Exploring Quantitative and Qualitative Methodologies using I-ADApT Framework for Understanding Vulnerabilities and Responses to Global Changes in Small-Scale Fisheries

by

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A thesis
presented to the University of Waterloo
in fulfillment of the
thesis requirement for the degree of
Master of Environmental Studies
in
Sustainability Management (Water)

Waterloo, Ontario, Canada, 2022

Author’s Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Small-scale fisheries (SSF) support over 90 percent of the 120 million people engaged in capture fisheries globally (FAO, 2020) but are facing multifaceted vulnerabilities due to global change impacts. Despite vulnerabilities, the SSF communities do possess certain strengths that enable them to respond to the vulnerabilities. However, these strengths and capacities are poorly understood. The Vulnerability to Viability (V2V) concept focuses on examining the inherent capabilities of the small-scale fisheries communities to build resilience through short-term and long-term responses. Though Vulnerability to Viability is a critical area of study in terms of achieving sustainability of the small-scale fisheries, there is an absence of methodological approaches to study SSF vulnerabilities and their responses using multiple case studies. The main aim of this research is to explore quantitative and qualitative data analysis approaches using the I-ADApT framework to understand the similarities and differences between small-scale fisheries case studies, compare the case studies in terms of vulnerabilities faced by small-scale fisheries communities, governability conditions, societal and governing responses, and appraisal of the responses, and develop a typology of the case studies based on secondary data collected using I-ADApT templates. I-ADApT is a research and decision-support tool that can be used for understanding the vulnerabilities and responses to global change. The data from twenty-nine small-scale fisheries social-ecological systems, representing nineteen different geographical locations, was used in quantitative analysis. The qualitative analysis included twenty-eight I-ADApT case studies.

The quantitative and qualitative data assessment methods employed in this research were multivariate analysis (multiple factor analysis (MFA) and hierarchical clustering (HC)) in R-Studio and thematic-content analysis in NVIVO, respectively. Hierarchical clustering (HC) on multiple factor analysis (MFA) conducted in this research was highly useful to simplify a complex set of variables and identify key variables that were most common in all the case studies. These methods were also crucial in grouping the case studies to form clusters of case studies that shared similar properties. Thematic-content analysis in this research enabled the identification of the actual vulnerabilities, social and governing responses, their enabling factors, and those that are preventing the social and governing responses. Both quantitative and

qualitative data assessment methods were effective in the study of transition of small-scale fisheries from vulnerability to viability. Both methodologies were explored as proof-of-concept and can be employed in future research considering a greater number of case studies. The I-ADApT framework was an important tool that facilitated the development of a consistent methodology for use in research focusing on small-scale fisheries social-ecological system. This research highlights the importance of using both qualitative and quantitative research methods in the study of small-scale fisheries.

Apart from methodological innovation, the results of this research will inform the decision-makers, managers, and a crosssection of stakeholders to manage small-scale fisheries more effectively by understanding the vulnerabilities and developing response strategies. In doing so, the critical contribution of this research is the dedicated focus on learning from small-scale fisheries community experiences of vulnerabilities and possible pathways towards their viability through the use of place-based case studies.

Keywords: Small-scale Fisheries; Social-Ecological Systems; I-ADApT; Global Change; Vulnerability; Responses; Viability; Quantitative; Qualitative; Decision-Support Tools; Typology.

Acknowledgements

I firstly express my gratitude and sincere thanks to my Co-Supervisor Dr. Prateep Kumar Nayak, Associate Professor, University of Waterloo, Canada for agreeing to supervise this research and helping to generate new ideas and methodologies to carry out this research work. I express my utmost appreciation to him for being available anytime in need and listening attentively to my concerns and offering high-level guidance. I would also like to thank him for providing all the support either personnel or financial whenever deemed necessary without any delay. I have nothing more to ask from Dr. Nayak as a supervisor.

I would like to give a very special thank you to my Co-Supervisor Dr. Alida Bundy, Research Scientist, Fisheries and Oceans, Canada. I feel extremely lucky to have got the opportunity to be your student. Thank you Dr. Nayak for introducing me to Dr. Bundy. I received consistent support and guidance from Dr. Bundy throughout my work. Dr. Bundy's suggestions and comments always motivated me to think more, dig deeper and build a better thesis. Thank you for all the help and support you have provided me. Thank you for arranging all the data to conduct this research.

I take this opportunity to express thanks to my thesis committee members Prof. Derek Armitage and Prof. Cameron McCordic for reviewing my thesis and providing useful comments. I would like to thank my supervisor Dr. Nayak and Vulnerability to Viability Global Partnership (V2V), which is supported by SSHRC, Canada for funding this research. I cannot imagine my academic success without the support of Dr. Ratnayake and Dr. Gomes. Thank you to all the V2V students and members, especially, Sevil Berenji and Dr. Dias for all the support and help. I feel proud to be part of V2V. I also would like to thank Dragana Kostic, at SEED. I give heartfelt credit to my colleagues for your friendship, Natasha, Ruyel, VB, Rabindra: you all are awesome. I cannot end complying tribute to my family members for their unconditioned love. A big thank you to Krisha for your invaluable support and advice on this beautiful journey. I owe you a lot.

Thanking you all!

Bhabishya Khaniya

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Chapter 1

Introduction

1.1 Background

Capture fisheries are classified into “small-scale” and “large-scale” fisheries (Smith & Basurto, 2019). Though definitions and understandings vary from one jurisdiction to other (Smith & Basurto, 2019), the distinction between the two types of capture fisheries is mainly related to the type of fishing technologies and nature of human involvement in capture fisheries. Small-scale fisheries (SSF) are characterized by small-sized vessels, small crews, simple fishing gears, family ownership, a traditional way of fish processing, and operating near the shorelines which differentiate them from the large-scale fisheries, also known as industrial fisheries (Halim et al., 2019). Large-scale fisheries use large sized-boats (greater than 10-15 m), sophisticated technology to catch fish, and are associated with high capital costs (Cánovas-Molina et al., 2021). The classification also consists of social-cultural dimensions such as different ethnic groups, caste, and religions involved in the fisheries (Nayak & Berkes, 2011; Smith & Basurto, 2019). SSF are not only important in terms of livelihood and food security for the millions of small-scale fishers (Béné et al., 2016) but they contribute significantly to the amount of fish destined for human consumption (McClanahan et al., 2009).

In this context, SSF are contributing to the socio-economic development of many regions around the world, especially the developing countries (Teh & Sumaila, 2013). However, SSF remains overshadowed by the large-scale fisheries (Teh & Pauly, 2018) and are undervalued despite having social, economic, cultural, and environmental contributions to food security, poverty alleviation and livelihoods, and local and national economies in several countries (Noman et al., 2019). Underlying issues have not improved in many parts of the world where SSF are still poorly planned, regulated, funded, governed, and neglected from mainstream sustainability debates (Kura et al., 2004; Chuenpagdee & Jentoft, 2019). Currently, it is unknown what aspects need to be emphasized in order to solve the fundamental problems in SSF.

Nevertheless, the positive side is that they have been gaining scientific attention over the last two decades (Purcell & Pomeroy, 2015) and are being studied from multiple perspectives to generate new knowledge for the sustainability of the SSF. One such perspective is the vulnerability to viability (V2V) concept (Nayak, 2021) which not only describes SSF communities as vulnerable groups but acknowledges the inherent capacity of these communities to absorb the shocks and pressures to retain their important identity as SSF.

SSF are an example of a complex social-ecological system (SES) (Berkes, 2003). SESs are self-organizing multifaceted adaptive systems governed by feedback mechanisms. SSF SESs emphasize that fisheries communities, fisheries resources, economies, societies, and cultures are embedded parts of the SSF system, and they function interconnectedly (Folke et al. 2016). In many cases, due to the problems arising from global changes (Bundy et al., 2016), the natural, social, and governing systems of SSF SESs have lost their ability to self-organize and adapt leading to a loss of resilience (Folke, 2006). Global changes are large-scale changes in the earth system characterized by anthropogenic and natural stressors such as environmental variability, resource depletion, habitat loss, pollution, climate change, war, market globalization, and more (Pimentel et al., 2013; Bundy et al., 2016; Nayak & Berkes, 2019). These changes directly or indirectly have created vulnerabilities (Adger, 2006) in SSF communities worldwide (Chuenpagdee, 2011; Cánovas-Molina & García-Frapolli, 2022) and have caused negative impacts on the livelihoods, and wellbeing of SSF communities (Weeratunge et al., 2014) leading to loss of resilience (Nayak & Berkes, 2019) and ultimately possessing threats to their existence.

Implementing sustainable solutions in the face of global change is challenging for managers, decision-makers, or a cross-section of stakeholders who are managing the SSF SES. Social-ecological changes are occurring at a much faster rate than experienced in the past and can outpace the response capacity of the governing bodies to deal with them efficiently (Salas et al., 2019). Multilevel drivers cause multiple vulnerabilities which need multiple responses targeted to fulfill specific objectives. The obstacle among the managers, decision-makers, authorities or other stakeholders managing the SSF SESs is not just to design the feasible management measures but also to operationalize those measures emphasizing SES thinking (Kittinger et al., 2013) and later assess the performance of those responses. The ongoing hardships of the SSF communities around the world entail that not all management objectives are successful and

contribute to the sustainability of SSF communities (Putten et al., 2018). It is necessary to identify the most appropriate response to deal with changes (Bundy, et al., 2016) and to continue strengthening sustainable efforts. This requires the help of decision-support tools (DSTs) (Macher et al., 2021) to understand the elements of SSF SES that needs to be improved or developed for transforming SSF SES from V2V.

Viability, in the context of SSF, is understood as a concept that describes a state of SSF SES where fishing communities are resilient to stressors arising from global change by developing coping, adapting, or transformative strategies. It goes beyond the idea of profit maximization (Schuhbauer & Sumaila, 2016) and encompasses the notion of social capital (Richmond & Casali, 2022), good governance (Chuenpagdee & Jentoft, 2018), and high levels of wellbeing (Nayak et al., 2020). Cury et al., (2005) coined the term "viability approach" to enable an ecosystem approach to fisheries, describing it as an approach where the performance indicators are used to reflect management effectiveness considering all the subsystems of the ecosystem.

Salas et al., (2019) highlighted that "viability theory" (Krawczyk & Pharo, 2013) answers important questions in SSF, especially on how to maintain a balance between ecological, economic, and social sustainability when aiming for stock sustainability. It was further mentioned that the use of the viability approach in SSF management is not just to find an optimal solution to the problem but to discover a satisfying solution. Hardy et al., (2017) also articulated the same idea relating the viability approach to the dynamic system-based approach. This thesis is oriented to advance the understanding of the V2V concept considering SSF SES around the world. The V2V process involves co-adaptation (Savit et al., 2013), co-creation, co-identification of the knowledge gaps, co-production, and co-dissemination (Woodall et al., 2021) of interdisciplinary knowledge related to SSF, to examine innovative and feasible ways for strengthening SSF SES.

1.2 Research Gap

Transitioning SSF SES from vulnerability to viability is considered a critical area of study (Nayak et al., 2020), yet there are few studies dedicated to understanding the vulnerabilities strategies followed to deal with those vulnerabilities in a single study in SSF. There is a need to use the existing methodologies by integrating them with suitable types of DSTs to study the

transition of SSF SES from vulnerability to viability. Methodological improvements are required to conduct a social-ecological analysis of SSF in terms of valuing the inherent capacity of the SSF communities to deal with changes and to transform them from the V2V. The improvements should be able to identify ecological, social, and governing variables that help in the integration of the social and ecological system and specify a common language for better comparisons of SSF SES across different geographical locations (Ostrom, 2009; McGinnis & Ostrom, 2014). Both qualitative and quantitative assessments are needed to understand the social-ecological interactions (Mathias et al., 2020) and the social-ecological change process over time. There has been progress in applying qualitative and quantitative methods in SES research analyzing the key concepts such as resilience, vulnerability, adaptive capacity, and governance (Refulio-Coronado et al., 2021). However, the use of current methodologies in the context of the V2V study of SSF SESs requires additional work.

The concept of transforming the SSF from V2V has just been initiated and is new in the academic and scientific domain. In this context, the development of specific methodologies on how to conduct studies to transform SSF SES from V2V holds paramount importance. Inconsistent methodologies in studying individual SES are considered one of the barriers to synthesizing the knowledge from those SESs to capture the ongoing changes in a broad context (Magliocca et al., 2018). The I-ADApT framework (Assessment based on Description and responses and Appraisal for a Typology) overcomes these inconsistencies by using a standardized template to document, compare and synthesize information about the stressors, vulnerabilities, governance, and response relating to multiple SSF SESs. This study makes use of the I-ADApT framework developed by Bundy et al., (2016) to explore similar and dissimilar characteristics of the SSF SESs located in different geographical regions.

1.3 Research Context

To date, there exist separate methodologies aimed at vulnerability or viability assessments of SSF SES. A literature review of the past studies (see Chapter 2) showed three distinct methodologies used in vulnerability assessments of SSF which are indicator-based methodology, model-based methodology, and stakeholder-based methodology (Barsley et al., 2013). Viability assessments in SSF to date, have mostly concentrated on economic and financial viability, including quantitative assessment methods such as cost-benefit analysis (Schuhbauer et al.,

2019). However, there is a lack of a comprehensive methodology that incorporates vulnerability and viability factors in assessing the impacts of global change on SSF.

I-ADApT was used in this study because it was designed to synthesize and compare different types of SSF SESs. The I-ADApT framework includes a template designed to collect the information from SSF SES as case studies and was built as a DST providing an opportunity for decision-makers and resource managers to learn from past experiences to deal with global changes. The design of I-ADApT was done in such a way that the information about the natural, social, and governing system can be analyzed both quantitatively and qualitatively.

1.4 Research Objectives

The overall goal of this thesis is to use quantitative and qualitative approaches to explore the linkages between vulnerability and viability in SSF SES using data collected with the I-ADApT template. It is intended as a proof of concept to explore the utility of these approaches to further understanding of vulnerability and viability in SSF.

The following two sub-goals and objectives guide this research:

- To understand the linkages between vulnerability and viability by conducting an in-depth analysis of the I-ADApT case studies using quantitative research methods.
    a. To expand the number of case studies in the typology,
    b. to further develop the method used by Bundy et al., (2016) and Guillotreau et al., (2018a) using R-Studio (RStudio Team 2022) and
    c. to develop new ways of communicating the results

- To understand the linkages between vulnerability and viability by conducting an in-depth analysis of the I-ADApT case studies using qualitative research methods.
    a. to develop a qualitative typology of case studies following the vulnerability to viability approach, considering similarities and differences in the vulnerabilities faced by SSF communities, responses, factors enhancing those responses, and factors preventing those responses

b. to improve understanding on the common types of vulnerabilities experienced and responses followed by fisheries communities that have helped them to make the transition from vulnerability to viability

In this study, qualitative and quantitative data collected from the I-ADApT templates were used to test the hypothesis that (i) having a consistent methodology to study the SSF SES helps to understand the vulnerabilities and responses in a better way that can help the transition of small-scale fisheries communities from vulnerability to viability (ii) both qualitative and quantitative assessments are needed to comprehend the impacts of the global changes on small-scale fisheries.

1.5 Research Design

A convergent mixed methods design was used where qualitative and quantitative secondary data were collected using the I-ADApT template (Bundy et al., 2016; Guillotreau et al., 2018a). Both forms of data were integrated to analyze the research data both quantitatively and qualitatively. This approach was followed assuming that the qualitative and quantitative data will provide in-depth knowledge of the ongoing social-ecological crisis due to the global change and the combination would yield an improved understanding of the impacts of the global changes on the SSF SES.

The research approach was pragmatic which helped in answering the research questions by recognizing the importance of the natural, physical, and psychological world that includes cultures, social institutions, and subjective thoughts. The pragmatic approach helped to view the available knowledge of SSF SES based on the reality of the world (Creswell & Tashakkori, 2007). Pragmatism is not connected to any system of philosophy and reality rather it offers freedom of choice to choose any type of research methodology to answer the research questions (Cresswell et al., 2018). This research will not emphasize the development of new or novel methodologies for the V2V study, however, will make use of existing knowledge to employ the best methodologies which can be used to conduct the V2V study and help the stakeholders managing the SSF SES to respond to the changes. Some of the approaches used in past

literatures to analyze the SES include typology development, expert modeling, pattern recognition, statistical analysis, qualitative content analysis, comparative case study analysis, and network analysis (Biggs et al., 2021).

Bundy et al., (2016) developed a typology using a quantitative methodology to understand the societal and governing responses to global changes. While exploring the quantitative methodology, this study will follow the theoretical and methodological base laid by Bundy et al., (2016) and Guillotreau et al., (2018a) throughout the study, however, a greater number of case studies are considered in this study while exploring the use of multivariate statistical methods in-depth. The qualitative methodology is guided by thematic-content analysis which is a type of qualitative comparative method that can be used to make comparisons of the case studies and perform a descriptive study of the qualitative information collected from the case studies.

1.6 Significance of Research

Globally, fisheries resources have been taken for granted by most people, and less attention is paid to understanding the change in the structure and functioning of the fisheries systems until recent decades (N. J. Bennett, 2019). The questions are not only the issues arising from the global change but there is a range of other issues concerning poor management and governance of SSF (Chuenpagdee & Jentoft, 2018a), collective rights issues (Sharma, 2011), good practices in SSF (Charles, 2011), open access issues (Arthur, 2020), overcapacity issues (Pomeroy, 2012) and other local issues experienced by SSF communities worldwide. With the severity and frequency of the global changes, directly affecting the economies and livelihood of several people, significant attention has been given to understanding the change processes as well as the responses to adapt to change (Paterson & Charles, 2019). Still, implementation of the adaptation measures on a local level across the globe remains a critical issue. So, this study holds paramount importance to understand the adaptation measures grounded in societal and governing systems and which were most beneficial to adapt to the social-ecological changes.

This study broadens existing knowledge to make use of statistical tools and qualitative data analysis tools in solving complex social-ecological problems in SSF. For developing countries

where many communities are dependent on SSF for sustaining livelihood, the results of this research may be important to achieving social-ecological sustainability. The results of this study would be highly beneficial for government authorities, policymakers, non-governmental organizations, and academicians to make decisions effectively, allocate resources effectively to reduce vulnerability, and prioritize responses to promote the socio-ecological viability of marine commons.

1.7 Thesis Overview

The thesis comprises five chapters in total – (1) Introduction, (2) Literature Review, (3) Quantitative methodology development (4) Qualitative methodology development (5) Conclusion chapter. Chapter 1 describes the background of the study, research context, research gaps, objectives, research questions, and research significance. Chapter 2 is a review of the literature regarding global changes, SSF SES, SSF governance, and management of the common-pool resources and explains the key concepts, terms, and theories of this thesis work. Chapter 3 discusses the use of quantitative data analysis tools such as statistical analysis in conducting V2V studies and represents the quantitative methodology development. Chapter 4 examines the use of qualitative data analysis tools such as thematic content analysis in conducting V2V studies and exemplifies the qualitative methodology development. Chapter 5 synthesizes the information from Chapter 3 and Chapter 4 and discusses the strengths and the weakness of each of the methods used in the analysis.

Chapter 2

Literature Review

2.1 Introduction

The first part of the chapter describes the I-ADApT framework and the theories that were used to develop the I-ADApT framework. The second part of the chapter consists of the description of the concepts of the well-being of small-scale fisheries, resilience, and the V2V approach. In the third part of the chapter, decision-support tools (DSTs) and the concept of typology development are discussed. The idea is to understand the research base and approaches used in this research, particularly related to untangling the complexity of SSF SESs in the face of global changes. The literature areas were selected based on the problem statement, and research objectives.

2.2 I-ADApT framework as Decision-Support Tool

The I-Adapt framework is a novel DST based on systems thinking approach that builds on existing concepts including Social-Ecological System (SES) (Berkes & Folke, 1998), Driver-Pressure-State-Impact-Response (DPSIR) framework (Patrício et al., 2016), and Interactive Governance (Kooiman, 2003). The systems thinking approach relates to the human-environment interaction (VanWey et al., 2005). Central areas of the systems thinking approach include the theory of wellbeing, resilience, SES, ecosystem services, and adaptive capacity (Bundy et al., 2016). Interactive governance theory emphasizes solving societal problems through interaction among all the actors of the society (Kooiman et al., 2008) and is situated on the assumption that social activities are governed by a combination of the governing forces (Kooiman et al., 2008). DPSIR framework highlights a link between driving forces, pressures, state, impact, and response to understand the integrated links between social and environmental factors for a complex system like SSF SES.

I-ADApT helps to collect information on the SES relating to the system state, stressors, change, impact, adaptive capacities, and responses of the natural, social, and governing systems to improve the understanding of the impacts of global changes on SSF SES through a consistent

template. The I-ADApT template allows the qualitative and quantitative data to be collected and analyzed together to understand the fundamental processes of the observed phenomena. Figure 2.1 is the conceptual framework of the I-ADApT (Bundy et al., 2016) which recognizes the linked social, governing, and social subsystems as the components of the SSF SES. I-ADApT framework explores (1) the type of social-ecological issues faced by SSF SES, (2) strategies used to deal with the global change issues at the local, regional, and national level, (3) appraisal of those strategies and (4) factors stimulating or hindering the success of those strategies (Guillotreau et al., 2018a).

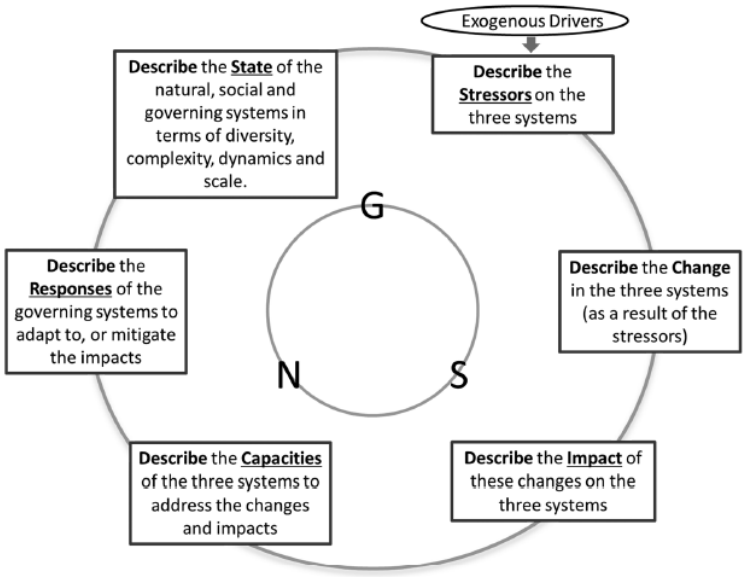

Figure 2. 1 I-ADApT Framework

Showing the outline of the different steps for the description and response component of I-ADApT. (N) is for the natural system, (S) for the social system, and (G) for the governing system (Guillotreau et al., (2018a)

2.2.1 What is a Social-Ecological System

Social-ecological systems are characterized by a complex network of interactions (Oestreich et al., 2019). Social-ecological systems can be defined as complex, adaptive, integrated, and interdependent systems where the human system (individuals, communities, societies,

economies) are linked with the natural system (the biophysical system) and vice versa (Berkes & Folke, 1998). SESs are complex in a way that human actions affect biophysical systems; biophysical factors affect human well-being and humans, in turn, again respond to these factors (Berkes, 2011). The two-way linkages between these two systems may consist of knowledge related to multiple fields including the local, traditional and indigenous knowledge, governance arrangements, management of commons institutions, motivation to engage in collection action (stewardship values), and rules and norms that arbitrate (Armitage et al., 2017) how humans interact with the environment (Berkes, 2003). Analysis of SSF SESs generally differs from the analysis of the social or ecological subsystems alone (Berkes, 2003). There is a need to connect the theoretical idea of SES to realities experienced by the fisher's communities to reveal how system components change as a result of exposure to the local and global changes. The SES framework developed by Ostrom, (2009) identifies four subsystems needed for the sustainability of SES which are resource systems, resource units, governance systems, and end-users which are all the core components of the I-ADApT framework. Both approaches or the framework developed by Ostrom, (2009) and Bundy et al., (2016) focus to characterize the interdependent linkages between social, environmental, and governance changes and how these connections affect the sustainability outcomes in natural, social, and governance systems, at different levels and scales.

SES research originated with a strong focus to understand the dynamics of complex human-environmental systems and management of the common pool resources (Berkes et al., 2002). Over several past years, the SES research concept has been widely used in sustainability science research to understand the human-environment interactions (Stern, 1993) from the perspective of global change and understand the process of social-ecological change within various sub-systems of the linked human-environmental systems (Galaz et al., 2016). However, understanding the change process hasn't been easy due to the co-evolving nature of the human-environment interactions. This is more complex for marine ecosystem management because of the varying interest of multiple actors mainly related to marine conservation and developmental goals (Chuenpagdee, 2011), especially in the case of SSF management (Brinson et al., 2009).

Global change effects on the natural, social, and governing systems have produced complicated feedback dynamics making it difficult to determine the cause and effect of the changes at

different levels of the SESs. SES perspective considers the integrated relationship of humans in nature and any delineation between them would be artificial and arbitrary (Berkes & Folke, 1998). The interactions between the various drivers of global change (Biggs et al., 2021) are creating challenges to discern the feedback process that helps SSF communities to adjust and adapt to the changing conditions (Ommer & Neis, 2014). SES research is itself an iterative and reflexive process (Vos et al., 2021) where there is no "one-size-fits-all" situation (Hazard et al., 2020). So, making decisions to manage these complex, intertwined systems would require the help of decision support tools (DSTs) to make effective decisions by choosing the most achievable alternatives out of many.

2.2.2 Interactive Governance Theory

Interactive governance theory is generated from the assumption that societies are governed by many governing actors through social and governing responses (Kooiman, 2003). These governing responses reflect the societal diversity, dynamics, and complexity of the ever-growing social-ecological issues nested in the SSF system. The interactive governance approach differs from others by its focus on horizontal and vertical linkages across different societal scales, from the local to the global, which can take place in any form (Kooiman et al., 2008; Chuenpagdee, 2011). The core concept of interactive governance is "interacting" which highlights the coordinating ability to deal with external pressure drivers, with shared responsibilities rather than doing tasks alone by the constituent actors of our society.

The concept of governability comes along with the idea of interactive governance which provides a conceptual basis for assessing and improving the interactive governance of the marine systems (Kooiman et al., 2008). As explained by Kooiman et al., (2008) governability depends on the characteristics of the system-to-be-governed, the governing system, and the governing interactions. When analyzing a complex, dynamic, and diverse system, the system-to-be-governed is the SSF SES which consists of the human system and the natural system; the governing system is the elements and order of governance which consists of the images, instruments, principles, and institutional arrangements (Bundy et al., 2016) and finally the governing interactions which are guided by various forms of interactions such as participatory,

collaborative, and management or policy interventions across different scales. Governing interactions in SSF at the structural level are classified as self-governance, co-governance, and hierarchical governance (Chuenpagdee & Jentoft, 2018). Initially, the practice of interactive governance was thought to be theoretical, however, with a broader understanding of the opportunities to solve problems using the theory, the concept has gained immense recognition in SSF research (Chuenpagdee & Jentoft, 2018).

2.2.3 DPSIR Framework

Drivers-Pressures-State change-Impact-Response (DPSIR) framework, one of the widespread frameworks, helps in understanding the links between human pressures, marine ecosystem changes, and the cause-effect relationships among the "chain of the events leading to state change, impact, and response" (Patrício et al., 2016). The framework was initially developed around two decades back by the European Environment Agency (Stanners & Bourdeau, 1995) to assist policymakers to solve environmental problems and better understand the "cause-effect relationship between environmental and human systems" (Lewison et al., 2016). DPSIR framework is helpful in the study of SSF SESs because it allows capturing and communicating the complex interactions between the anthropogenic activities, environment, and the SSF communities addressing different aspects of SSF management such as "research, monitoring, mitigation, policy and society" (Patrício et al., 2016). One of the advantages of the DPSIR framework is that it can be used both as a research tool, and decision-support tool (DSTs), and the framework can be utilized to conduct both qualitative and quantitative analysis (Lewison et al., 2016). Also, the DPSIR framework has been valued for its multidisciplinary approach toward problem-solving, and provisioning for stakeholder participation. The framework includes Drivers that exert Pressures on the environment which can lead to unwanted or unavoidable changes in the State of the environment which then can cause negative or positive Impacts on the natural and social system. Responses are the formal or informal actions taken by individuals, and/or households, and/or communities "to prevent, compensate, ameliorate or adapt to changes in the state of the environment by changing drivers or pressures through actor-driven shifts in behavior, prevention, mitigation or regulation" (Baldwin et al., 2016).

However, the DPSIR framework has several limitations. One of the most common shortcomings of the DPSIR approach is the interactions in the real-world realm are more complex than what can be explained by the cause-effect relationships (Gari et al., 2015). Another limitation is that the framework does not capture the dynamic trends except by repeating the same static indicators; it assumes linear chains of the interactions in the context of analyzing the social-ecological systems; there is a lack of explicit scale of analysis, and there is inconsistent use of terminologies in the framework.

2.3 Theoretical development of Vulnerability to Viability approach

There are four major conceptual theories describing the Vulnerability to Viability (V2V) research concept (conceptual framework shown in Figure 2.2) to study the transition of small-scale fisheries communities (SSF) in the context of global changes. These are social-ecological resilience and adaptive capacity; social wellbeing and sustainable livelihoods; interactive and multi-level governance; and gender and political ecology (Nayak, 2021). This research does not deal explicitly with the concept of gender and political ecology. Thus, this concept is not elaborated on in detail in this research. The other three concepts are discussed below.

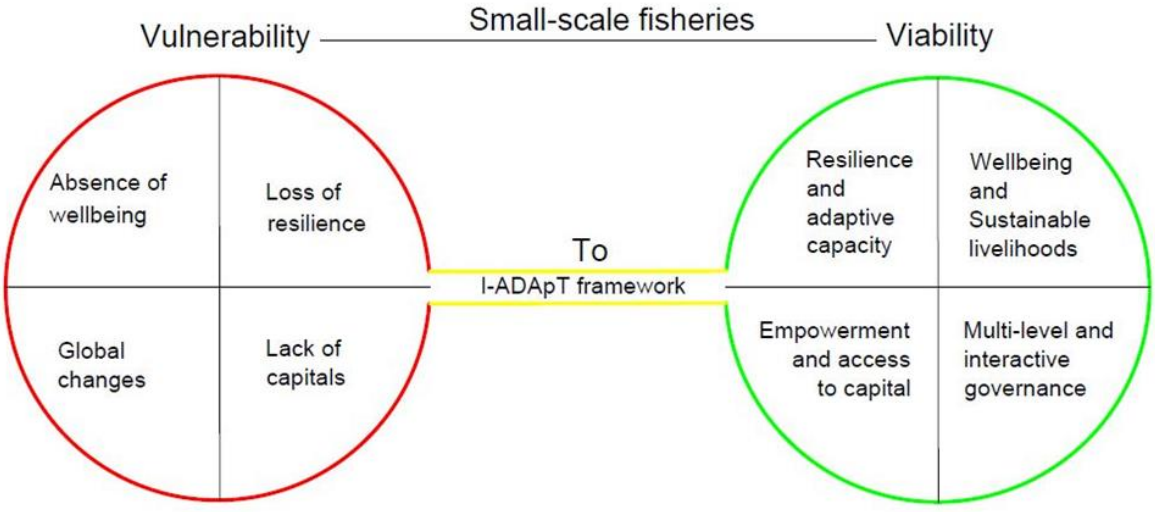

Figure 2. 2 Vulnerability to Viability Conceptual Framework

2.3.1 The Well-being of SSF communities

Wellbeing is defined as "a state of being with others, where human needs are met, where one can act meaningfully to pursue one's goals, and where one enjoys a satisfactory quality of life" (Armah et al. 2010). Well-being in the context of SSF can be characterized as having three dimensions: material, relational, and subjective (Gough and McGregor, 2007; Coulthard et al. 2011), which can influence the level of vulnerability and viability within a specific context (Fischer, 2014). The well-being of SSF communities means allocating sufficient resources to reduce vulnerability, build strength, and develop the adaptive capacity to enhance viability. The ability to adapt does not imply that the SSF communities are resilient, instead, it relates to the proactiveness and interactive capacity to prevent social-ecological regime shifts (Lade et al., 2013).

2.3.2 Theory of resilience and its connection to Social-Ecological System

To date, many definitions and classifications exist for resilience theory. Each interpretation of resilience theory reflects its corresponding origins in diverse fields and its perspective on sustainable development (Hayes et al. 2019). Resilience theory now has applications in various fields such as engineering science, social sciences, public health, organizational management, environmental science, and supply chain theory, among many others to achieve sustainable development goals (Bhamra et al. 2011). Holling (1973) first applied the concept of resilience to ecology by using "the resilience and stability of ecosystems" to explain the non-linear characteristics and unexpected changes in marine systems Berkes and Folke (1998) firstly started to use resilience theory as an integrated concept to investigate external disturbances in SESs, such as climate change (Folke, 2006; Nayak and Berkes, 2012).

Resilience theory explains how dynamic systems functioning at a variety of spatial and temporal scales interact with each other whether by accelerating or dampening the change process (Walker and Salt, 2006). Resilience theory challenges conventional approaches focused on control and stability, to understand sudden and abrupt changes to SES without letting the system enter into an undesirable state (Berkes & Folke, 1998b). Bounding to resilience theory, "social-ecological resilience" (Berkes & Folke, 1998b) can be defined as the capacity of SESs to absorb change and

disorder without shifting to a new regime that consists of a set of processes and structures, without changing into a new state (Walker and Salt, 2006). Social-ecological resilience theory shows the way how SSF communities and marine ecosystems can benefit from disturbance and reorganization to achieve overall sustainability (Gibbs, 2009).

2.3.3 Multi-level governance

Multi-level governance is defined as "institutional arrangements that facilitate the co-production, mediation, translation, and negotiation of information and knowledge of SSF management within and across levels" (Brondizio et al., 2009). Example of multilevel governance approaches includes co-management, adaptative co-management, adaptive management, polycentric governance, inclusive management, etc. (Armitage et al., 2017). The multi-level governance approach facilitates power-sharing, knowledge sharing, building trust among the resource users, institution building, and problem-solving to improve cross-scale linkages in marine commons (Pomeroy and Berkes, 1997). Multi-level governance carries the notion of institutional interplay in which the social and governing institutions interact horizontally (across the same level) and vertically (across levels of the organization) (Berkes, 2021) and facilitates cross-scale interaction (Young, 2002) which is one of the gaps I-ADApT filled. Vertical linkages focus on the coordination of the management responses at higher levels of the organization whereas horizontal linkages are helpful to coordinate the responses between the local SSF communities (Berkes, 2021).

Multi-level governance arrangements are most suitable for the management of SSF SES due to the complexity associated with the management of contested resources (e.g., in SSF the questions about excludability and subtractability always remain complex and uncertain). Excludability is one of the characteristics of commons which relates that exclusion of potential users through physical and institutional means can be tricky. "It pertains to the question of who is and who is not a legitimate user of a resource" (Nayak & Berkes, 2022). Subtractability is another property of the commons that can be "defined as the idea that exploitation of the resource by one user reduces resource availability for others, and deals with the rules of resource distribution and allocation among users" (Nayak & Berkes, 2022). By following multi-level

common-pool resource governance, the rulemaking system can be improved by issuing power to SSF communities following a certain model or form. Regardless of the style adopted, it is crucial for all the actors, especially SSF communities to remain actively involved in decision-making processes (Eckerberg and Joas, 2004; Ho et al., 2012). There is not any guarantee that the multi-level governance approach will always solve the problems related to SSF management, they may also tend to fail if there stands a lack of coordination between the actors at various levels (Ostrom, 2005).

2.4 Decision Support Tools

DSTs help to identify various strategies that will optimize a specific objective, detect knowledge gaps, and provide transparency in the decision-making (Walshe et al., 2019). The decision-making using DSTs is more systematic and objective, which can be used to support the long-term management plan (Pınarbaşı et al., 2017). DSTs have been widely adopted in marine ecosystem management to deal with wicked or complex problems (Courtney, 2001) such as the problems related to understanding the human-environment pressures on the marine ecosystem. There are various types of DSTs such as quantitative assessment tools (e.g. Krueck et al., 2019), model-based management tools (e.g. Parrott et al., 2011), and operational systems linked to databases (Nygård et al., 2020).

For example, Giupponi, (2007) developed a DST by combining DPSIR with multicriteria analysis. Similarly, Balzan et al., (2019) used the DPSIR model as a DST to facilitate decision-making and enhance collaborative interactions between various actors within the SES. Diedrich et al., (2010) developed a DST considering social and ecological indicators to guide decisions on integrated coastal management in the Balearic Islands, Spain with the focus on a participatory approach for the development of the most influential ecological indicator and monitoring systems. Defeo et al. (2017) assessed the responses of natural, social, and governance systems of the yellow clam small-scale fisheries to mass mortalities in Uruguay using I-ADApT and showed that the collaborative actions and adaptive responses coming from co-management initiatives are useful to mitigate the adverse effects stressors to the SES.

2.5 Typology in Social-Ecological System research

A typology can act as a guide for decision-making by grouping the case studies based on their similarities and differences. Grouping the case studies here relates to the classification of the SESs as described in the I-ADApT template. There have been various efforts by past researchers to develop the typology of SES in considering different types of SESs and have explained how typology helps in reducing the complexity of understanding the SESs.

For example, Alessa et al., (2009) developed a social-ecological typology to refine messy SESs to improve short- and long-term adaptive strategies using variables derived from other various frameworks. The authors concluded that there needs to be involvement of a diverse range of communities while developing typologies of complex SESs. Maru et al., (2011) used typology within the climate vulnerability assessment studies and highlighted that the application of typologies leads to the advancement of research analysis when dealing with climate change impacts. Considering social-ecological systems in the mountain regions, Altaweel et al., (2015) investigated the use of SES typology. Authors determined that typologies are best suited to systematically identifying the resilience and vulnerability levels. However, the authors here also pointed out that, it is crucial to identify social-ecological, and biophysical metrics for fostering resilience and vulnerability. Glaeser (2019) developed a typology considering the case study in Indonesia to compare the ecological, sociocultural, and economic aspects of coastal and marine ecosystem management. The author concluded that the typology can be used not only as an analytical instrument but also as a planning tool at different levels by using it further for multilevel and cross-scale analysis. The cross-scale analysis here means understanding the interactions across different scales (Young, 2002). The cross-scale analysis is important to understand the construction model of the successful management measures or governance types using both scientific and local ecological knowledge (Berkes & Seixas, 2005).

Developing typologies with a focus on the SSF SESs at a broad level does not incorporate the qualities and specialties of the social-ecological system at the community level. By developing the typology using the I-ADApT framework, an effort was made to understand the vulnerabilities and responses at the local, regional, and national levels. I-ADApT framework was used in conjunction with quantitative and qualitative research methods to reduce the complexity of

research data (consolidate a large number of variables into a small number of variables to understand which variables had the highest influence on the social-ecological change process) and identify major drivers causing the vulnerabilities and sustainable responses that helped small-scale fisheries community to deal with those vulnerabilities.

Chapter 3

Leveraging Multiple Factor Analysis and Hierarchical Clustering to Study the Impacts of Global Change on Small-Scale Fisheries: Expanding the use of I-ADApT as a Research and Decision Support Tool

3.1 Introduction

Interaction with marine ecosystems is central to our survival as individuals, communities, and societies. Marine ecosystems have provided critical nutritional, economic, cultural, and other non-monetary benefits to human communities for millennia (Selig et al., 2019). However, marine ecosystems have been confronting drastic changes, mostly due to global environmental changes associated with anthropogenic and natural stressors, over the last 200 years (Thurstan, 2022). Anthropogenic global changes are characterized by negative impacts due to increased human activities such as over-exploitation of resources, climate change, sea-level rise, rapid population growth, urbanization, industrialization, pollution, resource depletion, biological invasions, land-use changes, war, aquaculture intensification, and overfishing (Turner II et al., 1990; Owen et al., 2006; Bundy et al., 2016; Armitage et al., 2017). Natural global changes are described by extreme climatic and weather events such as hurricanes, earthquakes, flooding, and tsunamis, which are usually unpredictable and tend to occur mostly because of natural processes.

These environmental global changes, which are referred to hereafter, as global change (Bundy et al., 2016), directly or indirectly are causing hardships to coastal communities such as small-scale fisheries (SSF) communities (Firth & Hawkins, 2011) at the local level. Alongside, the political and economic interests of multiple stakeholders and varying laws at the national and international levels are presenting significant risks to sustainable resource extraction, trade, and marketing (Bundy et al., 2012; Okafor-Yarwood et al., 2022) of fish in SSF. These multidimensional drivers of change create impacts on multiple sectors within SSF and catalyze

the cascading effects (Nayak, 2014) in small-scale fisheries social-ecological system (SSF SES) (Berkes, 2003). SSF SES represents an integrated social (human) and biophysical (ecological) system and any delineation between these systems would fail to recognize the dynamic interconnectedness, two-way linkages, and vibrant interrelation between them (Berkes, 2003).

SSF SESs are at the forefront of sectors affected by global change (Barange et al., 2014). As a result, small-scale fishers are facing problems associated with poverty, marginalization, and social injustice making them vulnerable due to the biophysical and social drivers of change (Nayak & Berkes, 2010; Whitney et al., 2017; Glaeser, 2019). Nevertheless, the awareness of the global changes has grown (Bundy et al., 2016; Calò et al., 2022) presenting risks and opportunities for progressing toward the development of resilient (Hardy et al., 2017) SSF SES. The survivability of the SSF communities despite facing bountiful vulnerabilities (Kolding et al., 2014) across the globe suggests they have developed the adaptive capacity through coping, adaptive and transformative responses to deal with those multidimensional social-ecological vulnerabilities (Nayak, 2017). Methodological innovations are required to understand the existing and emerging vulnerabilities and successful and unsuccessful responses to foster sustainability in small-scale fisheries. There has been limited application of the quantitative methods in SSF research in terms of understanding the vulnerabilities and responses to global changes. There is a need to explore analytical quantitative research methods that can facilitate the analysis of multidimensional data of SSF SES and compare case studies of the SSF SES.

Quantitative multivariate data analysis methods such as multiple correspondence analysis (MCA), multiple factor analysis (MFA), and hierarchical clustering (HC) can be used to explore and untangle the complexity of the multidimensional data of multiple SSF SESs. Multivariate analyses such as MCA and MFA typically use the statistical procedure of dimensionality reduction, which enables the creation of plots of the variables and individual case studies in relation to the principal components (Lalloué et al., 2015). This allows the dimensionality (attributes) of the data to be reduced (transforming a large set of variables into a smaller one that still contains most of the information in the large set) and enables the interpretation of the most important attributes (Fetzer et al., 2021) which were common in the SSF SESs. Identification of the common characteristics provides a way to understand common experiences of small-scale

fisheries communities and devise feasible solutions for transitioning SSF from vulnerability to viability (V2V).

The main goal of this study was to employ multivariate analysis methods such as MCA, MFA, and HC to understand the links, associations, and correlations between categorical data/groups of data of the SSF SESs collected using the I-ADApT template as case studies. The objectives were (a) to further develop the method used by Bundy et al., (2016) and Guillotreau et al., (2018a) to conduct an in-depth analysis of the I-ADApT case studies using R-Studio (RStudio Team 2022) (b) to expand the number of case studies in the typology, and (c) to develop new ways of communicating the results. This study is motivated to fill the gap of the lack of comparative studies employing secondary data to assess ongoing and past empirical knowledge to inform global small-scale fisheries adaptation (Galappaththi et al., 2022) to social-ecological changes and assess the effectiveness of the responses/adaptation measures.

3.1.1 Vulnerability to Viability

The concept that recognizes the strengths and capabilities of the SSF communities and focuses on the co-production of knowledge about how these communities cope and adapt to social-ecological changes by developing resilience, adaptive capacity, and wellbeing is called the Vulnerability to Viability (V2V) concept (Nayak, 2021). Under the V2V concept, the objective is not just to identify the vulnerabilities and identify pathways to viability for SSF, but rather to reveal the lived experiences of SSF communities, sustainable policy, practice, and governance to build sustainable SSF across the world (more focus to developing countries). The concept envisions building a ‘viable SSF’ where the SSF communities have a high state of wellbeing, a healthy marine ecosystem, resilient governing systems, and a social system. It focuses on building on the existing “bright spots” (Kittinger et al., 2013) where the successful responses to deal with social-ecological issues have resulted in better outcomes.

3.2 Literature Review

3.2.1 Need for Decision Support Tools

Given the ubiquitous influences of global changes on SSF SES all over the world (Guillotreau et al., 2018a) there is growing interest to develop comprehensive knowledge about the impact of the global change on SSF SES connecting the local and regional experiences of social-ecological change at diverse locations (Magliocca et al., 2018). Decision-support tools (DSTs) can be used to synthesize the causes, responses, and patterns of the social-ecological change in a way that is useful for the decision-makers to understand those changes and make effective decisions to respond to those changes. Observations from the individual case studies are place-based and they give in-depth knowledge about the social-ecological changes in the local context. However, individual case studies alone do not help to inform the impacts of ongoing changes in the global context. Multiple case studies from different geographical locations need to be studied jointly to comprehend the global picture of the effects of global change on SSF. A combination of these case studies to disseminate important information in a global context requires the use of multivariate data analysis approaches, without which it would be arduous to understand the complexity of the data and synthesize the undergoing social-ecological processes.

