2 Practical Implication and Contribution to Research

This study contributes both empirically and conceptually to the field of climate change adaptation in aquaculture. It offers new insights into how climate risks are perceived and managed in a high-income, cold-water context, and highlights specific factors influencing the implementation, or lack thereof, of climate risk assessments among Norwegian aquaculture firms.

One of the central contributions of this research is its clarification of the knowledge gap that exists within the sector. While firms are aware of the general risks posed by climate change, they often lack access to localized data, sector-specific guidance, and internal expertise needed to translate climate projections into operational decisions. This highlights the importance of institutional and scientific support and knowledge sharing, tailored to the aquaculture sector, especially in the Norwegian context where sea-based salmon farming dominates.

The study also enhances our understanding of the role that institutional pressures play in shaping firm behavior. It finds that coercive mechanisms, such as formal regulation, legal mandates, and financial penalties, are viewed as the most effective external drivers of adaptation. This confirms existing literature while also demonstrating how voluntary frameworks, such as the CSRD, can raise awareness but often fail to catalyze concrete action unless accompanied by enforceable expectations.

In addition to these empirical findings, the research adds conceptual value by applying institutional theory to the specific case of CCA in aquaculture. It demonstrates how coercive, normative, and mimetic pressures interact to either hinder or enable adaptation. Importantly, it also identifies a critical temporal misalignment between climate research, policy implementation, and private sector decision-making, a gap that is often underexplored in adaptation literature.

Taken together, these contributions offer a more nuanced understanding of why adaptation progress in the sector remains slow, despite high awareness of climate risks and the availability of technical solutions. They also help build a foundation for future research and policymaking aimed at closing the gap between recognition and action.

6.3 Recommendations for Future Research

This study addresses a gap within the literature of CCA and Norwegian aquaculture. Several promising avenues for future research emerge from this study.

Firstly, more research is needed on the financial side of CCA for firms. As extreme weather events increase in frequency and severity, insurance providers and financial institutions are likely to play a more central role in shaping firm behavior through premiums, loan conditions, and investment risk frameworks. Examining how financial tools like parametric insurance are received, or resisted, within the aquaculture sector could reveal new mechanisms for incentivizing resilience.

Secondly, performing a quantitative analysis on the main climate risks of concern, estimating monetary values, could aid in providing another form of understanding the risks for both

polymakers and firm decisionmakers. Highlighting the finding that firms will not act unless they know what the cost is and what to expect, this can be a valuable contribution. It further provides a more economic and business focused angle to climate research. Where firms lack the resources to understand what the risks are and evaluate them, finding a common language and understanding is of importance.

Third, additional work should explore the operationalization of knowledge sharing and cross-sector collaboration. While this study identified normative support from government and research institutions as important, it also revealed gaps in how firms access and apply that support. Understanding how to make scientific information actionable and sector-specific could improve adaptation outcomes across industries.

Fourth, regulatory design and policy coherence remain critical areas for inquiry. As frameworks such as the CSRD evolve, future research should investigate how policies can be made more user-friendly, transparent, and aligned with firms' existing planning processes. In particular, exploring how climate policy can account for the shorter planning horizons typical of private firms would help ensure that CCA becomes part of standard risk management, rather than a parallel process.

Finally, the potential gap in the social perspective can be explored. The aquaculture sector considers reputational risks of high concern, due to its B2C position on the market. The social pressure to maintain legitimacy can be a catalyst towards CCA. Moreover, finding out why there is a lack of pressure from local communities and consumers for CCA can bring in another perspective as to how to push them towards action.

By addressing these questions, future studies can build on this thesis to develop more effective strategies for supporting CCA in aquaculture and other resource-intensive industries.

Bibliography

- Aas, T. S., Åsgård, T., & Ytrestøyl, T. (2022). Utilization of feed resources in the production of Atlantic salmon (*Salmo salar*) in Norway: An update for 2020. *Aquaculture Reports*, 26, 101316. <https://doi.org/10.1016/j.aqrep.2022.101316>
- Abu Samah, A., Shaffril, H. A. M., Fadzil, M. F., Ahmad, N., & Idris, K. (2021). A Systematic Review on Adaptation Practices in Aquaculture towards Climate Change Impacts. *Sustainability*, 13(20), 11410. <https://doi.org/10.3390/su132011410>
- Ahmed, N., Thompson, S., & Glaser, M. (2019). Global Aquaculture Productivity, Environmental Sustainability, and Climate Change Adaptability. *Environmental Management*, 63(2), 159–172. <https://doi.org/10.1007/s00267-018-1117-3>
- Aksom, H. (2022). Institutional inertia and practice variation. *Journal of Organizational Change Management*, 35(3), 463–487. <https://doi.org/10.1108/JOCM-07-2021-0205>
- Aksom, H., & Tymchenko, I. (2020). How institutional theories explain and fail to explain organizations. *Journal of Organizational Change Management*, 33(7), 1223–1252. <https://doi.org/10.1108/JOCM-05-2019-0130>
- Argyriou, I., & Barry, J. (2021). The political economy of socio-technical transitions: A relational view of the state and bus system decarbonization in the United Kingdom. *Energy Research & Social Science*, 79, 102174. <https://doi.org/10.1016/j.erss.2021.102174>
- Arthur, J. R., Bondad-Reantaso, M. G., Campbell, M. L., Hewitt, C. L., Phillips, M. J., & Subasinghe, R. P. (2009). *Understanding and applying risk analysis in aquaculture: A manual for decision-makers*. FAO.
- Asche, F., Cojocaru, A. L., & Roth, B. (2018). The development of large scale aquaculture production: A comparison of the supply chains for chicken and salmon. *Aquaculture*, 493, 446–455. <https://doi.org/10.1016/j.aquaculture.2016.10.031>
- Austevoll Seafood ASA. (2023). *Sustainability report 2023*. <https://www.auss.no/media/1573/auss-esg-2023.pdf>
- Azungah, T. (2018). Qualitative research: Deductive and inductive approaches to data analysis. *Qualitative Research Journal*, 18(4), 383–400. <https://doi.org/10.1108/QRJ-D-18-00035>
- Bag, S., Srivastava, G., Gupta, S., Zhang, J. Z., & Kamble, S. (2023). Climate change adaptation capability, business-to-business marketing capability and firm performance: Integrating institutional theory and dynamic capability view. *Industrial Marketing Management*, 115, 470–483. <https://doi.org/10.1016/j.indmarman.2023.11.003>