Related examples are the coordinated efforts to understand the impacts of climate change by intergovernmental panels on climate change (IPCC) (Pörtner et al., 2022) where they use multiple case studies considering all the countries to help the stakeholders take action on the issues related to climate change. DSTs can best answer the questions that policymakers often face: how to select the best response among many alternatives to ensure the viability of SSF? How to incorporate a multitude of information sources about SSF SES to make a logically consistent, defendable decision (Jarre et al., 2008)?

3.2.2 Development of Decision Support Tools

Any type of tool which helps to visualize the complex information in a more presentative manner and helps to reduce the complexity of the SES can be called the DSTs. The development of DSTs for marine ecosystem management has taken several shapes and forms over the decades based on its diverse applications in marine ecosystem management, including fisheries management. Different types of DSTs include the use of scientific and non-scientific knowledge;

integration of the ecological to the socio-economic data; integration of stakeholder involvement to non-expert knowledge in uncovering the knowledge gaps in comprehending human-environment interactions and contributing to the successful policy outcomes (Janßen et al., 2019). The use of any of these approaches or models as DSTs in SSF research is depends on the type of problem for which the solution is being sought by the researcher as each approach has its strength and weaknesses.

Bolman et al., (2018) argued that many DST tools are science-driven models and mentioned that solely making the information and scientific data available doesn't address the basic challenges of decision-making unless it is aligned with the needs of the decision-makers and the involvement of end-users. The potential of DSTs is high as they can help explore the capabilities and weaknesses of the existing systems for making more informed decisions. However, the full potential of DSTs in supporting practitioners in implementing real solutions fostering SSF viability doesn't seem to have been realized yet. There is a need to conduct a greater number of empirical studies that can produce results that can be used by decision-makers to make effective decisions to plan feasible responses to reduce vulnerabilities.

3.2.3 I-ADApT as Decision-Support Tool

It is now an accepted reality that both stakeholders and other parties such as scientists play important role in decision-making to make scientifically informed decisions (Bolman et al., 2018). There are limited DSTs that assist policy implementation to address the impacts arising from the global change and integrate multiple knowledge types in SSF research. Bundy et al., (2016) filled this gap by developing the I(MBER)-ADApT (Assessment based on Description and Responses and Appraisal for a Typology) framework using an interdisciplinary approach as a part of the Integrated Marine Biosphere Research (IMBeR) Human Dimensions Working Group (HDWG), global research program. I-ADApT is an integrated assessment framework that uses place-based case studies to capture essential information about vulnerabilities and guide the pathway towards viability. The information gathered using the I-ADApT framework can be used to make comparisons between the SSF SESs to guide effective management and governance. I-ADApT is the only framework found in the existing literature that helps to evaluate the most appropriate responses and assess what strategies worked and why they worked and how did it

work across scales (spatial and temporal) and levels (local, regional, and national). These sort of comparisons helps in developing concrete evidence to integrate knowledge and provide a learning opportunity to respond to the social-ecological crisis.

3.2.4 I-ADApT as Research Tool

The I-ADApT framework used as a research tool facilitates co-creation of new knowledge related to vulnerabilities and strategies enhancing viability in SSF. As a research tool the I-ADApT framework (i) provides a simplified template with indicators to collect evidence of the social-ecological change for different subsystems of SES (ii) it enables a systematic way of reporting and communicating the results through typology development (iii) it acts as a learning platform to co-develop knowledge through a collaborative and participatory process (iv) it can be used on conjunction with any other methodological approaches either qualitative or quantitative to integrate and analyze the data and (v) it offers flexibility for researchers to choose any type of research design and research philosophy based on the problem statement.

3.2.5 Application of Multivariate analysis in Small-scale Fisheries Research

Glaeser, (2019) defined typology as the "systematic grouping of entities that have common characteristics and specific differences". Developing the typology of complex systems like SSF SES from the V2V lens requires a focus on multi-disciplinary factors. Incorporating a broad range of multi-disciplinary factors requires the use of multi-variate analysis to understand the data pattern. There are plenty of examples where past researchers have used the multivariate analysis tools to develop typology in fisheries research which are quantitative. Béné, (2003) categorized the biophysical, socio-economic, and institutional factors to effectively manage the resource and understand the paradigms between fisheries and poverty. Dominique & Ferraris, (2000) developed typologies of fishing operations involving multivariate descriptive methods which included factorial analysis and clustering analysis to determine the most dominant fishing tactics considering the SSF of Senegal. Maynou et al., (2011) conducted a similar study to reveal the frequently adopted fishing tactics using Principal component analysis (PCA) and hierarchical clustering (HC) in the port of Vilanova, Spain. Tzanatos et al., (2005) examined the characteristics of Greek SSF using PCA and HC, where the authors defined the characteristics of

the Greek SSF by identifying the important characteristics, activity patterns, and differences of SSF with large-scale fisheries. Guillemot et al., (2009) developed a typology to identify the informal fishing activities practiced by fishers in the context of environmental degradation due to mining on the North-West coast of New Caledonia and concluded that environmental degradation was causing overfishing hindering the sustainability of the SSF in the region. Smith et al., (2011) developed the typology using PCA considering fishing communities across different countries and declared that factors such as strong leadership, allocation of protected areas, quota system, and social unity are overarching for achieving success in the management of SES. A more recent study Coronado et al., (2020) used PCA and HC to classify 22 SSF communities located in the Yucatan Peninsula, Mexico into a typology, Authors highlighted that the typology approach is suited to organize and integrate SSF data and understand the complexity and attributes associated with the SSF SES.

3.3 Methodology

This study used 29 I-ADApT case studies (Table 3.1 for detailed information) from 19 different geographical locations (Fig 3.1) to develop the typology. All case studies were collected using the same consistent structured I-ADApT template (Appendix B). Of the 29 case studies, 24 represent SSF, and 5 represent aquaculture systems. Twenty of these case studies were presented in detail by Guillotreau et al., (2018a), who used the case studies to develop a typology. The other 9 case studies were collected by the Too Big Too Ignore (TBTI) project and are unpublished. The I-ADApT templates were completed by the respondents from government agencies, scientists, and academic researchers who were contacted by the IMBeR HDWG and Too Big Too Ignore (TBTI).

Table 3. 1 List of case studies used in the study

#	Acronym	Case study	Main issue	Area (km^2)	% of local population affected
1	**SL-cora**	Sekisei lagoon coral reef (Ishigaki Island, Okinawa, Japan)	Deterioration of coral reefs, loss of fish habitats	600	>21
2	**ON_tour**	Onna village (Okinawa tourism, Japan)	Water pollution by red clay outflow	50.8	>20

#	Acronym	Case study	Main issue	Area (km^2)	% of local population affected
3	**OB_poll**	Omura Bay pollution (Japan)	Water quality degradation	320	>20
4	**SH_poll**	Jin-Shanzui village (Shanghai) (China)	Water pollution from urbanization	3.5	>20
5	**PH_poll**	MMO river system (Philippines)	Water pollution from a river system	130	<5
6	**BA_mang**	Bay of Bengal (Sundarbans) mangrove (Bangladesh)	Cyclones causing major damages to mangrove fisheries	6000	>20
7	**MB_oyst**	Matsushima Bay oysters (Japan)	Norovirus outbreak after the destruction of sewage facilities by a tsunami	35.3	<5
8	**BB_oyst**	Bourgneuf Bay oysters (France)	Oyster epizooty caused by herpes virus	100	<5
9	**GRC**	Kalloni	Ecosystem change (water temperature increase, alien species, human impacts) and social issues competition among fishing gears, income decrease, market access issues)	115	–
10	**CM_mang**	Cameroon mangrove	Overexploitation of mangrove ecosystems	2,800	5 to 10
11	**BU_pela**	Southern Benguela pelagic fishery (South Africa and Namibia)	Shift of natural conditions affecting small pelagic fish stocks	220,000	15 to 20
12	**GR_Amv**	Amvrakikos Gulf (Greece)	Upwelling of anoxic water killing farmed fish	525	<5
13	**GR_Mal**	Maliakos Gulf (Greece)	Ichthyotoxic algal blooms	92	5 to 10
14	**VL_clam**	Venice lagoon clams (Italy)	Introduction of an alien clam species	550	<5
15	**CB_oyst**	Chesapeake Bay oysters (USA, East coast)	Oyster disease (parasites) and depletion	1.2	5 to 10
16	**TB_shrm**	Tokyo Bay mantis shrimp (Japan)	Marine pollution caused by industry affecting shrimp populations	9000	<5
17	**IN_reef**	Spermonde Archipelago (Indonesia)	Population growth and overfishing	2500	10 to 15
18	**US_oyst**	U.S. Pacific Northwest (Puget Sound) oysters	Ocean acidification killing oyster larvae	49000	<5
19	**YB_clam**	Yokohama Bay clams (Japan)	Lack of property rights for clam gathering	470	<5

#	Acronym	Case study	Main issue	Area (km^2)	% of local population affected
20	**UR_clam**	La Coronilla- Barra Del Chuy-Yellow Clams (Uruguay)	Mass mortality of clams by freshwater runoffs	2.3	<5
21	**ESP_G**	Galicia	Declining of the sardine stock due to increases in average sea surface temperature and conflicts among fishers emerged.	29,365	<5
22	**VIC**	Lakes Victoria, Kyoga, and Albert	Reduction in size of small-sized pelagic species (SSPG), fluctuations in proportion of bycatch and variability in the socio-demographic landscape of SSPG in inshore waters of lakes Victoria	7.5	<5
23	**ARG**	Argentine	Uncertainty associated to the anchovy socio-ecological system and the vulnerability of the San Matias gulf anchovy stock	20,000	<5
24	**BS_fish**	Baltic Sea fishery	Variability of salinity conditions affecting fish stocks	415,000	15 to 20
25	**VEN**	Venezuela	Sharp decline in catches of sardine fisheries causing fragile condition of stock worsened by climatic conditions with a threat of collapsing fisheries	240	–
26	**ESP_M**	Murcia	Regulation no. 1967/2006 failed to account interests of local fisheries producing unfavorable technical conditions	180	–
27	**BGD**	Sundarban Mangrove Forest	Reduction of mangroves and mangroves inundated area, and its negative impact on the artisanal fishermen's livelihoods.	595,000	80
28	**TAN**	Lake Tanganyika	Fluctuation in fishing capacity for pelagic fish species	32,600	–

#	Acronym	Case study	Main issue	Area (km^2)	% of local population affected
29	**KAR**	Lake Kariba	Decline in fish catch due to various factors including increased fishing pressure, and climatic variability.	5500	–

Figure 3. 1 Representation of the case studies by the geographical locations (Number 1 corresponds to the first case study described in Table 1 and so on, refer to Table 1 for the locations of case studies)

3.3.1 Description of I-ADApT Template

The I-ADApT template consists of 30 questions which are grouped into six sections as described below (Guillotreau et al., 2018a):

I Background information (2 questions about the description of the main issue affecting the fishing or aquaculture in the SES)

II Description of the stressors and their impacts (5 questions about the scale of the affected natural, social, and governing systems; the main stressors affecting these systems, the consequences of the stressors, and their impacts on these systems)

III Vulnerability (6 questions about the outcomes of the stressors; exposure and sensitivity of the SSF communities to the social-ecological issues)

IV Governance and governability (8 questions about the management of the commons institutions)

V Response (2 questions about the actions of the natural, social, and governing systems to deal with the main issue)

VI Appraisal (7 questions to evaluate the response of the natural, social, and governing systems to deal with the main issue

To build the typology, the qualitative responses to the questions in the I-ADApT template were scored using a 5-point Likert Scale into categorical variables (semi-quantitative data) as described by Bundy et al., (2016) and Guillotreau et al., (2018b). Note that the data were provided to the author in this format. The details of the scoring are provided in Appendix C. The questions from 4 sections: vulnerability, governance and governability, response, and appraisal, were coded to 8, 11, 6, and 7 questions (Table 3.2) respectively The questions from the first 2 sections were not scored and were not used in the quantitative analysis.

Table 3. 2 Coded questions for the purpose of developing typology

A	**Vulnerability group**
QB	The number of people affected by the Main Issue (from Background section) expressed as a ratio to the total number of people in your case study area (also from Background Section) , ie, size of affected population/total population:
Q3	What are the main stressors that affect this ecological system?
Q6	What is the ecological status of the affected ecosystem at the ecosystem level prior to the main issue?
Q7	

	What is the productivity of the system (low, medium, or high)?
Q8	What are the main livelihood activities (e.g., fishing, tourism, etc.) directly affected by the main Issue?
Q9	What other livelihood opportunities (e.g., farming, manufacturing, forestry, etc.) are there in the affected area?
Q10	What % of the total catch/production is used for household consumption (not sold)?
Q11	What proportion of household income comes from local sales of fish catches, processing, and wholesaling?
B	**Governance and Governability group**
Q2N	Which of the following levels is the Main Issue related to for Natural system
Q2S	Which of the following levels is the Main Issue related to for Social system
Q2G	Which of the following levels is the Main Issue related to for Governing system
Q13	What is the mode of governance?
Q15	What are the key rules, regulations, instruments, and measures employed to achieve the management objectives?
Q16	Are there any informal rules, regulations, instruments, and measures that play an important role in the governance of fisheries and aquaculture?
Q17	What is the nature of the relationship between the different sectors or livelihood occupations in this system (i.e., ranging from conflict to cooperation)?
Q18	Who dominates or wields the most social power in the area (e.g., fishers', associations, unions, corporations, governments, business owners, etc.)?
Q19	How concentrated is social power in the area?
Q20	Were there any structural changes in the governing system or individuals prior to the main issue? Please describe the changes and why they occurred?
Q21	Were there any changes to the key rules, regulations, instruments, and measures, or have any new ones been introduced prior to the main issue? Please describe the changes and why they were introduced
C	**Response group**
Q22S	What were the short term responses of the social and governing systems to the main issue? (Include structural changes in the governing system(s) or individuals, or the changes in key rules, regulations, instruments and measures etc.)
Q22L	What were the long term responses of the social and governing systems to the main issue? (Include structural changes in the governing system(s) or individuals, or the changes in key rules, regulations, instruments and measures etc.)
Q26S	What factors contributed to the successful short term results described in Q24S (e.g., enabling policy, government funding)
Q26L	What factors contributed to the successful long term results described in Q24L (e.g., enabling policy, government funding)
Q27S	What factors (if any) prevented the short term objectives from being fully achieved? (e.g., regulatory barrier, lack of social cohesion, costs too high, climate variability, judicial decisions).

Q27L	What factors (if any) prevented the long term objectives from being fully achieved? (e.g., regulatory barrier, lack of social cohesion, costs too high, climate variability, judicial decisions).
D	**Appraisal group**
Q24S	What were the results of the short term response for the natural, social and governing systems (i.e., were the objectives in Q23S achieved)?
Q24L	What were the results of the long term response for the natural, social and governing systems (i.e., were the objective in Q23L achieved)?
Q25	Was the Main Issue addressed?
Q28	Has there been a formal evaluation of the response (how and when)?
Q29S	What were the benefits related to costs of the short term response?
Q29L	What were the benefits related to costs of the long term response?
Q30	Were other options considered for the short and/or long term responses? not selected?

Three phases were involved in the development of the typology (Fig 3.2). The first two phases, the conceptual and data collection phases were not part of this study. Thus, they are not described here, and the focus of this study is more on the third phase. The third phase is the data assessment phase using multivariate data analysis methods such as MCA, MFA, and HC to develop the typology of the case studies. All the analyses were performed using FactoMineR (Lê et al., 2008) and Factoextra (Kassambara, 2017) in the R-Studio interface.

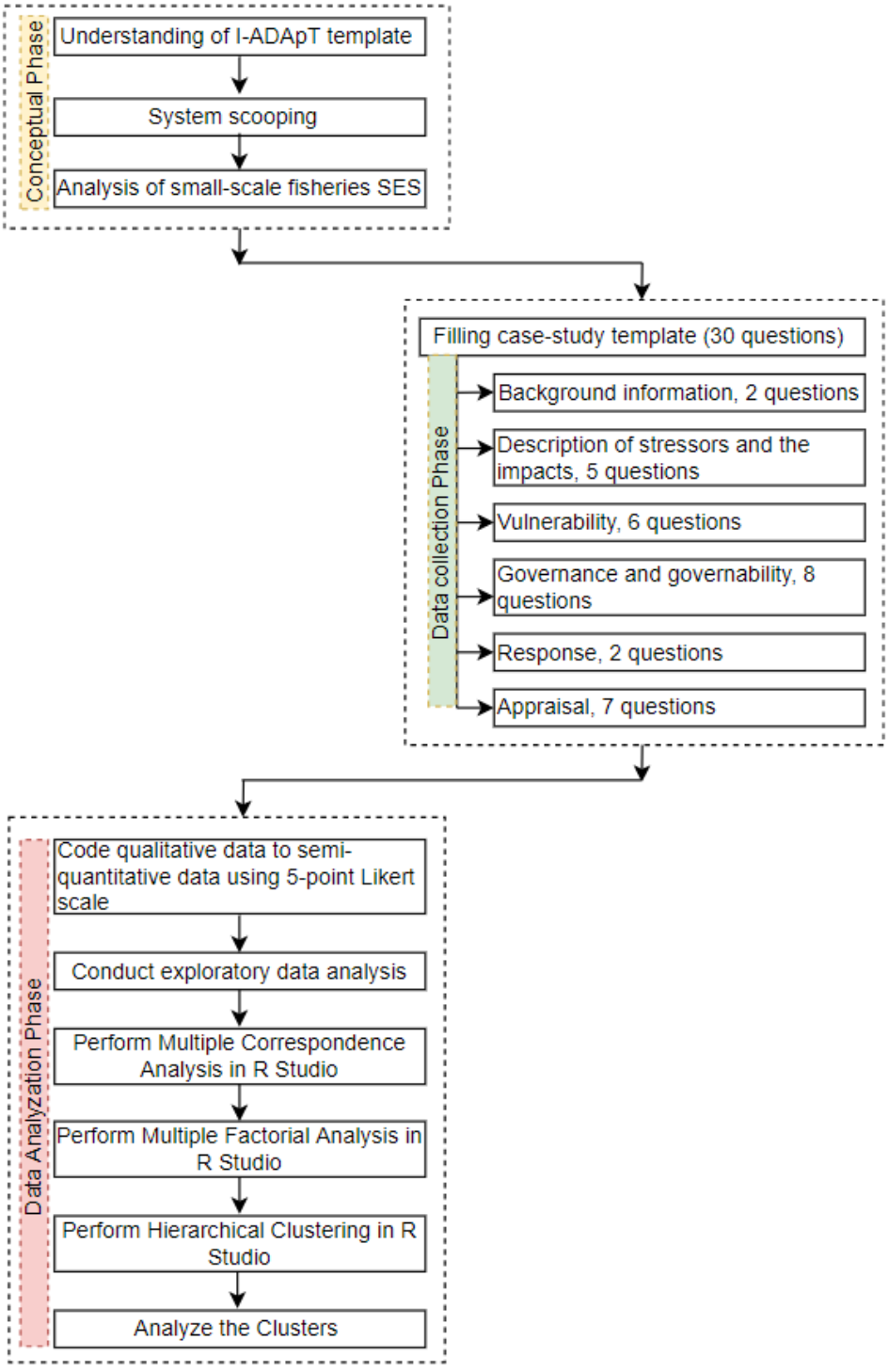

Figure 3. 2 Research Methodology

3.3.2 Exploratory Data Analysis

Exploratory data analysis is the process of performing an initial investigation of the data to familiarize with the data and understand what data were collected, what possible trends can be seen in the data, and what type of analysis will be suitable to use for the research purpose (Cox, 2017). In this research, exploratory data analysis was employed to fill 6 missing data in the final list of the semi-quantitative data. This represented 0.64 percent of total data used in the analysis [928 total data points (32 variables*29 case studies)]. The missing data were imputed using the missMDA R package (Josse & Husson, 2016). missMDA function in R-Studio employed an iterative MCA algorithm to predict the missing data.

3.3.3 Multiple Correspondence Analysis and Multiple Factor Analysis

Multiple factor analysis (MFA) (Escofier & Pagès, 1994) helps to analyze individual and groups of variables. There are two main steps involved in MFA analysis. The first step in MFA analysis is to perform MCA on each group of variables to normalize each group by dividing the variables by the square root of the first eigenvalue of the MCA (Lalloué et al., 2015). This process determines the weight of each group of variables through the process of data normalization. The second step was to perform MCA on the whole data set (global MCA), by merging normalized dataset to form a unique matrix to understand the linkages (similarities and differences) between the data (Abdi & Valentin, 2007). MCA analysis was used in this research as the variables were categorical. If they were quantitative, principles component analysis (PCA) would be used (Lalloué et al., 2015).

Multiple correspondence analysis (MCA) is an extension of correspondence analysis (White & Scheld, 2022) and represents a type of dimension reduction method for multivariate datasets that contains categorical variables. MCA analyzes the similarities between the case studies (I-ADApT templates), the individual variables, and the individual variable categories (referred as VC). Each question in the coded I-ADApT template was referred to as a variable (e.g., QB, Q3, Q6, etc. are variables. The categories of response for each question were coded as A, B, C, D, or E. A combination of a variable with its category is called a variable category (VC). For example, QB_A, QB_B, QB_C_QB_D, QB_E, Q3_A, etc. are variable categories. Refer to Appendix C to

see all the individual variables under vulnerability, governance, and governability, response, and appraisal group). The results were viewed on the two-dimensional map represented by the principal components (White & Scheld, 2022). Principal components are new variables that are constructed as linear combinations or mixtures of the initial variables in a multidimensional space.

MFA is a multivariate data analysis method for visualizing complex data which are categorized by individual or group of variables (here termed as vulnerability, governability, response, and appraisal) either continuous and/or categorical and/or nominal type (Kostov et al., 2013). The core of MFA is based on MCA when variables are categorical or nominal. MFA considered the contribution of all active groups of variables, called a 'group/s' for simplicity (here vulnerability, governability, and response) to define the distance between the individual case studies and the variables (725 data points). The supplementary group (here appraisal) did not have any contribution to the construction of the principal components (here called dimensions) and thus, did not play any role in the formation of clusters. However, they were highly important in terms of analyzing the results as they appeared on the two-dimensional plane along with the active variables (Di Franco, 2016). In MFA, the number of variables in each group was different and the nature of the variables (continuous or categorical) varied from one group to another group (Pagès, 2014).

MFA is a powerful multivariate tool because it helps to understand the linear relationships between the variables by detecting the main directions of the variability and it builds an integrated picture of the relationships between the groups of variables of any type. MFA was selected as the preferred type of analysis because it can handle a group of categorical data and it was assumed that the groups (vulnerability, governability, response, and appraisal), variables, and VC are correlated where a change in one variable affects other system variables directly or indirectly. The two important coefficients Lg and RV obtained as the result of MFA analysis (Josse & Holmes, 2016) were significant to understanding the relationships between the group of variables and between the variables of an individual group. See Table 3.3 for further details.

3.3.4 Hierarchical Clustering

Hierarchical clustering (HC) was conducted following the MFA analysis. MFA analysis was conducted before clustering to identify and retain only the meaningful information describing the variability in the data obtained from the case studies. This was a way to reduce the redundancy in the data and improve the clustering results to make it more significant in terms of understanding the vulnerabilities and sustainability responses.

Clustering is grouping the individuals or the set of objects which have some common features with each other. Clustering analysis is one of the best methods for developing typologies especially when multivariate variables are used in the analysis (Bailey, 1989). Clustering analysis is a general methodology to classify various datasets and has broadly been used in the field of statistics, bioinformatics, natural science, and other fields over the past decades (Janssen et al., 2012). In studies related to SSF SES, clustering analysis is most appropriate because SSF SES data are highly diversified and it requires interactive visualization and analytical tools to understand those data (Yajie et al., 2017).

The fundamental behind HC is calculating the distances between the data points or the cases until all the case studies ultimately turn into one cluster (Zolfaghari et al., 2019). This study used squared Euclidean distance and Ward's method to estimate the distance between two different clusters from the barycenter (see Table 3.3) of each cluster (Zhang et al., 2017). The Wards method was selected among various other clustering algorithms because it uses the same method to weight the units as in MFA to assess the inter-clusters distances (Zolfaghari et al., 2019). While performing HC, the hierarchical tree was developed by cutting the dendrogram at the most suitable location which best described the partitioning of the case studies. Generally, the partition that is chosen is the one preceding a strong decrease in the class's inertia. However, in this research, the optimal number of clusters was selected based on the form of the dendrogram and gain within inertia to serve the purpose of the research (ad hoc delineation) (Lukens & Zhan, 2011). The approach followed was an agglomerative type which was a bottom-up approach where each data point was assigned to its cluster and the similar pairs of the clusters were merged (Pezoulas et al., 2020).

The partitioning of the clusters was based on two principles. First, if case studies that belong to the same cluster were close to each other then it has a small within-cluster variability. Second, if

the case studies in a different cluster were far from each other then it has large between/across-cluster variability (Husson et al., 2017; Koh et al., 2022). Detailed mathematical explanations of the MCA, MFA, and clustering can be found in the study conducted by Bécue-Bertaut & Pagès, (2008).

3.3.5 Statistical data analysis

The significance of the relationships between the variables, variable categories, and dimensions was evaluated using the statistical tests: p-value (Schemmel & Friedlander, 2017), v.test (Frey, 2018), eta squared (eta^2) (Richardson, 2011), r^2 (Pearson, 1902), Table 3.3. All the statistical correlations in this study are with a confidence interval of 95%.

Table 3. 3 Key diagnostic terms used during data analysis

Diagnostic term	Acronym	Type of analysis corresponds to	Description
Lg coefficient	Lg	Multiple factor analysis	Lg coefficient is a measure of the dimensionality of the 4 groups of variables (vulnerability, governability, response, and appraisal groups) and also, the richness of the common structure between a single group and also between two different groups (Lê & Worch, 2018). A high Lg value (the higher the multidimensionality of the group, the more the Lg value. Lg value is always equal to or more than 1) indicates that the group is/are multidimensional and has a greater common structure (Visbal-Cadavid et al., 2020). It was used here to check which group consists of the most heterogenous variable (identify the most multidimensional group)
RV coefficient	RV	Multiple factor analysis	The RV coefficient is similar to the Pearson coefficient and measures the linkages between the groups (vulnerability, governability, response, and appraisal) (Robert & Escoufier, 1976). The RV coefficient varies between 0 and 1 and tends to be larger when the number of case studies is small or when the number of variables in each group is large (Josse & Holmes, 2016). It was used here to check the associations between the groups. Strong association means some form of similarity in the structure between two groups.

Diagnostic term	Acronym	Type of analysis corresponds to	Description
Inertia ratio	–	Hierarchical clustering	The inertia ratio is the quality of the partitioning of the cluster which is explained by the ratio of the between inertia over the total inertia. Inertia ratio is a numeric value between 0 and 1. If the value is closer to 1, it indicates that the partition is better (Koh et al., 2022). A better partitioning is when high variability is observed between the clusters. The total inertia can always be broken down into within-inertia (variability within clusters) and between-inertia (variability between clusters). It was used here to evaluate the quality of the clustering by linking it with the principal components.
Barycenter	–	Hierarchical clustering	The barycenter is the mean point of the partial points that lie at the center of gravity within the dimensional space of the cluster area.
Across-cluster variation	Cla/Mod	Hierarchical clustering	Cla/Mod measures the percentage of variable category that was specific to a particular cluster and was useful in characterizing the differences between the clusters (Weiand et al., 2019). It was used here to study the across-cluster variability. What are the characteristics that are different among the case studies that belonged to different clusters?
Within-cluster variation	Mod/Cla	Hierarchical clustering	Mod/Cla measures the percentage of the variable category within a cluster that represented the most common variable category linked to the variable. It was used here to study the within-cluster variability. What are the characteristics that are different among the case studies that belonged to the same cluster?
Global similarity percentage	GSP	Hierarchical clustering	GSP measures the percentage of the variable category (count of the variable category for that variable divided by the total number of case studies multiplied by 100%) that was repeated frequently in all the case studies.

Diagnostic term	Acronym	Type of analysis corresponds to	Description
			It was used here to study the similar characteristics between all the case studies. What are the most common similarities between all the case studies?
Specificity	–	Hierarchical clustering	Specificity measures the distance from the barycenters of each cluster to the case study that belongs to it. It was used here to find the closest case study that was linked to the cluster. The within-class and across-class variability are influenced by the characteristics of the case study that lies most close to its barycenter.
p-value	–	Multiple factor analysis and Hierarchical clustering	The p-values measures the association of the variables and their categories with the clusters using the chi-square test. A p-value less than 0.05 means that there is a high probability that the qualitative variable and its category can explain the characteristics of the clusters. The qualitative variable and the variable categories that had a p-value larger than 0.05 are not reported. It was used here as a statistical significance measure to understand the relationship between variables and its categories with the principal components, and variables and its categories with the clusters.

Diagnostic term	Acronym	Type of analysis corresponds to	Description
v.test (Frey 2018)	–	Multiple factor analysis and Hierarchical clustering	The v.test is the measure of the transformation of the p-value into a quantile of the normal distribution. It was used here to was used to describe the correlation between the two nominal/categorical variables or variable categories. Hence, if the value of the v.test is greater than 1.96 or less than -1.96 then the variable or the variable category has a large positive or negative value in each dimension which is significantly different from zero. v.test was also used to compare the proportion of the variable category in a cluster, or a principal component (dimension) compared to the proportion of the qualitative variables in all the data sets. v.test value can also be used in conjunction with the p.value. The sign of v.test is important to reckon if the variable or variable category is over or under-expressed in the principal components and the clustering results.
Differentiation ratio (Richardson, 2011)	eta squared (eta^2)	Multiple correspondence analysis	Eta squared (eta2) is the differentiation ratio that measured the degree of the association between the two variables (here between the variable and the principal component), especially the proportion of variation in the dependent variable that is associated with different dimensions. eta^2 was used to interpret the result of the multiple correspondence analysis to study the correlation between the dimension and the supplementary qualitative variable. A value of 1 means a strong correlation ratio between the dimension and the qualitative variables.
Coefficient of determination (Pearson, 1902)	r^2	Multiple factor analysis and Hierarchical clustering	r^2 explain the proportion of the variation in one variable based on its linear relationship with another variable (Richardson, 2011). r^2 was used here to evaluate the link between the active variable and the principal component to understand the result obtained from the MFA analysis.

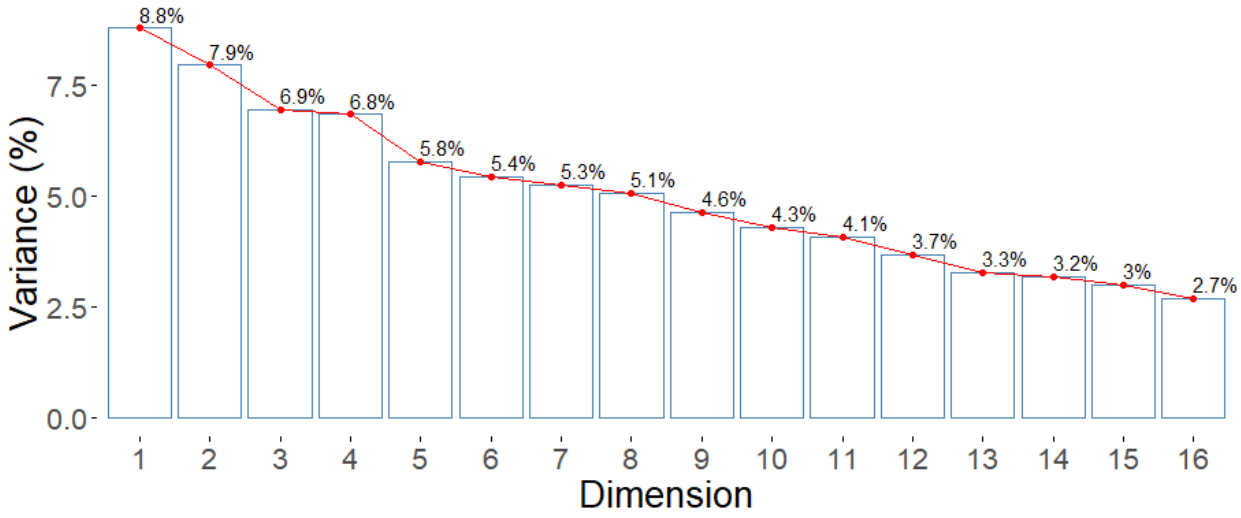

Figure 3. 3 Percentage of the variances explained by each dimension of the MFA

3.4 Results

3.4.1 MFA Results

3.4.1.1 Percentages of Variances

The first five dimensions of the MFA accounted for 8.8%, 7.9%, 6.9%, 6.8%, and 5.8% of the variation in the dataset, representing a total of 36.2% of the total variation (Fig 3.3). This percentage of variance associated with the first five dimensions is extremely low. However, the case studies used in the analysis were heterogeneous including the SSF SES from four different continents representing huge variation in the natural, social, and governing conditions and the global change issues across the spatial and temporal scale. Due to the nature of the data used in this research, which is multidimensional, the diversity noticed can be regarded as acceptable. Only the first sixteen dimensions out of twenty-eight are shown in Fig. 3.3. Theoretically, the number of principal components (dimensions) from the MFA is either the number of the case studies or the number of the variables, whichever is smaller. All the associations, links, and descriptions of the results are related to the first five dimensions (ncp =5). The results are shown as plots of dimension 1 vs. dimension 2 (called as 1-2 plane) and dimension 3 vs. dimension 4 (called as 3-4 plane).

3.4.1.2 MFA Dimensions, Variables, and Variable Categories

The first dimension of the MFA was most positively correlated with the first dimension of the governability group and the third dimension of the vulnerability group. It was most negatively correlated with dimension 1 of the response group (Fig 3.4, Table 3.4). The governability group contributed the highest to the construction of the first dimension with a contribution percentage of 40.8% (Table 3.5). The first dimension of the MFA was mostly linked to Q26S(R), Q2N(G), Q2G(G), Q22S(R), Q26L(R), Q2S (G), Q11(V), Q17 (G), Q13 (G), Q18(G), Q6 (V) variables (Table 3.6). The indication in the bracket after each of the variables refers to the group to which the variable belongs (V: vulnerability, G: governability, R: response, A: appraisal).

The VC that contributed most to the construction of the first dimension were Q26L_E, Q2G_E, Q26S_E, Q20_A, Q2S_E, Q21_E, Q26L_D, Q2N_E, Q22S_B, Q27S_E (Fig 3.6, Appendix D-Table 1A). The description of the variables (coded I-ADApT questions) and the details of the VC are shown in Appendix C. For the supplementary VC, the first dimension of the MFA is associated with the Q24L, Q25, and Q29L (Table 3.8). The governability group (first and third dimension), vulnerability group (third dimension), and response group (fifth dimension) were associated with the positive values of the first dimension of the MFA (Fig 3.8, Table 3.4).

The second dimension of the MFA was negatively correlated with the first dimension of the vulnerability group and positively associated with the third dimension of the governability and response group (Fig 3.4, Table 3.4). The vulnerability group contributed the highest to the construction of the second dimension with a contribution percentage of 47.9% (Table 3.5). The second dimension of the MFA was linked to Q19(G), Q9(V), QB(V), Q7(V), Q26S(R), Q6(V), Q22S(R), Q15(G) (Table 3.6). The VC associated with the second dimension were Q19_A, Q22S_A, Q19_B, QB_E, Q27S_E, Q9_C, Q6_E, and Q17_D (Fig 3.6, Appendix D-Table 1A). The second dimension of the MFA was also associated with Q25, Q24S, and Q29S supplementary VC (Table 3.8)

The third dimension of the MFA was associated with the positive values of the second dimension of the governability group, the second and third dimension of the vulnerability group, and the third and fourth dimension of the response group (Fig 3.5, Table 3.4). The governability group contributed the highest to the construction of the third dimension with a contribution percentage of 43.7% (Table 3.5). The third dimension of the MFA was linked to Q8(V), Q2N(G), Q19(G),

Q16(G), Q2S(G), Q20(G), Q27L(R), Q17(G), Q10(V), Q22L(R) (Table 3.5). The VC that contributed high to the construction of the third dimension were Q22L_A, Q17_A, Q2N_C, Q3_B, Q19_E, Q2N_E, Q27L_D, Q10_E, Q19_A, Q9_E (Fig 3.7, Appendix D-Table 1A). The third dimension of the MFA was also related to Q29L, and Q28 supplementary VC (Table 3.8)

The fourth dimension was associated with the negative values of the fourth dimension of the vulnerability and governability group and the positive values of the second dimension of the response and vulnerability group. The vulnerability group contributed the highest to the construction of the fourth dimension with a contribution percentage of 37.2% (Fig 3.5, Table 3.4). The subsequent response and governability group's contribution percentages were 32.3% and 30.3% respectively (Table 3.5). The vulnerability and response groups lie close to each other which indicates these groups have several dimensions in common (Fig 3.5). The fourth dimension of the MFA was linked to Q6(V), Q27L(R), Q11(V), Q3(V), Q22S(R), Q18(G), Q26S(R), Q13(G), Q16(G), Q21(G) (Table 3.7). The VC that contributed highest to the construction of the fourth dimension were Q3_B, Q3_C, Q22S_E, Q6_D, Q26S_D, Q6_C, Q27L_A, Q27L_D (Fig 3.7, Appendix D-Table 1B). The fourth dimension of the MFA was also linked to Q24S, Q25, and Q29S supplementary VC (Table 3.8)

The fifth dimension of the MFA was most associated with the positive values of the fourth dimension of the response group and fifth dimension of the governability group and the negative values of the second dimension of the vulnerability group (Table 3.4). The vulnerability group contributed highest to the construction of the fifth dimension with a contribution percentage of 36.5% followed by the response and governability groups with a contribution percentage of 33.3% and 30.09%. respectively (Table 3.5). The fifth dimension of the MFA was linked to the active variables like Q9(V), Q17(G), Q2S(G), QB(V), Q22L(R), and Q2N(G) (Table 3.6). The VC associated with the fifth dimension were Q22L_A, Q2S_D, Q17_A, QB_D, Q17_B, Q9_D, Q27S_C, and Q2S_A (Appendix D-Table1B). The fifth dimension of the MFA was also linked to Q29S, and Q28 supplementary VC (Table 3.8).

The appraisal group mapped on the 1-2 plane and 3-4 plane with very similar coordinate values of 0.4, 0.34, 0.4, and 0.44 in the first four dimensions (Table 3.5). This indicates that the appraisal group was slightly related to all four dimensions. The correlation value of the appraisal group on the fifth dimension was very low with a value of 0.18 (Table 3.5).

A high degree of correlation between the group of the three active groups of variables and dimensions (Table 3.9) indicates the existence of the common variables between the groups which are interrelated with each other. This shows that the association between the variables in can be studied further to understand the variance in the data. This also showed a broad array of the dispersion of the data along the multidimensional space where the groups had a high correlation (a value of 0.87) even until the fifth dimension. This explains that there is not a single characteristic group of variables/principal component that can explain the characteristics of the data and studying first five principal components is necessary.

The r^2 and eta^2 of the variables with all the MFA dimensions and MCA dimensions were low with r^2 for active variables varying from 0.22 to 0.75 (Table 3.6 and 3.7) and eta^2 for supplementary variables varying between 0.01 to 0.36 (Table 3.8). This indicated that the connection between the variables and the dimension of the MFA was not strong enough where the MFA dimensions can best be interpreted by the variables because r^2 was not close to 1 (Schober et al., 2018). This explains the complexity, diversity, and nonlinearity (Berkes, 2003) associated with data of the SSF SES when dealing with multiple case studies. Nevertheless, the test values were different from 0 and statistically significant ($P<0.05$). So, they were used to interpret the MFA dimensions.

The most important active VC that explained the first five principal dimensions were Q22L_A, Q27S_E, Q26S_E, Q6_E, Q3_B, Q9_D, Q27L_D, Q19_E, QB_E, Q22S_A, Q26S_A, Q2N_C, Q9_B, Q6_D, Q2N_E, Q2S_E, Q17_A, Q11_A, Q19_A, Q26L_E, Q9_C, Q2G_E, Q7_E, Q22S_E, Q11_E, QB_D, Q26S_D, Q9_E, Q10_E, Q22S_B (Fig 3.8, detailed questions in Table 3.10). Similarly, the important inactive VC mostly related to the first five principal dimensions were Q24L_A, Q25_D, Q24S_D, Q28_B, Q24L_D, Q25_A, Q28_A, Q29L_B, Q29S_D, Q29L_E, Q30_C, Q25_E, Q29L_E, Q28_C (Table 3.11 and 3.12). These groups, variables, and VC that had a close link to the MFA dimensions are the ones that contributed most to the partitioning of the. Other information from the sixth to the twenty-eighth dimension of the MFA was not used as the intent of the analysis was to reduce the dimensionality of the information.

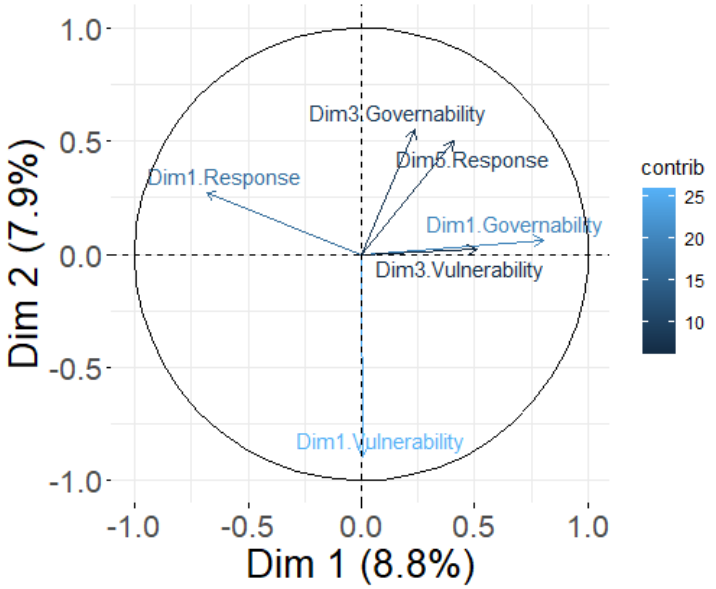

Figure 3. 4 Partial axes representation (1-2 plane).

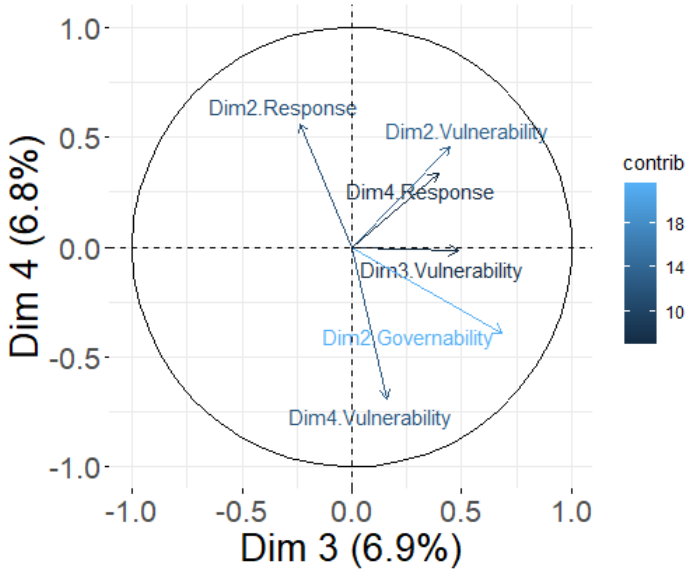

Figure 3. 5 Partial axes representation (3-4 plane).

The ones with faint blue color are the ones with a higher contribution

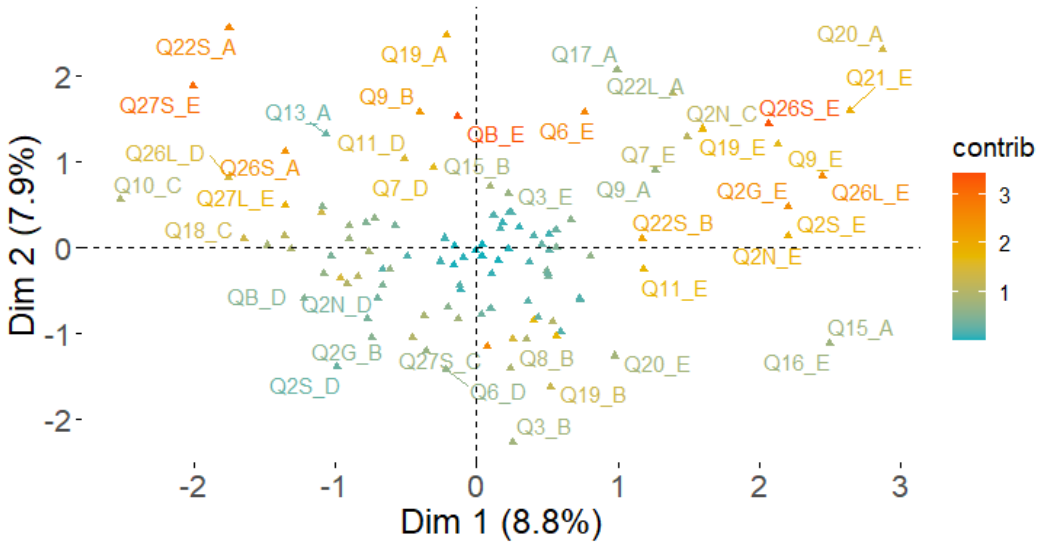

Figure 3. 6 Representation of the variable categories (1-2 plane).

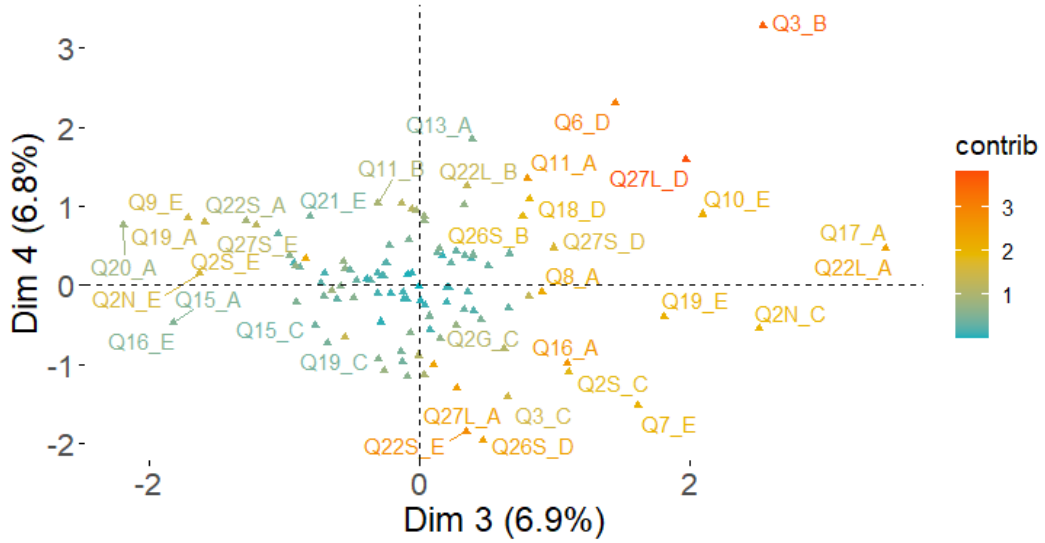

Figure 3. 7 Representation of the variable categories (3-4 plane)

The variable categories that have a greater contribution to the construction of the principal dimension are colored in red whereas the ones that have less contribution are colored in light blue.

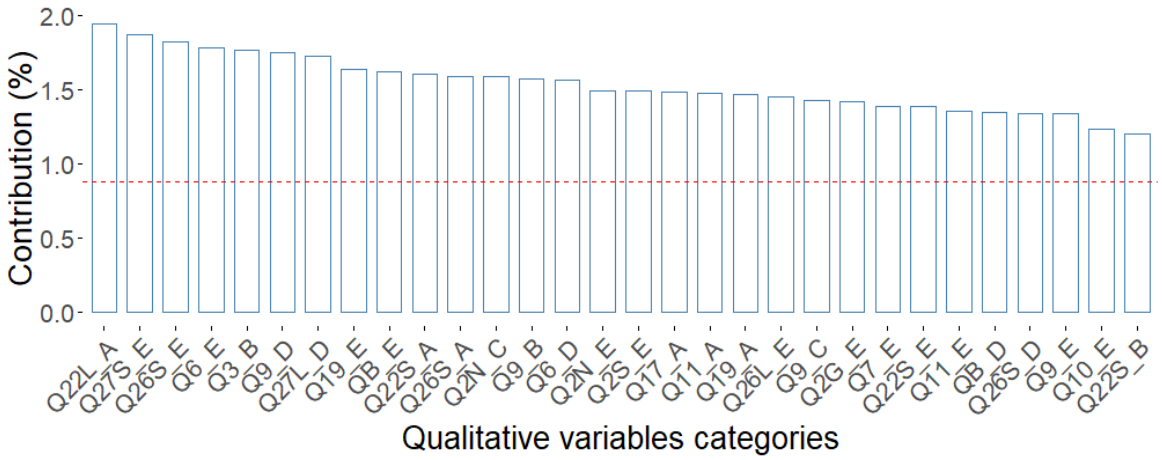

Figure 3. 8 Contribution of the variable category in the construction of the 5 dimensions

Table 3. 4 Correlation value of the partial axes with the MFA dimensions. Dim.1: Dimension1 and so on)

	Dim.1	Dim.2	Dim.3	Dim.4	Dim.5
Dim1.Vulnerability	0	-0.89	0.05	0.11	-0.15
Dim2.Vulnerability	-0.39	0.12	0.45	0.46	-0.45
Dim3.Vulnerability	0.51	0.02	0.49	-0.02	-0.13
Dim4.Vulnerability	-0.2	-0.07	0.16	-0.69	-0.42
Dim5.Vulnerability	0.05	0.04	0.09	-0.32	0.13
Dim1.Governability	0.8	0.06	-0.35	-0.07	-0.12
Dim2.Governability	0.23	0.18	0.68	-0.39	0.21
Dim3.Governability	0.23	0.55	0.03	-0.02	0.03
Dim4.Governability	-0.07	-0.2	-0.02	-0.45	0.15
Dim5.Governability	0.03	-0.07	-0.37	-0.09	0.49
Dim1.Response	-0.68	0.27	-0.12	-0.32	0.03
Dim2.Response	-0.25	0.32	-0.24	0.56	-0.13
Dim3.Response	0.15	0.25	0.44	0.18	-0.16
Dim4.Response	-0.15	-0.2	0.39	0.34	0.62
Dim5.Response	0.41	0.5	-0.11	0.09	0.06
Dim1.Appraisal	0.14	0.27	0.05	-0.17	0.14
Dim2.Appraisal	0.05	0.22	0.29	0.33	-0.11
Dim3.Appraisal	0.37	-0.02	0.12	-0.37	0.05
Dim4.Appraisal	0.37	0.12	0.03	-0.28	-0.28
Dim5.Appraisal	-0.19	0.09	-0.12	-0.05	0.03

Table 3. 5 MFA results on the group of variables. Ctr: contribution; Cod:Coordinate, Dim.: Dimension

	Dim. 1 Cod.	% Ctr.	Dim. 2 Cod.	% Ctr	Dim. 3 Cod.	% Ctr	Dim. 4 Cod.	% Ctr	Dim. 5 Cod.	% Ctr	
Vulnerability	0.48	24.05	0.87	47.95	0.48	30.18	0.58	37.26	0.48	36.56	
Governability	0.81	40.80	0.47	26.04	0.69	43.72	0.47	30.36	0.39	30.09	Active
Response	0.70	35.15	0.47	26.01	0.41	26.10	0.5	32.38	0.44	33.35	
Appraisal	0.40	–	0.34	–	0.40	–	0.44	–	0.18	–	Inactive

Table 3. 6 Description of the MFA dimensions by the active variables (dim 1 to dim 3)

Dim 1			Dim 2			Dim 3		
	r^2	p.value		r^2	p.value		r^2	p.value
Q26S	0.65	3.04E-05	Q19	0.75	5.09E-07	Q8	0.44	5.30E-04
Q2N	0.60	1.48E-04	Q9	0.70	4.20E-06	Q2N	0.51	1.27E-03
Q2G	0.58	2.42E-04	QB	0.67	1.36E-05	Q19	0.50	1.84E-03
Q22S	0.55	5.20E-04	Q7	0.50	5.21E-04	Q16	0.37	8.45E-03
Q26L	0.55	5.33E-04	Q26S	0.51	1.40E-03	Q2S	0.41	9.74E-03
Q2S	0.53	8.99E-04	Q6	0.40	4.80E-03	Q20	0.39	1.39E-02
Q11	0.44	6.27E-03	Q22S	0.37	2.11E-02	Q27L	0.37	2.29E-02
Q21	0.27	1.58E-02	Q15	0.33	3.86E-02	Q17	0.29	3.23E-02
Q17	0.32	2.08E-02				Q10	0.22	3.72E-02
Q13	0.29	3.10E-02				Q22L	0.33	3.83E-02
Q18	0.29	3.29E-02						
Q6	0.27	4.62E-02						

Table 3. 7 Description of the MFA dimensions by the active variables (dim 4 to dim 5)

Dim 4			Dim 5		
	r^2	p.value		r^2	p.value
Q6	0.61	2.83E-05	Q9	0.52	1.13E-03
Q27L	0.45	4.50E-03	Q17	0.42	2.82E-03
Q11	0.45	5.02E-03	Q2S	0.46	3.94E-03
Q3	0.44	6.50E-03	QB	0.37	2.05E-02
Q22S	0.40	1.27E-02	Q22L	0.37	2.13E-02
Q18	0.34	1.54E-02	Q2N	0.36	2.67E-02
Q26S	0.39	1.54E-02			
Q13	0.30	2.70E-02			
Q16	0.30	3.04E-02			
Q21	0.22	4.10E-02			

Table 3. 8 Description of the MCA dimensions by the supplementary variables (dim 1 to dim 5)

	Dim.1	Dim.2	Dim.3	Dim.4	Dim.5
Q24S	0.12	0.23	0.13	0.36	0.05
Q24L	0.31	0.09	0.17	0.17	0.03
Q25	0.30	0.28	0.14	0.29	0.13
Q28	0.12	0.06	0.19	0.06	0.15
Q29S	0.03	0.20	0.16	0.19	0.18
Q29L	0.21	0.12	0.21	0.11	0.16
Q30	0.17	0.14	0.14	0.13	0.01

Table 3. 9 Correlation of the MFA dimensions with the group of variables (dim 1 to dim 5) (r^2)

	Dim.1	Dim.2	Dim.3	Dim.4	Dim.5
Vulnerability	0.84	0.95	0.83	0.92	0.87
Governability	0.94	0.91	0.91	0.87	0.87
Response	0.9	0.85	0.83	0.81	0.87

Table 3. 10 Description of the active variables categories correlating with 5 dimensions

Q22L_A	Q: What were the long term responses of the social and governing systems to the main issue? Category A: no responses
Q27S_E	Q: What factors (if any) prevented the short term objectives from being fully achieved? Category E: no factors
Q26S_E	Q: What factors contributed to the successful short term results described in Q24S? Category E: a variety of short term factors within all three systems
Q6_E	Q: What is the ecological status of the affected ecosystem at the ecosystem level prior to the main issue? Category E: good
Q3_B	Q: What are the main stressors that affect this ecological system? Category B: fishing, e.g., causing changes in structure (e.g., reduced size structure), species composition, etc.
Q9_D	Q: What other livelihood opportunities (e.g., farming, manufacturing, forestry, etc.) are there in the affected area? Category D: several (5-6)
Q27L_D	Q: What factors (if any) prevented the long term objectives from being fully achieved? Category D: one key factor in the natural, social, or governing system
Q19_E	Q: How concentrated is social power in the area? Category E: concentrated
QB_E	Q: The number of people affected by the Main Issue? Category E: greater than 20%
Q22S_A	Q: What were the short term responses of the social and governing systems to the main issue? Category A: no responses
Q26S_A	Category A: no factors
Q2N_C	Q: Which of the following levels is the Main Issue related to natural system? Category C: national
Q9_B	Q: See rows above. Category B: limited (1-2)
Q6_D	Q: See rows above. Category D: improving
Q2N_E	Q: See rows above. Category D: all
Q2S_E	Q: Which of the following levels is the Main Issue related to social system? Category E: all
Q17_A	Q: What is the nature of the relationship between the different sectors or livelihood occupations in this system? Category A: conflict
Q11_A	Q: What proportion of household income comes from local sales of fish catches, processing, and wholesaling? Category A: less than 20%
Q19_A	Q: See rows above. Category A: dispersed
Q26L_E	Q: What factors contributed to the successful long term results described in Q24L. Category E: a variety of long term factors within all three systems
Q9_C	Q: See rows above. Category C: some (3-4)
Q2G_E	Q: Which of the following levels is the Main Issue related to governing system? Category C: international
Q7_E	Q: What is the productivity of the system? Category E: very high
Q22S_E	Q: See rows above. Category E: a variety of short term responses in both social and governing systems at more than one level (local, regional, national)
Q11_E	Q: See rows above. Category E: greater than 80%
QB_D	Q: See rows above. Category D: between 15% and 20%

Q26S_D	Q: See rows above. Category D: a variety of short term factors within one or two of natural, social or governing systems
Q9_E	Q: See rows above. Category E: lots (7+)
Q10_E	Q: What % of the total catch/production is used for household consumption (not sold)? Category E: greater than 80%
Q22S_B	Q: See rows above. Category B: one key response at one level

Table 3. 11 Description of the MFA dimensions by the supplementary variables (dim 1 to dim 5)

	Dim.1	v.test	Dim.2	v.test	Dim.3	v.test	Dim.4	v.test	Dim.5	v.test
Q24S_A	-0.28	-0.53	0.78	1.57	-0.19	-0.40	0.14	0.29	-0.13	-0.31
Q24S_B	0.29	0.92	0.10	0.33	-0.20	-0.71	-0.19	-0.67	0.09	0.33
Q24S_C	-0.43	-1.08	-0.57	-1.50	-0.06	-0.18	-0.03	-0.09	0.01	0.03
Q24S_D	0.26	0.18	-2.27	-1.69	2.54	2.02	3.28	2.63	-0.66	-0.58
Q24S_E	1.78	1.26	1.52	1.13	1.58	1.26	-1.57	-1.26	0.31	0.27
Q24L_A	1.00	2.73	0.28	0.79	0.18	0.55	-0.08	-0.24	-0.23	-0.76
Q24L_B	-0.30	-0.89	-0.35	-1.08	0.20	0.66	-0.36	-1.19	0.16	0.56
Q24L_C	-0.69	-1.18	-0.35	-0.62	-0.79	-1.52	-0.04	-0.07	0.05	0.11
Q24L_D	-1.08	-1.38	0.94	1.26	-0.01	-0.02	1.64	2.36	0.10	0.16
Q25_A	0.39	1.15	0.49	1.51	0.34	1.12	-0.70	-2.32	-0.42	-1.51
Q25_B	0.06	0.10	-0.83	-1.66	-0.09	-0.19	-0.49	-1.07	0.32	0.76
Q25_C	0.15	0.25	-0.92	-1.66	-0.43	-0.83	0.40	0.77	0.28	0.60
Q25_D	-1.30	-2.49	0.55	1.11	-0.27	-0.58	1.28	2.78	0.35	0.82
Q25_E	2.41	1.71	0.88	0.66	0.57	0.45	0.99	0.80	-0.82	-0.72
Q28_A	-0.36	-1.31	0.10	0.39	0.52	2.13	0.05	0.20	-0.33	-1.48
Q28_B	0.31	0.83	-0.10	-0.28	-0.80	-2.44	0.14	0.44	0.17	0.57
Q28_C	1.07	1.36	0.34	0.45	0.41	0.58	-0.10	-0.14	0.78	1.23
Q28_E	-0.60	-0.61	-0.73	-0.79	-0.28	-0.32	-0.91	-1.05	0.29	0.37
Q29S_A	0.02	0.06	-0.41	-1.08	-0.20	-0.57	-0.22	-0.61	0.18	0.54
Q29S_B	-0.30	-0.30	0.28	0.30	0.69	0.79	-1.42	-1.64	-0.83	-1.05
Q29S_C	0.32	0.68	0.83	1.83	-0.36	-0.85	-0.13	-0.30	0.28	0.73
Q29S_D	0.16	0.16	0.74	0.80	1.90	2.18	0.90	1.04	1.00	1.25
Q29S_E	-0.24	-0.61	-0.46	-1.22	-0.10	-0.27	0.43	1.22	-0.43	-1.33
Q29L_A	0.29	0.55	0.34	0.67	-0.48	-1.03	-0.20	-0.43	0.08	0.19
Q29L_B	-1.06	-2.24	0.10	0.23	-0.67	-1.58	0.08	0.19	0.50	1.31
Q29L_C	1.78	1.26	1.52	1.13	1.58	1.26	-1.57	-1.26	0.31	0.27
Q29L_D	0.53	0.38	-1.64	-1.22	-0.59	-0.47	-1.10	-0.89	0.84	0.73
Q29L_E	0.24	0.88	-0.19	-0.71	0.47	1.91	0.24	0.96	-0.37	-1.65
Q30_A	0.04	0.22	0.15	0.86	0.20	1.28	0.19	1.19	-0.02	-0.14
Q30_B	-0.29	-0.44	0.08	0.13	-0.90	-1.52	-0.19	-0.32	0.16	0.30

	Dim.1	v.test	Dim.2	v.test	Dim.3	v.test	Dim.4	v.test	Dim.5	v.test
Q30_C	2.49	1.77	-1.12	-0.84	-1.82	-1.45	-0.48	-0.38	-0.57	-0.50
Q30_D	-1.19	-1.22	0.19	0.20	0.82	0.94	-1.32	-1.52	-0.24	-0.31
Q30_E	0.14	0.15	-1.26	-1.35	-0.15	-0.17	0.05	0.06	0.41	0.51

Table 3. 12 Description of the supplementary variables categories relating with 5 dimensions

Q24L_A	Q: What were the results of the long term response for the natural, social and governing systems (i.e., were the objective in Q23L achieved)? Category A: objectives not achieved in N, S or G
Q25_D	Q: Was the Main Issue addressed? Category D: 80% addressed
Q24S_D	Q: What were the results of the short term response for the natural, social and governing systems (i.e., were the objectives in Q23S achieved)? Category D: Most objectives met in 1 or more of N, S and G
Q28_B	Q: Has there been a formal evaluation of the response (how and when)? Category B: yes, partially
Q24L_D	Q: See rows above. Category D: Most objectives met in 1 or more of N, S and G
Q25_A	Q: See rows above. Category A: no
Q28_A	Q: See rows above. Category A: no
Q29L_B	Q: What were the benefits related to costs of the long term response? Category B: costs equaled benefits
Q29S_D	Q: What were the benefits related to costs of the short term response? Category D: still being assessed
Q29L_E	Q: See rows above. Category E: unknown
Q30_C	Were other options considered for the short and/or long term responses? Why were these not selected? Category C: yes, but too complicated
Q25_E	Q: See rows above. Category E: 100% addressed
Q29L_E	Q: See rows above. Category E: unknown
Q28_C	Q: See rows above. Category E: yes, fully

3.4.1.3 Lg Values and RV Coefficient

Interpretation of the Lg value (Table 3.13) suggests that the appraisal group consisted of the most heterogeneous variables and VC (Lg= 5.09) followed by the governability, vulnerability, and response group (Lg = 4.41, 4.31, and 3.75 respectively). This highlights that the appraisal group

is a more heterogeneous group than the other groups., especially the response group, which had the most homogeneous data with similar variable categories. Heterogeneous here means that the group represents a wide range of the VC which are different across the case studies. Analysis of the RV coefficient (Table 3.14) illustrated that the most linked pair of the groups were appraisal with the governability group (a score of 0.57), governability with the vulnerability group (a score of 0.56), response with the governability group (a score of 0.52) and finally appraisal with the vulnerability group (a score of 0.5).

Table 3. 13 Lg values

	Vulnerability	Governability	Response	Appraisal	MFA
Vulnerability	4.31				4.34
Governability	2.46	4.41			4.52
Response	1.88	2.13	3.75		3.9
Appraisal	2.32	2.71	2.11	5.09	3.58
MFA	4.34	4.52	3.9	3.58	6.4

Table 3. 14 RV coefficient

	Vulnerability	Governability	Response	Appraisal	MFA
Vulnerability	1				0.83
Governability	0.56	1			0.85
Response	0.47	0.52	1		0.8
Appraisal	0.5	0.57	0.48	1	0.63
MFA	0.83	0.85	0.8	0.63	1

3.4.1.4 Results of the Case-Studies

The distribution of the case studies in the two-dimensional plane was uniform as the case studies were well-separated from each other into four quadrants along the principal dimensions (Fig 3.9). This indicated that the individual case studies were distinct from each other. This further supports the earlier argument for the low percentage of variance for the principal dimensions. However, this does not entail that they do not have common characteristics between them. Case studies that have an analogous group of variables and categories for each dimension lie close to

each other, for example, the case studies TAN, ESP_M, VEN or ON_tour, SL_cora or ESP_G, ARG or YB_clam, VL_clam (Fig 3.9 and 3.10).

3.4.1.5 MFA Dimension and the Case-Studies

Case studies TAN, ESP_M, ARG, ESP_G, VEN, and BGD were mostly related to the first dimension and had significantly higher contributions to the construction of the first dimension (Fig 3.9). The first dimension was also linked to the governability group and had a higher contribution to the construction of the dimension. This meant the case studies TAN, ESP_M, ARG, ESP_G, VEN, and BGD shared similar attributes related to the governability group of variables (Q2N, Q2G, Q2S, Q17, Q13, Q18) having high coordinate values. A similar concept applies to dimension 2 where the cases ON_tour, SL_cora, KAR, TAN, VEN, and OB_poll were mostly associated with dimension 2, and these case studies shared similar attributes related to the vulnerability group of the variables (Q9, QB, Q7, Q6).

Case studies KAR, YB_clam, TAN, ARG, BGD, and VEN had high coordinate values in the third dimension (Fig 3.10), contributed significantly to the construction of the dimension, and shared common variables related to the governability group (Q2N, Q19, Q16, Q2S, Q20, Q17). Case studies YB_clam, OB_poll, BU_pela, BA_mang, and BB_oyst were linked to the fourth dimension and shared similar attributes related to all the active groups of variables (Q6, Q27L, Q11, Q3, Q22S, Q18, Q26S, Q13, Q16, Q21. The case studies (first twenty) that contributed high to the construction of the first five dimensions were KAR, YB_clam, TAN, ON_tour, BS_fish, ARG, BGD, VEN, SL_cora, BA_mang, ESP_M, ESP_G, CM_mang, OB_poll, PH_poll, US_oyst, TB_shrm, and VIC. The contribution of the KAR case study was more than 4 folds higher than the contribution of the VIC case study. This indicated these case studies were important in terms of explaining the variability of the data and played a higher role in the partitioning of the case studies into clusters (Fig 3.11).

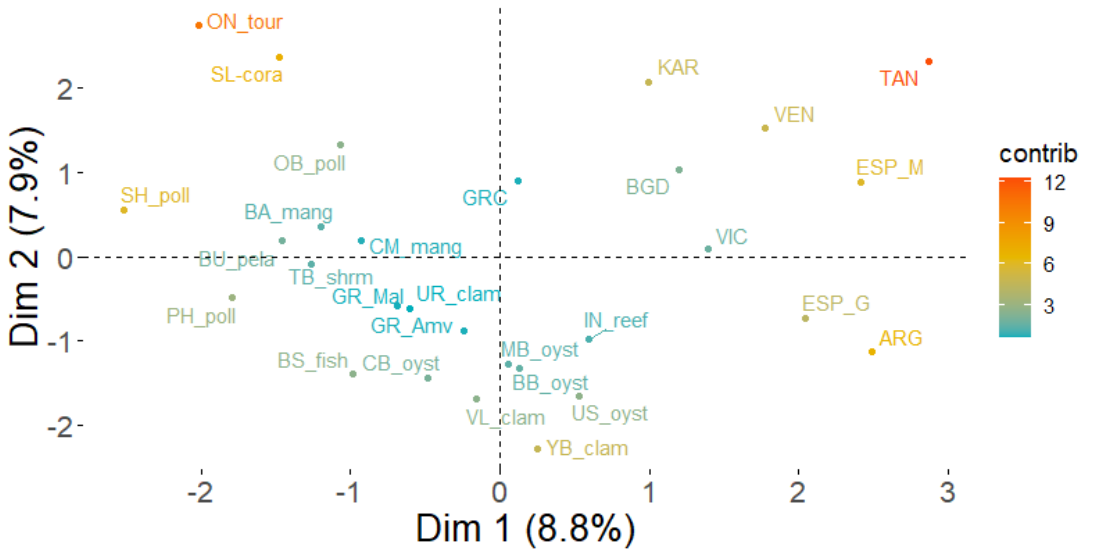

Figure 3. 9 Representation of the case studies in 1-2 plane.

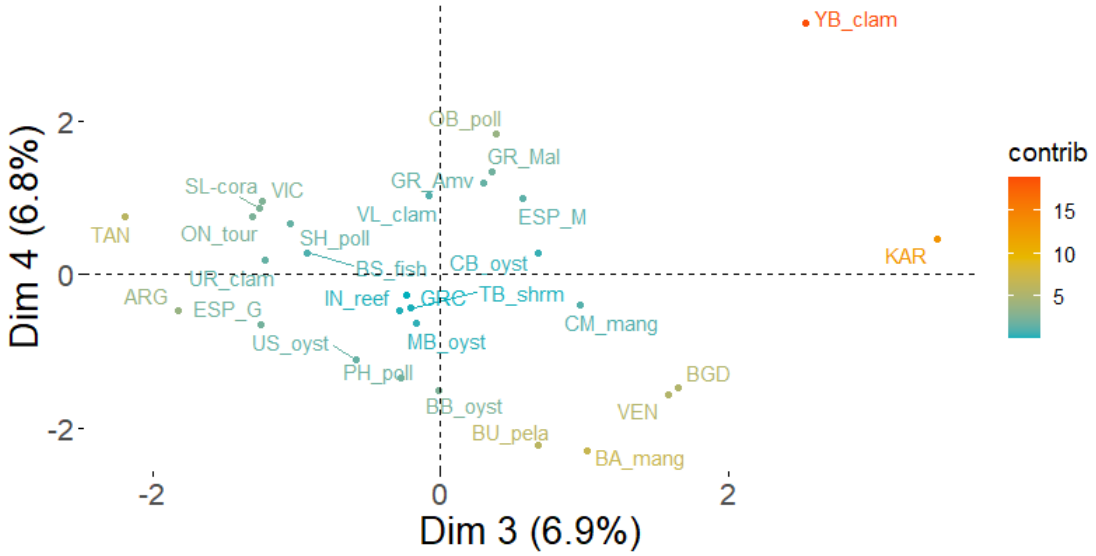

Figure 3. 10 Representation of the case studies in 3-4 plane.

The case studies that have a greater contribution to the construction of the principal dimension are colored in red whereas ones that have less contribution are colored in light blue.

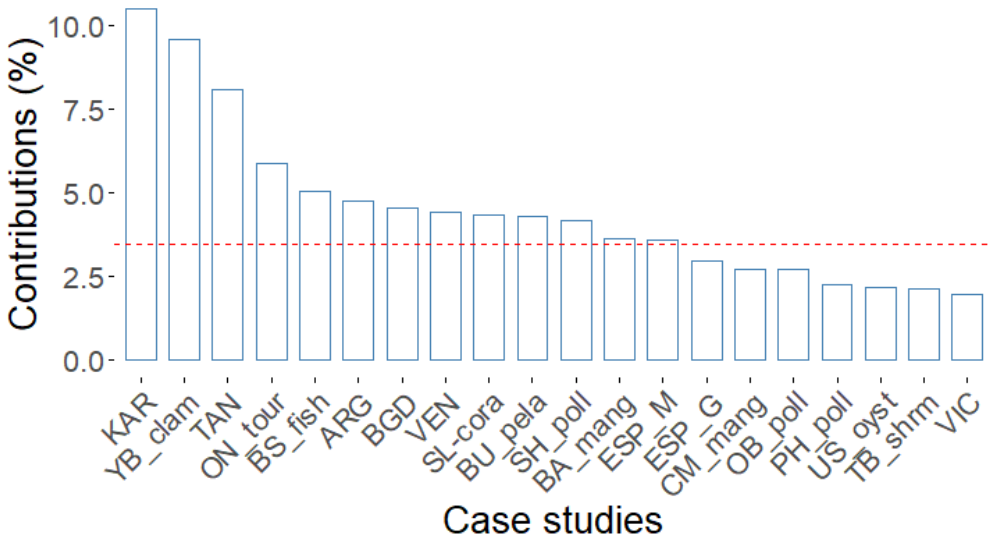

Figure 3. 11 Contribution of the case studies in the construction of 5 dimensions

3.4.1.6 Partial Point Representation of the Case-Studies

The point in black was the mean point corresponding to different groups when viewed from the barycenter of the partial points (Fig 3.12 and 3.13, only 20 case studies are shown in the plot in Fig 3.12 and 3.13 to make the plot readable). For any case study, the number of the partial point (also called as partial axes) was equal to the number of the active groups (here 3 active groups). The inertia ratio was calculated as 0.79 for dimension 1, 0.77 for dimension 2, 0.72 for dimension 3, and 0.75 for dimensions 4 and 5. This explains that partial points of the case studies for all the dimensions are somewhat close to each other. The partial points were closest when the case studies were viewed from the first dimension (highest ratio of 0.79) which shows a better partition of the data compared to other dimensions.

However, the influence of the different groups of variables on the case studies was not the same. For example, the partial points for the BS_fish case study lay closer to the mean points than the partial points of the ON_tour case study in the 1-2 plane (Fig 3.12, Appendix D-Table 2). This indicated that the variability of the ON_tour case was relatively higher than the BS_fish case study where some groups of variables had a higher influence on the ON_tour case study than the others (response group along the first dimension and vulnerability group along the second

dimension). The case-study YB_clam along the third and fourth dimensions had more influence of the vulnerability group of variables compared to the governability and response group. However, for the KAR case study, it has more influence of the governability and response group along the third dimension (Fig 3.13, Appendix D-Table2). Likewise, TAN and KAR were mostly influenced by the governability and response group along the first dimension and the vulnerability and governability group along the second dimension. This difference in the influence of the group of variables will impact the clustering results. The case studies ON_tour, YB_clam, and KAR had a varied influence of a different group of variables along the first four principal dimensions. So, they are likely to fall in different clusters, noticeably away from each other.

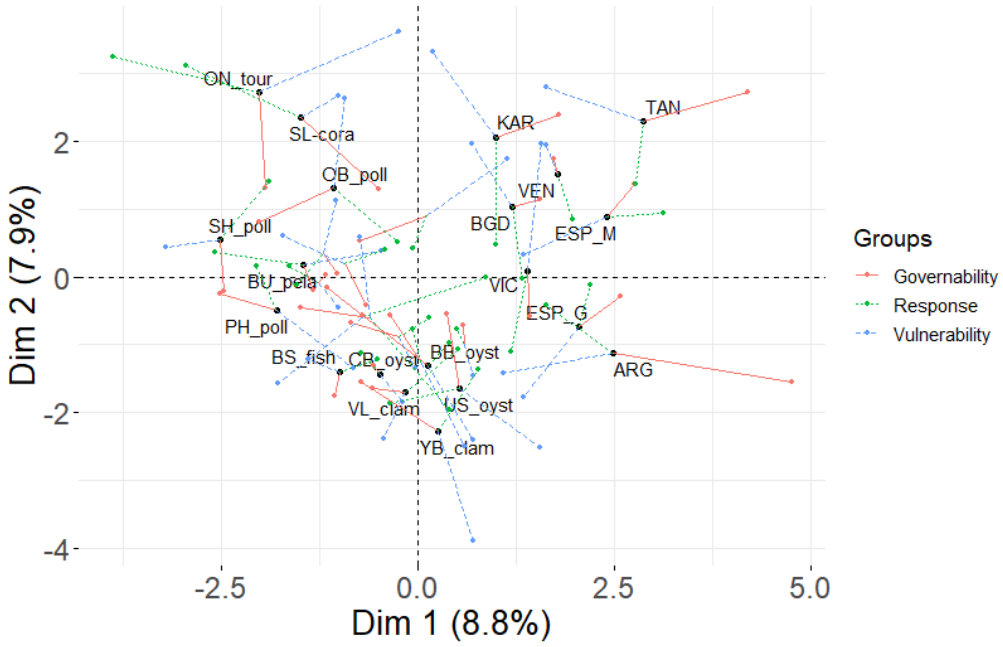

Figure 3. 12 Partial point representation of the case studies in 1-2 plane

The color point corresponded to the partial point (red for the governability group, green for the response group, and blue for the vulnerability group).

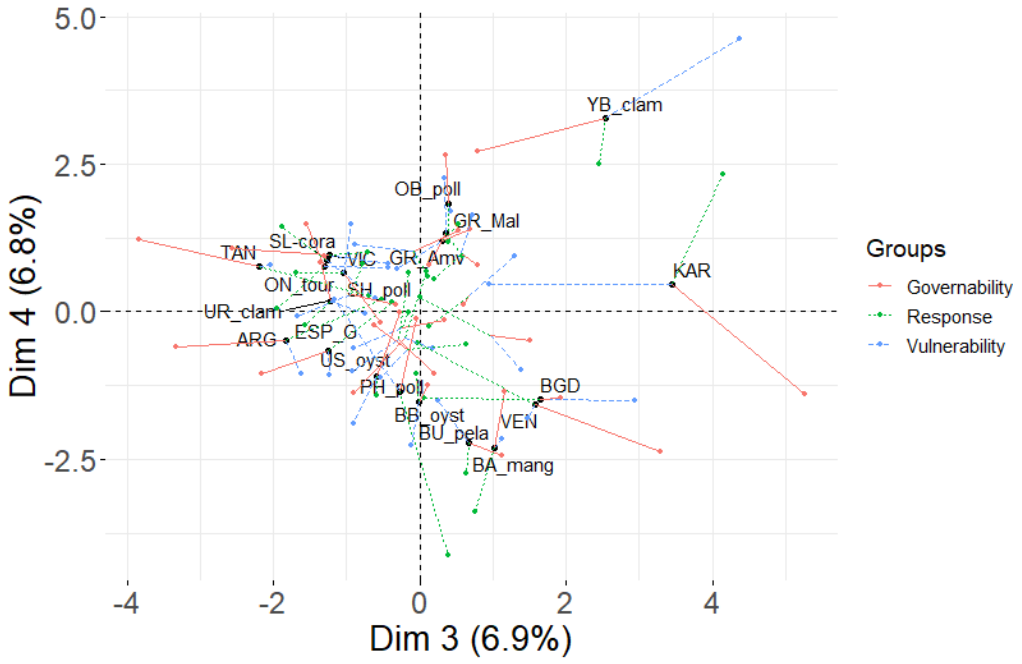

Figure 3. 13 Partial point representation of the case studies in 3-4 plane

3.4.2 Clustering Results

29 case studies were separated into 5 clusters based on the similarities and differences in which they have experienced the vulnerabilities, followed the governance mechanisms, and initiated the formal and informal sustainability responses (Fig 3.14 and 3.15). Cluster 1 was composed of four case studies. Three cases from Japan are the Sekisei lagoon coral reef from Ishigaki Island (SL_cora), Okinawa tourism at the Onna village (ON_tour), and Omura Bay pollution (OB_Poll) and one case from china which was represented by Jin-Shanzui village pollution at Shanghai (SH_Poll). Cluster 2 was composed of seven case studies all from different geographical locations (the second-largest cluster). The first case study was from Bangladesh referring to the Bay of Bengal Sunderbans mangrove (BA_mang). The second case study represented the Marilao-Meycauayan-Obrando river system in the Philippines (PH_poll) and the third case study was about the Southern Benguela pelagic fishery from South Africa (BU_pela). The fourth case study was from Japan regarding the Tokyo bay mantis shrimp (TB_shrm). The fifth case study was from France representing Bourgneuf bay oysters (BB_oyst). The sixth case study was from Greece representing the Kalloni coastal bay (GRC). The final case study was from Cameroon

representing the Cameroon mangroves (CM_mang). Cluster 3 was composed of five case studies from 4 countries: Amvrakikos fish kills aquaculture (GR_amv) and Maliakos gulf fish kills, fishery-tourism (GR_mal) both from Greece; the Venice lagoon clams ((Italy); Chesapeake bay oysters (east coast USA) and Yokohama bay clams (Japan).

Cluster 4 was the largest cluster with 8 case studies, each from a different geographical location, mostly from developed countries. The cases that fell in this cluster were the Spermonde archipelago from Indonesia (IN_reef), the U.S. Pacific coast (Puget Sound) from U.S. Pacific Northwest (US_oyst), Matsushima bay oysters from Japan (MB_oyst), La coronilla-barra del Chuy yellow clams from Uruguay (UR_clam), Galician grounds sardine fishery from Northwest Spain (ESP_G), small-sized pelagic fisheries in Lakes Victoria, Kyoga and Albert from Uganda (VIC), small-scale pelagic fisheries in San Matias gulf – North Patagonia from Argentina (ARG) and Baltic sea fisheries from the Baltic countries such as Estonia, Latvia, and Lithuania (BS_fish). Cluster 5 was composed of 5 case studies, all related to small-scale pelagic fisheries from different geographical areas. The first case study was from Venezuela representing the coastal fisheries in the Northeastern region of Venezuela (VEN). The second was the case study from Spain representing the whitebait fishery on the coast of the region of Murcia in Southeast Spain (ESP_M). The third case study was from the Sunderban mangroves forest SSF in Bangladesh. The fourth case study represented the freshwater small-scale pelagic fisheries at the lake of Tanganyika in Burundi, Congo, Tanzania, and Zambia (TAN). The last case study was the SSF at lake Kariba in Zambia and Zimbabwe (KAR). Figure 3.16 shows the five clusters distributed by their geographical locations.

Following the MFA results, the variables that were most important in partitioning and explaining the characteristics of the clusters are Q26S, Q19, Q22S, Q25, Q27S, Q11, Q17, Q27L, Q13, Q6, Q3, Q2N, and QB (statistically significant). Likewise, the case studies mostly specific to each cluster (called specificity, Table 3.15) are ON_tour and SL_cora for cluster 1, BA_mang, and BU_pela for cluster 2, YB_clam and GR_mal for cluster 3, ARG and BS_fish for cluster 4, KAR and TAN for cluster 5. The clustering results are described as global similarities between clusters, within-cluster variation (Mod/Cla), and across-cluster variation (Cla/Mod).

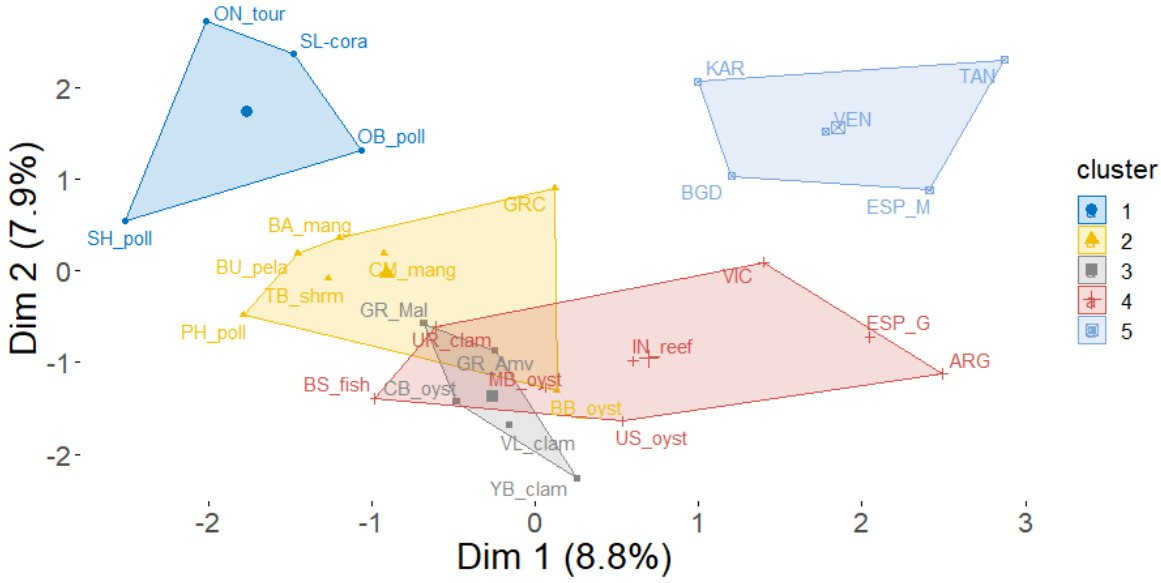

Figure 3. 14 Clusters of the case studies in 1-2 plane

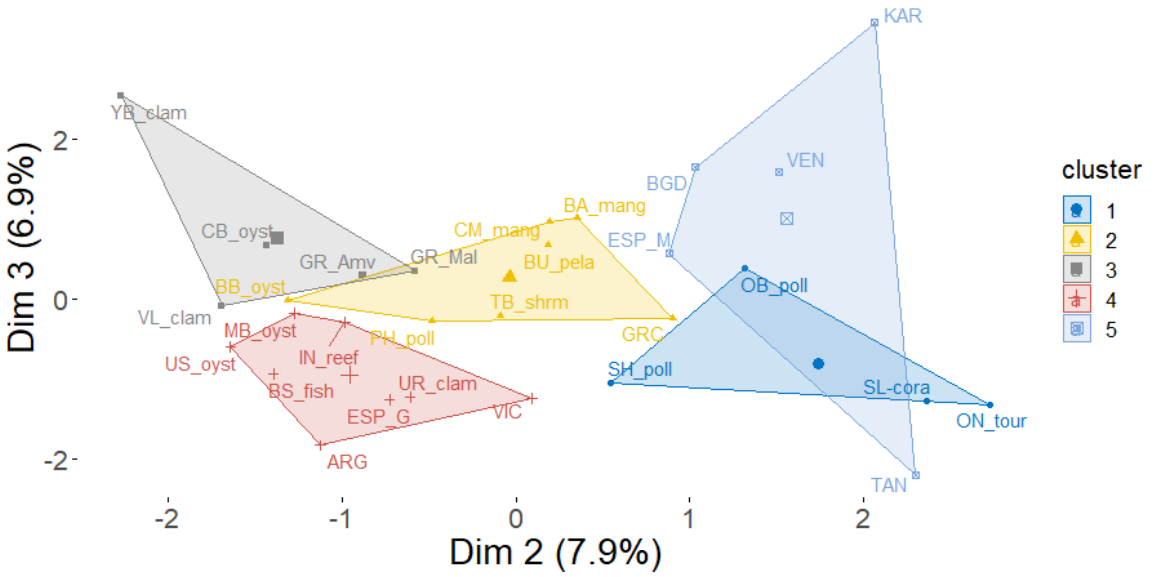

Figure 3. 15 Clusters of the case studies in 3-4 plane

Figure 3. 16 Representation of the clusters by the geographical locations.

Five clusters represented by Five different colors.

Table 3. 15 Specificity value for case studies in each cluster

Cluster 1	ON_tour	SL-cora	SH_poll	OB_poll	
	4.03	3.71	2.98	2.92	
Cluster 2	BA_mang	BU_pela	CM_mang	TB_shrm	PH_poll
	3.98	3.66	3.09	3.04	2.88
Cluster 3	YB_clam	GR_Mal	GR_Amv	CB_oyst	VL_clam
	5.31	2.63	2.23	2.12	1.95
Cluster 4	ARG	BS_fish	ESP_G	VIC	US_oyst
	4.00	3.85	3.32	3.00	2.69
Cluster 5	KAR	TAN	ESP_M	VEN	BGD
	5.58	4.42	3.52	3.49	3.05

3.4.2.1 Global Similarities between the Clusters

The commonalities identified across the clusters for each of the governability, response, vulnerability, and appraisal groups of VCs are detailed in Tables 3.16, 3.17, 3.18, and 3.19. Global similarity showed the common VC between the case studies. This meant that the count of these categories was very high because that issue was reported several times by the respondents in the case studies of all the cluster (p-value<0.05, v.test>1.96 or v.test<-1.96). For example, for the variable Q2S, category A was most common in all the clusters with a global similarity percentage (GSP) of 51.72% (Table 3.16).

The most common variables in the case studies were related to the governability group (Table 3.16) with four VC having the highest GSP of 51.7% (Q2S_A, Q13_D, Q15_B, Q19_D). In the governability group, there were six variables' categories with a GSP between 20-50% (Q20_C, Q2N_A, Q17_C, Q17_D, Q2G_A, Q13_C) and seven categories with a GSP between 0-20% (Q18_C, Q2G_E, Q19_B, Q19_E, Q19_A, Q21_E, Q2N_C). For the response group (Table 3.17), five VC (Q22L_D, Q26S_C, Q27L_E, Q22L_E, Q26S_A) were between 20-50%, out of which two categories had the highest GSP of 31.03% (Q22L_D, Q26S_C). Along with this, seven VC Q26S_E, Q22S_E, Q27L_C, Q26S_D, Q27S_C, Q27S_E, and Q22S_A in the response group had a GSP between 0-20%.

For the VC in the vulnerability group (Table 3.18), the most common VC between the clusters were Q9_C (44.8%), QB_E (34.5%), Q11_E (31%), Q7_C (27.6%), Q9_B, Q6_E. There were four VC (Q11_A, Q3_C, Q6_D, Q7_E) in the vulnerability group with a GSP between 0-20%. In the appraisal group (Table 3.19), there were three VC with a GSP between 20-50%, Q28_A (48.3%), Q24L_A (34.5%), Q25_D (20.7%), and one variable category with a GSP between 0-20% which is Q24L_D (10.3%).