- Barange, M., Bahri, T., Beveridge, M. C. M., Cochrane, K. L., Funge-Smith, S., & Poulain, F. (2018). *Impacts of climate change on fisheries and aquaculture: Synthesis of current knowledge, adaptation and mitigation options*. FAO. <https://openknowledge.fao.org/items/c914af92-fae1-467c-9dd0-7566a37afd11>
- Baxter, E., Rodger, H., McAllen, R., & Doyle, T. (2011). Gill disorders in marine-farmed salmon: Investigating the role of hydrozoan jellyfish. *Aquaculture Environment Interactions*, 1(3), 245–257. <https://doi.org/10.3354/aei00024>
- Benchmark Genetics. (2019). *Atlantic Salmon Hatchery Manual*. https://wp-bmkgenetics-2022.s3.eu-west-2.amazonaws.com/media/2021/05/01133146/Atlantic-Salmon-Hatchery-Manual_English.pdf
- Bjorkan, M., & Eilertsen, S. M. (2020). Local perceptions of aquaculture: A case study on legitimacy from northern Norway. *Ocean & Coastal Management*, 195, 105276. <https://doi.org/10.1016/j.ocecoaman.2020.105276>
- Blennow, K., Persson, J., Tomé, M., & Hanewinkel, M. (2012). Climate Change: Believing and Seeing Implies Adapting. *PLoS ONE*, 7(11), e50182. <https://doi.org/10.1371/journal.pone.0050182>
- Bosch-Belmar, M., Milisenda, G., Basso, L., Doyle, T. K., Leone, A., & Piraino, S. (2021). Jellyfish Impacts on Marine Aquaculture and Fisheries. *Reviews in Fisheries Science & Aquaculture*, 29(2), 242–259. <https://doi.org/10.1080/23308249.2020.1806201>
- Bowen, G. A. (2009). Document Analysis as a Qualitative Research Method. *Qualitative Research Journal*, 9(2), 27–40. <https://doi.org/10.3316/QRJ0902027>
- Bregnballe, J. (2015). *A Guide to Recirculation Aquaculture. An introduction to the new environmentally friendly and highly productive closed fish farming systems*. <https://www.fao.org/3/i4626e/i4626e.pdf>
- Chapin, F. S., Matson, P. A., & Vitousek, P. M. (2011). *Principles of terrestrial ecosystem ecology* (2nd ed). Springer.
- Chen, Y.-Y., Shek, D. T. L., & Bu, F.-F. (2011). Applications of interpretive and constructionist research methods in adolescent research: Philosophy, principles and examples. *International Journal of Adolescent Medicine and Health*, 23(2). <https://doi.org/10.1515/ijamh.2011.022>
- Choi, T.-M., Chiu, C.-H., & Chan, H.-K. (2016). Risk management of logistics systems. *Transportation Research Part E: Logistics and Transportation Review*, 90, 1–6. <https://doi.org/10.1016/j.tre.2016.03.007>
- Clarke, V., & Braun, V. (2017). Thematic analysis. *The Journal of Positive Psychology*, 12(3), 297–298. <https://doi.org/10.1080/17439760.2016.1262613>
- COSO. (2017). *Enterprise Risk Management—Integrating with Strategy and Performance*. <https://www.coso.org/guidance-erm>
- Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (Fifth edition). SAGE.

- Daddi, T., Bleischwitz, R., Todaro, N. M., Gusmerotti, N. M., & De Giacomo, M. R. (2020). The influence of institutional pressures on climate mitigation and adaptation strategies. *Journal of Cleaner Production*, 244, 118879. <https://doi.org/10.1016/j.jclepro.2019.118879>
- Daddi, T., Todaro, N. M., De Giacomo, M. R., & Frey, M. (2018). A Systematic Review of the Use of Organization and Management Theories in Climate Change Studies. *Business Strategy and the Environment*, 27(4), 456–474. <https://doi.org/10.1002/bse.2015>
- Department of Trade, Industry and Fisheries. (2025). *Fremtidens havbruk: Bærekraftig vekst og mat til verden* (Meld. St. 24). <https://www.regjeringen.no/contentassets/341de502286746b7803860a2199aa3d6/no/pdfs/stm202420250024000dddpdfs.pdf>
- DiMaggio, P. J., & Powell, W. W. (1983). The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields. *American Sociological Review*, 48(2), 147. <https://doi.org/10.2307/2095101>
- Döringer, S. (2021). ‘The problem-centred expert interview’. Combining qualitative interviewing approaches for investigating implicit expert knowledge. *International Journal of Social Research Methodology*, 24(3), 265–278. <https://doi.org/10.1080/13645579.2020.1766777>
- Eliassen, K., Jackson, D., Koed, A., Revie, C., Swanson, H. A., Turnbull, J., Vanhatalo, J., & Visser, A. (2021). *An evaluation of the Scientific Basis of the Traffic Light System for Norwegian Salmonid Aquaculture*. The Research Council of Norway. <https://www.forskningsradet.no/siteassets/publikasjoner/2021/an-evaluation-of-the-scientific-basis-of-the-traffic-light-system-for-norwegian-salmonid-aquaculture.pdf>
- Emblemsvåg, J., & Endre Kjølstad, L. (2006). Qualitative risk analysis: Some problems and remedies. *Management Decision*, 44(3), 395–408. <https://doi.org/10.1108/00251740610656278>
- European Commission. (2025, February 26). *Commission simplifies rules on sustainability and EU investments, delivering over €6 billion in administrative relief*. https://ec.europa.eu/commission/presscorner/detail/en/ip_25_614
- Falconer, L., Hjøllø, S. S., Telfer, T. C., McAdam, B. J., Hermansen, Ø., & Ytteborg, E. (2020). The importance of calibrating climate change projections to local conditions at aquaculture sites. *Aquaculture*, 514, 734487. <https://doi.org/10.1016/j.aquaculture.2019.734487>
- Falconer, L., Sparboe, L. O., Dale, T., Hjøllø, S. S., Stavrakidis-Zachou, O., Bergh, Ø., James, P., Papandroulakis, N., Puvanendran, V., Siikavuopio, S. I., Hansen, Ø. J., & Ytteborg, E. (2024). Diversification of marine aquaculture in Norway under climate change. *Aquaculture*, 593, 741350. <https://doi.org/10.1016/j.aquaculture.2024.741350>