Table 3. 16 Global similarity between the clusters for the governability group of variables

Variable categories	% common	Description of the question and category
Q2S=Q2S_A	51.72	The main issue was related to the social system at local level
Q13=Q13_D	51.72	The mode of the governance was hierarchical governance - regional/national/ international

Variable categories	% common	Description of the question and category
Q15=Q15_B	51.72	The key rules, regulations, instruments, and measures employed to achieve the management objectives were input measures (e.g., effort limitation, spatial and seasonal closures, gear limitations, limits on feed/chemical additions, stock enhancement, etc.)
Q19=Q19_D	51.72	The social power was eighty percent concentrated and twenty percent dispersed
Q20=Q20_C	44.83	There were not any structural changes in the governing system or individuals prior to the main issue
Q2N=Q2N_A	44.83	The main issue was related to the natural system at local level
Q17=Q17_C	34.48	There was equal cooperation and conflict between the livelihood occupations in the SSF SESs
Q17=Q17_D	31.03	The relationship between the different sectors or livelihood occupations in the SSF SES was four folds cooperation condition and one fold conflict situation.
Q2G=Q2G_A	24.14	The main issue was related to the governing system at local level
Q13=Q13_C	24.14	The mode of governance was hierarchical governance - local
Q18=Q18_C	17.24	The most social power in the area was dominated by business owners/corporations
Q2G=Q2G_E	17.24	The main issue was related to the governing system at international level
Q19=Q19_B	13.79	The social power was eighty percent dispersed and twenty percent concentrated
Q19=Q19_E	13.79	The social power was all concentrated
Q19=Q19_A	10.34	The social power in the SSF SES was all dispersed
Q21=Q21_E	6.90	There was addition of new sets of rules (e.g., introduction of output controls to a system previously having only input controls) prior to the main issue
Q2N=Q2N_C	6.90	The main issue was related to the natural system at national level

Table 3. 17 Global similarity between the clusters for the response group of variables

Variable categories	% common	Description of the question and category
Q22L=Q22L_D	31.03	There were variety of long term responses in social or governing system at more than one level (local, regional, national) such as structural changes in the governing system(s) or individuals, or the changes in key rules, regulations, instruments, and measures etc.
Q26S=Q26S_C	31.03	There were a few (2–4) key factors within one or two of natural, social, or governing systems that contributed to the successful short term results described in Q24S (e.g., enabling policy, government funding)

Variable categories	% common	Description of the question and category
Q27L=Q27L_E	24.14	There were no factors (e.g., regulatory barrier, lack of social cohesion, costs too high, climate variability, judicial decisions) that prevented the long term objectives from being fully achieved
Q22L=Q22L_E	24.14	There were variety of long term responses in both social and governing system at more than one level (local, regional, national) such as structural changes in the governing system(s) or individuals, or the changes in key rules, regulations, instruments, and measures etc.
Q26S=Q26S_A	20.69	There were no factors that contributed to the successful short term results described in Q24S (e.g., enabling policy, government funding)
Q26S=Q26S_E	13.79	There were a variety of short term factors within all three of natural, social, and governing systems that contributed to the successful short term results described in Q24S (e.g., enabling policy, government funding)
Q22S=Q22S_E	13.79	There were a variety of short term responses such as structural changes in the governing system(s) or individuals, or the changes in key rules, regulations, instruments, and measures etc. in both social and governing systems at more than one level (local, regional, national)
Q27L=Q27L_C	13.79	There were a few (2–4) key factors within one or two of natural, social, or governing systems (e.g., regulatory barrier, lack of social cohesion, costs too high, climate variability, judicial decisions) that prevented the long term objectives from being fully achieved
Q26S=Q26S_D	10.34	There were a variety of short term factors within one or two of natural, social, or governing systems that contributed to the successful short term results described in Q24S (e.g., enabling policy, government funding)
Q27S=Q27S_C	10.34	There were a few (2–4) key factors within one or two of natural, social, or governing systems (e.g., regulatory barrier, lack of social cohesion, costs too high, climate variability, judicial decisions) that prevented the short term objectives from being fully achieved
Q27S=Q27S_E	10.34	There were no factors that prevented the short term objectives from being fully achieved
Q22S=Q22S_A	6.90	There were no short term responses of the social and governing systems to the main issue

Table 3. 18 Global similarity between the clusters for the vulnerability group of variables

Variable categories	% common	Description of the question and category
Q9=Q9_C	44.83	There were some (3-4) livelihood opportunities (e.g., farming, manufacturing, forestry, etc.) in the affected area
QB=QB_E	34.48	The number of people affected by the main Issue was greater than 20%

Variable categories	% common	Description of the question and category
Q11=Q11_E	31.03	Greater than 80% of household income came from local sales of fish catches, processing, and wholesaling
Q7=Q7_C	27.59	The productivity of the SSF SES was medium
Q9=Q9_B	20.69	There were limited (1–2) livelihood opportunities (e.g., farming, manufacturing, forestry, etc.) in the affected area
Q6=Q6_E	20.69	The ecological status of the affected ecosystem at the ecosystem level prior to the main issue was good
Q11=Q11_A	17.24	Less than 20% of household income came from local sales of fish catches, processing, and wholesaling
Q3=Q3_C	10.34	The main stressors that affected the SSF ecological system were loss of key habitat or major habitat changes including invasive species
Q6=Q6_D	6.90	The ecological status of the affected ecosystem at the ecosystem level prior to the main issue was in improving condition
Q7=Q7_E	6.90	The productivity of the SSF SES was very high

Table 3. 19 Global similarity between the clusters for the appraisal group of variables

Variable categories	% common	Description of the question and category
Q28=Q28_A	48.28	There had been no formal evaluation of the response
Q24L=Q24L_A	34.48	The long-term response did not achieve the objectives in the natural, social, and governing systems
Q25=Q25_D	20.69	The main issue was eighty percent addressed and twenty percent not addressed
Q24L=Q24L_D	10.34	The long-term response contributed to achieve most objectives in 1 or more of natural, social, and governing system

3.4.2.2 Across Cluster variation (Cla/Mod)

The VC such as Q27S_E(R), and Q22S_A(R) only belonged to cluster 1 (Table 3.20) and these categories were not present in other clusters these categories were vital in separating cluster 1 from other clusters. These variables were also highly associated with the first five MFA dimensions (Table 3.6 and 3.7). Furthermore, VC Q24L_D, Q19_A, Q25_D, Q26S_A, and Q9_B belonged 66.7% to cluster 1. The variable category Q13_D did not belong to cluster 1 at

all. This indicated that the Q13 variable was not linked to category D and the response category was evenly distributed among 4 other categories, A, B, C, and E (no specific patterns).

Similarly, the VC Q22S_E(R), Q26S_D(R), and Q3_C(V) belonged to cluster 2 case studies (Table 3.21). Additionally, almost 80% of Q18_C and 57% of Q22L_E belonged to cluster 2. However, VC Q22L_D and Q17_D did not belong to cluster 2 by any means. For cluster 3 (Table 3.22), there were not any VC that entirely belonged to it. Nonetheless, the Q11_A (V), and Q19_B (G) were most close to cluster 3 with a membership percentage of 80%, and 75% respectively. There were two more VC Q2N_A, Q2S_A that belonged to 57% and 38% percent in cluster 3, whereas VC Q6_D does not belong to cluster 3 in any way.

Cluster 4 had two VC that fully belonged to it, Q27L_C(R) and Q27S_C(R) (Table 3.23). Apart from this, there were five other VC that belonged to cluster 4 Q17_D (66%), Q7_C (63%), Q26S_C, Q11_E (56%), Q20_C (8%), and (Q28_A, Q2S_A (7%). Likewise, VC Q17_D and QB_E did not belong to cluster 4 at all. Cluster 5 had the five VC that completely belonged to it, Q26S_E(R), Q19_E(G), Q21_E(G), Q2N_C(G), Q7_E(V) (Table 3.24). The VC Q2G_E is 60%, Q6_E is 50%, Q24L_A and QB_E are 40%, and Q15_B is 33% related to cluster 5. Likewise, VC Q2N_A, Q9_C, and Q19_D did not belong to cluster 5 in any way.

The variables that did not contribute to any clusters were Q8(V), Q10(V), Q16(G), Q26L(R), Q24S(A), Q29S(A), Q29L(A), and Q30 (A). These variables might not have contributed to the delineation of clusters because these variables did not represent the overall variability of the data. Two variables correspond to the vulnerability group, one corresponds to each governance and governability group, and the response group. Four variables correspond to the appraisal group. Q8 relates to the main livelihood activities such as fishing, tourism, etc. that were directly affected by the main issue. Q10 relates to the percentage of the total catch that was used for household consumption that was not sold. Q16 relates to any informal rules, regulations, instruments, and measures that played an important role in the governance of fisheries and aquaculture. Q26L relates to the factors that contributed to the successful long-term results such as enabling policy, government funding, etc. Q24S relates to the results of the short-term response for the natural, social, and governing systems. Q29S and 29L relate to the benefits related to the costs from the short-term and long-term response respectively. And Q30 relates to

the additional options considered for the short and/or long-term responses and the reason behind why they were not selected.

3.4.2.3 Within-Cluster characteristics (Mod/Cla)

Cluster 1: SSF SESs vulnerable due to the main issue, the main issue due to global change mostly addressed, neither conflicting nor cooperative relationships between the livelihood occupations, no hierarchical mode of governance

The SSF SESs in this cluster were characterized mainly by the response and governability group and partially by the vulnerability group (Table 3.20) because most of the VC that belonged to the response and governability group explained the characteristics of this cluster. VC Q25_D, Q17_C, and QB_E were 100% associated with cluster 1 to explain within-cluster characteristics. This meant that category D of Q25, category C of Q17, and category E of QB are 100% related to cluster 1. The mode of governance in the case studies of this cluster was not the hierarchical type for all the case studies, the variable category 13_D having a null value of Mod/Cla.

Cluster 2: Variety of short and long-term responses at more than one level (local, regional, national), social power dominated by business owners, loss of key habitat as the main stressor to social-ecological changes, most of the fish catch used for commercial purpose

These case studies were mostly related to the response and governability group and partially related to the vulnerability group (Table 3.21). 3 VC that were mostly linked to this cluster are Q22S_E, Q18_C, and Q22L_E and these VC were just 57% related to cluster 2.

Cluster 3: The main issue related to the natural and social system at the local level, low degree of sensitivity to fishing, and hierarchical governance at the local level.

The case studies in this cluster were represented by the vulnerability and governability groups (Table 3.22). VC that was 100% linked to cluster 3 were Q2N_A and Q2S_A. VC Q11_A and Q13_C were 80% linked to cluster 3.

Cluster 4: Most of the total fish catches are used for commercial purposes, cooperative relationships between various livelihood occupations, and a higher degree of sensitivity to fishing.

The case studies in this cluster were mostly associated with the governability and vulnerability groups and are partially represented by the response group (Table 3.23). VC that were mostly

linked to this cluster are Q10_A, Q17_D, Q7_C, Q26S_C, and Q11_E. Q10_A and Q17_D were 100% and 75% linked to cluster 4 respectively whereas Q7_C, Q26S_C, and Q11_E were only 62.5% related to cluster 4. Q10_A was also 100% linked to cluster 2. Also, the number of people affected by the main issue was less than 5% for six case studies that belonged to this cluster and there was not any case study in this cluster that had greater than 20% of the people affected by the main issue (QB_E, Mod/Cla value being zero).

Cluster 5: Input measures as management objectives, variety of short-term factors contributing to successful short-term results, concentrated social power, futile long-term responses, vulnerable small-scale pelagic fisheries

This cluster was primarily represented by the governability and vulnerability groups and partially described by the response group (Table 3.24). VC that was mostly linked to cluster 5 are Q15_B, Q26S_E, Q19_E, Q24L_A, and QB_E. Variable category Q15_B was 100% associated with cluster 5 whereas other VC were only 80% related to cluster 5.

Table 3. 20 Across cluster and within-cluster variation for cluster 1

Variable categories with significant p-value and v.test value are shown. A v.test value greater than 1.96 corresponds to a p-value less than 0.05. The sign of the v.test indicates if the mean of the cluster is under or over-expressed for the VC: same applies to Table 3.20, 3.21, 3.22, 3.23)

Cluster number 1: Across-cluster (Cla/Mod) and With-in cluster (Mod/Cla) variation					
Variable category	Cla/Mod	Mod/Cla	p.value	v.test	Description of the variable category
Q25=Q25_D	66.67	100.00	6.32E-04	3.42	The main issue was eighty percent addressed and twenty percent not addressed
Q27S=Q27S_E	100.00	75.00	1.09E-03	3.26	There were no factors that prevented the short-term objectives from being fully achieved
Q17=Q17_C	40.00	100.00	8.84E-03	2.62	There was equal cooperation and conflict between the livelihood occupations in the SSF SESs
QB=QB_E	40.00	100.00	8.84E-03	2.62	The number of people affected by the main issue was greater than 20%
Q22S=Q22S_A	100.00	50.00	1.48E-02	2.44	There were no short-term responses from the social and governing systems

Cluster number 1: Across-cluster (Cla/Mod) and With-in cluster (Mod/Cla) variation					
Q26S=Q26S_A	50.00	75.00	2.06E-02	2.31	There were no factors that contributed to the successful short term results
Q9=Q9_B	50.00	75.00	2.06E-02	2.31	There were limited (1–2) livelihood opportunities in the affected area
Q27L=Q27L_E	42.86	75.00	3.54E-02	2.10	There were no factors that prevented the long term objectives from being fully achieved
Q2G=Q2G_A	42.86	75.00	3.54E-02	2.10	The main issue was related to the governing system at local level
Q24L=Q24L_D	66.67	50.00	4.32E-02	2.02	The long term response contributed to achieve most objectives in 1 or more of natural, social and governing system
Q19=Q19_A	66.67	50.00	4.32E-02	2.02	The social power in the SSF SES was all dispersed
Q13=Q13_D	0.00	0.00	4.21E-02	-2.03	The mode of the governance was hierarchical governance - regional/national/ international

Table 3. 21 Across cluster and within-cluster variation for cluster 2

Cluster number 2: Across-cluster (Cla/Mod) and With-in cluster (Mod/Cla) variation					
Variable category	Cla/Mod	Mod/Cla	p.value	v.test	Description of the variable category
Q22S=Q22S_E	100.00	57.14	1.47E-03	3.18	There were a variety of short term responses in both social and governing systems at more than one level (local, regional, national)
Q18=Q18_C	80.00	57.14	6.84E-03	2.70	The most social power in the area was dominated by business owners/corporations
Q26S=Q26S_D	100.00	42.86	9.58E-03	2.59	There were a variety of short term factors within one or two of natural, social or governing systems that contributed to the successful short term results
Q3=Q3_C	100.00	42.86	9.58E-03	2.59	The main stressors that affected the SSF ecological system was loss of key-habitat or major habitat changes including invasive species

Cluster number 2: Across-cluster (Cla/Mod) and With-in cluster (Mod/Cla) variation					
Q22L=Q22L_E	57.14	57.14	4.09E-02	2.04	There were variety of long term responses in both social and governing system at more than one level (local, regional, national)
Q22L=Q22L_D	0.00	0.00	4.97E-02	-1.96	There were variety of long term responses in social or governing system at more than one level (local, regional, national)
Q17=Q17_D	0.00	0.00	4.97E-02	-1.96	The relationship between the different sectors or livelihood occupations in the SSF SES was four folds cooperation condition and one fold conflict situation.

Table 3. 22 Across cluster and within-cluster variation for cluster 3

Cluster number 3: Across-cluster (Cla/Mod) and With-in cluster (Mod/Cla) variation					
Variable category	Cla/Mod	Mod/Cla	p.value	v.test	Description of the variable category
Q11=Q11_A	80.00	80.00	1.03E-03	3.28	Less than 20% of household income came from local sales of fish catches, processing, and wholesaling
Q13=Q13_C	57.14	80.00	6.84E-03	2.70	The mode of governance was hierarchical governance - local
Q19=Q19_B	75.00	60.00	1.05E-02	2.56	The social power was eighty percent dispersed and twenty percent concentrated
Q2N=Q2N_A	38.46	100.00	1.08E-02	2.55	The main issue was related to the natural system at local level
Q6=Q6_D	0.00	40.00	2.46E-02	2.25	The ecological status of the affected ecosystem at the ecosystem level prior to the main issue was in improving condition
Q2S=Q2S_A	33.33	100.00	2.53E-02	2.24	The main issue was related to the social system at local level

Table 3. 23 Across cluster and within-cluster variation for cluster 4

Cluster number 4: Across-cluster (Cla/Mod) and With-in cluster (Mod/Cla) variation					
Variable category	Cla/Mod	Mod/Cla	p.value	v.test	Description of the variable category
Q27L=Q27L_C	100.00	50.00	2.95E-03	2.97	There were a few (2–4) key factors within one or two of natural, social, or governing systems that prevented the long term objectives from being fully achieved
Q17=Q17_D	66.67	75.00	4.06E-03	2.87	The relationship between the different sectors or livelihood occupations in the SSF SES was four folds cooperation condition and one fold conflict situation.
Q27S=Q27S_C	100.00	37.50	1.53E-02	2.42	There were a few (2–4) key factors within one or two of natural, social or governing systems that prevented the short term objectives from being fully achieved
Q7=Q7_C	62.50	62.50	2.02E-02	2.32	The productivity of the SSF SES was medium
Q26S=Q26S_C	55.56	62.50	4.12E-02	2.04	There were a few (2–4) key factors within one or two of natural, social or governing systems that contributed to the successful short term results
Q11=Q11_E	55.56	62.50	4.12E-02	2.04	Greater than 80% of household income came from local sales of fish catches, processing, and wholesaling
Q20=Q20_C	7.69	12.50	4.06E-02	-2.05	There were no any structural changes in the governing system or individuals prior to the main issue
Q28=Q28_A	7.14	12.50	2.40E-02	-2.26	There had been no formal evaluation of the response
Q17=Q17_C	0.00	0.00	1.76E-02	-2.37	There was equal cooperation and conflict between the livelihood occupations in the SSF SESs
QB=QB_E	0.00	0.00	1.76E-02	-2.37	The number of people affected by the main issue was greater than 20%
Q2S=Q2S_A	6.67	12.50	1.34E-02	-2.47	The main issue was related to the social system at local level

Table 3. 24 Across cluster and within-cluster variation for cluster 5

Cluster number 5: Across-cluster (Cla/Mod) and With-in cluster (Mod/Cla) variation					
Variable category	Cla/Mod	Mod/Cla	p.value	v.test	Description of the variable category
Q26S=Q26S_E	100.00	80.00	2.11E-04	3.71	There were a variety of short-term factors within all three of natural, social and governing systems that contributed to the successful short-term results
Q19=Q19_E	100.00	80.00	2.11E-04	3.71	The social power was all concentrated
Q21=Q21_E	100.00	40.00	2.46E-02	2.25	There was addition of new sets of rules prior to the main issue
Q2N=Q2N_C	100.00	40.00	2.46E-02	2.25	The main issue was related to the natural system at national level
Q7=Q7_E	100.00	40.00	2.46E-02	2.25	The productivity of the SSF SES was very high
Q2G=Q2G_E	60.00	60.00	2.53E-02	2.24	The main issue was related to the governing system at international level
Q15=Q15_B	33.33	100.00	2.53E-02	2.24	The key rules, regulations, instruments and measures employed to achieve the management objectives were input measures
Q24L=Q24L_A	40.00	80.00	3.78E-02	2.08	The long term response did not achieve the objectives in the natural, social and governing systems
QB=QB_E	40.00	80.00	3.78E-02	2.08	The number of people affected by the main issue was greater than 20%
Q6=Q6_E	50.00	60.00	4.85E-02	1.97	The ecological status of the affected ecosystem at the ecosystem level prior to the main issue was good
Q2N=Q2N_A	0.00	0.00	3.68E-02	-2.09	The main issue was related to the natural system at local level
Q9=Q9_C	0.00	0.00	3.68E-02	-2.09	There were some (3-4) livelihood opportunities in the affected area
Q19=Q19_D	0.00	0.00	1.69E-02	-2.39	The social power was eighty percent concentrated and twenty percent dispersed

3.4.2.4 Appraisal of the responses

Q24S What were the results of the short-term response for the natural, social, and governing systems?

a) Out of 4 case studies, cluster 1 had two case studies where the objectives were not achieved in natural (N), social (S), and governing systems(G) (N, S, or G systems) (Fig 3.17). Some objectives were met in one of the N, S, or G systems for one of the case studies, and some objectives were met in more than 1 subsystem N and/or S and/or G systems for one of the other case studies.

b) Out of 7 case studies, cluster 2 had two case studies where the objectives were not achieved in N, S, or G systems. Three case studies where some objectives were met in one of N, S, or G systems and two case studies where some objectives were met in more than 1 subsystem N and/or S and/or G systems. The common short-term responses in cluster 2 were mobilization of the local fishing communities in rehabilitation activities after the occurrence of hazards to improve the health of the degraded ecosystem. Migration of fisher communities in search of new jobs while leaving women and children alone in the fishing occupation (BA_mang, CM_mang). Switching the target species, e.g., from fish to crab even by crossing the religious norms or boundaries. Adaptation to the remedial technologies to increase income such as the mechanization of the fishing equipment (BU_pela, PH_poll).

c) Out of 5 case studies, cluster 3 had three case studies where some objectives were met in more than 1 subsystem N and/or S and/or G systems and one case study each where some objectives were met in one of N, S or G systems and most objectives met in 1 or more of N, S, and G. The common short term responses in cluster 3 were the support from local media publishing news about the environmental health of fishing grounds, the effects of environmental degradation on the fishermen's incomes, and illegal activities prevalent in the fishing grounds (GR_mal, VL_clam). Shift to alternative livelihood opportunities such as farming and aquaculture (VL_clam). For cluster 3, the results of short-term response were much more productive as either some or most of the management objectives were met in 1 or more than 1 subsystem of N and/or S and/or G systems. Cluster 3 had no objectives that were not achieved in N, S, or G subsystems.

d) Out of 8 case studies, four case studies in cluster 4 had the state where some objectives were met in one of the N, S, or G systems. Some objectives were met in more than 1 subsystem N and/or S and/or G systems for three case studies and objectives were not achieved at all for one case study in this cluster. The common short-term responses in cluster 4 were a shift to alternative employment during the low catch season (UR_clam, VIC), advocacy campaigns from NGOs and INGOs introducing new technologies to empower the fisheries communities (IN_reef, VIC).
e) Out of 5 case studies, cluster 5 had three case studies where some objectives were met in one of the N, S, or G systems. One case study had met all the objectives in N, S, and G subsystems whereas the other case study had the state where no objectives were met at all. The common short-term responses in cluster 5 were a violation of management measures indicating that they do not benefit fisheries communities (KAR, VEN). Migration to nearby cities in search of better employment opportunities leaving fisheries occupation permanently (BGD, KAR). Increased catch of premature species leading to resource depletion (BGD, TAN).

Q24L What were the results of the long-term response for the natural, social, and governing systems?

a) Cluster 1 had two case studies where most objectives were met in 1 or more of N, S, and G. One case study had some objectives met in one of the N, S, or G systems and the other had some objectives met in more than 1 subsystem N and/or S and/or G systems. The common long-term responses in cluster 1 were formulating an effective strategy to execute the individual measures formed by each management level and the establishment of networks to monitor the effectiveness of those responses (OB_poll, ON_tour). Formation of legally regulated areas to conserve the fisheries resources and forming the ecosystem restoration committee incorporating all the stakeholders, i.e., adopting a co-management type of governance (SL_cora). Formation of multilevel partnerships, and government agencies making agreements with fisheries associations to provide the roles and responsibilities to fishers in fisheries management (co-management) (OB_poll, ON_tour).

b) Cluster 2 had four case studies where some objectives were met in one of the N, S, or G systems. Two case studies where the objectives were not achieved in N, S, or G subsystems and one case study where some objectives were met in more than 1 subsystem N and/or S and/or G systems. The common long-term responses in cluster 2 were the development of the adaptive capacity of the fisherfolks through better collaboration with the private sector (CM_mang, PH_poll), initiation of effective monitoring activities and regulations with a special focus to reduce the impacts of anthropogenic activities (BU_pela, GRC). Availability of external funding through the INGOs and NGOs in consultation with the government agencies (BB_oyst, PH_poll). Formation of strong governing institutions consisting of fisher communities, civil societies, industry partners, scientists, and researchers to develop policy, instruments, and acts for regulating the small-scale fisheries (BB_oyst, CM_mang, TB_shrm).

c) Cluster 3 had three case studies where some objectives were met in one of the N, S, or G systems. One case study where most of the objectives were met in 1 or more of N, S, and G and one case study where objectives were not achieved in N, S, or G. The common long-term responses in cluster 3 were the establishment of risk communication and monitoring system to improve the ecological health of natural ecosystem (GR_mal, VL_clam), development of social power by grouping into cooperative and consortiums to prevent illegal fishing (VL_clam, YB_clam).

d) Cluster 4 had three case studies where the objectives were not achieved in N, S, or G. Some objectives were met in one of the N, S, or G systems for two case studies, and some objectives were met in more than 1 subsystem N and/or S and/or G systems for other three case studies. The common long-term responses in cluster 4 were permanently switching to new employment alternatives (ARG, ESP_G, VIC), developing social cohesion, and trust to strengthen the co-management practice (UR_clam, VIC), developing experimental fishing to increase fish production, effective coordination with research scientists, and research centers to find ways to consolidate the co-management system (MB_oyst, UR_clam, US_oyst), strengthen the polycentric governance system based on both vertical and horizontal cooperation to improve systems resilience (IN_reef, VIC).

e) Cluster 5 had four case studies where the objectives were not achieved in N, S, or G. One case study had a situation where some objectives were met in one of the N, S, or G systems. The common long-term response in cluster 5 was a shift to a co-management form of governance from a hierarchical model of governance (ESP_M, TAN). The co-management in the case of the TAN case study worked only for a short time.

Q25 Was the Main Issue addressed?

a) The main issue in cluster 1 was partially addressed for all the case studies.
b) For cluster 2, the main issue remained completely unresolved for 71% of the case studies and the main issue was somewhat unresolved for 29% of the case studies in cluster 2.
c) For cluster 3, the main issue was somewhat unresolved for 40% of the case studies, undetermined for 40% of the case studies, and partially addressed for 20% of the case studies.
d) For cluster 4, the main issue was completely unaddressed for 25% of the case studies, somewhat unresolved for 25% of the case studies, undetermined for 37% of the case studies, and partially addressed for 13% of the case studies.
e) For cluster 5, the main issue remained completely unresolved for 80% of the case studies, and the main issue was completely addressed for 20% of the case studies.

Q28 Has there been a formal evaluation of the response (how and when)?

a) For cluster 1, two case studies did not have a formal evaluation of the responses and the rest of the two case studies had a partial evaluation of the responses.
b) For cluster 2, no evaluation had been done for 5 case studies, partial evaluation was done for one case study and the status of the evaluation was undetermined for one of the case studies.
c) For cluster 3, no evaluation of the response had been done for 4 case studies and partial evaluation was done for one case study.
d) For cluster 4, no evaluation of the response had been done for one case study, partial evaluation was done for 5 case studies, full evaluation was conducted for one case study, and the status of the evaluation was unknown for one case study.

e) For cluster 5, no evaluation had been done for 4 case studies and the status of the evaluation was unknown for one case study.

Q29S What were the benefits related to the costs of the short-term response?

a) Out of four case studies in cluster 1, the cost exceeded benefits for one case study, benefits exceeded costs for one case study and the benefits related to costs were unknown for two case studies.
b) Out of seven case studies in cluster 2, the cost exceeded benefits for three case studies, costs equaled benefits for one case study, benefits exceeded costs for one case study, and the benefits related to costs were unknown for two case studies.
c) Out of 5 case studies of cluster 3, the cost exceeded benefits for one case study, benefits related to costs are still being assessed for one case study and the benefits related to costs were unknown for three case studies.
d) Out of 8 case studies of cluster 4, the cost exceeded benefits for four case studies, benefits exceeded costs for two case studies, and the benefits related to costs were unknown for two case studies.
e) Out of 5 case studies of cluster 5, costs equaled benefits for one case study, benefits exceeded costs for three case studies, and benefits related to costs are still being assessed for one case study.

Q29L What were the benefits related to the costs of the long-term response?

a) For cluster 1, the cost exceeded benefits for one case study, costs equaled benefits for two case studies, and benefits related to costs were unknown for one case study.
b) For cluster 2, the cost exceeded benefits for two case studies, costs equaled benefits for two case studies, and benefits related to costs were unknown for three case studies.
c) For cluster 3, costs equaled benefits for one case study, and benefits related to costs were unknown for four case studies.
d) For cluster 4 the pattern was very similar to cluster 2. However, cluster 4 had one more case study where benefits related to costs is still being assessed.
e) For cluster 5, the cost exceeded benefits for one case study, benefits exceeded costs for one case study, and benefits related to costs were unknown for three case studies.

Q30 Were other options considered for the short and/or long-term responses? Why were these not selected?

a) For cluster 1, no other options were being considered.

b) For cluster 2, no other options were considered for the three case studies. Other options were considered for two case studies, but they were found to be very expensive. Also, for the other two case studies, additional options were considered but they were not selected because of a lack of social support.

c) For cluster 3, no other options were considered for four case studies. Also, for the other case study, the status of other options was unknown.

d) For cluster 4, no other options were considered for five case studies. Other options were considered for two case studies, but they were found to be very expensive and complicated. Also, for the other case study, the status of other options was unknown.

e) For cluster 5, no other options were considered for four case studies. Other options were considered for one case study, but it was found to be very expensive

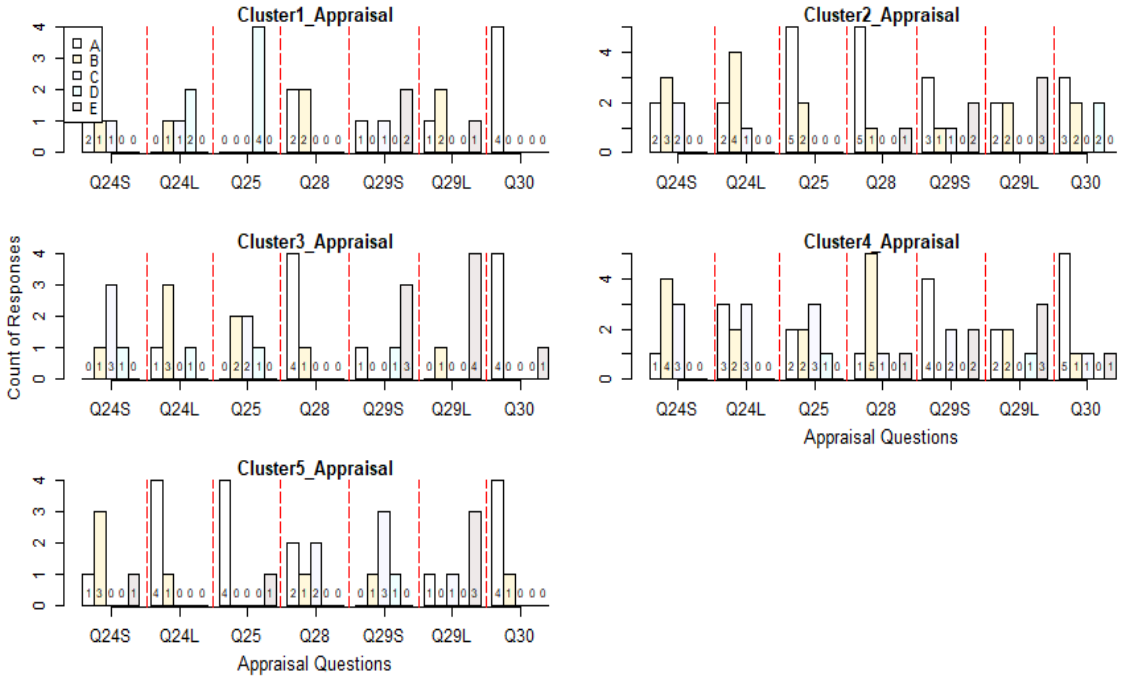

Figure 3. 17 Appraisal of the responses for 5 clusters

3.5 Discussion

3.5.1 Synthesis of Appraisal

Most of the short-term responses were coping responses related to adaptation at the household and community level mostly within the social subsystem. For clusters 2, 4, and 5, in the majority of cases, only some objectives were met in one of the N, S, or G systems. This shows that the result of short-term responses was partially effective where only some objectives were met in N, S, or G systems. Most of the long-term responses were adaptive and transformative responses related to adaptation at the community to international level mostly within governing and natural subsystems. Also, most of the long-term responses were management responses targeted at improving existing management and governance systems such as co-governance, ecosystem-based management, community-based management, and adaptive co-governance. These approaches have already been identified as progressive approaches in terms of dealing with the complex social-ecological changes arising from global changes (McConney et al., 2019; Miller et al., 2018; Galappaththi et al., 2022). The result of the long-term response yielded slightly positive benefits for clusters 1, 2, 3, and 4. However, the long-term responses did not meet the management objectives for case studies in cluster 5 except for 1 case study where all the objectives were met. The adaptation intervention was mostly intended to solve problems on the social and governing scale. (Berkes et al., 1998) stated that "resource management is people management". The focus should be given much more to building the resilience and adaptive capacity of the social and governing system. However, devising adaptation measures related to the natural systems is equally essential for maintaining the stock level of fish and conserving the marine ecosystem, and sustaining a healthy ecosystem. This is imperative when trying to solve the problems due to global change in SSF from the SES perspective and systems thinking perspective.

The overall analysis showed that the main issue mostly remained unaddressed for all the clusters. Even when the main issue was addressed, it was addressed partially, for example, in the case of cluster 1. Only one case study in cluster 5 was found to have the main issue completely addressed (ESP_M from Spain). However, this is an ongoing process where the outcomes of some responses might not still be noticeable. The case studies in cluster 4 had done well in terms of assessment of the responses to evaluate whether the responses were able to address the

effects due to the main issue. For most other case studies in different clusters, no evaluation of the response was conducted. Poor monitoring and evaluation are regarded to be one of the major causes of failure of fisheries management and policies (Komul Kalidin et al., 2020). Monitoring and evaluation of the responses are key for effective decision-making because it helps to identify the successful management objectives and increase the efficiency of ongoing activities. Effective application of monitoring activities might require additional capacity and resources (either human or financial) to plan and execute various activities.

Considering benefits related to the costs for implementing the short-term response, the benefits exceeded the costs of implementing the short-term response only for cluster 5. For other clusters, the common pattern witnessed was either the cost exceeded benefits, and/or the benefits related to costs were unknown. The benefits related to the costs of implementing the long-term response were mostly unknown for most of the case studies. Usually, the outcomes of long-term response might take a longer time to appear in social and governing subsystems. Therefore, any conclusions indicating the failure of management objectives resulting from the long-term response would be premature. However, timely monitoring and appraisal should be conducted to elucidate the effectiveness of the long-term responses.

3.5.2 Variation Across the Clusters

Five clusters contrasted distinctly from each other and therefore had unique characteristics that were related only to the case studies of the cluster. The case studies in cluster 1 (SL_cora, ON_tour, OB_poll, SH_poll) lacked short-term responses to deal with the main issue and therefore had no factors that prevented the short-term objectives from being fully achieved. Cluster 4 (IN_reef, US_oyst, MB_oyst, UR_clam, ESP_G, VIC, ARG, BS_fish) instead had a few (2-4) key factors within one or two natural, social, or governing systems that prevented both the short term and long term objectives from being fully achieved.

In contrast to cluster 1, cluster 2 (PH_poll, BA_mang, TB_shrm, BB_oyst, GRC, CM_mang, BU_pela) had a variety of short-term responses at more than one level, i.e., local, and regional and national and predictably had a variety of short term factors within one or two of natural, social, or governing systems contributing to the successful short term results. A bit different from

cluster 2, cluster 5 (VEN, ESP_M, BGD, TAN, KAR) had a variety of short-term factors but within all three natural, social, and governing systems. The main stressors that affected the SSF SES of cluster 2 were loss of key habitat or major habitat changes including invasive species. The case studies in cluster 2 did not have a variety of long-term responses in the social or governing system at more than one level (local, regional, national). The number of people affected by the main issue was not greater than 20% for the case studies in cluster 4.

For the case studies in Cluster 3 (GR_Amv, GR_Mal, VL_clam, CB_oyst, YB_clam), less than 20% of household income came from local sales of fish catches, processing, and wholesaling. This indicates that the degree of dependency on fishing was low. This could have happened because fishers abandoned the SSF occupation and joined other livelihood options, which can be referred to as livelihood diversification. The ecological status of the affected ecosystem at the ecosystem level before the main issue was not in improving condition for the case studies in cluster 4. The social power in the SSF SES was highly dispersed (80%). Inverse to cluster 3, the social power in the SSF SES of cluster 5 was entirely concentrated. The main issue in cluster 5 was related to the natural system at the national level and the productivity of the SSF SES was very high. In addition to this, there was the addition of new sets of rules (e.g., the introduction of output controls to a system previously having only input controls) before the occurrence of the main issue. The main issue for the case studies in cluster 5 was not related to the natural system at the local level. Also, some (3-4) livelihood opportunities (e.g., farming, manufacturing, forestry, etc.) were not open in the affected areas in cluster 5.

3.5.3 Similarity between the Case-Studies

The results of the global analysis showed that the main issue faced by more than half of SSF SES (e.g., over-fishing, invasive species, ocean acidification, pollution, globalized markets, tourism, etc.) was related to the social system at the local level (Q2S_A). Almost half of the SSF SES (45%) had the main issue related to the natural system at the local level (Q2N_A). Q2S_A and Q2N_A were also the two most linked VC with cluster 3. This demonstrates, that though the effects of global changes are much apparent on the natural system, the consequences are significantly high in the social system, SSF SES being coupled human-environmental systems governed by complex feedback and interactions between the sub-systems (Salgueiro-Otero & Ojea, 2020). At the same time, global drivers are causing local changes hindering the

sustainability of SSF. This result is consistent with previous findings by Chuenpagdee, (2011) and Nayak & Berkes, (2014). Nayak & Berkes, (2014) highlighted that the linkages between the global driver and social-ecological changes at the regional and local level are a two-way process where global drivers of change affect the sustainability of the SSF SES and in return, the invisible bottom-up processes having governance implications catalyze the global change process, both processes potentially impacting each other. The main issue was relevant to the local scale also clarifies that the vulnerabilities were most prevalent at the local level. Hence, the adaptation activities should also be undertaken at the local level based on the local practices, indigenous knowledge, and traditional understanding of the ecosystem (Miller et al., 2018) following evidence-based management (Refer to Appendix A for definitions) (Cooke et al., 2017).

The mode of governance in most of the case studies (more than half) was hierarchical governance on a regional/national/international scale (Q13_D). Having a hierarchical mode of governance does not necessarily mean the governing system is not appropriate (Jentoft & Chuenpagdee, 2015) because even the self-governance may only be suitable for some SSF SES but not all (Chuenpagdee & Jentoft, 2018). However, the hierarchical mode tends to work only in right and tight conditions, for example, if there is strong support from the state and other organizations (Putten et al., 2018). Governance arrangement can be of any type (single, hybrid, or mixed), however, it should be suitable in local, regional, and national contexts helping to build strong SSF. The single mode of governance system includes a standalone type of governance arrangement to govern SSF SES. Hybrid or mixed modes of governance refer to a mixture of different types of governance modes to address governability (Kooiman, 2003) and management issues and “promote cross-scale networks and multi-level interactions” in SSF (Chuenpagdee & Jentoft, 2018). Governability conditions under the governance should be strong and of high quality to ensure SES are adapting to changing social-ecological, political, and economic conditions. Proper governance and strong fisheries management can ultimately lead to improved ecosystem status (Bundy et al., 2017).

The key rules, regulations, instruments, and measures employed to achieve the management objectives were input measures (e.g., effort limitation, spatial and seasonal closures, gear limitations, limits on feed/chemical additions, stock enhancement, etc.) for more than half of the

case studies (Q15_B). Q15_B is also mostly linked variable category to cluster 5. Input measures are usually laid by the resource managers to slow down or control resource exploitation to bring fisheries on track (Purcell et al., 2013). Input control measures are different from the output control measures such as territorial user rights fisheries (TURFs), and total allowable catch and catch quotas (Purcell & Pomeroy, 2015b). In simple terms, "input controls limit the amount of fishing effort as a way to control the number of fish caught, while output controls are direct limits on the amount of fish harvested" (Selig et al., 2017). In addition to this, there is another type of control measure called a technical measure which describes where and when the fishermen can fish and the size they can harvest (e.g., marine protected areas, time-area closures, and size limits) (Selig et al., 2017). The result observed in this study doesn't support the previous findings by Purcell & Pomeroy, (2015) where the authors highlighted that SSF management heavily rely upon output control measures (in this study more than half of the case studies were found to have input measures as the management objectives). However, the suggestion by Purcell & Pomeroy, (2015) to impose a balanced set of input and output control measures is a reasonable recommendation. The management decision should be decided based on the type of fishery and the ecosystem and fisheries species being managed. For example, output control measures are more appropriate for the management of SSF SES having single target species, low fisher density, and centralized landing sites (Selig et al., 2017) as monitoring and enforcing the laws becomes easier in this condition. All in all, adopting input control measures can be regarded as one progressive practice to move SSF from vulnerability to viability. This is not because input measures are less costly but it's because output measures are considered to have as many disadvantages as advantages in the context of SSF (Purcell et al., 2014).

The social power was highly concentrated (80%) in more than half of the case studies (Q19_D). This shows a lack of pluralistic approach in managing the SSF SES and the power relations are contested. This leads to challenges in collective decision-making through the social institutions (Alexander et al., 2018) in managing the fisheries resources. With concentrated social power community-based management systems, co-management, or any formal/informal partnership/collaboration may not yield viable outcomes in SSF management (Ostrom, 2009; Berkes, 2021). Practically, it creates challenges in coordination, delegation, cooperation, and alliance formation creating hurdles in the collective action to form relevant policies and establish good governance to address emerging challenges. Concentrated social power may not favor the

move from hierarchical to co-governance or self-governance mode of governance. From the perspective of global change, an inclusive approach (Berkes, 2021) is vital to building diverse social power. Diverse social power may lead to well-connected social networks (horizontal, vertical, and cross-scale connections) that can possibly influence fishers to engage in some form of cooperative management and execute common goals. The well-distributed social network in SSF helps to build robust social bonding ultimately enhancing social capital (Pamungkas, 2018), and governance of the SSF SES. The key to developing social-ecological resilience is building social networks and social capital through the decentralization of power to all governance actors through social institutions at all scales (Berkes, 2021). This helps in the timely implementation of response, effective utilization of the resources, and disaster preparedness (Marín, 2019). Results show that vulnerability reduction requires subtle attention to how social power is constructed in the SES (Eriksen et al., 2021).

There had been no formal evaluation of the response in almost 48% of the case studies (Q28_A). This is an important observation because the formal evaluation of the responses is key to ascertaining whether management objectives have helped to reduce the vulnerability and develop the adaptive capacity (resilience) to deal with changes. One of the unique features of the I-ADApT framework is that it provides the opportunity to assess the effectiveness of the responses which were formal or informal either implemented for the short or long term. Most of the past studies have focused to identify the coping and adaptive responses in face of climate change from the international level to even household level (e.g., Silas et al., 2020) however very few have assessed the outcome of the response. For example, Marín, (2019) evaluated the factors causing successful and unsuccessful responses and concluded that identifying underlying mechanisms or factors behind success helps to create a more resilient and less vulnerable SSF system. Future research should dive more to answer the questions as to whether the responses met the intended management objectives to deal with the vulnerabilities? were the responses successful? what factors led to the successful implementation of the responses?

There were some (3-4) livelihood opportunities (e.g., farming, manufacturing, forestry, etc.) in the 44% of the affected SSF SES (Q9_C). This suggests that small-scale fishers had an alternative form of livelihood opportunities to diversify income in case of livelihood crisis in 44% of the SSF SES. Success in livelihood diversification doesn't mean SSF communities are

transitioning from V2V. Livelihood diversification is an adaptation option to reduce vulnerability by reducing poverty and increasing wealth (Davies & Hossain, 1997; Roscher et al., 2022). However, it causes human-environmental disconnection of fishers with the fisheries resource while they engage in other occupations other than fisheries (Nayak, 2017). In the short, term, when followed as a coping strategy, they may provide some benefits (Huynh et al., 2021) but if practiced in long term it leads to marginalization of the SSF communities by failing to improve the resource condition and weakening the social and governing institutions (Nayak, 2017). Following livelihood diversification as a single management and policy goal may potentially lead to vulnerability of the SSF in long term and potentially lead to building a situation of social-ecological traps (Cinner, 2011; Hanh & Boonstra, 2018). Livelihood diversification should not be used as use alone adaptive or transformative strategy but can be used in conjunction with other strategies which are more sustainable.

This research has contributed by expanding the multivariate method of data analysis that can be used to assess the vulnerabilities and viabilities in the SSF SES and make comparisons between the case studies individually and as a cluster. The use of the I-ADApT framework as a research tool was successful as the data analysis provided promising results that were helpful to reduce the complexity of data and understand the impacts of global changes. I-ADApT framework was instrumental in designing sequential and exclusive research steps to fulfill the research objectives. The vulnerabilities and efforts toward viability would have been more evident if more case studies were used in the analysis. Despite less, in number, huge variability was observed in the case studies. With the addition of more case studies, the pattern will appear overtly and start to settle showing the usefulness of the proposed methodology and functionality of the I-ADApT framework as a DSTs. Still, this analysis is being explored as proof of the concept and can further be improved to use it in the context of the transition of SSF from vulnerability to viability. Hence, it is suggested to conduct an analysis using the same methodology with a greater number of case studies, nevertheless, all case studies used in the analysis should be related to SSF, and the I-ADApT template should be filled with all the information. The results could have been biased due to several reasons. There could have been biasness when choosing the number of principal components while conducting the clustering analysis and when deciding the number of clusters. The number of the principal components used in the clustering was decided based on the percentage of the information retained by the principal components and the

critical observation of the results obtained from the MFA analysis. The number of clusters was decided based on the preliminary observation of the pattern of formation of the clusters, inertia gain results, and the research objectives. There could have been biasness in the way the number of the cluster was decided because the process was not purely technical and included a reflective process.

3.6 Conclusions

This research aimed to explore the use of MFA and HC in-depth and synthesize the lessons that can be learned from the I-ADApT case study templates. The approach was useful in delineating the similarities as well as the differences between the I-ADApT case studies representing the SSF SESs with different attributes. This method of multivariate analysis was found to be highly valuable in studying the global similarities between the case studies, across cluster variation, and within cluster characteristics (typology of the case studies). MFA was used to understand the relationship between the individual variable, variable categories, group of variables, group of variable categories and I-ADApT case studies with each other. It was seen that variable categories related to the vulnerability, governability, response, and appraisal groups were somewhat interrelated with each other creating complex relations. Further, the appraisal group had the most diverse variable categories, and the response group the least. High Lg values for appraisal group indicates that there is a low probability of successful response as different types of responses might have caused the data to be heterogeneous. Moreover, the richness of the common structure between the response and appraisal group is not high (Lg=2.11) relative to other pairs which have higher richness. The most linked pair of groups were appraisal with the governability group; governability with the vulnerability group; and response with the governability group. As the governability group was found to have a higher affinity with all other groups, the most common variables in the case studies were related to the governability group highlighting similar type of governance issues. The five case studies that had a high contribution in separating the clusters were KAR, YB_clam, TAN, ON_tour, and BS_fish.

Most of the short-term responses were coping responses related to adaptation at the household and community level mostly within the social subsystem. Instead, most of the long-term responses were management responses targeted at improving existing management and governance systems. Cluster 3 had somewhat successful short-term responses which helped to

meet some objectives, however, the benefits related to cost were mostly unknown for the majority of the case studies (3 case studies out of 5). Some of these short-term responses are support from local media by reporting the illegal and unregulated SSF issues and shifting to alternative livelihood opportunities. Cluster 1 had somewhat successful long-term responses which helped to meet some objectives, however, the benefits related to cost were unknown for the majority of the case studies (2 case studies out of 4). Some of these long-term responses are the formulation and execution of coherent plans, and the establishment of networks to monitor the effectiveness of long-term responses (OB_poll, ON_tour). Formation of legally regulated areas to conserve the fisheries resources and forming the ecosystem restoration committee incorporating all the stakeholders, i.e., adopting a co-management type of governance (SL_cora). Formation of multilevel partnerships, and government agencies making agreements with fisheries associations to provide the roles and responsibilities to fishers in fisheries management (co-management) (OB_poll, ON_tour). Cluster 5 had four case studies (out of five) where the objectives were not achieved from the long-term responses. One of the long-term responses was a shift to a co-management form of governance from a hierarchical model of governance (TAN). This suggests that co-governance doesn't always result in success. Institutional transformation is regarded to be one of the major necessities for co-governance to function (Chuenpagdee & Jentoft, 2018). Strong institutions, regular interactions between the government and other actors, a well-defined resource system and property rights system, coordination between the actors across scales and levels, and capacity development at the state and community levels are crucial to achieving benefits from co-governance. For cluster 5, there were a variety of factors within all three of natural, social, and governing systems that prevented the long term objectives from being fully achieved. The major cause of failure of co-management in TAN case study was the social unrest which caused failure of local institutions due to lack of funding and management plans.

The main issue faced by more than half of SSF SES was related to the natural and social system at the local level. The mode of governance in most of the case studies (more than half) was hierarchical governance at a regional/national/international scale. The key rules, regulations, instruments, and measures employed to achieve the management objectives were input measures. The social power was highly concentrated (80%) in more than half of the case studies. There had been no formal evaluation of the response in almost 48% of the case studies. There were no

structural changes in the governing system or individuals before the main issue. There were some (3-4) livelihood opportunities (e.g., farming, manufacturing, forestry, etc.) in the 44% of the affected SSF SES.

Chapter 4

Vulnerability and Adaptation to Global Change in Small-scale fisheries: A Thematic-Content analysis using the I-ADApT framework

4.1 Introduction

Small-scale fisheries (SSF) around the world are in a state of continuous decline (Palomares & Pauly, 2019) due to the increasing demand, outpacing the natural sustainable yield limit. Nevertheless, in present times, SSF have received prominent attention because fisheries resources are getting scarce at an alarming rate with decreasing fish stocks and the future of the millions of SSF communities is at risk (Pita et al., 2019). The sustainable management of SSF, also known as artisanal or subsistence fisheries (Palomares & Pauly, 2019) has been a challenging task to pursue due to the increase in the manifold vulnerabilities resulting from the global change.

Global change is a complex process, that occurs on large scales, with multiple factors impacting the state of the SSF systems (Turner et al., 1990; Vitousek, 1992). Global changes are characterized by events such as climate change, rapid population growth, urbanization, pollution, resource depletion, biological invasions, and land-use changes (Turner et al., 1990; Owen & Pickering, 2006; Stott et al., 2016). Global change is one of the drivers, while there are other multiple drivers causing vulnerabilities within SSF. Most of these are attributed to the expansion of large-scale fisheries, aquaculture expansion, developmental goals targeting tourism and recreation, industrialization (Nayak & Berkes, 2010), economic transformation, technological change, sociocultural evolution, and demographic change (Bennett et al., 2016). The open-access nature and common property regimes of SSF make it more challenging to manage these resources (Berkes, 2001; Nayak & Berkes, 2022). Unclear property rights can lead to changes in the structure and functioning of institutions, governance failure, and overall violation of the excludability and subtractability characteristics (Refer Appendix A for definitions) creating

practical challenges for managing the fisheries commons and maintaining their state as commons (Nayak & Berkes, 2011).

Different types of vulnerabilities due to the negative effects of multiple drivers in the SSF sector are already apparent and do not remain hidden facts anymore (Cinner et al., 2015). Islam & Chuenpagdee (2022) classified the vulnerabilities within SSF into five different groups mainly biophysical, social, economic, technological, and governance. These vulnerabilities may not only impact the livelihood and wellbeing of the SSF communities directly, but they can also interact with each other to disturb the stability of the natural, social, and governing system (Bundy et al., 2016) indirectly and thereafter giving rise to a new type of vulnerability having feedback effects. The concepts that often come with vulnerability are exposure, sensitivity, and adaptive capacity (Tuler et al., 2013). Vulnerability can be understood as an impact due to global changes because of the inability of the natural, social, and/or governing systems to respond to changes (Bennett et al., 2016). The magnitude of impact usually depends on the capacity of system components to self-organize, adjust, resist and absorb the change (Bennett et al., 2016). Adaptive capacity is defined as "the ability of systems, institutions, humans, and other organisms to adjust to potential damage, take advantage of opportunities, or to respond to the consequences" (IPCC, 2014). Adaptive capacity is usually high when small-scale fisheries social-ecological system (SSF SES) (Berkes et al., 1998) have high access to capital (human, social, physical, financial, ecological), self-organization capability, good leadership, mutual learning and knowledge systems (Folke et al., 2002; Bennett et al., 2014). Exposure, sensitivity, and adaptive capacity are interrelated with each other in a way that vulnerability for any system can be determined by exposure plus sensitivity minus the adaptive capacity of the system (Adger, 2006a).

Considering any type of system (natural, social, or governing), stressors such as global change cause exposure to the system components, which can cause consequences for SSF communities. Consequences can be positive or negative and can be realized immediately or after some time after the occurrence of the outcomes. Sensitivities are the factors that mediate the way stressors act on the system (Tuler et al., 2013). Responses are any formal or informal action taken by the state, non-state agencies, or the SSF communities themselves to mitigate or avoid the short-term and long-term effects of these consequences due to global change (Bundy et al., 2016).

Responses can have various forms with different targets such as coping with, adapting, preventing, recovering, and responding to the stressors (Green et al., 2021).

The premise is that responses help to build the adaptive capacity of the SSF communities by building resilience. Resilience is a dynamic concept and useful for understanding the self-organizing capability of the SSF SES, and the ability of the natural, social, and governing system to buffer the undesirable external and internal changes (Mason et al., 2022). Resilience can be understood as a "function of coping capacity, adaptive capacity, and transformative capacity" in response to social-ecological changes (Galappaththi et al., 2019). If the SSF communities have a low adaptive capacity, then they will not be able to take advantage of the opportunities and utilize the ecosystem services. Also, with a high adaptive capacity, they may be better able to use all the resources (either biophysical or economic resources) to convert them to successful adaptation outcomes to reduce vulnerability (Cinner et al., 2015). Adaptation can be defined as "proactive planning or taking collective action, reaction as an unplanned response, and coping as passive acceptance of consequences" (Green at al., 2021). In this sense, vulnerability (consequences of exposure, sensitivity), adaptation, adaptive capacity, and resilience are interrelated when it comes to understanding the impacts of global change phenomena in SSF (Smit & Wandel, 2006; (Refulio-Coronado et al., 2021). The vulnerability concept bridges the ideas of resilience and adaptive capacity together (Oestreich et al., 2019). An integrated approach should be followed to study the associations between stressors, vulnerabilities, responses, adaptive capacity, and resilience. The I-ADApT framework (Bundy et al., 2016) recognizes all these components, providing the opportunity to record and analyze information about the stressors and their impact on the SSF, vulnerabilities faced by SSF communities, governance, and issues related to the governability, short term and long-term responses and appraisal of those responses considering the natural, social, and governing systems of the SSF. The I-ADApT framework bridges the ideas of vulnerability, governance and governability, response, adaptive capacity, and resilience in the context of marine SSF SES to holistically understand vulnerabilities, as well as the responses from household level to international level.

A growing number of research studies have explored the strategies and responses for adaptation in SSF (e.g., Aguilera et al., 2015; Frawley et al., 2019; Silas et al., 2020; Green et al., 2021; Huynh et al., 2021; Susilo et al., 2021; March & Failler, 2022; Mpomwenda et al., 2022).

Galappaththi et al., (2022) conducted a relevant study to identify common adaptive responses, management responses, and barriers to responses considering climate change adaptation responses by taking 230 case studies of global fisheries. Though relevant studies exist, three major gaps were noticed in past literature. First, none of these studies has performed a comparative study analyzing the vulnerabilities and responses combinedly. Second, there were limited efforts to understand the barriers to responses. Third, no effort was made to classify SSF SES based on the observed similarities and differences of response followed and vulnerabilities faced. Analyzing the responses or the adaptation strategies alone without examining the vulnerabilities would be inadequate. It is necessary to study the factors causing vulnerabilities and factors strengthening viability together following the same thread which is referred to as the Vulnerability to Viability (V2V) (Nayak, 2021). V2V concept particularly focuses on the transition of small-scale fisheries from a vulnerability situation to a viability situation where SSF are not just economically viable but have developed social-ecological resilience and adaptive capacity; social wellbeing and sustainable livelihoods; and good governance (see Fig 2.2, chapter 2). Though SSFs are affected by different types of drivers, the prognosis is not all negative (Nayak et al., 2020). The survivability of the SSF communities around the world to date shows that they possess certain capacities and strengths which are poorly understood (Nayak & Berkes, 2019). Understanding strengths include identifying various forms of resilience (Berkes & Seixas, 2005) grounded within the SSF SES and which are being practiced to deal with the drivers of change.

The goal of this chapter was to explore a qualitative approach to understanding the vulnerabilities faced and the responses followed by SSF communities from the V2V lens. The two objectives of this research are (i) to develop a qualitative typology of case studies following the V2V approach, considering similarities and differences in the vulnerabilities faced by SSF communities, responses, factors enhancing those responses, and factors preventing those responses (ii) to improve understanding on the common types of vulnerabilities experienced and responses followed by fisheries communities that have helped them to make the transition from vulnerability to viability.

4.1.1 Concept of Transition and Transformation

Unlike the concept of transformation, which deals only with the large-scale change in structure, properties, and control of the SSF SESs (Biggs et al., 2010; Chapin et al., 2010), transitioning means focusing on small-scale changes as well as large-scale changes within various sub-systems of the natural, social, and governing systems that trigger resilience development through coping, adaptive and transformative responses (Hölscher et al., 2018). The concept of transition may be helpful in understanding how the components of the SSF SESs undergo non-linear shifts (Hölscher et al., 2018) from one state to another to bring up a profound change within the linked natural, social, and governing systems. Small perturbations to SES might not cause transformation in SES but it might cause a transition of the subsystems (or its components) from one state to another state. If the perturbation is large enough then the subsystems might get transformed due to a lack of adaptive capacity (Armitage et al., 2017).

4.1.2 The Transition from Vulnerability to Viability

One of the approaches to the transition of the SSF SESs from V2V is understanding the drivers of change, discovering responses followed to deal with change and uncertainty, and assessing the effectiveness of those responses to progress toward viability following the I-ADApT framework. It is pivotal to understand whether these responses enhance or harm the resilience of the SSF SESs (Guillotreau et al., 2018). The premise is such that all responses followed might not carry the notion of sustainability, but it's necessary to recognize those responses to enhance sustainable ones and eliminate others. The approach to viability here in this research is developing comprehensive knowledge about the social and governing responses grounded within the SSF systems, which have helped to develop the strengths of SSF communities. This is a process of policy evaluation where lessons deriving from past experiences are used to debate the current policy development (Bovens & Hart, 1995). While doing so, the ideas from the SES perspective, resilience, and sustainability science are used in this study. It is necessary to identify various aspects of social-ecological resilience and sort the factors enabling the resilience of SSF. The V2V approach focuses on both incremental and transformative adaptation measures (Eriksen et al., 2021), which includes both small-scale and large-scale adaptation measures for SSF viability.

4.2 Methodology

In this research, a qualitative methodology was followed to understand the vulnerabilities faced by the SSF communities, and the responses being implemented. Furthermore, the factors enhancing those responses and barriers to those responses are analyzed in detail. To do so, twenty-eight case studies[1] from 19 different geographical locations, collected using the I-ADApT template were used (See chapter 3 for the detail of the case studies and how these case studies were collected, Table 3.1). The I-ADApT template consists of six sections background information, a description of stressors and their impacts, vulnerability, governance, and governability, response, and appraisal (see Chapter 3, section 3.3.1 for the detailed description of these sections). Out of these six sections, all of the information in the first five sections of the I-ADApT template was used for the thematic-content analysis. The appraisal section was not included in the data analysis as it was not completed in several of the case studies, therefore there was insufficient information. The Qualitative- Data Analysis Software (Q-DAS) NVIVO 12 Plus (QSR International, 2022) was used to import data from the I-ADApT template, encode data, classify, and display data.

Qualitative methodologies such as a qualitative descriptive approach include multiple approaches that include content analysis, and thematic analysis (Vaismoradi et al., 2013). Thematic content analysis was employed as a method of data analysis in this research (Green & Thorogood, 2018). A theme can be defined as an "abstract entity that brings meaning and identity to a recurrent experience and its variant manifestations. As such, a theme captures and unifies the nature or basis of the experience into a meaningful whole" (DeSantis & Ugarriza, 2000) Thematic analysis (Sparker & Holloway, 2005) was used to create themes and the content analysis (Powers & Knapp, 2010) was used to code the qualitative information in the I-ADApT template to the themes created in the thematic analysis and analyze them. Content analysis can be defined as a "systematic coding and categorizing approach used for exploring large amounts of textual information unobtrusively to determine trends and patterns of words used, their frequency, their

[1] Note that the Sekisei lagoon Japan (SL-cora) case study used in Chapter 3 was not used in this analysis because the I-ADApT template was not available.

relationships, and the structures and discourses of communication" (Vaismoradi et al., 2013). The conceptual research framework is shown in Figure 4.1.

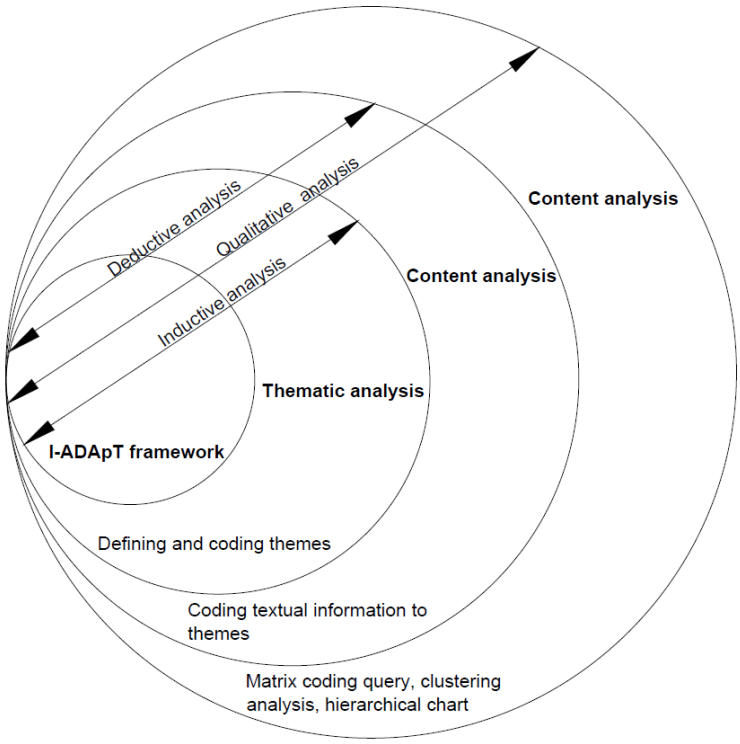

Figure 4. 1 Conceptual research framework

The research procedure is shown in Figure 4.2. Firstly, the I-ADApT template was reviewed in detail to create the major themes. Secondly, the information in each of the I-ADApT templates was reviewed to explore the sub-themes (here referred to as minor themes). This included searching for frequently repeating terms in the I-ADApT template that carried social-ecological meaning in the context of V2V research. Both inductive and deductive data analysis (Creswell & Creswell, 2017) were employed in this research to conduct the thematic content analysis. The inductive process included working back and forth between the I-ADApT case study template and the minor themes. This process resulted in the consolidation of the minor themes after a better understanding of the context of the answers to each I-ADApT question. A codebook (see: Appendix E) was developed to outline the major and minor themes with a description of the

common terms, or the elements found in the I-ADApT template that contributed to the structure of the minor themes in this research. The codebook shows the number of files which contains information related to the minor theme and references which indicates how many times the information in the template was referenced to the minor theme.

After creating the themes (both major and minor), the information in the I-ADApT templates was coded to the minor theme based on the matching criteria (qualitative content analysis). Several times, a deductive process was employed to revise the themes based on the analysis of the information in the I-ADApT template during the content analysis. Usually, the information in the I-ADApT was reviewed more intensively during content analysis than the thematic analysis as the information is read line by line. This process was conducted for all 28 case studies, reviewing all the qualitative information in the I-ADApT templates. Inductive analysis was purely data-driven; however, the deductive analysis involved some level of the analytical interpretation of the qualitative information or researchers' judgment to re-organize the themes. Usually, during the deductive analysis, some themes collapsed onto the other themes, some themes were deleted and most of them were refined. Deductive analysis was useful to maintain the coherence and consistent flow of the themes (Braun & Clarke, 2006).

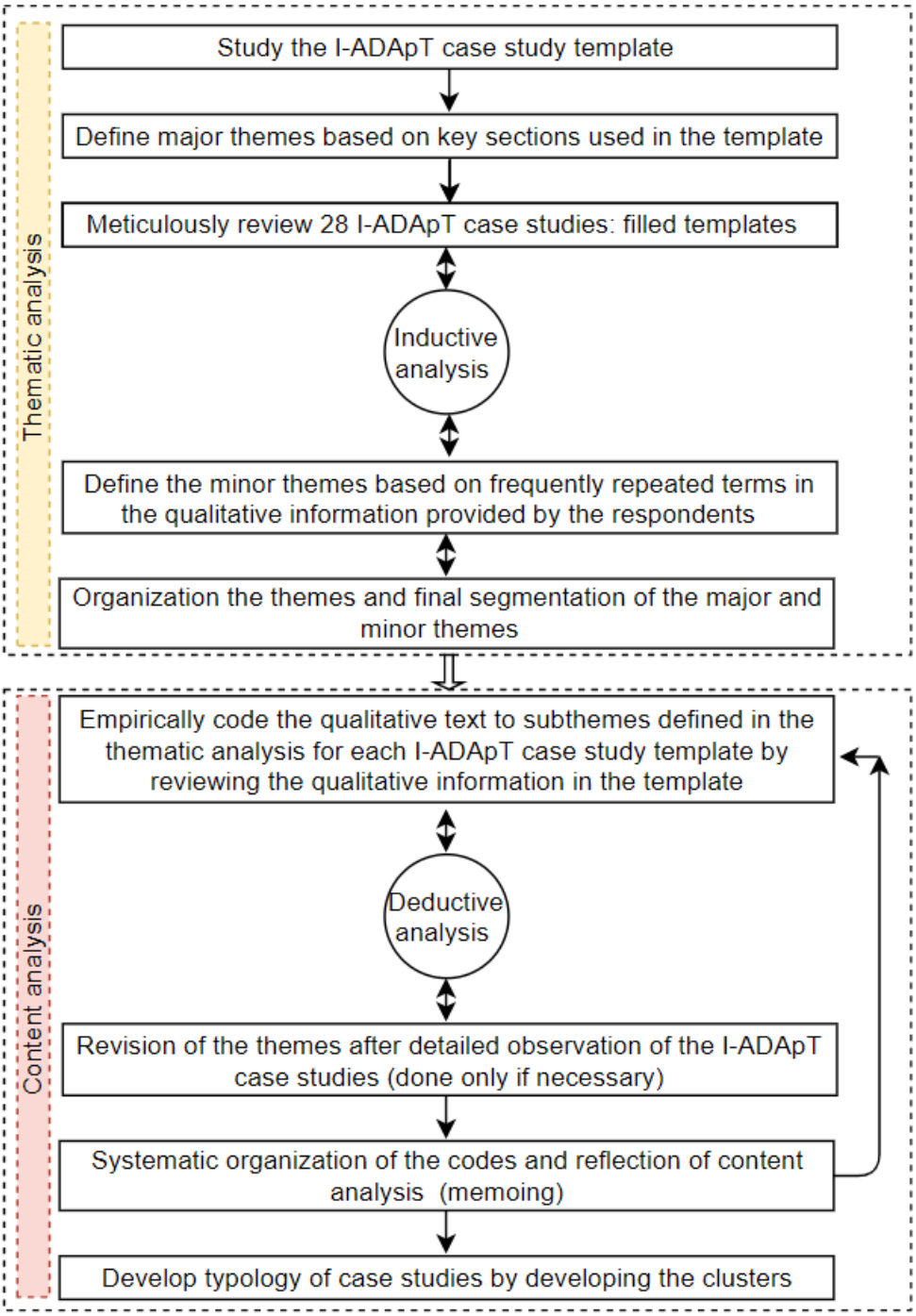

Figure 4. 2 Research methodology

As the aim of the study was to use the lens of V2V in the research analysis, two major distinctions were made while coding the themes. The first section was named ‘Vulnerability’ which was further subdivided into 5 major themes named ecological, economic, institutional, social, and technological vulnerability, which were further coded into minor themes. Ecological, economic, institutional, social, and technological vulnerability consisted of 9, 9, 11, 7, and 2 minor themes, respectively. The second section was identified as ‘Towards Viability’ which was further segmented into 6 major themes as a governing response, social response, enabling governing response, enabling social response, preventing governing response, and preventing the social response, which comprised 13, 10, 9, 10, 16, and 8 minor themes, respectively. Table 4.1 shows all the major and minor themes that were coded into NVIVO 12 plus.

The results of the analysis were generated by comparing the codes and minor themes. Three types of analyses were conducted, beginning with clustering analysis of the case studies, followed by matrix coding and development of hierarchical charts using the major and minor themes in NVIVO software. The results are described for all the case studies (called global analysis) and consequently for the clusters of the case studies. The relative proportion of different minor themes is shown in the pie chart. The count of the different minor themes referenced in each I-ADApT case study template is shown in the bar chart. The major and minor themes for the clusters are shown in the form of a tree map.

Table 4. 1 Major and minor themes defined in research study

The number after the themes indicates the number of I-ADApT templates that consist of information related to the minor theme (the first number, e.g., 18 for resource depletion) and the number of times the information in the I-ADApT template was coded to the minor theme (the second number, e. g., 38 for resource depletion). Main parent themes: bold and underlined. Major themes: in bold.

Vulnerability (28, 511)		**Towards Viability** (28,799)			
Ecological vulnerability (26, 214)	Resource depletion (18,38)	**Governing response** (28, 269)	Revisions & inspections (13,17)	**Enabling social response** (24, 72)	Youth engagement (2,3)
	Pollution (17,32)		Relief & subsidies (9,16)		Valuing fishers (6,8)
	Overfishing (10,16)		Proper funding (10,16)		Switch target species (4,5)
	Extreme weather (8,14)		Policies & regulations (21,42)		Social unity (8,14)
	Environmental degradation (22,36)		Participatory management (11,15)		Social campaigns (4,5)
	Disease outbreak (8,11)		Management systems (18,31)		Permanent migration (2,4)
	Climate change (13,26)		Institutional framework (7,15)		Media outreach (3,5)
	Biodiversity loss (14,24)		Good governance (5,8)		Control invasive species (2,2)
	anthropogenic activities (11,17)		Extended collaboration (12,20)		Awareness (9,11)
Economic vulnerability (24, 103)	Productivity decrease (19,36)		Evidenced-based management (13,16)		Active involvement (8,15)
	Poverty & illiteracy (6,11)		Decentralization (5,5)	**Preventing governing response** (25,147)	Revenue oriented policies (5,5)
	Poor value chain (4,5)		Co-management (16,38)		Poor enforcement (11,16)
	Lack market (6,6)		Appropriate legislation (14,30)		Political interference (6,7)
	Lack investment (5,5)	**Social response** (28, 161)	Temporary migration (6,10)		Lack resource (3,6)
	Lack income (15,26)		Partnership development (8,13)		Lack monitoring (11,14)
	Lack credit (3,4)		Nature-based solutions (5,5)		Lack management plans (16,28)
	High production		Multi-level		Lack coherent strategy

Vulnerability (28, 511)		**Towards Viability** (28,799)			
	cost (2,2)	**Social response** (28, 161)	collaboration (12,22)	**Preventing governing response** (25,147)	(11,14)
	Corruption (4,8)		Malpractices (8,16)		Insufficient funding (9,11)
Technological vulnerability (3,4)	Destructive technology (3,3)		Livelihood diversification (14,28)		Ignoring science (8,11)
	Poor connectivity (1,1)		Informal local practices (12,20)		Ignoring climate change (6,6)
Institutional vulnerability (20,82)	Weak property rights (9,13)		Habitat conservation (6,6)		Hierarchical decision-making (5,5)
	Unsuitable governance (9,16)		Community-based management (7,19)		Fund mismanagement (4,5)
	Poor legislation (10,17)		Capacity development (16,22)		Distrust to government (5,5)
	Lack accountability (6,6)	**Enabling governing response** (22,87)	Restrict access (5,5)		Delayed responses (6,8)
	Inappropriate management (7,11)		Restore fish stock (9,12)		Conflicting agendas (4,4)
	Fragile Institutions (2,3)		Quota system (7,11)		Communication problems (2,2)
	Centralized management (11,16)		License system (8,8)		Social un-rest (7,8)
Social vulnerability (24, 108)	Unemployment (9,13)		Implementation of plans (10,13)	**Preventing social response** (15, 63)	Short-term measures (5,7)
	Political instability (2,2)		Government incentives (7,10)		Opportunistic behavior (8,10)
	Outward migration (6,9)		Experimental fishing (5,5)		Lack social institution (4,5)
	Newcomers in fisheries (6,7)		Expansion of fishing grounds		Lack social cohesion (10,16)

<table>
<tr><td colspan="2"><u>Vulnerability</u> (28, 511)</td><td colspan="4"><u>Towards Viability</u> (28,799)</td></tr>
<tr><td rowspan="7"></td><td></td><td rowspan="4">Enabling governing response (22,87)</td><td>(3,3)</td><td rowspan="4">Preventing social response (15, 63)</td><td></td></tr>
<tr><td>Low environmental concern (3,4)</td><td>Empowerment (4,6)</td><td>Lack fishing knowledge (3,4)</td></tr>
<tr><td>Lack wellbeing (5,5)</td><td>Control exploitation (7,12)</td><td>Excludability (7,10)</td></tr>
<tr><td>Intrasectoral conflict (12,18)</td><td>By-catch limit (2,2)</td><td>Dependency in state (3,3)</td></tr>
<tr><td>Intersectoral conflict (14,23)</td><td colspan="4" rowspan="4"></td></tr>
<tr><td>Illegal activities (6,9)</td></tr>
<tr><td>Catch uncertainty (7,10)</td></tr>
<tr><td>Behavior issues (5,8)</td></tr>
<tr><td colspan="2">Social vulnerability (24, 108)</td></tr>
</table>

4.2.1 Clustering Analysis in NVIVO

Clustering analysis was carried out in NVIVO to group the case studies based on the similarities and differences in the information coded to each minor theme created in this study and develop typology of the case-studies. NVIVO first builds a table where it sorts rows and columns automatically based on the themes and the information coded from each I-ADApT case study to the theme. Rows are the I-ADApT for each case study, and columns are each minor theme. NVIVO assigns a value of 1 if the minor theme is present in the case study (which means if any information from the I-ADApT case study has been coded to that theme then a value of 1 is assigned), otherwise, a value of 0 is assigned. NVIVO then calculates the similarity index using the Pearson correlation coefficient metric for each pair of items (row and column) and forms the cluster and dendrogram using a complete linkage (farthest neighbor) hierarchical clustering algorithm (Vijaya et al., 2019; QSR International, 2022). The default number of clusters formed by NVIVO is 10 and the method of generating a cluster map was an iterative multidimensional scaling algorithm (QSR International, 2022).

4.3 Results

4.3.1 Global Results Considering 28 Case-Studies: Vulnerabilities

The most common ecological vulnerabilities within the twenty-eight SSF case studies are shown in Fig 4.3. and Table 4.2. The most ecologically vulnerable SSF SESs, based on the total number of ecological vulnerabilities experienced were ARG from Argentina, BGD from Bangladesh, CM_mang from Cameroon, VEN from Venezuela, and BA_mang from Bangladesh (Fig 4.4). (Refer to Table 3.1 for the acronyms of the case studies). The ecological vulnerability was tracked in 26 case studies and was referenced or coded 214 times in total in all the case studies.

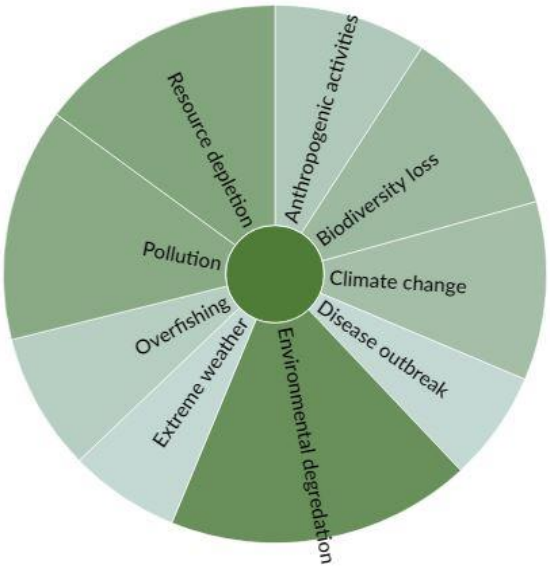

Figure 4. 3 Relative proportions of different types of ecological vulnerabilities across all case studies

Table 4. 2 Most common ecological vulnerabilities

Rank order	Ecological vulnerabilities	Common examples in I-ADApT case-studies
1	Environmental degradation	Environmental variability Changes in hydrological regimes
2	Pollution	Eutrophication Oil spills and agricultural effluents Toxic industrial effluents Ocean acidification

3	Resource depletion	Over-exploitation of resources (uncontrolled exploitation, commercial exploitation, destructive fishing such as bombing, use of chemicals) Changes in distribution and availability of resource
4	Climate change impacts	Global warming
5	Biodiversity loss	Changes in species abundance, loss of species Continuous encroachment of protected forest areas Illegal poaching of wildlife Disappearing mangroves Decrease in breeding and nursery grounds of mangrove fisheries
6	Anthropogenic activities	Unsustainable use of resources Urbanization, industrialization, and environmentally irresponsible development
7	Overfishing	Overfishing due to a decrease in fish catch Increased mechanization of fishing equipment
8	Extreme weather events	Cyclones, hurricanes
9	Disease outbreaks	Mass mortalities

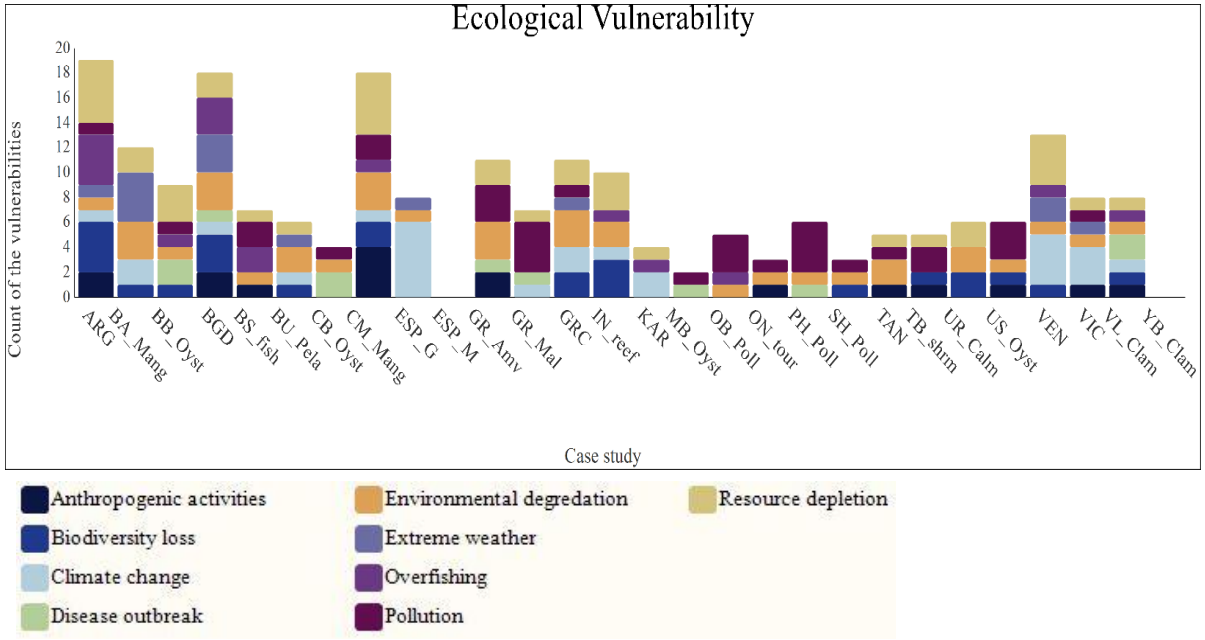

Figure 4. 4 Frequency of ecological vulnerabilities for each case-study

The most common economic vulnerabilities within the twenty-eight SSF case studies are shown in Fig 4.5. and Table 4.3. The economic vulnerability was seen as the major type of vulnerability for the BGD and BA_mang case from Bangladesh, the VEN case from Venezuela, and the ARG case from Argentina (Fig 4.6). The economic vulnerability was found in 24 case studies and was coded 103 times in total in all the case studies.

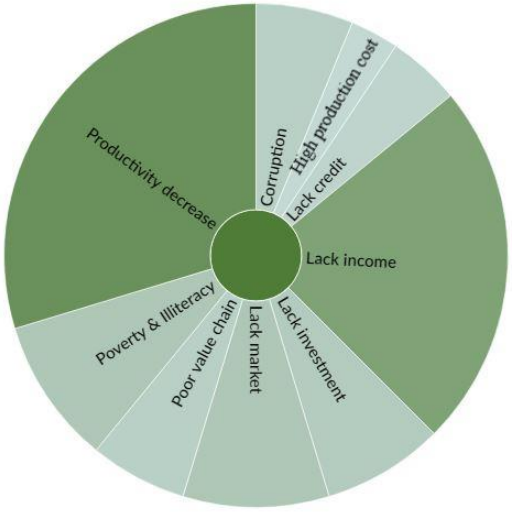

Figure 4. 5 Relative proportions of different types of economic vulnerabilities across all case studies

Table 4. 3 Most common economic vulnerabilities

Rank order	Economic vulnerabilities	Common examples in I-ADApT case-studies
1	Productivity decrease	Low fish catch Impact of fish stock fluctuation and decrease in economic yields from fisheries
2	Lack of income	Unemployment Drop in fish price Increase in fishing costs
3	Poverty and illiteracy	Illiteracy leading to unemployment, and unemployment leading to poverty The nearest school were inaccessible because of distance or poor road connectivity
4	Lack of a market	Inaccessible market High cost of transport of caught fish Syndicate controls the price of fish catch where fishers end up getting paid lesser

		Fishers live far from the city where they don't get a good market for their catch
5	Poor fisheries value chain	The conventional approach, which is inequitable, complex, and lengthy Changed with women and youths involved in all value-chain segments
6	Lack of investment	Lack of new investments to bring opportunities for fishers such as establishing alternative employment opportunities
7	Corruption	Need to pay a bribe to governmental officials Corrupted officials as well as leaders of fisher's associations.
8	Lack of credit access	Lack of credit access because fishers failed to pay back previous loans NGOs or cooperatives providing micro-credit did not provide further loans Unaffordable credit system High-interest rates

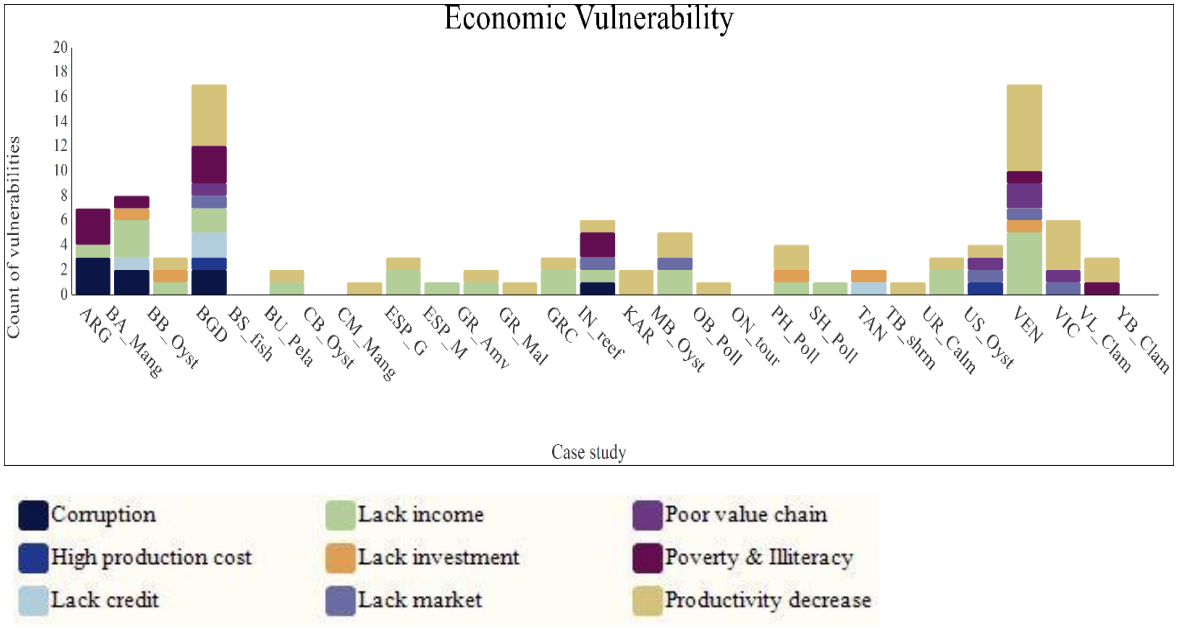

Figure 4. 6 Frequency of economic vulnerabilities for each case-study

The most common social vulnerabilities within the twenty-eight SSF case studies are shown in Fig 4.7 and Table 4.4. Social vulnerability was the most common type of vulnerability for the cases IN_reef from Indonesia, VIC from Uganda, VEN from Venezeula, BA_mang from Bangladesh, and VL_clam from Italy (Fig 4.8). Social vulnerability occurred in 24 case studies and was coded 108 times in total in all the case studies.

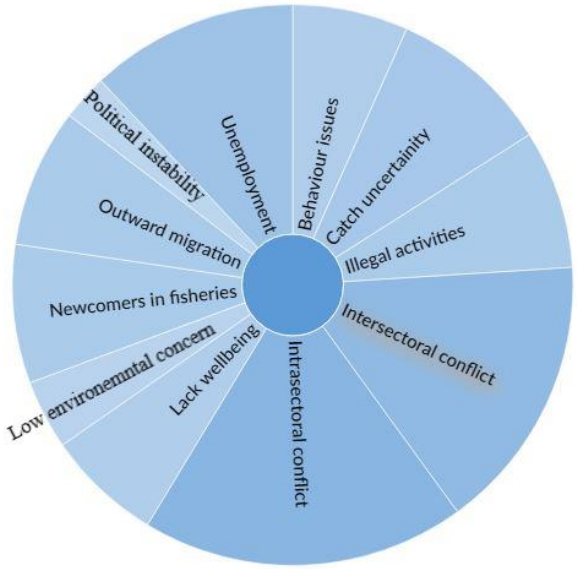

Figure 4. 7 Relative proportions of different types of social vulnerabilities across all case studies

Table 4. 4 Most common social vulnerabilities

Rank order	Social vulnerabilities	Common examples in I-ADApT case-studies
1	Intersectoral conflict	The conflict between SSF communities with other groups of people following different professions such as tourism, oil companies, and large-scale fisheries
2	Intrasectoral conflict	The conflict between the fishermen group, and new entrants' fishermen. The conflict between aquaculture and the small-scale fishers
3	Unemployment	Lack of alternative livelihood opportunities
4	Newcomers in fisheries	Outplacing fishers who use traditional methods of fishing

5	Outward migration	Youths migrate in search of new opportunities leaving the historical profession followed by their parents or the older generation.
6	Catch uncertainty	Uncertainties were the common feature of the fisheries making it difficult for fishermen to estimate what type of catch becomes abundant and what can be supplied to the markets to meet the demanded quota.
7	Illegal activities	Illegal unauthorized fishing Unsustainable fishing methods such as the use of poisons and bombing Illegal fishing gears Unlicensed fishermen
8	Behavioral issues	Opportunistic behavior of the fishermen
9	Lack of wellbeing	Social frustration due to lack of job, and income Effects on physical and mental wellbeing

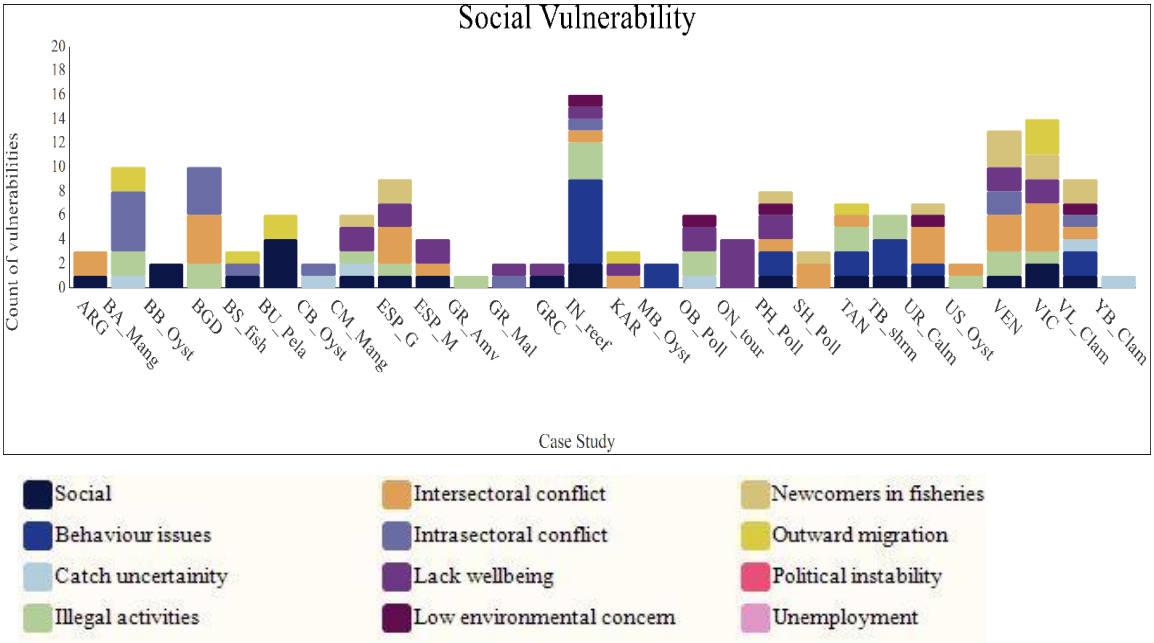

Figure 4. 8 Frequency of social vulnerabilities for each case-study

The most common institutional vulnerabilities within the twenty-eight SSF case studies are shown in Fig 4.9 and Table 4.5. The institutional vulnerability was the most common type of vulnerability for the ARG case from Argentina, CM_mang from Cameroon, GRC from Greece, and IN_reef from Indonesia. (Fig 4.10). The institutional vulnerability was found in 20 case studies and was coded 82 times in total in all the case studies.