- Falconer, L., Telfer, T. C., Garrett, A., Hermansen, Ø., Mikkelsen, E., Hjøllø, S. S., McAdam, B. J., & Ytteborg, E. (2022). Insight into real-world complexities is required to enable effective response from the aquaculture sector to climate change. *PLOS Climate*, 1(3), e0000017. <https://doi.org/10.1371/journal.pclm.0000017>
- FAO. (2021). *FAO's work on climate change—Fisheries and aquaculture 2020*. <https://doi.org/10.4060/cb3414en>
- FAO. (2022). *In Brief to The State of World Fisheries and Aquaculture 2022*. FAO. <https://doi.org/10.4060/cc0463en>
- FAO. (2024). *The State of World Fisheries and Aquaculture 2024*. <https://doi.org/10.4060/cd0683en>
- Finke, T., Gilchrist, A., & Mouzas, S. (2016). Why companies fail to respond to climate change: Collective inaction as an outcome of barriers to interaction. *Industrial Marketing Management*, 58, 94–101. <https://doi.org/10.1016/j.indmarman.2016.05.018>
- Finstad, B., Bjørn, P. A., Todd, C. D., Whoriskey, F., Gargan, P. G., Forde, G., & Revie, C. W. (2010). The Effect of Sea Lice on Atlantic Salmon and other Salmonid Species. In Ø. Aas, S. Einum, A. Klemetsen, & J. Skurdal (Eds.), *Atlantic Salmon Ecology* (1st ed., pp. 253–276). Wiley. <https://doi.org/10.1002/9781444327755.ch10>
- Forskrift Om Bekjempelse Av Lakselus i Akvakulturanlegg, FOR-2023-12-14-2087 (2013). <https://lovdata.no/dokument/SF/forskrift/2012-12-05-1140>
- Galappaththi, E. K., Ichien, S. T., Hyman, A. A., Aubrac, C. J., & Ford, J. D. (2020). Climate change adaptation in aquaculture. *Reviews in Aquaculture*, 12(4), 2160–2176. <https://doi.org/10.1111/raq.12427>
- Gatzert, N., & Schmit, J. (2016). Supporting strategic success through enterprise-wide reputation risk management. *The Journal of Risk Finance*, 17(1), 26–45. <https://doi.org/10.1108/JRF-09-2015-0083>
- Gephart, J. A., Deutsch, L., Pace, M. L., Troell, M., & Seekell, D. A. (2017). Shocks to fish production: Identification, trends, and consequences. *Global Environmental Change*, 42, 24–32. <https://doi.org/10.1016/j.gloenvcha.2016.11.003>
- Green, P. E. J. (2016). *Enterprise risk management: A common framework for the entire organization*. Butterworth-Heinemann.
- Grefsrud, E. S., Andersen, L. B., Agnalt, A.-L., Bui, S., Bøhn, T., Diserud, U., Dunlop, K. M., Escobar, R., Fiske, P., Folkedal, O., Geitung, L., Glover, K., Grøsvik, B. E., Halvorsen, K., Hannisdal, R., Hansen, P. K., Hindar, K., & Hjøllø, S. S. (2025). *Risikorapport norsk fiskeoppdrett 2025* (15742; Rapport Fra Havforskningen). Havforskningsinstituttet. <https://www.hi.no/hi/nettrapporter/rapport-fra-havforskningen-2025-14#sec-1>
- Guest, G., MacQueen, K., & Namey, E. (2012). *Applied Thematic Analysis*. SAGE Publications, Inc. <https://doi.org/10.4135/9781483384436>

- Hayhoe, K., Edmonds, J., Kopp, R., LeGrande, A., Sanderson, B., Wehner, M., & Wuebbles, D. (2017). *Climate models, scenarios, and projections*. U.S. Department of Commerce. <https://digitalcommons.unl.edu/usdeptcommercepub/589/>
- Henke, L., Knoth, K., & Sandberg, E. (2024). Climate change adaptation in Norwegian businesses – Awareness, integration and barriers. *Climate Risk Management*, 45, 100647. <https://doi.org/10.1016/j.crm.2024.100647>
- Hennes, K., Bendig, D., & Löschel, A. (2024). Facing the storm: Developing corporate adaptation and resilience action plans amid climate uncertainty. *Npj Climate Action*, 3(1), 37. <https://doi.org/10.1038/s44168-024-00116-2>
- Hermansen, Ø., & Heen, K. (2012). NORWEGIAN SALMONID FARMING AND GLOBAL WARMING: SOCIOECONOMIC IMPACTS. *Aquaculture Economics & Management*, 16(3), 202–221. <https://doi.org/10.1080/13657305.2012.704617>
- Herrmann, J., & Guenther, E. (2017). Exploring a scale of organizational barriers for enterprises' climate change adaptation strategies. *Journal of Cleaner Production*, 160, 38–49. <https://doi.org/10.1016/j.jclepro.2017.03.009>
- Hersoug, B. (2022). “One country, ten systems” – The use of different licensing systems in Norwegian aquaculture. *Marine Policy*, 137, 104902. <https://doi.org/10.1016/j.marpol.2021.104902>
- Ho, C.-H. (2022). Climate Risks and Opportunities of the Marine Fishery Industry: A Case Study in Taiwan. *Fishes*, 7(3), 116. <https://doi.org/10.3390/fishes7030116>
- Hodgson, G. M. (2006). What Are Institutions? *Journal of Economic Issues*, 40(1), 1–25. <https://doi.org/10.1080/00213624.2006.11506879>
- Holmen, I. M., Utne, I. B., & Haugen, S. (2018). Risk assessments in the Norwegian aquaculture industry: Status and improved practice. *Aquacultural Engineering*, 83, 65–75. <https://doi.org/10.1016/j.aquaeng.2018.09.002>
- Hopkin, P. (2018). *Fundamentals of risk management: Understanding, evaluating and implementing effective risk management* (5th Edition). Kogan Page.
- IFAD. (2014). *Guidelines for Integrating Climate Change Adaptation in Fisheries and Aquaculture Projects*.
- Imslund, A. K., Handeland, S. O., & Stefansson, S. O. (2014). Photoperiod and temperature effects on growth and maturation of pre- and post-smolt Atlantic salmon. *Aquaculture International*, 22(4), 1331–1345. <https://doi.org/10.1007/s10499-014-9750-1>
- International Organization for Standardization. (2018). *Risk Management: Guidelines* (ISO 31000:2018). <https://www.iso.org/standard/65694.html>

- IPCC. (2021). *Climate Change 2021 – The Physical Science Basis: Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (V. Masson-Delmotte, P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, & B. Zhou, Eds.; 1st ed.). Cambridge University Press. <https://doi.org/10.1017/9781009157896>
- IPCC. (2022a). Annex III: Scenarios and Modelling Methods. In C. Guivarch, E. Kriegler, J. Portugal-Pereira, V. Bosetti, J. Edmonds, M. Fisschedick, P. Havlík, P. Jaramillo, V. Krey, F. Lecocq, A. Lucena, M. Meinshausen, S. Mirasgedis, B. O'Neill, G. P. Peters, J. Rogelj, S. Rose, Y. Saheb, G. Strbac, ... N. Zhou (Eds.), *Climate Change 2022—Mitigation of Climate Change* (1st ed., pp. 1841–1908). Cambridge University Press. <https://doi.org/10.1017/9781009157926.022>
- IPCC. (2022b). *Climate Change 2022 – Impacts, Adaptation and Vulnerability: Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, & B. Rama, Eds.; 1st ed.). Cambridge University Press. <https://doi.org/10.1017/9781009325844>
- Jankensgård, H. (with Kapstad, P.). (2021). *Empowered Enterprise Risk Management: Theory and Practice*. John Wiley & Sons, Incorporated.
- Jensen, F., Tveterås, R., & Nielsen, R. (2024). The traffic light system. Is it a solution to a nonpoint pollution problem? *Aquaculture Economics & Management*, 28(2), 177–207. <https://doi.org/10.1080/13657305.2024.2301993>
- Johansen, U., Nistad, A. A., Ziegler, F., Mehta, S., Langeland, M., Wocken, Y., & Skontorp Hognes, E. (2022). *Greenhouse gas emissions of Norwegian salmon products* (2022:01198). Sintef. https://sintef.brage.unit.no/sintef-xmllui/bitstream/handle/11250/3044084/Rapport_klimafotavtrykk.pdf?sequence=1
- Kauppi, K. (2013). Extending the use of institutional theory in operations and supply chain management research: Review and research suggestions. *International Journal of Operations & Production Management*, 33(10), 1318–1345.
- Ketzler, G., Römer, W., & Beylich, A. A. (2021). The Climate of Norway. In A. A. Beylich (Ed.), *Landscapes and Landforms of Norway* (pp. 7–29). Springer International Publishing. https://doi.org/10.1007/978-3-030-52563-7_2
- Kouloukoui, D., Da Silva Gomes, S. M., Torres, F. A., & Torres, E. A. (2023). Business climate risk management: International perspectives and strategic determinants. *Environment, Development and Sustainability*, 27(2), 4683–4724. <https://doi.org/10.1007/s10668-023-04094-z>