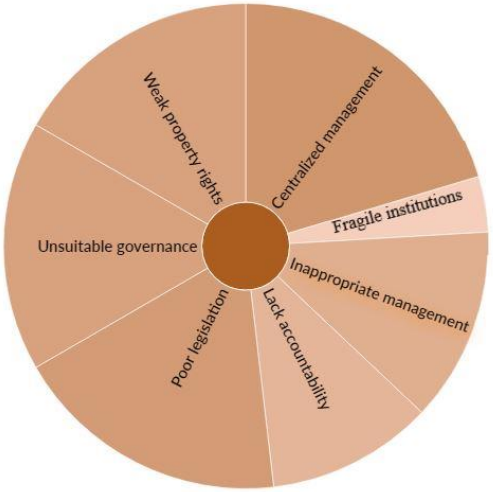

Figure 4. 9 Relative proportions of different types of institutional vulnerabilities across all case studies

Table 4. 5 Most common institutional vulnerabilities

Rank order	Institutional vulnerabilities	Common examples in I-ADApT case-studies
1	Unsuitable governance	Weak and poor governance of hierarchical (top-down) type Weak governing institutions
2	Centralized management	Fishermen must comply with any type of rules the administration legislates Poor participation of fishers in decision making Concentrated social power Absence of common fishery right
3	Poor legislation	Poor law enforcement, rules, regulations, instruments, and policies
4	Weak property rights	Encroachment of resources by external agents Open-access nature of property rights Lack of defined ownership and established rights in the management of fisheries commons Unclear rules about the resource excess
5	Inappropriate management	Uncoordinated developmental activities Lack of management measures

		Lack of area-based management measures
6	Lack of accountability	Lack of transparency, and accountability in management decisions Management decisions are politically biased Compliance has been a key challenge in fisheries Unfair distribution of relief and subsidies

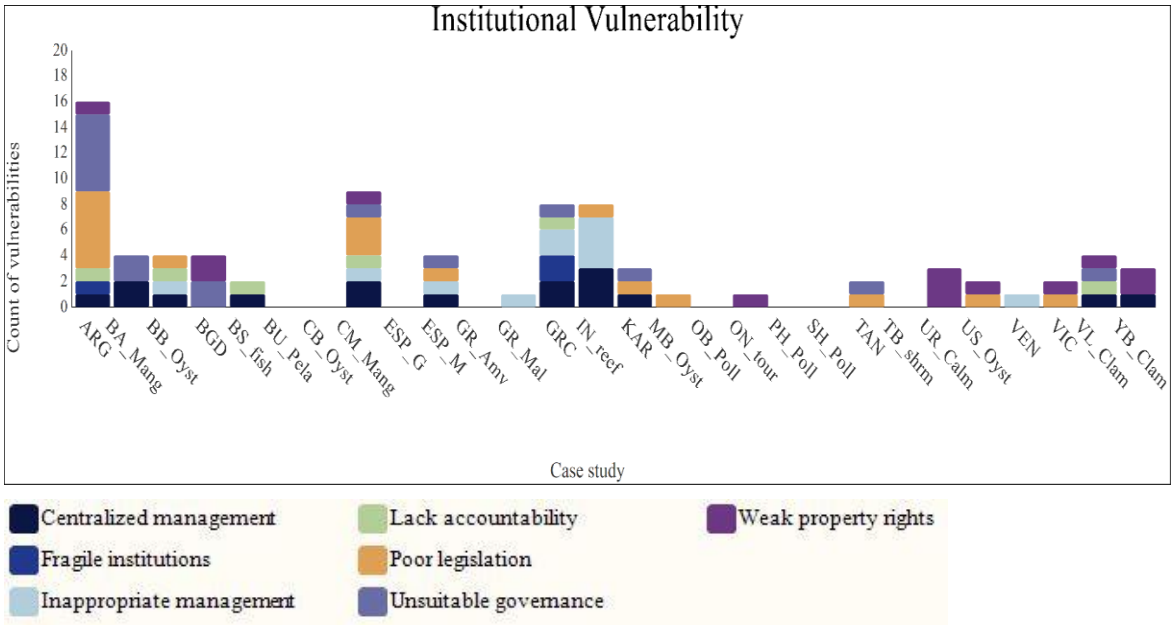

Figure 4. 10 Frequency of institutional vulnerabilities for each case-study

Only two types of technological vulnerabilities were discovered in 28 case studies (Table 4.6). Technological vulnerability was the most common vulnerability in the case studies from Bangladesh (BGD), South Africa (BU_pela), and IN_reef (Indonesia). The technological vulnerability was found in 3 case studies and was coded 4 times in total in those case studies.

Table 4. 6 Most common technological vulnerabilities

Rank order	Technological vulnerabilities	Common examples in I-ADApT case-studies
1	Destructive technology	Heavy mechanization of the fishing boats led to unequal fish catches within the fishing communities
2	Poor connectivity	Use of digital technologies, digital connectivity to market

Results showed that the SSF SESs dealt with multiple types of vulnerabilities at a given time. Based on the count of the items coded to the minor themes for each of the five main vulnerabilities, the ecological vulnerability was the most widespread type of vulnerability followed by the social, institutional, economic, and technological vulnerability.

4.3.2 Global Results Considering 28 Case-Studies: Towards Viability

4.3.2.1 Social and Governing Responses

Different responses were designed and implemented to deal with the vulnerabilities to help the SSF communities progress toward viability. Not all responses were coming from the governmental agencies, many responses were initiated by the local communities themselves through collective action and also by non-state agencies such as non-governmental organizations and international non-governmental organizations.

The most frequent governing response within the twenty-eight SSF case studies are shown in Fig 4.11 and Table 4.7. The governing response was mostly implemented in the following case studies: ESP_M, ESP_G (Spain), VIC (Uganda), VEN (Venezuela), UR_clam (Uruguay), TAN (Burundi, Congo, Tanzania, and Zambia) (Fig 4.12). The governing response was reported in all 28 case studies and was referenced 269 times in total in the coding process.

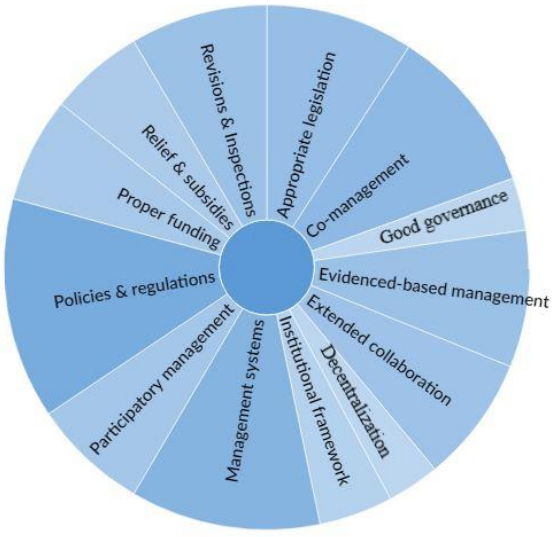

Figure 4. 11 Relative proportions of different types of governing response across all case studies

Table 4. 7 Most common governing responses

Rank order	Governing response	Common examples in I-ADApT case-studies
1	Policies and regulations	Formulation of rules, policies & regulations at the regional and national level Clear property rights Giving autonomous rights to fishers to make their own rules Resolutions to solve practical challenges, legal agreements
2	Management systems	Beach management systems Water quality management systems
3	Evidenced-based management	Management based on findings from the scientific reports, research, and investigations Backing up fisheries through its research programs including indigenous knowledge
4	Co-management	Moving from a hierarchical system to a co-management model Involvement of multiple stakeholders in the management of fisheries Co-existence, the co-prosperity relationship between government and fishers
5	Appropriate legislation	Legislation for development planning Prohibition to use small sized mesh Oyster harvest rotation plan o capture oysters before they die Control dredging Prohibition of inappropriate fishing gear
6	Monitoring and inspection	Check the progress of implementation of the plans such as by surveys, and surveillance system
7	Extended collaboration	Collaboration between fishermen, NGOs, INGOs, and the governments at regional and national levels (horizontal and vertical interactions)
8	Relief and subsidies	Subsidy and relief distribution (usually temporary) after the occurrence of disasters
9	Proper funding	Allocation of funding to kick start and execute the management plans
10	Institutional framework	Establishment of frameworks for policy development Frameworks to develop a management plan, and acts

In most of the cases, governance responses were seen as management responses that included a transition from a hierarchical form of governance to co-governance, integration of the concept of adaptive co-management into the policy formulation, and management systems more focused on

ecosystem-based management and evidenced-based management. The governing responses were adaptive types of responses, which were usually designed as long-term responses or proactive responses except for a few. For example, relief & subsidies, and inspection activities may not be considered as long-term responses but are reacting responses to help the fishers sustain a living. Governing responses were focused on establishing the strong management systems needed to deal with both acute and chronic stressors through adaptive management at different levels.

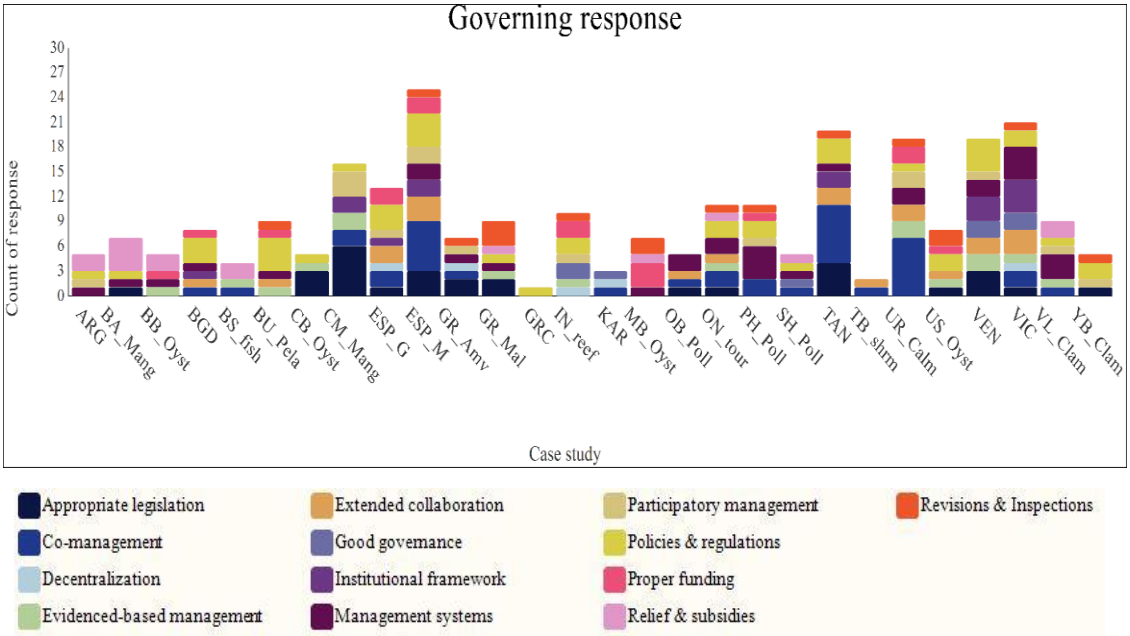

Figure 4. 12 Frequency of governing response for each case-study

The most frequent social response within the twenty-eight SSF case studies are shown in Fig 4.13 and Table 4.8. Social responses were largely followed in cases like IN_reef (Indonesia), VIC (Uganda), VEN (Venezuela), VL_clam (Italy), BA_mang, and BGD (Bangladesh) (Fig 4.14). The social response was reported in all 28 case studies and was referenced 161 times in total in the coding process.

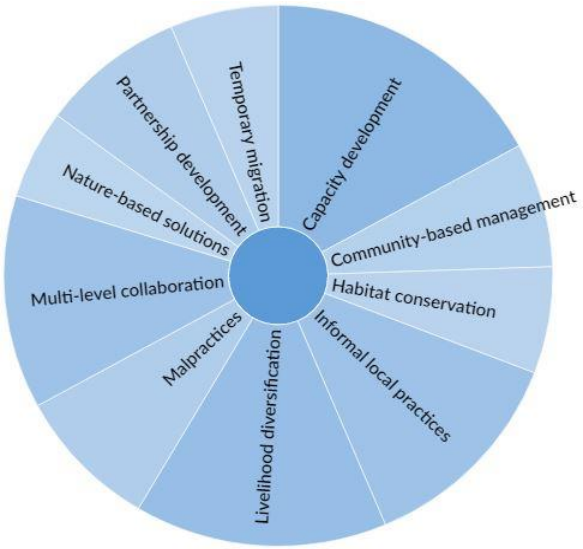

Figure 4. 13 Relative proportions of different types of social response across all case studies

Table 4. 8 Most common social responses

Rank order	Social response	Common examples in I-ADApT case-studies
1	Capacity development	Educating them about sustainable fisheries practice Introduction of new technologies among fishers Technological development and promotion of modern fishing equipment among fishers Opportunity to engage in other professions
2	Livelihood diversification	Fisheries communities changed their professions from fisheries to other sectors such as starting to practice aquaculture, new jobs in the food processing industry for large-scale fisheries
3	Multi-level collaboration	Collaboration of the fishing communities with other stakeholders, governmental agencies, non-governmental agencies, and international non-governmental agencies at local, regional, and national levels
4	Malpractices in fisheries	Catching pre-mature species Violating and disobeying management rules
5	Community-based management	Joint community-based management initiatives to implementation of plans and programs Community-based knowledge mobilization activities
6	Informal local practices	Low price trading of fish

		Self-compromising and eating an unhealthy diet to save money for family and children Using children as labor without sending them to school
7	Partnership development	Partnership to strengthen the local actions through the formation of associations and councils
8	Temporary migration	Migration where small-scale fisheries communities migrated to other cities to pursue other occupations during low catch fishing season
9	Nature-based solutions	Implementation of nature-based solutions through community-based initiatives to reduce the harm from the extreme weather events
10	Habitat conservation	Local initiatives supporting habitat conservation activities such as the implementation of the marine protected areas

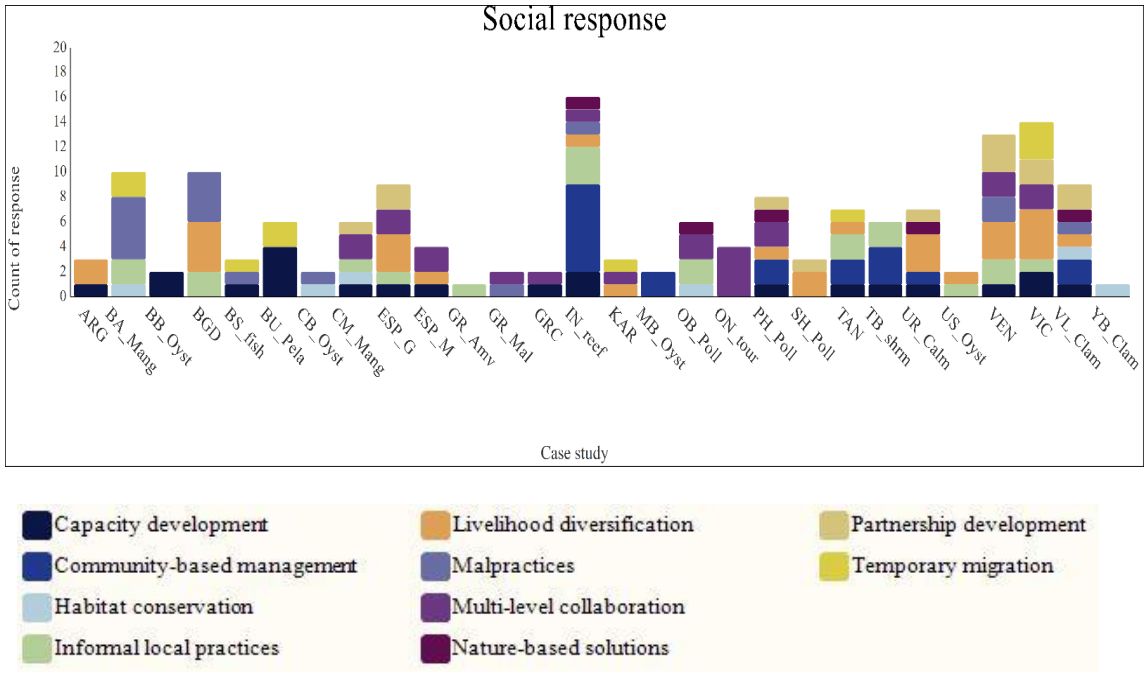

Figure 4. 14 Frequency of social response for each case-study

There were varied kinds of social responses, some of which included unsustainable responses from SSF communities such as illegal activities violating the fishing norms and changing to unsustainable fishing practices. Most of the social responses were directly or indirectly associated with the household and community-based adaptation and management measures. Such community-based adaptation measures were the result of a bottom-up management approach (Schlüter et al., 2021) which included collaboration with multi-level stakeholders and collective action by the SSF communities. Social responses were a mix of the adapting and reacting responses (Green et al., 2021), where the adapting responses included collective action to formulate strategies to reduce the vulnerabilities and reacting responses included personal effort through informal practices to deal with vulnerabilities. These types of informal local practices may provide temporary financial benefits to the fishers usually in the short term. However, this may negatively influence the relational and subjective well-being (Coulthard et al., 2011) of the fishers.

4.3.2.2 Factors Enabling the Social and Governing Responses

The most common factors enabling social response within the twenty-eight SSF case studies are shown in Fig 4.15 and Table 4.9. The case studies ESP_G (Spain), VIC (Uganda), and VEN (Venezuela) had numerous factors enabling the social response in comparison to the other 28 case studies (Fig 4.16). Factors enabling social responses were reported in 24 case studies and were referenced 72 times in total in the coding process. Four case studies, ARG, BU_pela, CB_oyst, and GRC, did not report any factors enabling social response. Most of the factors enabling the social response were the factors that helped the SSF communities build resilience either through social unity, social campaigns, awareness activities, media outreach activities, or informal activities that ultimately helped to build the adaptive capacity of the SSF communities.

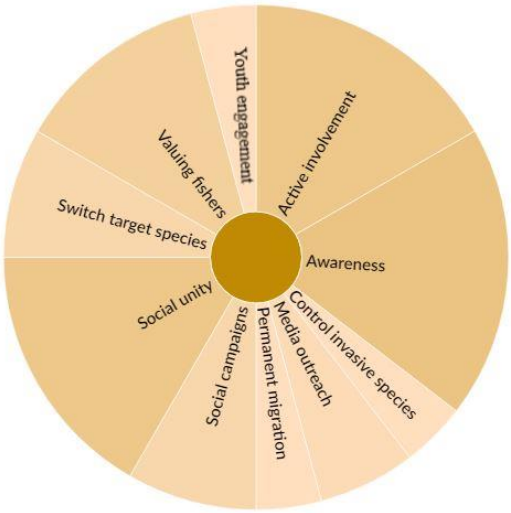

Figure 4. 15 Relative proportions of different types of factors enabling social response across all case studies

Table 4. 9 Most common factors enabling social responses

Rank order	Factors enabling social response	Common examples in I-ADApT case-studies
1	Social unity	Fishers remained united to achieve a common goal such as reducing the economic crisis Joint acceptance of the leadership decision Unity through involvement in the fisheries associations and organizations
2	Active involvement	Active involvement of fishers in decision-making and policy formulation The willingness of fisher communities to work jointly
3	Awareness	Awareness among the fishers through training, workshops, and public hearing on the need to conserve the resources
4	Valuing fishers	Fishers being valued in the management and governance of SSF Participation of the fishermen in regional advisory councils and coastal action groups (with other stakeholders) Fishermen themselves also have realized that it is much better to participate in the management of the fishery (co-management) than to be simple compliers with the regulations imposed on them
5	Switching target species	Switching target species such as from fish to crab to catch economically profitable fish species

		Switch target species as per the demand in the local and international market
6	Social campaigns	Campaigns among the fishers to put pressure on the government to fulfill their demands Campaigns targeting youths Campaigns lobbying for more research funding and potential subsidies Political campaigns to raise the voice of fishers
7	Permanent migration	Fishers permanently left the SSF occupation and joined new occupations such as opting to work as a construction worker after being severely affected by the social-ecological changes
8	Media Outreach	Media support disseminating the problems in small-scale fisheries to the broader audience Reporting of illegal fishing activities and resource depletion issues
9	Controlling invasive species	Finding scientific ways to control invasive species to reduce the mortality rate

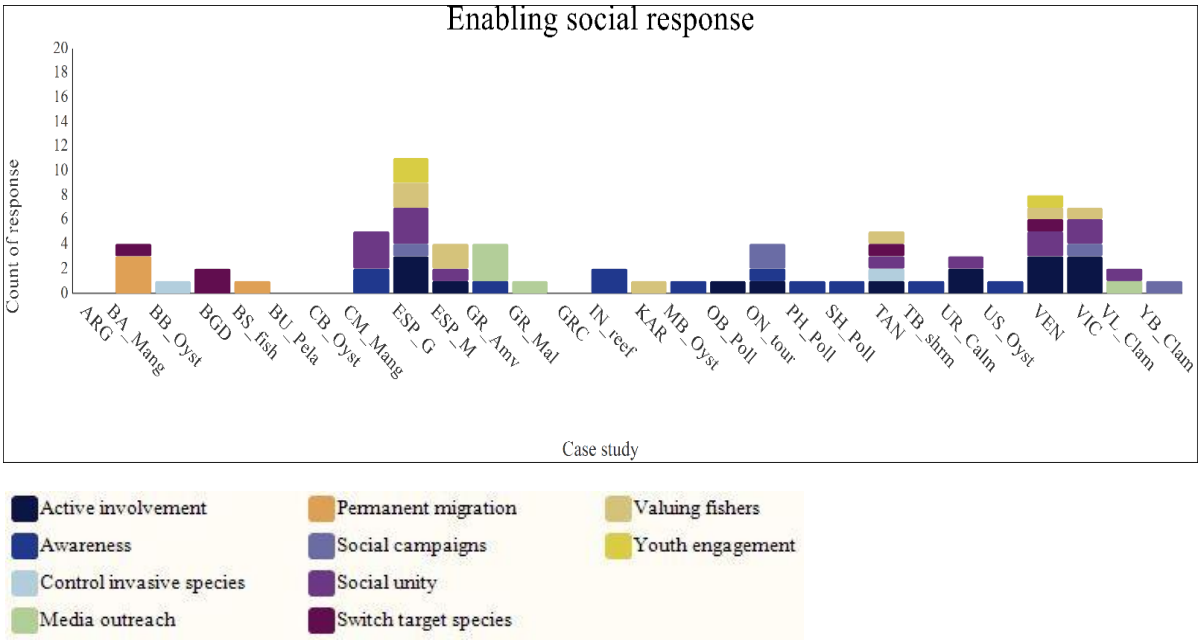

Figure 4. 16 Frequency of common factors enabling social responses considering all cases

The most common factors enabling governing response within the twenty-eight SSF case studies are shown in Fig 4.17 and Table 4.10. These factors were mostly targeted toward marine ecosystem management (Larkin, 1996), which incorporated long-term adaptation planning. This showed that the adaptation measures were not only limited to developing the strategies that provided immediate benefits, but the focus was also given to the development of sustainable strategies aiming specifically at biodiversity protection, and habitat conservation. The factors that enabled the governing response were most dominant in the case study ESP_G (Spain), BGD (Bangladesh), BA_mang (Bangladesh) and BU_pela (South Africa), KAR (Zambia and Zimbabwe) (Fig 4.18). Factors enabling governing responses were reported in 24 case studies and were referenced 72 times in total in the coding process.

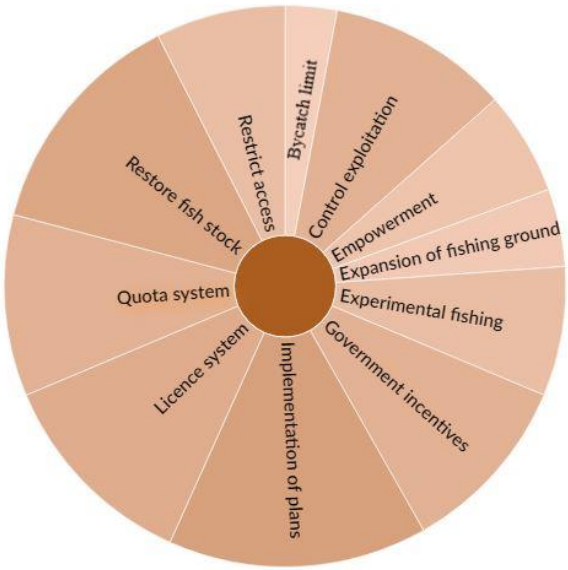

Figure 4. 17 Relative proportions of different types of factors enabling governing response across all case studies

Table 4. 10 Most common factors enabling governing responses

Rank ordet	Factors enabling governing response	Common examples in I-ADApT case-studies
1	Implementation of the plans	Implementation of developmental plans for the development of coastal areas Crisis management plans and fisheries management plans Special focus on the execution of the formulated plans
2	Restoration of fish stocks	Collaborative efforts to restore the fish stocks focusing on the sustainable practices
3	Exploitation control mechanisms	Seasonal bans on the exploitation of commercially important fish species Ban on the extraction of wood to protect the mangroves
4	Quota and license system	Limit the no. of the resource users, somewhere set by the regional government, and somewhere thorough local institutions
5	Government incentives	Tax rebates to the fishers Subsidies for survival following the occurrence of the disasters
6	Experimental fishing	Experimental fishing provision before implementing the new fishing systems to test and validate such techniques Establishment of labs/ factories for testing and assessment purposes
7	Access Restrictions	Administrative restrictions to access to the fishing grounds without the fishing permit and during no fishing period to allow stock rejuvenation
8	Empowerment	Empowerment of the social institutions (commons institutions) through a democratic system of election to elect the leaders Empowerment of the local communities at the local level through training and workshops to re-engage in fisheries Introduction and promotion of the commercially viable fisheries among the communities
9	Expansion of the fishing grounds	Expanding the harvesting grounds development of the fishing village

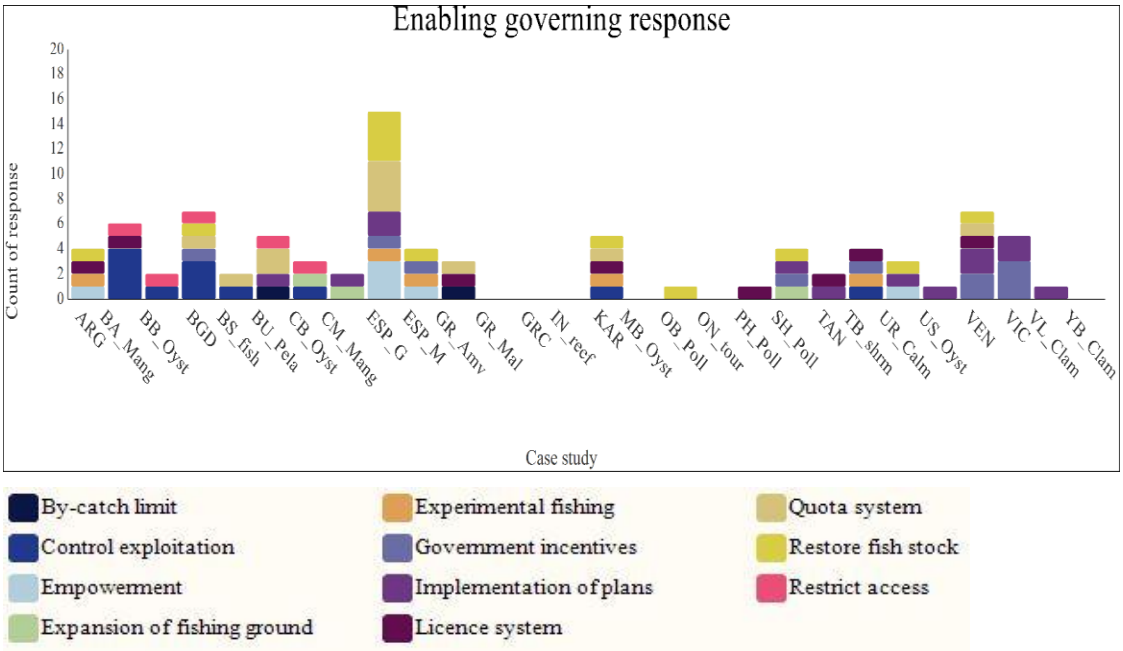

Figure 4. 18 Frequency of common factors enabling governing responses considering all cases

4.3.2.3 Factors Preventing the Social and Governing Responses

There were a large number of factors preventing the governing response relative to the factors preventing the social response. The most common factors preventing the social response within the twenty-eight SSF case studies are shown in Fig 4.19 and Table 4.11. Most of these factors were dominant in UR_clam (Uruguay), ESP_G, ESP_M (Spain), IN_reef (Indonesia), VL_clam (Italy), VIC (Uganda), and VEN (Venezuela) (Fig 4.20). Factors preventing the social responses were reported in 15 case studies and were referenced 63 times in total.

Figure 4. 19 Relative proportions of different types of factors preventing social response across all case studies

Table 4. 11 Most common factors preventing social responses

Rank order	Factors preventing social response	Common examples in I-ADApT case-studies
1	Opportunistic behavior of fishers	Individualism and opportunistic behavior of fishermen and stakeholders Fishers and the fisher leaders concentrated on personal benefits and wellbeing
2	Lack of social cohesion	Lack of organization of fishing communities Limited cooperation between government officials and between the small-scale fisheries communities Lack of trust Lack of willingness to work jointly and engage in collective action
3	Social unrest	Differences in political ideology, and culture, that affected the co-management initiative negatively Unfair social divisions Violence and threats among fisher
4	Excludability	Exclusion of marginalized fishers from the community from decision making Inequitable distribution of subsidies, reliefs, funds, and other incentives

5	Short term measures	Local community-based initiatives were conducted in the short-term due to a lack of adaptation planning
6	Lack of social institutions	Poor institutional arrangements Fragile social institutions which are functional only for a short time Lack of common property rights
7	High dependency on state	The high expectation on state agencies to fulfill all the needs
8	Lack of fishing knowledge	Newcomers in fisheries lacked fishing knowledge Newcomers did not harmonize with the customary/traditional fishing groups

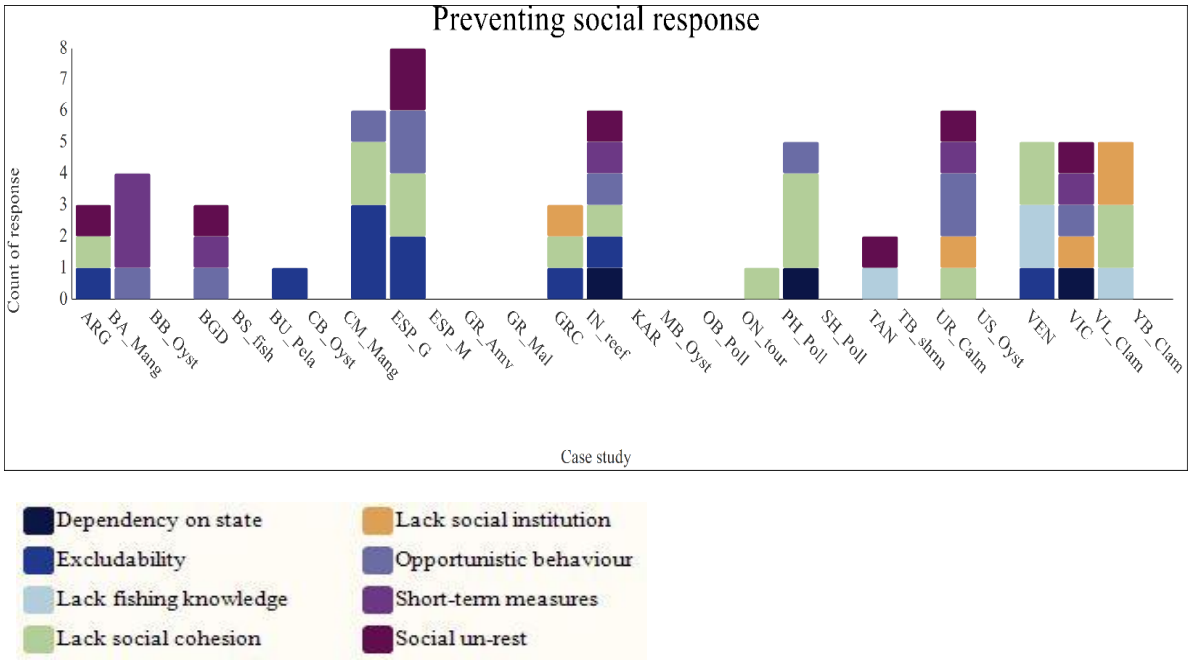

Figure 4. 20 Frequency of common factors preventing social response considering all cases

The most common factors preventing the governing response within the twenty-eight SSF case studies are shown in Fig 4.21 and Table 4.12. Most of these factors were dominant in GR_mal (Greece), IN_reef (Indonesia), MB_oyst (Japan), PH_poll (Philippines), TAN (Burundi, Congo, Tanzania, and Zambia), CM_mang (Cameroon), VIC (Uganda) and VEN (Venezuela) (Fig 4.22). Factors preventing the governing responses were reported in all 25 case studies and were referenced 147 times in total.

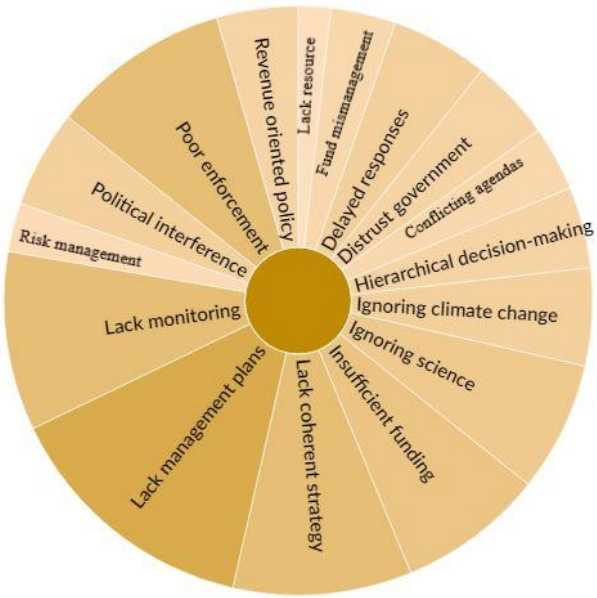

Figure 4. 21 Relative proportions of different types of factors preventing governing response across all case studies

Table 4. 12 Most common factors preventing governing responses

Rank order	Factors preventing governing response	Common examples in 28 I-ADApT case-studies
1	Lack of management plans	Lack of operational management plans with performance indicators to manage the fishing zones, fishing market, and risk management plans Lack of risk management plan
2	Lack of monitoring activities	Poor monitoring due to the lack of financial capital and human capital Lack of technical expertise to conduct effective monitoring activities
3	Lack of coherent strategies	Poor coordination between different government agencies while developing frameworks, policies, rules, and act balancing all needs of all the sectors (e.g., coastal area development and small-scale fisheries fishing ground expansion)
4	Poor enforcement	Negligence of government agencies to operationalize their management plans Lack of the community support Weak enforcement of regulatory measures

		Limited action from the central public administration
		Require a lot of approval process to implement rules and policies at the local level
5	Insufficient funding	Lack of funding to operationalize the monitoring, control, and surveillance activities
6	Political interference	Political biases in the allocation of the resources
		Co-management initiatives were interrupted due to varied political interests
7	Revenue-oriented policy	Government objectives strongly shifted towards operationalizing profit-generating strategies for local government
8	Hierarchical decision-making	Top-down governance where there was no involvement of fishers in decision making
		Centralized governance does not allow local action to foster
		Leadership became too dictatorial and hypocritical in the governance of the resources
9	Delayed response	Delayed response from the governmental agencies after the effect of the crisis has reduced significantly (e.g., delayed reconstruction of damaged embankments, parts of which were broken during the cyclone, delayed restoration of sewage treatment facility)
		The government agencies were not resilient to deal with surprises from extreme weather events and disasters
		The delayed response followed by the slow implementation of the response
10	Distrust towards government	Mistrust the political leaders and their agendas
		Mistrust towards the local, regional and national government
11	Ignoring climate change impacts	The response did not explicitly address the sustainability of fisheries resources in respect of climate change impacts
		Legislation and policies incorporate climate change to a much lesser extent because authorities assume climate change to be a global problem
		Government agencies were unable to find mitigation measures to cope with unusual changes in the fisheries due to climate change
		Government institutions did not consider any proactive and preventive plan against the climatic variability that impacted fishing communities

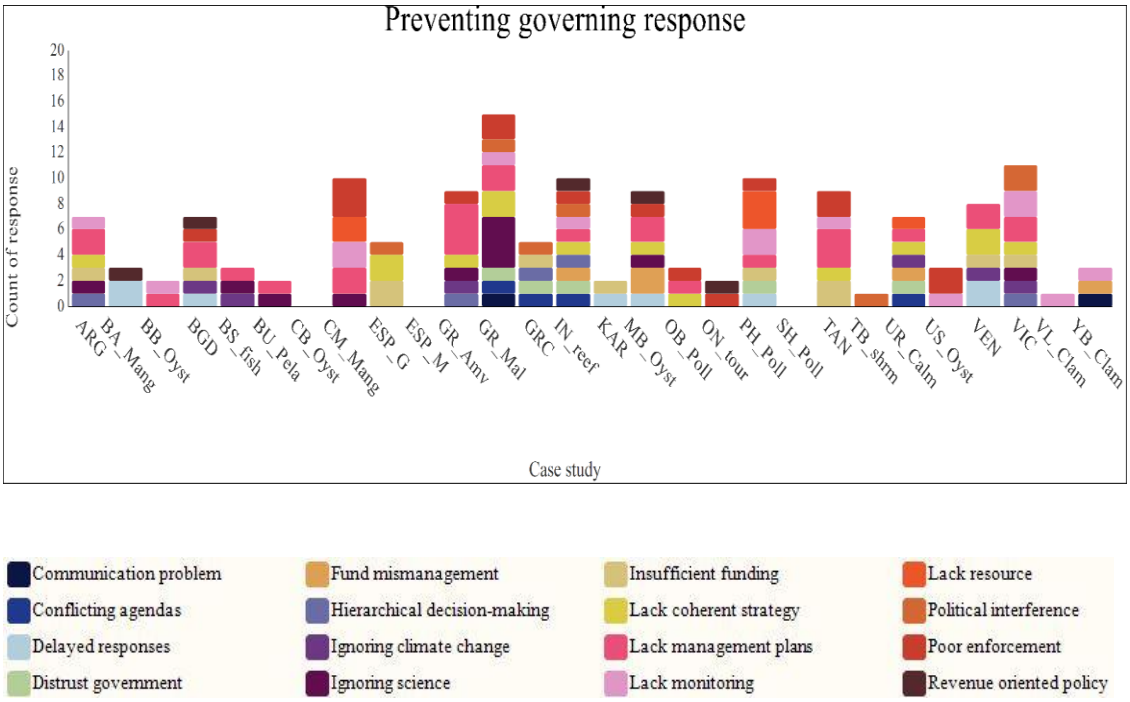

Figure 4. 22 Frequency of common factors preventing governing response considering all cases

4.3.3 Clustering Results

The 28 case studies were separated into 5 different clusters as depicted in the cluster dendrogram in Fig 4.23. Two case studies in cluster 1 (KAR from Zambia and Zimbabwe, TB_shrm from Japan). Seven case studies in cluster 2 (IN_reef from Indonesia, PH_poll from the Philippines, UR_clam from Uruguay, ARG from Argentina, GRC from Greece, CM_mang from Cameroon, and VL_clam from Italy). Six case studies in cluster 3 (CB_oyst from East Coast of the USA, BB_oyst from France, BS_fish from Baltic sea region, BU_Pela from South Africa and Namibia, BA_mang and BGD from Bangladesh). Nine case studies in cluster 4 (SH_poll from China, OB_poll from Japan, ON_tour from Japan, US_oyst from Northwest USA, TAN from Burundi, Congo, Tanzania, and Zambia, VIC from Uganda, VEN from Venezuela, ESP_G and ESP_M from Spain. Four case studies in cluster 5 (YB_clam from Japan, GR_mal and GR_Amv from Greece, and MB_oyst from Japan. Each cluster is interpreted based on the major vulnerabilities

encountered by the SSF SES and responses that helped them to develop resilience against the global changes.

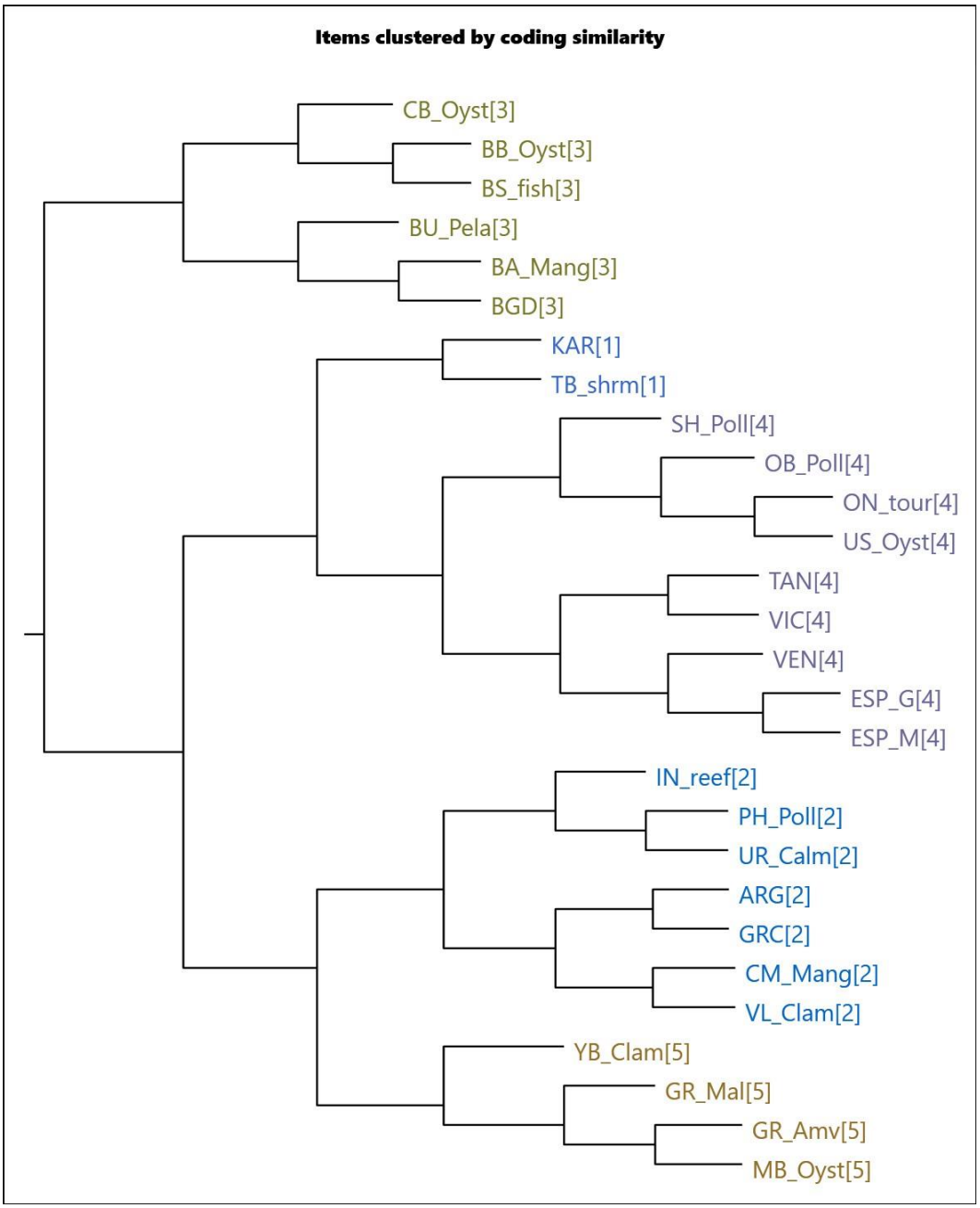

Figure 4. 23 Cluster dendrogram

4.3.3.1 Cluster 1

The major types of ecological vulnerabilities faced by the 2 SSF communities that belonged to this cluster (Fig 4.24) were resource depletion, pollution, overfishing, climate change impacts, biodiversity loss, and anthropogenic activities. The institutional vulnerabilities were a mix of unsuitable governance, centralized top-down management, and poor legislation of the rules and regulations. Economic vulnerability included productivity decrease due to low catch of the fish and the social vulnerability constituted by intersectoral and intra-sectoral conflicts. None of the technological vulnerabilities were found in the case studies of this cluster.