- Krøvel, A. V., Gjerstad, B., Skoland, K., Lindland, K. M., Hynes, S., & Ravagnan, E. (2019). Exploring attitudes toward aquaculture in Norway – Is there a difference between the Norwegian general public and local communities where the industry is established? *Marine Policy*, 108, 103648. <https://doi.org/10.1016/j.marpol.2019.103648>
- Lammers, J. C., & Garcia, M. A. (2013). Institutional theory. In *The SAGE Handbook of Organizational Communication: Advances in Theory, Research, and Methods* (pp. 195–216). SAGE Publications.
- Lebel, L., Navy, H., Jutagate, T., Akester, M. J., Sturm, L., Lebel, P., & Lebel, B. (2021). Innovation, Practice, and Adaptation to Climate in the Aquaculture Sector. *Reviews in Fisheries Science & Aquaculture*, 29(4), 721–738. <https://doi.org/10.1080/23308249.2020.1869695>
- Lillehammer, M., Boison, S. A., Norris, A., Løvoll, M., Bakke, H., & Gjerde, B. (2019). Genetic parameters of resistance to amoebic gill disease in two Norwegian Atlantic salmon populations. *Aquaculture*, 508, 83–89. <https://doi.org/10.1016/j.aquaculture.2019.04.072>
- Lindegren, M., & Brander, K. (2018). Adapting Fisheries and Their Management To Climate Change: A Review of Concepts, Tools, Frameworks, and Current Progress Toward Implementation. *Reviews in Fisheries Science & Aquaculture*, 26(3), 400–415. <https://doi.org/10.1080/23308249.2018.1445980>
- Lindland, K. M., Gjerstad, B., Krøvel, A. V., & Ravagnan, E. (2019). Governing for sustainability in the Norwegian aquaculture industry. *Ocean & Coastal Management*, 179, 104827. <https://doi.org/10.1016/j.ocecoaman.2019.104827>
- Linnenluecke, M. K., Griffiths, A., & Winn, M. I. (2013). Firm and industry adaptation to climate change: A review of climate adaptation studies in the business and management field. *WIREs Climate Change*, 4(5), 397–416. <https://doi.org/10.1002/wcc.214>
- Luna, M., Llorente, I., & Luna, L. (2023). A conceptual framework for risk management in aquaculture. *Marine Policy*, 147, 105377. <https://doi.org/10.1016/j.marpol.2022.105377>
- Malik, I. H., & Ford, J. D. (2024). Addressing the Climate Change Adaptation Gap: Key Themes and Future Directions. *Climate*, 12(2), 24. <https://doi.org/10.3390/cli12020024>
- Marotta, I. (2025, March 18). Oceans under pressure: Balancing fisheries, aquaculture and environmental resilience. *Nordea*. <https://www.nordea.com/en/news/oceans-under-pressure-balancing-fisheries-aquaculture-and-environmental-resilience>
- Marsh. (2025). *Parametrics*. <https://www.marsh.com/en/services/parametrics.html>
- Marshall, N. A., Park, S., Howden, S. M., Dowd, A. B., & Jakku, E. S. (2013). Climate change awareness is associated with enhanced adaptive capacity. *Agricultural Systems*, 117, 30–34. <https://doi.org/10.1016/j.agsy.2013.01.003>

- Marvin, H., Bouzembrak, Y., van Asselt, E., Meijer, N., Kleter, G., Lorentzen, G., & Johansen, L. (2019). Applicability of a food chain analysis on aquaculture of Atlantic salmon to identify and monitor vulnerabilities and drivers of change for the identification of emerging risks. *EFSA Supporting Publications*, 16(7). <https://doi.org/10.2903/sp.efsa.2019.EN-1619>
- Marvin, H. J. P., Van Asselt, E., Kleter, G., Meijer, N., Lorentzen, G., Johansen, L.-H., Hannisdal, R., Sele, V., & Bouzembrak, Y. (2020). Expert-driven methodology to assess and predict the effects of drivers of change on vulnerabilities in a food supply chain: Aquaculture of Atlantic salmon in Norway as a showcase. *Trends in Food Science & Technology*, 103, 49–56. <https://doi.org/10.1016/j.tifs.2020.06.022>
- Mishra, B. K., Rolland, E., Satpathy, A., & Moore, M. (2019). A framework for enterprise risk identification and management: The resource-based view. *Managerial Auditing Journal*, 34(2), 162–188. <https://doi.org/10.1108/MAJ-12-2017-1751>
- MOWI. (2023). *Integrated Annual report 2023*. https://mowi.com/wp-content/uploads/2024/03/Mowi_Integrated_Annual_Report_2023.pdf
- Munck Af Rosenschöld, J., Rozema, J. G., & Frye-Levine, L. A. (2014). Institutional inertia and climate change: A review of the new institutionalist literature. *WIREs Climate Change*, 5(5), 639–648. <https://doi.org/10.1002/wcc.292>
- Negrete, M. (2025, April 11). *Norway's new aquaculture report: Moving from quantity to sustainability*. <https://weareaquaculture.com/news/aquaculture/norways-new-aquaculture-report-moving-from-quantity-to-sustainability-2>
- Negri, M., Cagno, E., Colicchia, C., & Sarkis, J. (2021). Integrating sustainability and resilience in the supply chain: A systematic literature review and a research agenda. *Business Strategy and the Environment*, 30(7), 2858–2886. <https://doi.org/10.1002/bse.2776>
- Nocco, B. W., & Stulz, R. M. (2022). Enterprise Risk Management: Theory and Practice. *Journal of Applied Corporate Finance*, 34(1), 81–94. <https://doi.org/10.1111/jacf.12490>
- Nordgarden, U., Oppedal, F., Taranger, G. L., Hemre, G.-I., & Hansen, T. (2003). Seasonally changing metabolism in Atlantic salmon (*Salmo salar* L.) I - Growth and feed conversion ratio: Seasonal changes in growth and feed conversion in Atlantic salmon. *Aquaculture Nutrition*, 9(5), 287–293. <https://doi.org/10.1046/j.1365-2095.2003.00256.x>
- Norwegian Directorate of Fisheries. (2024). *Laks, regnbueørret og ørret—Matfiskeproduksjon* [Excel].
- Norwegian Ministry of Foreign Affairs. (2022, April). *The EEA Agreement*. <https://www.norway.no/en/missions/eu/areas-of-cooperation/the-eea-agreement/>

- Norwegian Seafood Council. (2025, January 6). <https://en.seafood.no/news-and-media/news-archive/2024-was-the-best-year-ever-for-norwegian-seafood-exports/>. <https://en.seafood.no/news-and-media/news-archive/2024-was-the-best-year-ever-for-norwegian-seafood-exports/>
- Olaussen, J. O. (2018). Environmental problems and regulation in the aquaculture industry. Insights from Norway. *Marine Policy*, 98, 158–163. <https://doi.org/10.1016/j.marpol.2018.08.005>
- Olsen, M. S., Amundsen, V. S., & Osmundsen, T. C. (2023). Exploring public perceptions and expectations of the salmon aquaculture industry in Norway: A social license to operate? *Aquaculture*, 574, 739632. <https://doi.org/10.1016/j.aquaculture.2023.739632>
- Olsen, M. S., Thorvaldsen, T., & Osmundsen, T. C. (2021). Certifying the public image? Reputational gains of certification in Norwegian salmon aquaculture. *Aquaculture*, 542, 736900. <https://doi.org/10.1016/j.aquaculture.2021.736900>
- Olson, D. L., & Wu, D. (2023). Enterprise Risk Management in Supply Chains. In D. L. Olson & D. Wu, *Enterprise Risk Management Models* (pp. 1–14). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-68038-4_1
- Pham, T. T. T., Friðriksdóttir, R., Weber, C. T., Viðarsson, J. R., Papandroulakis, N., Baudron, A. R., Olsen, P., Hansen, J. A., Laksá, U., Fernandes, P. G., Bahri, T., Ragnarsson, S. Ö., & Aschan, M. (2021). Guidelines for co-creating climate adaptation plans for fisheries and aquaculture. *Climatic Change*, 164(3–4), 62. <https://doi.org/10.1007/s10584-021-03041-z>
- Podsakoff, P. M., MacKenzie, S. B., & Podsakoff, N. P. (2016). Recommendations for Creating Better Concept Definitions in the Organizational, Behavioral, and Social Sciences. *Organizational Research Methods*, 19(2), 159–203. <https://doi.org/10.1177/1094428115624965>
- Poulain, F., Himes-Cornell, A., & Shelton, C. (Eds.). (2018). Chapter 25: Methods and tools for climate change adaptation in fisheries and aquaculture. In *Impacts of Climate Change on Fisheries and Aquaculture: Synthesis of current knowledge, adaptation and mitigation options*. FAO. https://www.researchgate.net/profile/Manuel-Barange/publication/325871167_Impacts_of_Climate_Change_on_Fisheries_and_Aquaculture_Synthesis_of_Current_Knowledge_Adaptation_and_Mitigation_Options/links/5b5f1e48aca272a2d6754247/Impacts-of-Climate-Change-on-Fisheries-and-Aquaculture-Synthesis-of-Current-Knowledge-Adaptation-and-Mitigation-Options.pdf
- Priya, A. (2021). Case Study Methodology of Qualitative Research: Key Attributes and Navigating the Conundrums in Its Application. *Sociological Bulletin*, 70(1), 94–110. <https://doi.org/10.1177/0038022920970318>
- Roulston, K., & Choi, M. (2018). Qualitative Interviews. In U. Flick, *The SAGE Handbook of Qualitative Data Collection* (pp. 233–249). SAGE Publications Ltd. <https://doi.org/10.4135/9781526416070.n15>

- Sakhel, A. (2017). Corporate climate risk management: Are European companies prepared? *Journal of Cleaner Production*, 165, 103–118. <https://doi.org/10.1016/j.jclepro.2017.07.056>
- SalMar. (2023). *Annual Report 2023*. <https://ml-eu.globenewswire.com/Resource/Download/86a88695-45a1-4624-b187-8f4cfa90e789>
- Samadi, A. H., & Afroozeh, S. (2024). Legitimacy, Institutional Inertia, and Climate Change. In N. Faghih & A. H. Samadi (Eds.), *Institutional Inertia* (pp. 275–302). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-51175-2_12
- Samadi, A. H., Alipourian, M., Afroozeh, S., Raanaei, A., & Panahi, M. (2024). An Introduction to Institutional Inertia: Concepts, Types and Causes. In N. Faghih & A. H. Samadi (Eds.), *Institutional Inertia* (pp. 47–86). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-51175-2_3
- Schmeer, K. (1999). Stakeholder analysis guidelines. *Policy Toolkit for Strengthening Health Sector Reform*, 1, 1–35.
- Schulte, J., & Hallstedt, S. I. (2018). Company Risk Management in Light of the Sustainability Transition. *Sustainability*, 10(11), 4137. <https://doi.org/10.3390/su10114137>
- Shepherd, D. A., & Suddaby, R. (2017). Theory Building: A Review and Integration. *Journal of Management*, 43(1), 59–86. <https://doi.org/10.1177/0149206316647102>
- Sminia, H. (2024). *Strategizing With Institutional Theory* (1st ed.). Cambridge University Press. <https://doi.org/10.1017/9781009357654>
- Smith, C. W. (1995). Corporate Risk Management: Theory and practice. *The Journal of Derivates*, 30, 21–31.
- Swiss Re. (2023, July). What is parametric insurance? *Swiss Re*. https://corporatesolutions.swissre.com/insights/knowledge/what_is_parametric_insurance.html
- Tiller, R., & Richards, R. (2018). Ocean futures: Exploring stakeholders' perceptions of adaptive capacity to changing marine environments in Northern Norway. *Marine Policy*, 95, 227–238. <https://doi.org/10.1016/j.marpol.2018.04.001>
- Vlachos, I., & Malindretos, G. (2023). Supply chain redesign in the aquaculture supply chain: A longitudinal case study. *Production Planning & Control*, 34(8), 748–764. <https://doi.org/10.1080/09537287.2021.1959663>
- Vollset, K. W., Dohoo, I., Karlsen, Ø., Halttunen, E., Kvamme, B. O., Finstad, B., Wennevik, V., Diserud, O. H., Bateman, A., Friedland, K. D., Mahlum, S., Jørgensen, C., Qviller, L., Krkošek, M., Åtland, Å., & Barlaup, B. T. (2018). Disentangling the role of sea lice on the marine survival of Atlantic salmon. *ICES Journal of Marine Science*, 75(1), 50–60. <https://doi.org/10.1093/icesjms/fsx104>
- Vormedal, I., & Larsen, M. L. (2021). *Regulatory Processes for Setting Sensitive-Period Sea-lice Thresholds in Major Salmon Producer Jurisdictions: An Evaluation*. Aquaculture Stewardship Council. <https://www.asc-aqua.org/wp->