Governing responses were a shift to a co-management form of governance, increased collaboration, good governance, and decentralization of the power and authority from the national to the local level. Social responses were temporary migration to find alternative employment opportunities during the off-seasons, livelihood diversification, informal local practices, and community-based adaptation measures. Factors enabling the governing response were the provision of licenses and the quota system, experimental fishing practices, government incentives, and a ban on overexploitation of the resources. Factors enabling the social response included awareness programs.

Factors preventing the governing responses were political interference, insufficient findings to achieve the management objectives, and delayed response from the government. For the case studies in cluster 1, vulnerabilities were mostly of the ecological type with other issues of governance, lack of social and outdated regulations. The social and governing responses were targeted to foster the governance systems. Most of the responses were governing responses while the social responses were limited and applied less rarely.

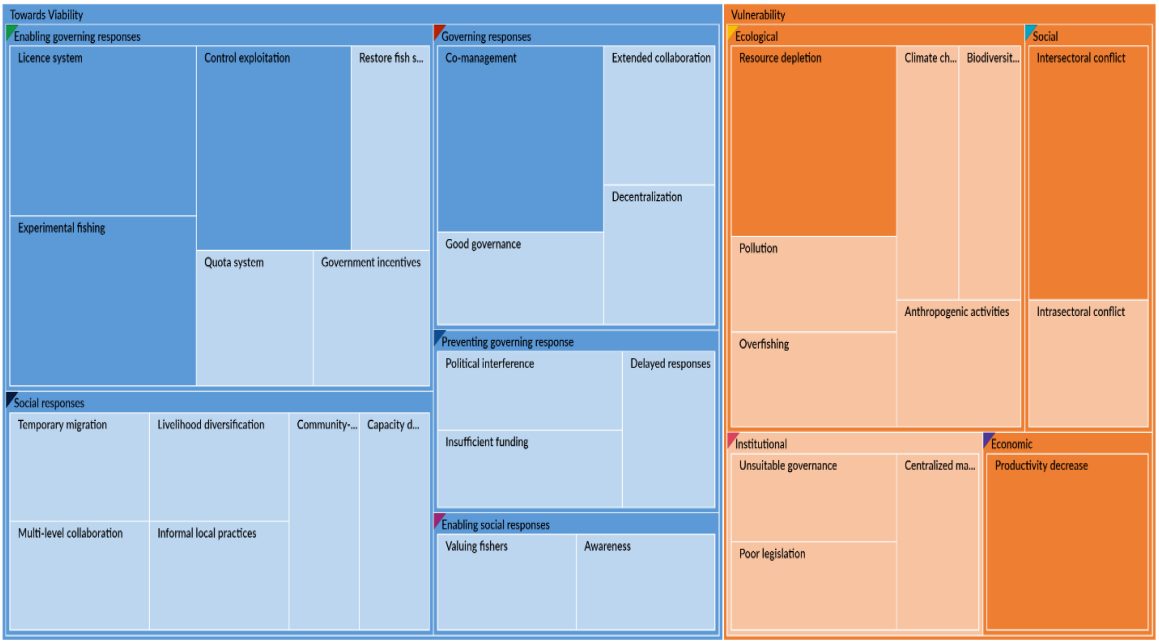

Figure 4. 24 Cluster 1

4.3.3.2 Cluster 2

The most frequently observed ecological vulnerabilities for the 7 case studies that belonged to cluster 2 (Fig 4.25) were environmental degradation, resource depletion, biodiversity loss, pollution, climate change impacts, and overfishing. Institutional vulnerabilities included centralized management systems, poor legislation of the rules and policies, and the lack of accountability among the stakeholders. Intra-sectoral and intersectoral conflicts, unemployment, and behavioral issues among the fishers were seen as the major social vulnerabilities. Economic vulnerabilities were productivity decrease and lack of income to sustain a living. None of the technological vulnerabilities were found in the case studies of this cluster.

Governing responses were the formulation of the policies and regulations, participatory management, effective monitoring activities such as frequent revisions of the management objectives & inspections, co-management form of governance, and proper funding. Social responses were capacity development of the SSF communities, community-based management, multi-level collaboration, and livelihood diversification. Factors enabling the governing response

were restoring the fish stock by restricting access for a certain time and implementing the management plan. Factors enabling the social responses included awareness among the fishers and social unity among the fishers in joint management of the marine resource. Lack of operational management plans, a distrust of the government, lack of monitoring activities, conflicting agendas due to different management objectives, and hierarchical decision-making were the reasons that prevented the successful application of the governing response. Factors preventing the social response contained lack of social cohesion and exclusion of some members of the community from decision-making.

The most frequent type of vulnerability seen in the case studies of this cluster were ecological and social vulnerabilities. This cluster had plenty of factors preventing the governing responses while there were few factors enabling the social and the governing response. Governing responses were more common than the social response, nevertheless, some factors were preventing the social response.

The governance responses in the case studies in cluster 2 were as follows:

- Formation of local regulations for the access and use of marine resources (IN_reef).
- Ban on using marine resources after the occurrence of major hazards (UR_clam).
- Development of co-management institutions by creating new governance bodies and implementation of the site-specific plan by local stakeholders (UR_clam).
- Practicing ecosystem-based management approach to fisheries management to stop overexploitation of the resources (UR_clam).
- Continuous monitoring of the resource extraction, performance of the governance model, and effectiveness of the ecosystem-based approach through periodic meetings between scientists, fishers, and governmental authorities (UR_clam).
- Implementation of short-term responses such as distribution of relief assistance including food, cash, drinking water, emergency medicine, and other non-food materials to the affected communities by the government agencies. Introduction of effective training and awareness to upgrade the fishing practices instructing fishers about the ways to be more productive and economical (CM_mang).
- Joint experimentations involving government officials and local fisheries management committees to test various approaches for restoring the natural habitat (CM_mang).

- Provisioning of concessions for aquaculture (VL_clam). Development of scientific studies to evaluate issues such as impacts of fish farming, fishing market, and biological assessments (VL_clam). Development of management model which includes diversified roles of government agencies in governance including local stakeholders, fisheries communities (co-management), and adoption of an ecosystem-based approach (VL_clam). Proper government funding to implement the monitoring activities (VL_clam).

The social responses in the case studies in cluster 2 were as follows:

- Development of community-based resource conservation measures (CM_mang).
- Community empowerment to educate sustainable fisheries practices to increase income (UR_clam).

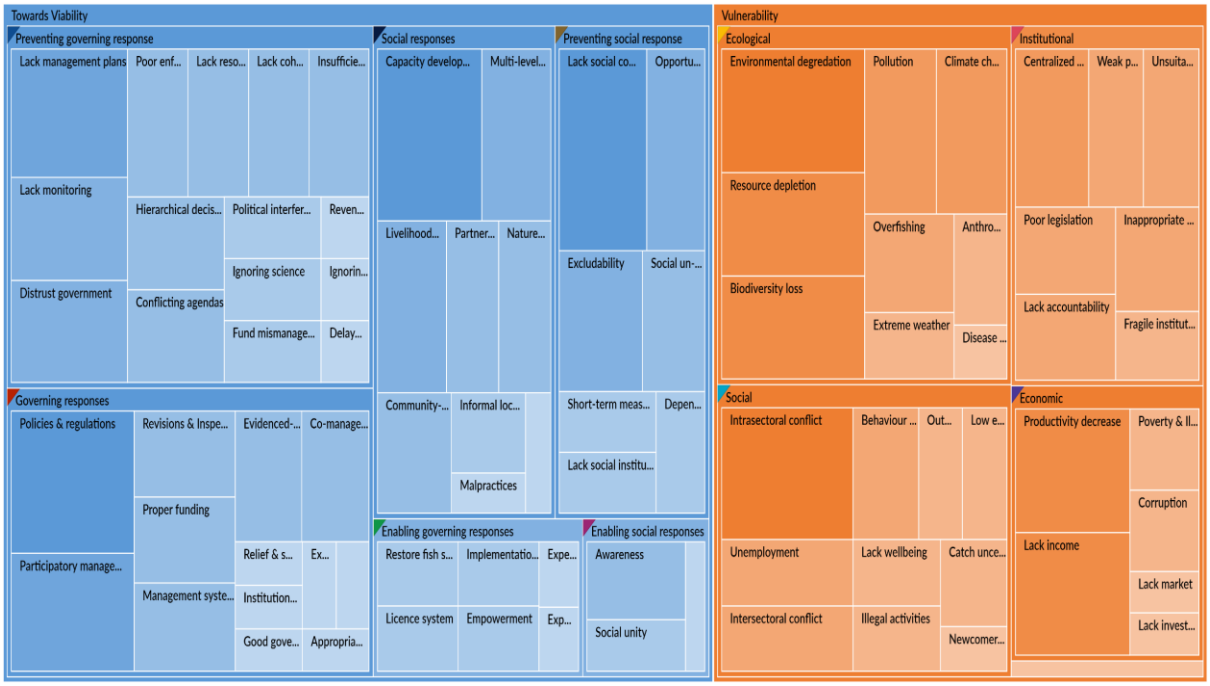

Figure 4. 25 Cluster 2

4.3.3.3 Cluster 3

The ecological and economic vulnerabilities for the 6 case studies that belonged to cluster 3 (Fig 4.26) were the same as those for cluster 2. The most frequently occurring social vulnerabilities

included unemployment, newcomers in fisheries, intra-sectoral conflicts, and lack of well-being. Institutional vulnerabilities were comprised of centralized management systems and unsuitable governance. Technological vulnerabilities included destructive technology and poor connectivity issues.

The governing responses were the development of the policies and regulations, the establishment of the management systems, evidence-based management, relief & subsidies, and proper funding. Factors enabling this governing response included measures such as a quota system and a ban on the exploitation of the resources by restricting access. Factors that prevented the governing responses were lack of management plans, delayed responses to deal with social-ecological issues, and ignoring the climate change effects on management plans.

The social response included malpractices from the fishers, capacity development of the fishers, and habitat conservation efforts. Factors enabling the social responses were switching the target species and permanent migration of the fishers leaving the SSF profession. The themes that prevented the successful application of the social responses were short-term measures and opportunistic behavior from the SSF communities. This cluster was mainly impacted by ecological and economic vulnerabilities.

Responses were mostly related to strengthening the governance systems of the SSF SES. Most of the social responses were coping responses that included unsustainable and illegal activities such as using the family member and children as labor to increase the family income. Factors enabling these social responses were also unsustainable factors where the fishers were permanently leaving the SSF and were migrating to find an alternative form of livelihood opportunity.

The governance responses in the case studies in cluster 3 were as follows:

- Establishment of land use regulations and agricultural policies (CB_oyst).
- Execution of administrative restrictions on the transfer of fisheries species between basins to improve the market in short term (BB_oyst).
- Opening of breeding and research centers to test disease-resistant fisheries species and develop hybrid breeds which are commercially viable (BB_oyst).
- Revisions of rules acts, and development of frameworks for enhancing participatory resource management involving all the stakeholders (BB_oyst).

- Implementation of the open-access to use the marine resources for the short term to reduce the impact of acute stressors (BA_mang).
- Implementation of prohibitions, restrictions, and quota system for sustainable fisheries development (BS_fish).
-

The social responses in the case studies in cluster 3 were as follows:

- Local fisher communities implemented joint control mechanisms such as increasing the vessel size, no. of boats, and autonomous ban of operation for a certain time (BA_mang).
- Allocation of different harvesting zones and rotation plans by the agreement among the fisherman to reduce pressure on the fishing ground (CB_oyst).
- Higher exploitation of the marine resources due to a lack of alternative income generation methods (BA_mang).
- Switch target species to catch commercially viable fish species (BGD). Increase in the number of families taking loans from cooperatives and NGOs to meet their basic needs (BGD).

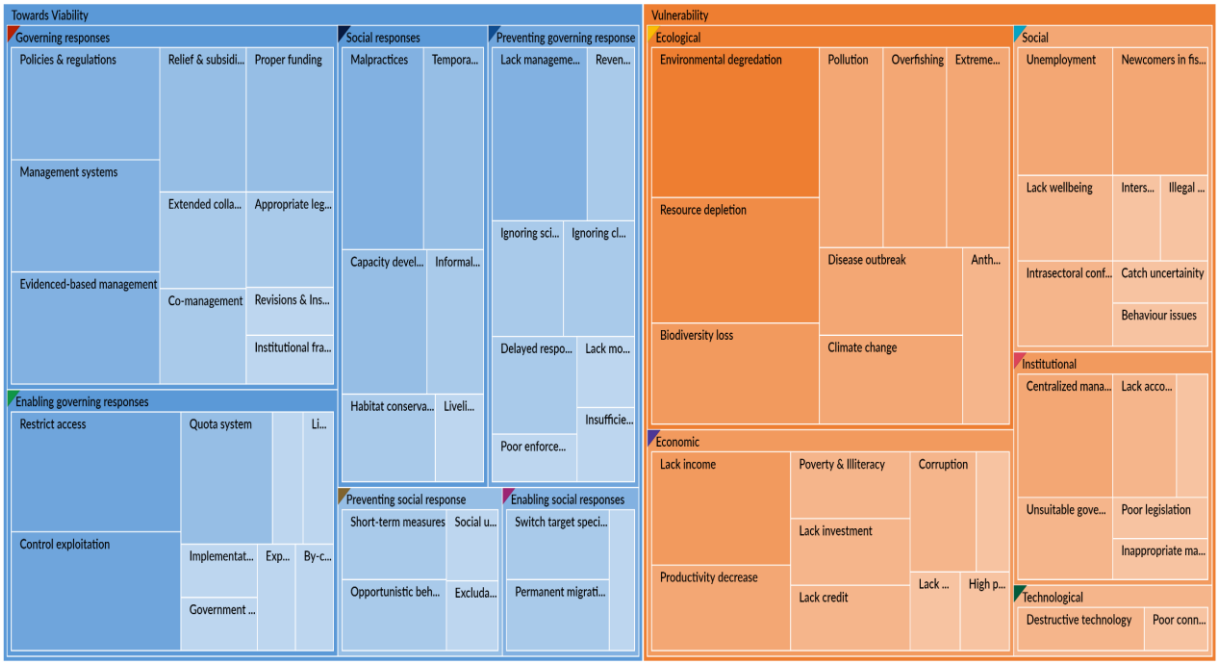

Figure 4. 26 Cluster 3

4.3.3.4 Cluster 4

Cluster 4 (Fig 4.27) which consisted of 9 case studies had environmental degradation, anthropogenic activities, and pollution as the most common drivers of ecological vulnerability. Intra-sectoral conflicts, unemployment, and outward migration were the major drivers causing the social vulnerabilities. The economic vulnerability was mainly due to the decrease in productivity, lack of market, and lack of income. Poor legislation and weak property rights were considered the major source of institutional vulnerability.

The governing responses were the formation of the policies and regulations, extended collaboration, appropriate legislation of the local rules & plans, and establishment of the institutional frameworks. Factors enabling the governing response were the implementation of the plans, efforts to restore the fish stocks, and the government incentives to the fishers. Factors preventing the governing response were lack of coherent strategies, insufficient funding to execute the management plans, and lack of monitoring to assess the effectiveness of the plans implemented.

Social responses were livelihood diversification, multi-level collaboration, informal local actions, and capacity development of the fishers. Factors enabling the social responses were the active involvement of the fishers in community-based management initiatives, social campaigns, and social unity. Factors preventing the social responses were social unrest, opportunistic behavior of the fishers, lack of social cohesion, and excludability. Social unity was the enabling factor, simultaneously, lack of social cohesion was the factor preventing the social response. This is a matter of concern. This may be due to the difference in fishers' behavior which directly affects the policy outcomes. The psychological behavioral differences and the adaptation behavior of the fishers (Andrews et al., 2021) can be considered as one of the drivers affecting the outcomes of the adaptation and strategic planning to SSF viability.

Few vulnerabilities were reported in the case studies of this cluster, while there were numerous governing and social responses reported in the I-ADApT templates. The most common type of vulnerabilities were ecological and economic vulnerabilities. Responses were mostly governing responses which were limited to the policy development and legislation of the rules and regulations. However, implementation of plans and enforcement of the laws were particularly

poor. Responses and the factors enabling those responses were most common and were repeatedly mentioned than the factors preventing those responses.

The governance responses in the case studies in cluster 4 were as follows:

- Government policy to motivate the fishing communities to shift to alternative employment options and strengthen the infrastructure to foster other sectors (SH_poll).
- Formation of autonomous management units to fulfill specific objectives such as the creation of the institutional framework, promoting co-management (good governance), sustainable resource management, and ensuring democratic participation for small-scale fisheries viability (VIC).
- Formation of councils involving fisheries leaders, researchers, and technical experts from government authorities to innovate new management measures (VEN).
- Joint training courses for newcomers in the fisheries profession by the active involvement of the government authorities and fishers' organization (ESP_G).
- Implementation of decentralization concept granting administrative and economic autonomy to the SSF regions called "autonomous communities" (ESP_G).
- Provisioning of tax reductions to the businesses opened by the small-scale fisheries communities (ESP_G).
- Development of management plans consisting of operational management measures and monitoring plans (ESP_M).

The social responses in the case studies in cluster 4 were as follows:

- Providing better multifunctional roles to all the actors involved in sustainable management of fisheries to execute the management plan to revitalize fishing activities and overall small-scale fishing industries (OB_poll).
- Introduction of the series of new local rules concerning fisheries development, and regional collaboration (ON_tour).
- Formation of the prior consultation system, co-existence, co-prosperity relationship among the stakeholders (tourism operators, fisheries communities, and village officials, etc.) (ON_tour).
- Proper property rights systems, autonomous management practice, bold leadership, and willingness to jointly enhance the fishery practice and the economic situation (ON_tour).

- Development of protective policies, informal rules, and creating public awareness (US_oyst). Development of innovative solutions to reduce loss during catch and post-harvesting period (TAN).
- Revision of management plans including most recent social-ecological changes (TAN). Realization by fishers to shift to a co-management form of governance to be the part of the leadership committee and form better collaboration to respond to regulations from national and regional levels (ESP_M).
- Promotion of activities like conservation of marine resources to restore fishing grounds. Overexploitation of the resources to sustain the livelihood of the fishing communities (ON_tour, OB_poll, SH_poll).

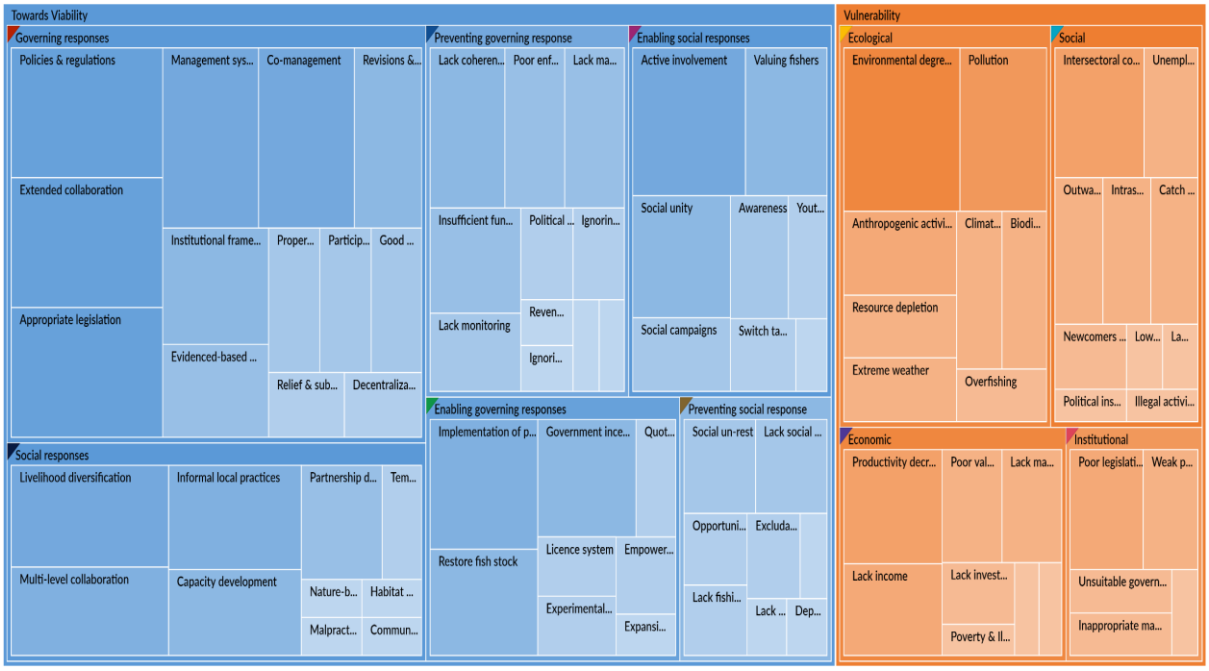

Figure 4. 27 Cluster 4

4.3.3.5 Cluster 5

The most recuring ecological vulnerabilities for the 4 case studies that belonged to cluster 5 (Fig 4.28) included pollution, mass mortalities due to disease outbreaks, and resource depletion. Economic vulnerabilities were a decrease in productivity, and lack of income. Institutional

vulnerabilities were weak property rights and poor legislation. Social vulnerabilities were represented by political instability and outward migration.

The governing responses were timely revisions & inspections, formation of the management systems, appropriate legislation, relief & subsidies, and participatory management. The factors enabling the governing responses were setting up the by-catch limit, along with the establishment of the quota & license system. This cluster had the largest number of factors preventing the governing responses which were poor enforcement of the policies & regulations, lack of coherent strategy, lack of feasible management plans, ignoring the scientific evidence while formulating the management objectives, lack of proper monitoring activities, fund mismanagement and communication problems between the stakeholders. There were few social responses such as community-based management and habitat conservation. Factors enabling the social responses were proper media outreach where the issues of mass mortalities and environmental degradation were frequently reported in the local and national media. No factors were preventing the successful application of the social responses.

The governance responses in the case studies in cluster 5 were as follows:

- Field management of the social-ecological crisis through direct interaction between different authorities (local, public, and private) and decision-making at multiple levels for successful action on the field (GR_amv).
- Public acceptance of government policies acts, and regulations (GR_amv).
- Inspection of land-based facilities (e.g., processing units) that do not meet the environmental standards as per the rules (GR_mal).
- Collaboration between various stakeholders such as research institutes and academic institutions (GR_amv, GR_mal).

The social responses in the case studies in cluster 5 were as follows:

- Promotion of monitoring activities to prevent environmental degradation (GR_mal).
- Development of negative behavioral attitude among fisheries communities discarding locally caught fish referring they were caught from polluted water ecosystem (GR_mal).
- Formation of cooperatives and coordination committee to revitalize the fisheries market (MB_oyst).

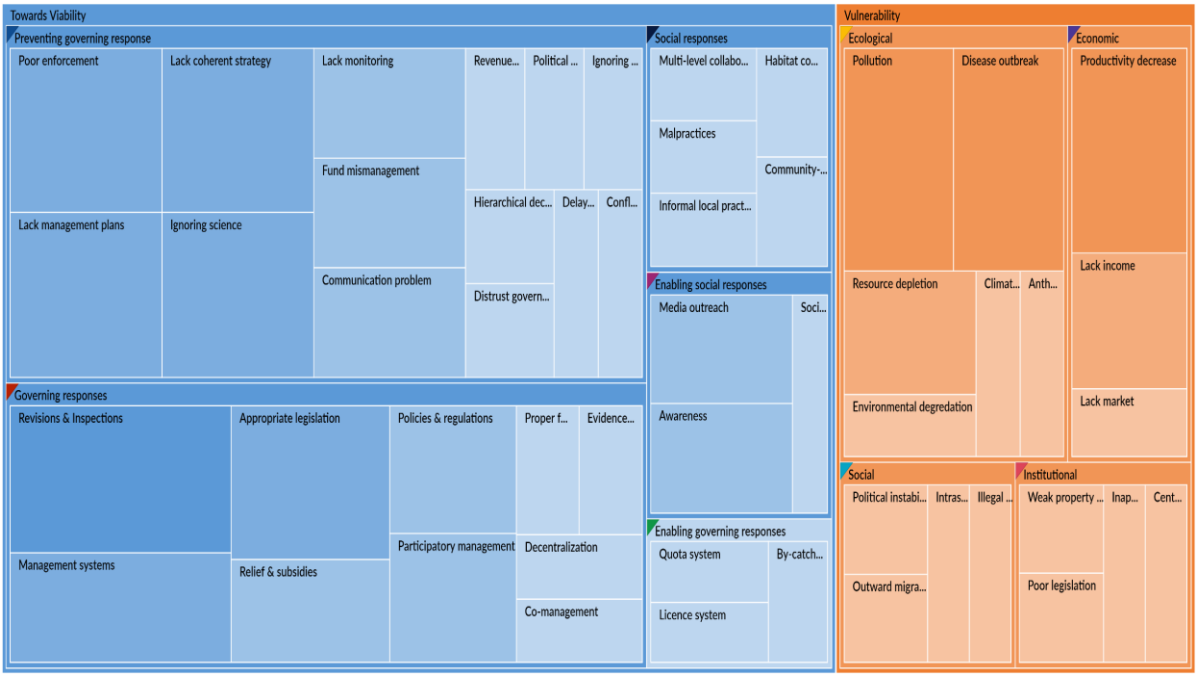

Figure 4. 28 Cluster 5

4.4 Discussion

4.4.1 Vulnerability in Small-Scale Fisheries

Vulnerabilities in the context of SSF were seen as multidimensional and multilayered (Islam & Chuenpagdee, 2022) arising from the perturbations in economic, environmental, ecological, political, and social systems. As witnessed, vulnerabilities were of different types intertwined with each other and it was challenging to differentiate between the stressors, exposures, sensitivities, and consequences due to multiple feedback effects happening within the SSF SESs. For example, in the case of GR_mal and GR_amv (refer to Table 1 for details of the case studies), "*Pollution to the water bodies had negative impacts on tourism as well as the fish caught from those water bodies did not get any market directly affecting the supply chain"*. This requires a transdisciplinary perspective to study the vulnerabilities in SSF to understand the complex vulnerability dynamics. The vulnerability discourse should go beyond the concept of

just managing the usual problems in the short term. Vulnerabilities in the context of global changes should be viewed as inherent to the SSF systems where they are part of SSF systems. Therefore, should be given priority and incorporated into management plans, policies, and regulations (Chuenpagdee, 2011).

Three classes of vulnerability were observed. First-class represented the vulnerabilities that were the direct consequences of the outcomes from the global changes, second, was the indirect vulnerabilities due to feedback effects because of reactive response from SSF communities, state agencies, and non-state agencies (outcome of the social and governing response); and third was the new sources of vulnerabilities due to interaction among emerging vulnerabilities, feedback outcomes, and dormant responses. This explains that there are different determinants of vulnerabilities that vary by type, are dynamic, and vary from stimulus to stimulus (Smit & Wandel, 2006). The first class of vulnerabilities linked directly to local and global drivers of change, the interplay between these drivers (Nayak & Berkes, 2019) giving rise to various stressors, and the lack of adaptive capacity to absorb theshocks and pressures. The most important examination is the second and third class of vulnerability, which was caused due to the social and governing interventions and their interactions - despite those interventions being designed with good intentions, were reinforcing new sources of vulnerabilities. Eriksen et al., (2021) specified three different reasons behind this phenomenon occurring in the social-ecological realm. First, is the lack of ability of decision-makers and policymakers to understand the contextual basis of sources of vulnerabilities before implementing the responses. Understanding the current problems and pattern of change is important for adaptive planning of strategies to reduce the vulnerabilities. The second is the inequitable participation of the vulnerable groups in planning the responses and the final reason is the poor approach to retrofitting the adaptation plans in line with other developmental goals and previously designed interventions.

The results of this study about the global context of vulnerabilities are largely coherent with other studies such as Ruiz-Díaz et al., (2020); Sowman, (2020); Cánovas-Molina & García-Frapolli, (2022), and Islam & Chuenpagdee, (2022) where the ecological vulnerability was the most reported type of vulnerability followed by the social vulnerability. These vulnerabilities include overfishing, poor stakeholder participation, overcapacity of fishing fleets, conflicting

agendas where there were overlaps in the management objectives, unsustainable fishing practices, unrestricted access, and unnecessary and untimely relief and subsidies Islam & Chuenpagdee, (2022) reported institutional and technological as the least reported vulnerabilities, however, the results in this study showed that economic and technological vulnerability were the least reported types of vulnerability. Most of the minor theme's considered in the 5 domains of vulnerability were the same, nevertheless, Islam & Chuenpagdee, (2022) found more drivers of technological vulnerabilities such as gear side effects, catching power of the boats, safety condition of the devices, and vessel capacity. Along with this, the authors reported gender issues and biases as one of the major social vulnerabilities. However, gender issues, religious issues, economic valuation, and psychological behavior issues were not reported in this study as those themes are not included in the I-ADApT template. This points to a potential gap in the I-ADApT template. However, the template is being actively revised based on experts' opinions.

4.4.2 Towards Viability

Important steps to viability included the development of reacting capacity (to react to vulnerabilities and be able to live with change) (Green et al., 2021) and adaptive capacity (to proactively plan responses to respond to vulnerabilities), i.e., building resilience to reduce vulnerabilities (Reyers et al., 2022). Factors that helped to make that leap included effective leadership, balanced authority and power relationships, social cohesion, and a shift to a co-management form of governance from the hierarchical type of governance. The most influential reacting strategies were livelihood diversification, collective actions, malpractices in fisheries, migration, and opportunistic behavior of fishers. Long-term adaptive strategies included formal and informal management systems, multi-level collaboration, capacity development, and participatory management. In most situations, the government agencies played a dynamic role in creating a favorable environment for community-based management through extended collaboration & multi-level governance and incorporating fishers' values in the process of policy formulation forms of multi-level governance. However, the government agencies in developing countries lacked accountability and were corrupted and the SSF communities had a high distrust of their government. Most of the adaptive and coping response strategies found in this study are

compatible with the previously documented adaptation measures by past researchers such as Deb & Haque, (2017); Limuwa et al., (2018); Galappaththi et al., (2021); Galappaththi et al., (2022).

Moving forward, the problem doesn't seem to be a lack of rules and policies but it's the enforcement of those rules which requires robust management measures and a diverse and flexible governance system that suits the local, regional, and national context. Enforcement of rules to control overfishing is rather challenging given that SSF communities want proper rights to access the resources to make up a standard living in the fisheries profession. The deep-rooted problem is depleting fish stock in the oceans due to overfishing. Weak governance and fragile institutions were found to be one of the major underlying causes of overfishing. With the increase in the population of the fishermen and relative increase in the capacity of fishers with the mechanization of the fishing equipment (Jadhav, 2018), overfishing has increased which has created other vulnerabilities. If the current trend continues for some more years the SSF might be difficult to manage as it may lose its capacity to self-organize and protect their resource. There are already clear signs that fishers are not able to make their living through SSF. With this, the decision-makers and managers should have a clear vision, mostly to balance the social and economic sectors within SSF. The strategies should be clear where the goal should be the restoration of fish stocks and optimization of benefits from SSF. Lacking plans and the ability to restore fish stocks yet aiming to generate more livelihood opportunities from SSF will result in a situation where the poor will be invited to join the poor.

4.4.2.1 Inviting Poor to Join Poor

Growing studies are demanding that currently employed SSF communities and youths should stay in SSF and continue fishing as major employment (Blythe, 2015; Tzanatos et al., 2020). But it's time to think if there are enough opportunities for fishers to get hold of fishing. With current SSF communities already vulnerable, are we inviting poor people to join other poor people? The absolute focus should be on the SDG target 14.4 which motivates to eliminate unregulated and illegal fishing and implement science-based management practices to restore the fish stocks in the shortest time feasible.

4.4.3 Transition of Small-Scale Fisheries from Vulnerability to Viability

The transition of SSF SESs from V2V (Nayak et al., 2020) is a discontinuous, iterative, disruptive, and turbulent process. The components of SSF SESs i.e., the natural, social, and governing systems do not remain constantly static at any point of time when various multidimensional drivers are acting adversely and delimiting the self-organizing capabilities of those linked systems across spatial and temporal scales. Nayak et al., (2020) while studying the traditional fishing communities postulated that the transition of SSF from V2V is multidimensional, dynamic, complex, and relative. Nayak & Berkes, (2019) referring to vulnerable fishing communities presented three approaches to pave the way towards viability. First, by building resilience, secondly by aggregating the capital and the resources, and thirdly by promoting the well-being of the SSF communities. These three approaches should be given high consideration while devising the responses to enhance the viability.

The transition of the whole of SES is rather challenging due to the non-linear nature of feedback dynamics between the social, ecological, and governing systems. Transitioning is much more like trial and error or a back-and-forth process of fitting the right objects to fill the voids in the sub-systems when a social-ecological crisis looms. The concept of trial and error in managing the SSF was initially suggested by McClanahan et al., (2009) to test various alternatives and the progress of those alternatives. This may be understood as an adaptive learning process involving several cycles of learning-by-doing (Berkes et al., 2000). Transition requires the system to have flexibility and should undergo continuous improvisation which are the key derivatives of adaptive management (Armitage et al., 2015). It may involve several cycles of commonisation and decommonisation of the fisheries' pool of resources which comes along with the notions of resource sustainability, questions about access and property rights along with formation and destruction of the social and political institutions (Nayak & Berkes, 2011). For example, in the case of UR_clam case, it was reported that *"after several years in which successful co-management was in place, the fishery collapsed because of the occurrence of mass mortalities and the fishery was closed again until the resource was recovered in 2008/2009. Then the fishery was reopened with a co-managed system following the previous successful experience during the early 90s".* This indicates several cycles of commonisation and decommonisation of the resources in the process of transition from V2V. A shift in the perceptions and actions such as

"shift from capital to capacity, from object to relation, from generic interventions to context-specific interventions, from linear understanding to social-ecological understanding, from closed to open SSF system and shift from outcomes to processes" (Reyers et al., 2022) is necessary for the transition of SSF from V2V. Much of the answers to current management problems can be better addressed if we can understand how SSF communities have adapted to change and by understanding the patterns of social-ecological change with time (following the vulnerability to viability approach). It was found that household and community-based actions such as social unity, social campaigns, awareness activities, media outreach activities, or informal activities helped the SSF communities build resilience that helped them to build the adaptive capacity. Two pathways are suggested that might help the SSF transition from Vulnerability to Viability.

- Adaptive co-management as a transition pathway (Galappaththi et al., 2021)

Transition in the context of global change requires balanced environmental, social, economic, and governance objectives (Kotzé, 2019). What constitutes a balanced objective is a shared vision of SSF stewardship, valuing varied knowledge inputs and supported by strong social institutions at all scales as shown in the description of the cluster of the case studies (typologies). There is not a single ideal pathway that can be followed to progress the way towards viability. What responses did produce successful results for one SSF SES may not be entirely suitable for others and even within a single SES, all responses might not yield useful benefits, helping fisheries communities to transform from V2V. For example, in the case of Uruguay clam management (UR_clam), authorities forcefully closed the access to fishing grounds immediately after the mass mortalities began where no alternatives were provided to the fishers to sustain their livelihoods which caused financial problems for the fishers. The understanding after analyzing 28 SSF SES is that the natural, social, and governing systems need to be resilient to deal with changes. What defines the resiliency of these systems, again, may have different constituent aspects based on the specific context of how the SES has been managed. Generally, the review of 28 SES showed system resiliency is achieved when these systems develop adaptive capacity through management partnerships at multiple levels (adaptive co-management) (Armitage et al., 2008) and community-based management (Berkes, 2021). However, they seem to have worked only when there is willingness shown from the local communities and there is a periodic investigation of the governance outcomes to ascertain if they are working accurately and

have fulfilled the required objectives for which they were formulated. Community surveillance and monitoring are important factors to improve adaptive co-management by constantly communicating and negotiating the needs and demands of fisheries communities as they continue to deal with various challenges. The dynamic nature of vulnerabilities and viabilities requires flexibility and adaptability from all the stakeholders. This establishes a learning opportunity for all actors involved in governance to reflect on ongoing practices and discover future strategies.

- Effective communication as a transition pathway

The key to developing the adaptive capacity to deal with global change is deciding on the appropriate choice of responses in time (Putten et al., 2018). Choosing the appropriate mitigation response entails clear communication that can be challenging due to differences in power, social values, priorities, and social structure. Risk assessment and communication involve quantifying and communicating the shared goals, knowledge, and risks to prevent the SSF SES to shift towards an unfavorable state, which can be referred to as the black hole state of the SSF SESs. The term black hole state of the SSF SESs is conceptualized to describe a state of SSF SES after undergoing a rough transition where natural, social, and governing systems are all vulnerable due to a lack of adaptive capacity, capital, and well-being. To prevent SSF SES to enter such a state, there should be clear communication about the vulnerabilities, and ways to build adaptive capacity, and resilience of the natural, governing, and social systems. Communication might be challenging when stakeholders are managing a larger ecosystem as changes occur disproportionately faster in the larger ecosystem (Cooper et al., 2020) and it may take time to frame strategies to communicate. E.g., risk communication was one of the major barriers in the case of Amvrakikos fish kills in Greece (GR_amv) where the governing system was unprepared to handle multi-tiered outcomes of responses, and this prevented the successful application of the short-term objectives. Ineffective risk communication among the stakeholders creates distrust about the management measures and eventually leads to the failure of the operational management plan. The conflicting interest of multiple actors involved in the management of SSF commons requires certain flexibility from each of the stakeholders to agree to a common goal.

4.4.4 Summary of the Research Approach

The approach of employing qualitative methodology to understand the vulnerabilities and the progress towards the viability of SSF SES was found to be useful. Results can be biased due to the way data has been coded, analyzed, and reported which included the personal reflection of the researcher about the field of study, personal lived experiences, and perception of the problem context itself (Galdas, 2017). However, the methodological approach used in this study holds importance in the context of further understanding SSF from a V2V perspective. This concept can be further expanded by incorporating the appraisal component of the I-ADApT framework which has not been incorporated in this study. Incorporating the appraisal component in this analysis would enable the assessment of the effectiveness of the social and governing responses. Moreover, it is suggested to consolidate the minor themes to reduce the number of the minor themes which makes the analysis simpler. Re-coding should be conducted to make sure there are no faulty codes and there is not any inappropriate information coded to the minor themes which don't relate to it. The link between the frequently observed vulnerabilities and responses can be further studied by conducting a query search in NVIVO. Separate analysis can be conducted only considering higher order themes to understand the links between vulnerabilities, responses, adaptive capacity, and resilience.

Thematic-content analysis was employed in this study assuming that these approaches would help to identify the vulnerabilities faced by fishers because of global change and discover responses that helped fisher communities adapt and respond to those vulnerabilities. It was assumed that both approaches would help to analyze the data qualitatively. However, content analysis was not purely qualitative. Though it involved some form of descriptive analysis of the qualitative data, the interpretation was based on the quantitative count of the codes and minor themes. Antagonistically thematic analysis was purely qualitative. Thematic analysis was chosen assuming that the qualitative information in the twenty-eight case studies had common terms and patterns that were similar to each other. Content analysis was chosen assuming that the I-ADApT case studies had rich information about the impacts of global changes on SSF SES and this information could be used to reveal the experience of fishers. NVIVO software was handy to use, and it was user-friendly to conduct both analyses even dealing with multiple case studies.

However, the formatting options to edit charts and figures weren't built nicely and it was difficult to format the charts and figures using the software.

4.5 Conclusions

The typology of the SSF SES developed in this research clarified the vulnerabilities and current efforts towards viability in a simple way that is easy for stakeholders to understand the ongoing processes in SSF SES. Most importantly, the factors preventing the efforts to viability are discovered which shows the weaknesses of the current responses/management objectives. The most frequently observed factors preventing the social and governing response were opportunistic behavior of the fishermen, lack of social cohesion, excludability, social unrest, lack of management plans, poor enforcement of the rules, law, and policies, lack of coherent strategy for management of the marine ecosystem, lack of monitoring activities and lack of funding.

The prognosis was not all negative and the results showed SSF communities are capable and have adapted to social-ecological changes through adapting and reacting responses. The similar social and governing responses among various case studies included a shift toward alternative livelihood opportunities by the fishers, a shift from hierarchical management to a co-management type of governance, formulation of formal and informal rules, regulations, and policies by collaboration with various stakeholders. The most common factors that prevented the application of short and long-term management objectives in the case studies were lack of social cohesion and unity among the fishers to work for collective good, lack of financial capital, and delayed response to deal with the social-ecological crisis. Multiple examples showed the importance of a favorable environment for policy development, the establishment of social-economic enterprises such as cooperatives, the formation of research institutes, and good leadership at all management levels for transforming SSF SES from vulnerability to viability. Reacting strategies or the short-term responses included using children as labor to increase additional income, temporary migration, switching the target species, adopting traditional fishing practices, conducting training programs, distributing relief packages, providing concessions to change the employment option, tax exemptions to small-scale fisheries businesses. The long-term adapting responses included capacity development of small-scale fisheries communities,

establishing effective governance, building partnerships at multiple levels, valuing varied knowledge inputs in policy formulation, adapting to new technologies, providing rights to fisher communities to establish social institutions, and economic incentives to strengthen local participation in resource management, market revitalization, and livelihood diversification. Large-scale transformative actions are needed to transform SSF from V2V (Wise et al., 2014). Small scale incremental changes at all levels supporting sustainable practices in catching, harvesting, and marketing the fish products would be enough to cope and adapt to the global changes. However, they will not be able to transform SSF from vulnerability to viability.

The self-organizing capability of the small-scale fishers is best regulated when they are given the power, authority, and resources to govern the fisheries resource however the institutional and governance arrangements should be robust which helps fishers to develop resilience to social-ecological changes (Ostrom et al., 2007). A global governance system (Brodie Rudolph et al., 2020) is required to promote the transitioning process and further explicitly recognize the SSF SESs as the global commons. A governance system that is flexible, polycentric, network-based, and, adaptive is required to accommodate the varying interest of the stakeholders. Enough space should be given for equitable participation of the resource users in designing, planning, and implementing the response strategies by implementing a participatory form of governance to deal with the change. With this, stakeholders themselves also should be proactive to learn and adapt to the change. Motivation and approach to learn and adapt may be different for the different SES across the world, but stakeholders should thrive to overcome the friction and contestations to transform SSF from V2V.

Chapter 5

Appraisal of the Data Analysis Approaches: Implications for Typology Development

5.1 Introduction

The objective of this research was to explore quantitative and qualitative approaches to synthesize and compare SSF SES case studies that were collected using the I-ADApT Framework and link the analysis with enhancing our understanding of transitioning from vulnerability to viability. Two specific objectives guided this research: (1) to explore quantitative research methods for conducting vulnerability to viability study using the I-ADApT framework; (2) to explore qualitative research methods for conducting vulnerability to viability study using the I-ADApT framework. The quantitative research method used in this research was a statistical approach that included multiple factor analysis and hierarchical clustering (known as the multivariate method of analysis) in the R-Studio interface. The qualitative research method used in this study was thematic-content analysis in NVIVO software. An attempt was made to enumerate the vulnerabilities and current efforts to progress towards viability using similar data (29 case studies for the quantitative analysis and 28 case studies for the qualitative analysis, all collected using the I-ADApT template), however, applying separate research methods. The goal of the research was not just to compare the results obtained from qualitative and quantitative analysis but to understand what can be explored about vulnerabilities, social and governing responses, the effectiveness of the responses and governability conditions in the SSF SESs, and what were the common characteristics between the clusters and vice-versa using both types of research methods for data analysis.

5.2 Summary of the Findings from the Quantitative Approach

The quantitative research method was explored to full depth and an effort was made to interpret all the useful results obtained from multiple factor analysis and hierarchical clustering. Twenty-nine case studies were grouped into five clusters. Typology was developed by taking the variables that were most correlated with each of the clusters (within-cluster characteristics). The result showed that there were many similar and dissimilar characteristics between the case studies and between the clusters of the case studies. Each cluster had unique characteristics which only belonged to the cluster. For example, the case studies in cluster 1 lacked short-term responses to deal with the main issue and therefore had no factors that prevented the short-term objectives from being fully achieved. Cluster 4 instead had a few key factors that prevented both the short-term and long-term objectives from being fully achieved. Different from cluster 1, cluster 2 had a variety of short-term responses and a variety of short-term factors within one or two natural, social, or governing systems contributing. Resembling cluster 2, cluster 5 also had a variety of short-term factors but within all three natural, social, and governing systems. The formation of the social power was entirely different in cluster 3 and cluster 5 where the social power in cluster 3 was highly dispersed while the social power in cluster 5 was entirely concentrated. Likewise, the result of the quantitative research approach revealed that most of the short-term responses related to adaptation at the household and community level mostly within the social subsystem and most of the long-term responses were management and institutional responses targeted at improving existing governance systems. This shows that the adaptation measures were somewhat circular aiming to develop adaptive capacity within multiple linked systems.

5.3 Summary of Findings from Qualitative Approach

The qualitative data analysis was novel as the thematic-content methods has not been explored very often in the past studies in the development of the typologies of the small-scale fisheries social-ecological system. In the qualitative analysis, twenty-eight case studies were grouped into five clusters. Typology was developed by taking the major and minor themes to which the data was coded from the case studies belonging to that cluster.