- content/uploads/2022/03/Regulatory-Processes-for-Setting-Sensitive-Period-and-Sea-lice-Thresholds-in-Major-Salmon-Producer-Jurisdictions.pdf
- Webster, M. D., Babiker, M., Mayer, M., Reilly, J. M., Harnisch, J., Hyman, R., Sarofim, M. C., & Wang, C. (2002). Uncertainty in emissions projections for climate models. *Atmospheric Environment*, 36(22), 3659–3670. [https://doi.org/10.1016/S1352-2310\(02\)00245-5](https://doi.org/10.1016/S1352-2310(02)00245-5)
- WEF. (2023). *Taking Stock of Business Efforts to Adapt to Climate Change*. World Economic Forum. https://www3.weforum.org/docs/WEF_Taking_Stock_of_Business_Efforts_to_Adapt_to_Climate_Change_2023.pdf
- Yang, S., & Cui, X. (2019). Building Regional Sustainable Development Scenarios with the SSP Framework. *Sustainability*, 11(20), 5712. <https://doi.org/10.3390/su11205712>
- Yang, X., Utne, I. B., & Holmen, I. M. (2020). Methodology for hazard identification in aquaculture operations (MHIAO). *Safety Science*, 121, 430–450. <https://doi.org/10.1016/j.ssci.2019.09.021>
- Yin, R. K. (2014). *Case study research: Design and methods* (5. edition). SAGE.
- Yue, X.-L., & Gao, Q.-X. (2018). Contributions of natural systems and human activity to greenhouse gas emissions. *Advances in Climate Change Research*, 9(4), 243–252. <https://doi.org/10.1016/j.accr.2018.12.003>

Appendix

Consent form and information

Climate adaptation in Norwegian Aquaculture

Information and Consent form

This consent form allows you to read and inform yourself on this master thesis project. It further allows you to confirm through a signature that you want to participate in this research. If any questions arise, I am available through the following means:

Name: Elísabet Jónsdóttir, student M.Sc. Environmental Management and Policy, Lund University

Email: elisabetjonsdottir@hotmail.com

Phone: +46 0702969634

Institution: International Institute for Industrial Environmental Economics (IIIEE), Lund university, PO-Box 196, 22100 Lund, Sweden

Description of the thesis project

Risk management is becoming increasingly more extensive for firms, and climate change brings a new dimension to it. This research aims to explore how the aquaculture industry in Norway views climate risks and adaptation. I aim to find the risks of most concern within the value chain of the industry, what climate perils are of highest impact and finally what firms need in order to identify and respond to these risks. This will yield a comprehensive overview of the climate risk landscape for aquaculture in Norway.

Purpose of the interview

For this research I will conduct semi-structured interviews, consisting of open-ended questions. There I want to enhance my knowledge on several key areas. Below the main themes are listed with a generalized question:

- Risk management: how you view risk management in the aquaculture sector
- Climate adaptation within risk management: what is your view on climate adaptation within the industry.
- Climate risk identification: are there climate risks you think are of particular concern for the sector?
- Climate perils and climate tools: what do you think firms need to identify and respond to climate risks?
- Drivers and barriers of climate risk management: what does the aquaculture sector need to implement climate risk management?

The information will be used for my M.Sc thesis in Environmental Management and policy from IIIEE with Lund University. With your permission I will record the interview in order to transcribe it. Afterwards the recording will be deleted. Should you not want a recording to be done, only written notes will be taken. The recorder can be turned off at any time by your request and interview stopped.

Data management

All the data for this project is collected and stored in accordance with the General Data Protection Regulation (GDPR) 2016/679 of the European Union, which entered into force in May 2018. The regulation protects individuals regarding the processing and collection of their personal data. All the research materials, including the participants' data will be securely stored for 10 years. After that time period, any personal data collected will be deleted. In addition, data will be deleted at any time on request of the participant. From the beginning of the process, pseudonymization of personal data is applied. Pseudonyms will also be used for further processing the responses. Special attention is paid to direct quotes, for which I will use indirect identifiers (such as gender, region, role) in the transcription protocols, so that they cannot inadvertently identify respondents. The audio/video-recordings, if authorized by the interviewee, will be deleted after they have been transcribed and analyzed, hence they will not be stored for 10 years. At any stage of the research project, the research participants have a right to gain access to their own personal data, request data correction or limitations to how their data is processed (latest until 15th of April 2025).

For all activities below, please indicate which applies to you (*checked box indicates consent*):

☐	I have been familiarised with the Master thesis project, I have had the possibility to ask questions and I have received satisfactory answers to my questions before being interviewed
☐	As a research participant, I am aware of my right to withdraw participation at any time
☐	I give my consent that the interview can be recorded in writing , translated and analysed
☐	I give my consent that the interview can be audio- or video-recorded , transcribed using a third party speech-to-text transcription application, translated (if necessary) and analysed
☐	I give my consent to be identified by my organization
☐	I understand that the results of the research will be presented so that no information can be traced to me personally / I have been informed that pseudonymity of participants will be ensured
☐	I give my consent that a record of my interview can be safely stored for future reference
☐	I have been informed who will benefit from the participation
☐	I have been informed how data will be either destroyed or reused at the end of the research
☐	I have been informed of the secondary use of data

Note: Your participation is voluntary. As an interviewee, you do not have to answer all the questions that are asked; you reserve the right to refuse or cease participation in the interview process without stating your reason and may request to keep certain materials confidential. In addition, you have the right to review any summary or synthesis of the interview at any time up until the data is actually published.

There will be no monetary payment for participating in the research, but you will have contributed to a research project about climate risk adaptation in aquaculture and a published document will be sent to you.

Please, sign below to confirm your consent – digital signatures are possible:

	Participant(s)	Researcher(s)
Name(s) + ID		
Signature(s)		
Date(s)		

Interview protocol

Basic information about the interview

Time and date:

Place:

Name and occupation of interviewee:

File name: occupation_date

Introduction

My name is Elísabet, and I am a master's student in Environmental Management and Policy at Lund University. First, I would like to sincerely thank you for taking the time to speak with me today. This interview is being recorded, the data will be stored offline and then on Nvivo for analytical purposes. After the publication of the thesis all data will be deleted.

The purpose of my thesis is to explore how aquaculture firms in Norway are responding to climate risks that may threaten their production. Through open-ended questions, I aim to understand what risks have been identified, what tools are needed to address them, and what challenges lie ahead.

Before we begin, I would like to ask you a few general questions about yourself to help set the stage for our conversation.

Questions

Background information

- Could you tell me a little bit about yourself
- What is your current role at your workplace?
- What is your educational background?
- Could you briefly describe your general work experience?

Main questions

For stakeholders that do not work for a specific firm questions are rephrased so they apply on a general level to firms.

Risk management

- Is risk management integrated in aquaculture practices?
 - o Is it across the value chain?
- How important do you think risk management is to aquaculture?
 - o What aspects of it do you find are important
 - o Where do you see that it could be improved
- Do you think that firms are incorporating the different types of risks across the entire enterprise?
- What do you think is the main incentive/barrier to firms a risk management framework for the entire firm?

CCA and risk management

- Do you think CCA is being considered across firms?
 - o To what extent?
- What do you think firms need in order to start implementing CCA?

Climate Risk identification

- Have you noticed any climate change impact on aquaculture practices?
 - o Where in the supply chain is the highest impact?
- What part of the value chain do you think is of most concern for climate risks?
 - o What are those risks?
 - o How would you prioritize those risks?
- What is the time horizon you would consider when looking at climate risks?

Climate perils and climate risk tools

- What do you think firms need to effectively assess and respond to climate risks?
- Do you think there are climate perils that are of particular concern to the aquaculture industry?
 - o Where in the value chain are these perils having the biggest impact?
- Are there climate perils that are being monitored already?
- Are there specific tools, data, or expertise that are required?
- What role do collaboration and knowledge sharing within the industry play in improving preparedness?

Drivers of CCA

- What do you think will be the primary driver for firms to address future climate risks?
- Are stakeholders such as investors, insurers, consumers pushing for CCA measures?
- Is CCA or climate risk management driven by internal or external pressures?
- Do you think regulatory pressure such as the CSRD will influence firms when it comes to risk management?
- What form of support do you think firms need to address these climate risks?

Closing discussions

- Is there anything we haven't covered that you believe is important?
- Would you like to add any final comments or insights?

Final Remarks

Thank you for your time and for sharing your insights. Your input is invaluable to my research.

This thesis will be published in August, and I will defend it in June. I would be happy to share the final version with you once it is completed. Please feel free to reach out if you have any follow-up questions.

Thematic coding structure

Theme	Category	Sub-category	Description
The value chain	Hatchery	Operational risk	Risks that will impact the operation of the firm, whether physical impact or financial
		Reputational risk	Risks that can make stakeholders view the firm negatively, ultimately resulting in loss of costumers, investors or operational changes
		Legislative risk	Risks that originate from legislative changes, new regulations or complicated frameworks
	The grow-out phase	Operational risk	N/A (see above)
		Reputational risk	N/A
		Legislative risk	N/A
	Slaughter	Operational risk	N/A
		Reputational risk	N/A
		Legislative risk	N/A
	Transport	Operational risk	N/A
		Reputational risk	N/A
		Legislative risk	N/A
	Feed	Operational risk	N/A
		Reputational risk	N/A
		Legislative risk	N/A
Climate Risks	Sea temperature		Risks that stem from higher or rising sea temperature, both as a continuous rise and high temperature events
		Sea lice	Can cause operational, legislative and reputational risks
		Diseases	Can cause operational, legislative and reputational risks
		Deoxygenation	Can cause operational, legislative and reputational risks
		Algal blooms	Can cause operational, legislative and reputational risks
	Ocean acidification		Can cause operational, legislative and reputational risks

	Jelly fish		Can cause operational, legislative and reputational risks
	Increased precipitation		Can cause operational, legislative and reputational risks
	Storms		Can cause operational, legislative and reputational risks
	Rising air temperature		Can cause operational, legislative and reputational risks
Adaptation measures	Technology		
	Species diversification		
	Relocation		
	Monitoring		
	Knowledge sharing		
External pressure	Coercive isomorphism	Formal institutions	Formal (government, financial institutions, insurance firms) and informal institutions (consumers, society) can install pressure on firms to change
		Informal institutions	
	Normative isomorphism		Through best practices and knowledge sharing firms can be influenced to change
	Mimetic isomorphism		When faced with uncertainty firms can take up strategies and actions of other firms
Climate inertia	Uncertainty		Lack of certainty delays response
	Power		Fixed social structures prefer status quo
	Path dependency		Positive feedback loops and lock ins reinforce the status quo
	Legitimacy		The contribution of a firm to the greater society
	Cost	Free rider cost	Actors benefit from the investment of other firms/actors
		Transaction cost	The investment for CCA
Time horizon			Formal institutions form their strategies over different time frames, which can impact prioritization of actions