The most common type of vulnerabilities considering all the 28 case studies used in the analysis were environmental degradation, resource depletion, pollution, productivity decrease, lack of income, poverty and illiteracy, centralized management, poor legislation, unsuitable governance, intersectoral and intra-sectoral conflicts, and unemployment. The most frequently observed social and governing responses were effective policies and regulations, appropriate legislation, co-management, livelihood diversification, capacity development of the fishers, multi-level collaborations, informal local practices, and partnership development. Factors enabling the social and the governing response were social unity, awareness among fishers, active involvement of fishers in decision making, valuing fishers as an integral part of the system, implementation of the plans, government incentives, and license and quota system. Factors preventing the social and governing response were opportunistic behavior of the fishers, lack of social cohesion, short-term measures, social unrest, lack of management plans, lack of coherent strategy, lack of monitoring activities, and insufficient funding.

5.4 Comparison of the Clustering Results

Though the qualitative and quantitative analysis both resulted in five clusters, the grouping of the case studies was different (Table 1). This was because they were subjected to completely different types of analysis which were independent of each other.

Table 5 1 Similarities in the clustering results

Cluster	Case-Study	Comparison with qualitative clustering analysis
Cluster 1 from quantitative analysis	SL-cora ON_tour OB_Poll SH_poll	Slightly matches with cluster 4 of the qualitative clustering results (Three case studies out of Four)
Cluster 2 from quantitative analysis	PH_poll BA_mang TB_shrm BB_oyst GRC CM_mang BU_pela	Slightly matches with cluster 3 of the qualitative clustering results (Three case studies out of Seven)
Cluster 3 from	GR_Amv	Slightly matches with cluster 5 of the qualitative clustering results

quantitative analysis	GR_Mal VL_clam CB_oyst YB_clam	(Three case studies out of Five)
Cluster 4 from quantitative analysis	IN_reef US_oyst MB_oyst UR_clam ESP_G VIC ARG BS_fish	Slightly matches with cluster 2 of the qualitative clustering results (Three case studies out of Eight)
Cluster 5 from quantitative analysis	VEN ESP_M BGD TAN KAR	Slightly matches with cluster 4 of the qualitative clustering results (Three case studies out of Five, highlighted ones)

In the quantitative study, it was challenging to drive the research focus toward vulnerability to viability context because of uncertainty in what variables will be retained by the principal components and what variables will be correlated to the clusters. As the coding of the qualitative data was not conducted specifically in the vulnerability to viability context, it was challenging to expand the thread. In the qualitative study, the whole of the approach was dedicated to vulnerability to viability establishing them as the parent theme. However, the qualitative coding was highly subjective where the textual information could be interpreted in various ways based on the researcher's experience, background, and personal understanding of the subject matter (Creswell & Creswell, 2017). Early career researchers might not have enough background understanding of the problem context, and this was true in my case. There is a higher probability that the qualitative results might change if the coding is carried out by a different researcher as data might be interpreted differently. Overall, both methods were found to be useful and fulfilled the research objectives, and helped to answer the research questions. Two approaches were found to be useful because the two were undertaken in parallel to each other which allowed for drawing comparisons and gaining insights about the vulnerabilities and efforts to viability.

There were some similarities in the clustering results derived from the quantitative and the qualitative methods (Table 1). Cluster 1 from the quantitative analysis matches 75% with cluster 4 obtained from the qualitative analysis. Cluster 2 from the quantitative analysis matches 43% with cluster 3 obtained from the qualitative method. Cluster 3 from the quantitative analysis matches 60% with cluster 5 obtained from the qualitative analysis. Cluster 4 from the quantitative analysis matches 38% with cluster 2 obtained from the qualitative analysis. And cluster 5 from the quantitative analysis matches 60% with cluster 4 obtained from the qualitative analysis.

Similarity in the clustering results signifies that the qualitative and quantitative methods can provide somewhat similar outcomes and may be used complementary to each other. There are some similarities between the quantitative and qualitative methods as both methods use the same type of clustering algorithm (hierarchical clustering algorithm) to group the case studies into the cluster. In both cases, the qualitative data were transformed into categorical data, but using different methods, to test similarities in the data using statistical analysis. Unfortunately, some of the I-ADApT templates lacked all the relevant information to conduct detailed coding because respondents did not fill those sections. Hence, there are chances that the qualitative and quantitative analysis might be more similar if all information is available in the templates. However, all the I-ADApT templates used in the analysis should have all the data filled for all the sections, minor themes optimized, and the coding carried out by an interdisciplinary group of researchers which can be done in NVIVO. Overall results though show broad similarities observed in Table 1 provide encouragement to dig deeper to understand the similarities and differences between the methods.

5.5 Strengths and Weakness of the Quantitative and Qualitative methods

5.5.1 Strengths of the Quantitative Approach

Based on the results from Chapter 3, the quantitative approach, which used multiple factor analysis and hierarchical clustering analysis, was found to be useful in terms of elucidating the overall patterns in the data such as identifying the type of vulnerabilities, the types of responses (one or few or variety of short-term responses and/or long-term responses) and the factors that

enabled those responses. The quantitative approach helped find the similarities and dissimilarities between the clusters of case studies and make comparisons between the clusters. One of the strengths of the quantitative approach was the simplicity of the data analysis tools in terms of understanding the theoretical base and the computational methods to reckon how the results were generated. Multiple factor analysis was useful for simplifying multi-dimensional data on small-scale fisheries social-ecological systems (multidimensional here means multiple variables or the system properties that describe small-scale fisheries social-ecological systems) to low dimensions (few variables) making it easier to understand the common attributes of different case-studies located in different geographical regions. Multiple factor analysis was also instrumental in examining both single and multiple variables. Hierarchical clustering was important in terms of categorization of the case studies and understanding their interrelationships, commonalities, and differences. Clustering analysis does not require specifying the number of clusters in advance which is less burden to the researcher as it is always difficult to estimate the number of clusters in advance just by looking at the number of case studies and this method of clustering is also reliable because even a small similarity between the variables of the case studies would form clusters.

One of the strengths of the quantitative approach is its strong theoretical foundation which has already been explored in-depth. This method has already been tested and verified by researchers worldwide and has been used in multiple research fields in science, engineering, economics, health, agriculture, and medicine. This method of data analysis has been robust to reveal the underlying structure of the data. There are no issues of credibility and validity in the results obtained from the quantitative analysis and it has a high level of trustworthiness providing high-quality results. The method was less time-consuming relative to the qualitative methods in context of data assessment that was conducted in this study.

5.5.2 Weakness of the Quantitative Approach

The findings from the quantitative analysis were limited to the interpretation (scope) of thirty-two questions that were coded to develop the typology. However, the case study templates contained additional information that could be used to identify major drivers causing

vulnerabilities and link them with the responses. Before conducting the multiple factor analysis and hierarchical clustering it was assumed that the variables used in the study (i.e., the questions in the I-ADApT template) were both linearly and non-linearly correlated with each other. Non-linear interactions between the linked natural and social systems are also important properties of the small-scale fisheries social-ecological systems. However, multiple factor analysis only considers the linear combination of the original data to form the principal components or the dimensions. Hence, there was a high probability of missing some of the original information provided by the respondents in the I-ADApT case study templates, especially the data representing outliers which sometimes can be a loss of important variables explaining the characteristics of small-scale fisheries social-ecological systems.

Principal components (also called dimensions) were not straightforward to interpret. The results of the MFA can also be challenging to interpret, with different aspects of the 4 groups, vulnerability, governance, response, and appraisal captured across the 5 principal components. This made it difficult to connect the information captured by the principal components, for example, connecting the threads related to vulnerability, governance, governability, response, and appraisal because a disproportionate number of variables was retained by the principal components which belonged to different groups. It is recommended that the information retained by principal components should be discussed among a multidisciplinary group of researchers through a workshop or similar form of meeting.

The researcher should not blindly follow the results from the clustering analysis, however, should closely assess if it makes sense to have the case studies in the same clusters. The use of different distance metrics in the clustering analysis might change the formation of the clusters providing completely different results to what was obtained in this study. It is recommended to check the results by altering different distance metrics to optimize the clustering results further. The interpretation of the clustering results obtained from the quantitative analysis was highly subjective. Other researchers might interpret the results differently to come up with new or different findings.

5.5.3 Strength of the Qualitative Approach

The qualitative approach was highly useful to reveal the actual vulnerabilities and responses reported by the respondents in the I-ADApT case study templates. Thematic-content analysis was found to be a sophisticated tool in terms of recording, systematizing, and analyzing the qualitative data collected through the I-ADApT case study templates to study the vulnerabilities and prospects of the viability of the small-scale fisheries social-ecological systems. No prior significant prior theoretical knowledge about the qualitative research methods was required to employ the thematic-content analysis as these methods are independent of others and can be used as standalone methods. The method was simple to learn and was used to derive a descriptive explanation of the qualitative data collected using the I-ADApT case studies.

Thematic analysis was helpful in "identifying, analyzing, organizing, describing, and reporting themes" (Nowell et al., 2017). The application of the thematic analysis did not require any previous experience in working with qualitative methods. However, there was a need to review all the case studies in detail to identify the common terms in the data. During the thematic analysis, the interpretation of the qualitative data in the I-ADApT case studies was kept to a minimum making it very easy to learn and apply. This method was useful to summarize the key features of the I-ADApT case study templates to produce an organized list of themes that represents the majority of information provided by the respondents in the I-ADApT template. Thematic analysis was the foundational step for the content analysis.

Content analysis was useful in examining the contextual meaning of the qualitative data in the I-ADApT case study templates. The coding approach followed was a conventional type (Hsieh & Shannon, 2005) where all of the codes were derived during the process of the data analysis from the I-ADApT case study templates filled by the respondents. This was a very effective method of distilling and communicating the essential information in the data. Content analysis also had some portion of the quantitative analysis (hidden use of statistics) while creating the hierarchical charts, performing the clustering analysis, and performing the matrix coding. This increased the significance of the results.

Results of the thematic-content analysis in this research highly relied on the quality of the data, the quality of the creation of the minor themes, and most importantly, the quality of coding of the qualitative data. Improper creation of the themes can potentially lead to poor quality of the content analysis and vice-versa. Hence, it is required to conduct a rigorous analysis that can confirm the research findings and reflect the information provided by the respondents as accurately as possible.

5.5.4 Weakness of the Qualitative Approach

Sometimes it can be difficult to make a distinction between thematic and content analyses as individual researchers have used the concept of thematic-content analysis (Vaismoradi et al., 2013) differently and interpreted the method in different ways. Thematic-content analysis itself has not been used very frequently in research related to small-scale fisheries social-ecological systems, though it has been used in other fields of study such as nursing and psychology (Hsieh & Shannon, 2005). There can be questions about the overall data analysis process in the thematic-content analysis as a pure qualitative data analysis approach (Nowell et al., 2017) because this concept is relatively new in the academic domain. Hence, the focus should be more on the type of results generated from the use of a method if it satisfies the purpose of conducting qualitative analysis. If the data analysis process yields meaningful results and helps in fulfilling research objectives, credibility should not be of major concern provided that the assumptions are clearly laid out and the researchers explain the methodological process well which is easy for the reader to understand. The entire process of data analysis was time-consuming and required a detailed analysis of the qualitative information in the I-ADApT template.

Thematic-content analysis requires the researcher to familiarize themselves with the research data. Both methods used in this research have potential issues of bias when working and interpreting the qualitative data from the I-ADApT templates and included subjectivity. It was challenging to define the themes because there was a lot of information and other details provided by the respondents in the I-ADApT templates which were difficult to define and categorize. This resulted in the creation of too many themes and coding the same sentence multiple times to different sub-themes which could have led to biases in the research. The data

analysis process was not simple, as it was required to conduct both inductive and deductive analysis working back and forth between twenty-eight case studies.

Though thematic-content analysis offered flexibility in designingand interpreting the different groups of qualitative data, the same flexibility could also lead to weak "consistency and cohesion" (Holloway & Todres, 2003) when working back and forth with a large number of case studies. Therefore, it is recommended to take a clear epistemological position when conducting thematic-content analysis to ensure that the research does not divertin a different direction which might not fulfill the research objectives. Thematic-content analysis is also a kind of reductive approach to data analysis, the same as the multiple factor analysis where the complex data was treated to make it as simple as possible to understand. This might have caused the loss of some information. One of the other important drawbacks of content analysis was that the context of qualitative data might have been ignored in several places during the coding process. Coding involved assigning some textual data to the minor themes. So, taking a small section of textual data and assigning it to a theme can be confusing to readers and it may not give a clear understanding of why the sentence was coded to that theme.

One of the important drawbacks of content analysis is that the plots generated may be analytically biased. The results (hierarchy charts, matrix coding, and clustering analysis) will vary according to the length of data/response provided by the respondents in the I-ADApT case study template. The more information provided by the respondents in the template, the more the probability that data gets coded to the themes. While conducting the data analysis, for most of the case studies, the length of the responses was not the same (some respondents had provided a lot of information, and some had provided few or no answers). However, the final comparison of the result was done based on the count of the codes that were coded to the themes. So, the overall analysis could have been biased due to this.

5.6 I-ADApT framework as a Research and Decision-Support Tool

The I-ADApT framework was used as a research tool here as a proof of concept to explore qualitative and quantitative methods of data analysis using 29 I-ADApT case studies. It is

ultimately intended as a decision-support tool and this type of analysis contributes to its development as both a research and decision-making tool. I-ADApT was designed to inform decision-making choices for effective responses to deal with the impacts of the global changes, based on lessons learned from detailed, place base case studies. The results obtained in this study may not be directly useful in terms of decision-making, but the methodological concepts used in this study are valuable and can be used as a tool to develop a 'full' typology that includes all the information about the social-ecological crisis. From the appraisal of the responses, it was seen that the outcomes of the responses in most of the cases were unknown. This indicates that it is early to develop a full typology including the vulnerabilities, strategies used to respond (coping, and/or adaptive and/or transformative) to those vulnerabilities and appraisal of those responses. Some patterns have started to appear where it was seen that the short-term responses and some long-term responses were helpful to reduce the vulnerabilities and develop the adaptive capacity of the small-scale fisheries communities. To use the results of the typology in decision-making, the typology should include detailed results including the outcomes of the responses to deal with vulnerabilities. To understand the transition of small-scale fisheries from vulnerability to viability, it is recommended to code more questions or maybe different types of questions, especially about vulnerability and responses which can help to understand existing vulnerabilities and detailed coping, adaptive and transformative responses to those vulnerabilities. There is a need to tailor the coded questions to the context of the V2V study.

5.7 Quantitative and Qualitative Approaches in Development of Typology

Both qualitative and quantitative analysis resulted in clusters of case studies which were further used to develop a typology of the SSF SES. Developing typology was found to be an effective way of communicating the common characteristics of complex social-ecological systems like small-scale fisheries which are inherently distinct yet are analogous in numerous aspects when viewed from a multidisciplinary lens (e.g., interdependencies, cross-level and cross-scale interactions, numerous domains of emergence, non-linear feedbacks, and uncertainty).

In the case of quantitative research, the typology concept was more valuable in terms of the identification of common characteristics related to vulnerabilities, governance, response, and

appraisal of response (Chapter 3). Identification of key common characteristics helped in better understanding the most common attributes of small-scale fisheries social-ecological systems. This may be of importance for managers and stakeholders to make comparisons between small-scale fisheries social-ecological systems at regional and global level, linking common types of vulnerabilities, measures being followed to reduce those vulnerabilities either through coping or adaptive or transformative responses, and appraisal of those responses. Overall, it can be concluded that the typologies developed in this research using the I-ADApT framework serve to inform the knowledge base required to help small-scale fisheries transition from vulnerability to viability.

The notion of typology in the qualitative research helped identify the attributes of vulnerabilities and viabilities to understand the common types of drivers causing vulnerabilities, responses, factors enhancing those responses, and factors preventing those responses for five different clusters (Chapter 4). This result may be important to stakeholders in terms of understanding existing vulnerabilities, types of responses followed to deal with those vulnerabilities, and further understanding of what factors enabled those responses and what factors prevented those responses. This provides an opportunity for the stakeholders to assess whether existing interventions or the responses were able to capture short-term and long-term shocks and stresses and whether stakeholders can use the results to design proactive interventions in the future that support viability.

5.8 Sustainable Development Goals and Small-scale Fisheries

United Nations Sustainable Development Goals, (UN SDG) target number 14 relates to life in water and is associated with conserving the aquatic resources in our oceans. There are 10 targets under SDG 14, five out of which are related to fisheries and how humans can sustainably use the living aquatic resource to promote overall sustainable development (Neumann et al., 2017). Sub-target SDG14b specifically stresses the provision of "access of small-scale artisanal fishers to marine resources and markets" (Nayak & Berkes, 2019). Furthermore, sub-target 14.b.1 highlights the necessity to monitor "progress by countries in the degree of application of a legal/regulatory/policy/institutional framework, which recognizes and protects access rights for

small-scale fisheries" (Nayak & Berkes, 2019). Targets are high, yet the path to achieving those targets is still unclear due to the growing conflicting agendas such as blue economy initiatives, existing competition for resources, and climate change (Martínez-Vázquez et al., 2021). In this context, there is a growing need to conduct comprehensive studies considering multiple case studies to observe the progress toward achieving SDG14b (Said et al., 2020). With SDG14b and small-scale fisheries guidelines (Nayak & Berkes, 2019) providing a clear direction, there is a need to conduct more studies on a global scale incorporating different methods to reach the globally relevant targets.

5.9 Recommendation on the Methodological Approaches

It is suggested to conduct both quantitative and qualitative analysis separately but parallel in the context of vulnerability to viability study of SSF SES and explore the methods in-depth, especially the qualitative research method. The quantitative method was explored in-depth analyzing all the results. Both research methods have their importance in terms of identifying the vulnerabilities, understanding the prospects of the viability, comparing the case studies, and finally developing the typology. However, both methods require high analytical skills and knowledge of small-scale fisheries (such as knowledge about social-ecological systems, environmental governance, social and environmental equity, political ecology, fisheries ecology, and indigenous knowledge) to be employed in vulnerability to viability study. Typologies using the quantitative and qualitative methods can be conducted separately and later can be merged to develop a combined typology. Another way, after both methods are explored in-depth as suggested above, it is recommended to conduct the quantitative study first using the multivariate methods to develop the clusters and later employ the thematic-content analysis to assess vulnerabilities, social and governing responses, factors enabling the social and governing responses, factors preventing the social and governing responses and appraisal of the responses. It is suggested to develop the clusters using the quantitative method because it has a stronger theoretical base relative to the qualitative method which has not been used frequently in small-scale fisheries research and still has not been widely used in other fields too.

5.10 Personal Reflections

My master's research began with no prior knowledge of fisheries, even I had not heard of small-scale fisheries before getting to the University of Waterloo. Not knowing anything about fisheries and being able to write this thesis is a steep learning curve for me. Lots of reading involved, being confused with several times, reflecting constantly, and experimenting new ways were the things I did the most in the last 2 years. I came from a background of civil engineering where every analysis or laboratory test was aimed to get a value that could be considered a "pass". I now feel the world I was living in at that time was completely black and white (fail or pass). Getting into transdisciplinary research, I sought knowledge relating to multiple disciplines, and perspectives and I can say this world is more colorful where everything has a meaning in its ways be it right or wrong, pass or fail.

For the first year of my master's, I studied online from my home country due to COVID. That time was challenging, and I was a bit slow at that moment where I couldn't make much progress. I should thank my supervisors for allowing me that flexibility during those times and for understanding my situation. I never felt discouraged due to the constant motivation from my supervisors. Thank you both for your unprecedented support to finalize this thesis. I am lucky that I got the opportunity to be supervised by the best people.

Personal perspective about small-scale fisheries

SSF are not only about how much fish is contributed by SSF destined for human consumption or the share of SSF in the global market. Once we start to understand the SSF from the business perspective alone, then they will start to lose their essential characteristics. This would further complicate the situation by making small-scale fishers the competitors of the large-scale fisheries or aquaculture which would make them much more vulnerable. A significant proportion of SSF communities do not follow SSF occupation not only because it's a way to live their lives and feed their family but because they are emotionally and physically connected to the oceans for the whole of their lifetime, and they cannot imagine themselves being in other occupations. SSF communities in developing countries do not only need monetary support, incentives, reliefs & subsidies, but they also need care, and warm hearts to hold their hands to help them progress towards viability.

Bibliography

Abdi, H., & Valentin, D. (2007). Multiple Factor Analysis (MFA). 14.

Adger, W. N. (2006). Vulnerability. Global Environmental Change, 16(3), 268–281. https://doi.org/10.1016/j.gloenvcha.2006.02.006

Adger, W. N., Huq, S., Brown, K., Conway, D., & Hulme, M. (2003). Adaptation to climate change in the developing world. Progress in Development Studies, 3(3), 179–195. https://doi.org/10.1191/1464993403ps060oa

Aguilera, S. E., Cole, J., Finkbeiner, E. M., Cornu, E. L., Ban, N. C., Carr, M. H., Cinner, J. E., Crowder, L. B., Gelcich, S., Hicks, C. C., Kittinger, J. N., Martone, R., Malone, D., Pomeroy, C., Starr, R. M., Seram, S., Zuercher, R., & Broad, K. (2015). Managing Small-Scale Commercial Fisheries for Adaptive Capacity: Insights from Dynamic Social-Ecological Drivers of Change in Monterey Bay. PLOS ONE, 10(3), e0118992. https://doi.org/10.1371/journal.pone.0118992

Alessa, L., Kliskey, A., & Altaweel, M. (2009). Toward a typology for social-ecological systems. Sustainability: Science, Practice and Policy, 5(1), 31–41. https://doi.org/10.1080/15487733.2009.11908026

Alexander, S., Bodin, Ö., & Barnes, M. (2018). Untangling the drivers of community cohesion in small-scale fisheries. International Journal of the Commons, 12(1), 519–547. https://doi.org/10.18352/ijc.843

Altaweel, M., Virapongse, A., Griffith, D., Alessa, L., & Kliskey, A. (2015). A typology for complex social-ecological systems in mountain communities. Sustainability: Science, Practice and Policy, 11(2), 1–13. https://doi.org/10.1080/15487733.2015.11908142

Andrachuk, M., & Armitage, D. (2015). Understanding social-ecological change and transformation through community perceptions of system identity. Ecology and Society, 20(4). http://www.jstor.org/stable/26270290

Andrews, E. J., Wolfe, S., Nayak, P. K., & Armitage, D. (2021). Coastal Fishers Livelihood Behaviors and Their Psychosocial Explanations: Implications for Fisheries Governance in a Changing World. Frontiers in Marine Science, 8. https://www.frontiersin.org/article/10.3389/fmars.2021.634484

Armitage, D. R., Plummer, R., Berkes, F., Arthur, R. I., Charles, A. T., Davidson-Hunt, I. J., Diduck, A. P., Doubleday, N. C., Johnson, D. S., Marschke, M., McConney, P., Pinkerton, E. W., & Wollenberg, E. K. (2009). Adaptive co-management for social–ecological complexity. Frontiers in Ecology and the Environment, 7(2), 95–102. https://doi.org/10.1890/070089

Armitage, D., Alexander, S., Andrachuk, M., Berdej, S., Dyck, T., Nayak, P. K., Pittman, J., & Rathwell, K. (2015). Emerging Concepts in Adaptive Management. In C. R. Allen & A. S.

Garmestani (Eds.), Adaptive Management of Social-Ecological Systems (pp. 235–254). Springer Netherlands. https://doi.org/10.1007/978-94-017-9682-8_13

Armitage, D., Andrews, E. J., Blythe, J., Dias, A. C. E., Nayak, P. K., Pittman, J., & Sultana, S. (2021). Governance and the process of (de)commonisation. In Making Commons Dynamic. Routledge.

Armitage, D., Berkes, F., & Doubleday, N. (2010). Adaptive Co-Management: Collaboration, Learning, and Multi-Level Governance. UBC Press.

Armitage, D., Charles, A., & Berkes, F. (2017). Towards transformative change in the coastal commons. In Governing the Coastal Commons. Routledge.

Armitage, D., Marschke, M., & Plummer, R. (2008). Adaptive co-management and the paradox of learning. Global Environmental Change, 18(1), 86–98. https://doi.org/10.1016/j.gloenvcha.2007.07.002

Arthur, R. I. (2020). Small-scale fisheries management and the problem of open access. Marine Policy, 115, 103867. https://doi.org/10.1016/j.marpol.2020.103867

Bailey, K. D. (1989). Constructing Typologies Through Cluster Analysis. Bulletin of Sociological Methodology/Bulletin de Méthodologie Sociologique, 25(1), 17–28. https://doi.org/10.1177/075910638902500102

Baldwin, C., Lewison, R. L., Lieske, S. N., Beger, M., Hines, E., Dearden, P., Rudd, M. A., Jones, C., Satumanatpan, S., & Junchompoo, C. (2016). Using the DPSIR framework for transdisciplinary training and knowledge elicitation in the Gulf of Thailand. Ocean & Coastal Management, 134, 163–172. https://doi.org/10.1016/j.ocecoaman.2016.09.005

Balzan, M. V., Pinheiro, A. M., Mascarenhas, A., Morán-Ordóñez, A., Ruiz-Frau, A., Carvalho-Santos, C., Vogiatzakis, I. N., Arends, J., Santana-Garcon, J., Roces-Díaz, J. V., Brotons, L., Campagne, C. S., Roche, P. K., Miguel, S. de, Targetti, S., Drakou, E. G., Vlami, V., Baró, F., & Geijzendorffer, I. R. (2019). Improving ecosystem assessments in Mediterranean social-ecological systems: A DPSIR analysis. Ecosystems and People, 15(1), 136–155. https://doi.org/10.1080/26395916.2019.1598499

Barange, M., Merino, G., Blanchard, J. L., Scholtens, J., Harle, J., Allison, E. H., Allen, J. I., Holt, J., & Jennings, S. (2014). Impacts of climate change on marine ecosystem production in societies dependent on fisheries. Nature Climate Change, 4(3), 211–216. https://doi.org/10.1038/nclimate2119

Barsley, W., Young, C. D., & Brugère, C. (2013). Vulnerability assessment methodologies: An annotated bibliography for climate change and the fisheries and aquaculture sector (No. 1083; Fisheries and Aquaculture Circular, p. 54). FAO.

Bécue-Bertaut, M., & Pagès, J. (2008). Multiple factor analysis and clustering of a mixture of quantitative, categorical and frequency data. Computational Statistics & Data Analysis, 52(6), 3255–3268. https://doi.org/10.1016/j.csda.2007.09.023

Béné, C. (2003). When Fishery Rhymes with Poverty: A First Step Beyond the Old Paradigm on Poverty in Small-Scale Fisheries. World Development, 31(6), 949–975. https://doi.org/10.1016/S0305-750X(03)00045-7

Béné, C., Arthur, R., Norbury, H., Allison, E. H., Beveridge, M., Bush, S., Campling, L., Leschen, W., Little, D., Squires, D., Thilsted, S. H., Troell, M., & Williams, M. (2016). Contribution of Fisheries and Aquaculture to Food Security and Poverty Reduction: Assessing the Current Evidence. World Development, 79, 177–196. https://doi.org/10.1016/j.worlddev.2015.11.007

Bennett, N. J. (2019). Marine Social Science for the Peopled Seas. Coastal Management, 47(2), 244–252. https://doi.org/10.1080/08920753.2019.1564958

Bennett, N. J., Blythe, J., Tyler, S., & Ban, N. C. (2016). Communities and change in the anthropocene: Understanding social-ecological vulnerability and planning adaptations to multiple interacting exposures. Regional Environmental Change, 16(4), 907–926. https://doi.org/10.1007/s10113-015-0839-5

Bennett, N., Dearden, P., Murray, G., & Kadfak, A. (2014). The capacity to adapt?: Communities in a changing climate, environment, and economy on the northern Andaman coast of Thailand. Ecology and Society, 19(2). https://doi.org/10.5751/ES-06315-190205

Berkes, F. (2001). Managing Small-scale Fisheries: Alternative Directions and Methods. IDRC.

Berkes, F. (2003). Alternatives to Conventional Management: Lessons from Small-Scale Fisheries. Environments, 31.

BERKES, F. (2004). Rethinking Community-Based Conservation. Conservation Biology, 18, 621–630. https://doi.org/10.1111/j.1523-1739.2004.00077.x

Berkes, F. (2021). Toward a new social contract: Community-based resource management and small-scale fisheries. TBTI Global.

Berkes, F., & Folke, C. (1998). Linking social and ecological systems for resilience and sustainability. Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience, 1(4), 4.

Berkes, F., & Nayak, P. (2018). Role of communities in fisheries management: “One would first need to imagine it.” Maritime Studies, 17. https://doi.org/10.1007/s40152-018-0120-x

Berkes, F., & Seixas, C. S. (2005). Building Resilience in Lagoon Social–Ecological Systems: A Local-level Perspective. Ecosystems, 8(8), 967–974. https://doi.org/10.1007/s10021-005-0140-4

Berkes, F., Colding, J., & Folke, C. (2000). Rediscovery of Traditional Ecological Knowledge as Adaptive Management. Ecological Applications, 10(5), 1251–1262. https://doi.org/10.2307/2641280

Berkes, F., Colding, J., & Folke, C. (Eds.). (2002). Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press. https://doi.org/10.1017/CBO9780511541957

Berkes, F., Folke, C., & Colding, J. (1998). Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience. Cambridge University Press.

Berkes, F., Folke, C., & Colding, J. (1998). Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience. Cambridge University Press.

Biggs, R., Clements, H., Vos, A. de, Folke, C., Manyani, A., Maciejewski, K., Martín-López, B., Preiser, R., Selomane, O., & Schlüter, M. (2021). What are social-ecological systems and social-ecological systems research? In The Routledge Handbook of Research Methods for Social-Ecological Systems. Routledge.

Biggs, R., Clements, H., Vos, A. de, Maciejewski, K., Preiser, R., & Schlüter, M. (2021). How to use this handbook. In The Routledge Handbook of Research Methods for Social-Ecological Systems. Routledge.

Biggs, R., Peterson, G., & Rocha, J. (2018). The Regime Shifts Database: A framework for analyzing regime shifts in social-ecological systems. Ecology and Society, 23(3). https://doi.org/10.5751/ES-10264-230309

Biggs, R., Westley, F., & Carpenter, S. (2010). Navigating the Back Loop: Fostering Social Innovation and Transformation in Ecosystem Management. Ecology and Society, 15(2). https://doi.org/10.5751/ES-03411-150209

Blythe, J. L. (2015). Resilience and social thresholds in small-scale fishing communities. Sustainability Science, 10(1), 157–165. https://doi.org/10.1007/s11625-014-0253-9

Bodin, Ö. (2017). Collaborative environmental governance: Achieving collective action in social-ecological systems. Science, 357(6352), eaan1114. https://doi.org/10.1126/science.aan1114

Böhnke-Henrichs, A., Baulcomb, C., Koss, R., Hussain, S. S., & de Groot, R. S. (2013). Typology and indicators of ecosystem services for marine spatial planning and management. Journal of Environmental Management, 130, 135–145. https://doi.org/10.1016/j.jenvman.2013.08.027

Bolman, B., Jak, R. G., & van Hoof, L. (2018). Unravelling the myth – The use of Decisions Support Systems in marine management. Marine Policy, 87, 241–249. https://doi.org/10.1016/j.marpol.2017.10.027

Bovens, M., & Hart, P. (1995). Frame multiplicity and policy fiascoes: Limits to explanation. Knowledge and Policy, 8(4), 61–82. https://doi.org/10.1007/BF02832230

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Brinson, A. A., Die, D. J., Bannerman, P. O., & Diatta, Y. (2009). Socioeconomic performance of West African fleets that target Atlantic billfish. Fisheries Research, 99(1), 55–62. https://doi.org/10.1016/j.fishres.2009.04.010

Brodie Rudolph, T., Ruckelshaus, M., Swilling, M., Allison, E. H., Österblom, H., Gelcich, S., & Mbatha, P. (2020). A transition to sustainable ocean governance. Nature Communications, 11(1), 1–14. https://doi.org/10.1038/s41467-020-17410-2

Bundy, A., Chuenpagdee, R., Boldt, J. L., de Fatima Borges, M., Camara, M. L., Coll, M., Diallo, I., Fox, C., Fulton, E. A., Gazihan, A., Jarre, A., Jouffre, D., Kleisner, K. M., Knight, B., Link, J., Matiku, P. P., Masski, H., Moutopoulos, D. K., Piroddi, C., … Shin, Y.-J. (2017). Strong fisheries management and governance positively impact ecosystem status. Fish and Fisheries, 18(3), 412–439. https://doi.org/10.1111/faf.12184

Bundy, A., Chuenpagdee, R., Cooley, S. R., Defeo, O., Glaeser, B., Guillotreau, P., Isaacs, M., Mitsutaku, M., & Perry, R. I. (2016). A decision support tool for response to global change in marine systems: The IMBER-ADA pT Framework. Fish and Fisheries, 17(4), 1183–1193.

Bundy, A., Chuenpagdee, R., Cooley, S., Glaeser, B., & McManus, L. T. (2016). Global change, ensuing vulnerabilities, and social responses in marine environments. Regional Environmental Change, 16(2), 273–276. https://doi.org/10.1007/s10113-015-0906-y

Bundy, A., Coll, M., Shannon, L. J., & Shin, Y.-J. (2012). Global assessments of the status of marine exploited ecosystems and their management: What more is needed? Current Opinion in Environmental Sustainability, 4(3), 292–299. https://doi.org/10.1016/j.cosust.2012.05.003

Burgess, J., Dunnigan, J. H., Mechling, J. S., & Norton, E. C. (2005). NOAA'S ecosystem approach to management. Proceedings of OCEANS 2005 MTS/IEEE, 1–4.

Calò, A., Di Franco, A., Quattrocchi, F., Dimitriadis, C., Ventura, P., Milazzo, M., & Guidetti, P. (n.d.). Multi-specific small-scale fisheries rely on few, locally essential, species: Evidence from a multi-area study in the Mediterranean. Fish and Fisheries, n/a(n/a). https://doi.org/10.1111/faf.12689

Cánovas-Molina, A., García-Charton, J. A., & García-Frapolli, E. (2021). Assessing the contribution to overfishing of small- and large-scale fisheries in two marine regions as determined by the weight of evidence approach. Ocean & Coastal Management, 213, 105911. https://doi.org/10.1016/j.ocecoaman.2021.105911

Cánovas-Molina, A., & García-Frapolli, E. (2022). A review of vulnerabilities in worldwide small-scale fisheries. Fisheries Management and Ecology, n/a(n/a). https://doi.org/10.1111/fme.12538

Chapin, F. S., Carpenter, S. R., Kofinas, G. P., Folke, C., Abel, N., Clark, W. C., Olsson, P., Smith, D. M. S., Walker, B., Young, O. R., Berkes, F., Biggs, R., Grove, J. M., Naylor, R. L., Pinkerton, E., Steffen, W., & Swanson, F. J. (2010). Ecosystem stewardship: Sustainability strategies for a rapidly changing planet. Trends in Ecology & Evolution, 25(4), 241–249. https://doi.org/10.1016/j.tree.2009.10.008

Charles, A. (2011). Good practices for governance of small-scale fisheries. World Smallscale Fisheries: Contemporary Visions.

Charles, A., Loucks, L., Berkes, F., & Armitage, D. (2020). Community science: A typology and its implications for governance of social-ecological systems. Environmental Science & Policy, 106, 77–86. https://doi.org/10.1016/j.envsci.2020.01.019

Chuenpagdee, R. (2011). World Small-scale Fisheries: Contemporary Visions. Eburon Uitgeverij B.V.

Chuenpagdee, R., & Jentoft, S. (2018). Transforming the governance of small-scale fisheries. Maritime Studies, 17(1), 101–115. https://doi.org/10.1007/s40152-018-0087-7

Cinner, J. E. (2011). Social-ecological traps in reef fisheries. Global Environmental Change, 21(3), 835–839. https://doi.org/10.1016/j.gloenvcha.2011.04.012

Cinner, J. E., Huchery, C., Hicks, C. C., Daw, T. M., Marshall, N., Wamukota, A., & Allison, E. H. (2015). Changes in adaptive capacity of Kenyan fishing communities. Nature Climate Change, 5(9), 872–876. https://doi.org/10.1038/nclimate2690

Cooke, S. J., Wesch, S., Donaldson, L. A., Wilson, A. D. M., & Haddaway, N. R. (2017). A Call for Evidence-Based Conservation and Management of Fisheries and Aquatic Resources. Fisheries, 42(3), 143–149. https://doi.org/10.1080/03632415.2017.1276343

Cooper, G. S., Willcock, S., & Dearing, J. A. (2020). Regime shifts occur disproportionately faster in larger ecosystems. Nature Communications, 11(1), 1175. https://doi.org/10.1038/s41467-020-15029-x

Coronado, E., Salas, S., Torres-Irineo, E., & Chuenpagdee, R. (2020). Disentangling the complexity of small-scale fisheries in coastal communities through a typology approach: The case study of the Yucatan Peninsula, Mexico. Regional Studies in Marine Science, 36, 101312. https://doi.org/10.1016/j.rsma.2020.101312

Coulthard, S., Johnson, D., & McGregor, J. A. (2011). Poverty, sustainability and human wellbeing: A social wellbeing approach to the global fisheries crisis. Global Environmental Change, 21(2), 453–463. https://doi.org/10.1016/j.gloenvcha.2011.01.003

Courtney, J.F., 2001. Decision making and knowledge management in inquiring organizations: toward a new decision-making paradigm for DSS. Decision support systems, 31(1), pp.17-38.

Cox, V. (2017). Exploratory Data Analysis. In V. Cox (Ed.), Translating Statistics to Make Decisions: A Guide for the Non-Statistician (pp. 47–74). Apress. https://doi.org/10.1007/978-1-4842-2256-0_3

Creswell, J. W., & Creswell, J. D. (1994). Research design. Thousand Oaks, CA: Sage.

Creswell, J. W., & Creswell, J. D. (2017). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. SAGE Publications.

Creswell, J. W., & Tashakkori, A. (2007). Differing perspectives on mixed methods research. In Journal of mixed methods research (Vol. 1, Issue 4, pp. 303–308). Sage publications Sage CA: Los Angeles, CA.

Cury, P. M., Mullon, C., Garcia, S. M., & Shannon, L. J. (2005). Viability theory for an ecosystem approach to fisheries. ICES Journal of Marine Science, 62(3), 577–584. https://doi.org/10.1016/j.icesjms.2004.10.007

Davies, S., & Hossain, N. (1997). Livelihood Adaptation, Public Action and Civil Society: A Review of the Literature. https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/3361

Deb, A. K., & Haque, C. E. (2017). Multi-dimensional coping and adaptation strategies of small-scale fishing communities of Bangladesh to climate change induced stressors. International Journal of Climate Change Strategies and Management, 9(4), 446–468. https://doi.org/10.1108/IJCCSM-06-2016-0078

Defeo, O., Gianelli, I., Martínez, G., Ortega, L., Celentano, E., Lercari, D., & Rosa, A. de la. (2017). Natural, social and governance responses of a small-scale fishery to mass mortalities: The yellow clam (Mesodesma mactroides) in Uruguay. In Global Change in Marine Systems. Routledge.

DeSantis, L., & Ugarriza, D. N. (2000). The Concept of Theme as Used in Qualitative Nursing Research. Western Journal of Nursing Research, 22(3), 351–372. https://doi.org/10.1177/019394590002200308

Di Franco, G. (2016). Multiple correspondence analysis: One only or several techniques? Quality & Quantity, 50(3), 1299–1315. https://doi.org/10.1007/s11135-015-0206-0

Diedrich, A., Tintoré, J., & Navinés, F. (2010). Balancing science and society through establishing indicators for integrated coastal zone management in the Balearic Islands. Marine Policy, 34(4), 772–781. https://doi.org/10.1016/j.marpol.2010.01.017

Dominique, P., & Ferraris, J. (2000). A multivariate approach for defining fishing tactics from commercial catch and effort data. Canadian Journal of Fisheries and Aquatic Sciences, 57, 51–65. https://doi.org/10.1139/cjfas-57-1-51

Elliott, R., & Timulak, L. (2005). Descriptive and interpretive approaches to qualitative research. A Handbook of Research Methods for Clinical and Health Psychology, 1(7), 147–159.

Engle, N. L. (2011). Adaptive capacity and its assessment. Global Environmental Change, 21(2), 647–656. https://doi.org/10.1016/j.gloenvcha.2011.01.019

Eriksen, S., Schipper, E. L. F., Scoville-Simonds, M., Vincent, K., Adam, H. N., Brooks, N., Harding, B., Khatri, D., Lenaerts, L., Liverman, D., Mills-Novoa, M., Mosberg, M., Movik, S., Muok, B., Nightingale, A., Ojha, H., Sygna, L., Taylor, M., Vogel, C., & West, J. J. (2021). Adaptation interventions and their effect on vulnerability in developing countries: Help, hindrance or irrelevance? World Development, 141, 105383. https://doi.org/10.1016/j.worlddev.2020.105383

Escofier, B., & Pagès, J. (1994). Multiple factor analysis (AFMULT package). Computational Statistics & Data Analysis, 18(1), 121–140. https://doi.org/10.1016/0167-9473(94)90135-X

FAO. (2020). *The State of World Fisheries and Aquaculture 2020: Sustainability in action*. Rome, Italy. FAO. https://doi.org/10.4060/ca9229en

Fetzer, I., Piemontese, L., Rocha, J. C., & Martín-López, B. (2021). Statistical analysis. In The Routledge Handbook of Research Methods for Social-Ecological Systems. Routledge.

Firth, L. B., & Hawkins, S. J. (2011). Introductory comments - Global change in marine ecosystems: Patterns, processes and interactions with regional and local scale impacts. Journal of Experimental Marine Biology and Ecology, 400(1), 1–6. https://doi.org/10.1016/j.jembe.2011.02.001

Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. Global Environmental Change, 16(3), 253–267. https://doi.org/10.1016/j.gloenvcha.2006.04.002

Folke, C., Colding, J., & Berkes, F. (2002). Synthesis: Building resilience and adaptive capacity in social–ecological systems. In C. Folke, F. Berkes, & J. Colding (Eds.), Navigating Social-Ecological Systems: Building Resilience for Complexity and Change (pp. 352–387). Cambridge University Press. https://doi.org/10.1017/CBO9780511541957.020

Frawley, T. H., Crowder, L. B., & Broad, K. (2019). Heterogeneous Perceptions of Social-Ecological Change Among Small-Scale Fishermen in the Central Gulf of California: Implications for Adaptive Response. Frontiers in Marine Science, 6. https://www.frontiersin.org/article/10.3389/fmars.2019.00078

Frey, B. B. (2018). The SAGE Encyclopedia of Educational Research, Measurement, and Evaluation. 2455 Teller Road, Thousand Oaks, California 91320. SAGE Publications, Inc. https://doi.org/10.4135/9781506326139

Galappaththi, E. K., Ford, J. D., & Bennett, E. M. (2019). A framework for assessing community adaptation to climate change in a fisheries context. Environmental Science & Policy, 92, 17–26. https://doi.org/10.1016/j.envsci.2018.11.005

Galappaththi, E. K., Ford, J. D., Bennett, E. M., & Berkes, F. (2021). Adapting to climate change in small-scale fisheries: Insights from indigenous communities in the global north and south. Environmental Science & Policy, 116, 160–170. https://doi.org/10.1016/j.envsci.2020.11.009

Galappaththi, E. K., Susarla, V. B., Loutet, S. J. T., Ichien, S. T., Hyman, A. A., & Ford, J. D. (2022). Climate change adaptation in fisheries. Fish and Fisheries, 23(1), 4–21. https://doi.org/10.1111/faf.12595

Galaz, V., Österblom, H., Bodin, Ö., & Crona, B. (2016). Global networks and global change-induced tipping points. International Environmental Agreements: Politics, Law and Economics, 16(2), 189–221. https://doi.org/10.1007/s10784-014-9253-6

Galdas, P. (2017). Revisiting Bias in Qualitative Research: Reflections on Its Relationship With Funding and Impact. International Journal of Qualitative Methods, 16(1), 1609406917748992. https://doi.org/10.1177/1609406917748992

Gari, S. R., Newton, A., & Icely, J. D. (2015). A review of the application and evolution of the DPSIR framework with an emphasis on coastal social-ecological systems. Ocean & Coastal Management, 103, 63–77. https://doi.org/10.1016/j.ocecoaman.2014.11.013

Garmendia, E., Gamboa, G., Franco, J., Garmendia, J. M., Liria, P., & Olazabal, M. (2010). Social multi-criteria evaluation as a decision support tool for integrated coastal zone management. Ocean & Coastal Management, 53(7), 385–403. https://doi.org/10.1016/j.ocecoaman.2010.05.001

Gawne, B., Price, A., Koehn, J., King, A., Nielsen, D., Meredith, S., Beesley, L., & Vilizzi, L. (2012). A Bayesian belief network decision support tool for watering wetlands to maximise native fish outcomes. Wetlands, 32, 277–287. https://doi.org/10.1007/s13157-011-0255-7

Giupponi, C. (2007). Decision Support Systems for implementing the European Water Framework Directive: The MULINO approach. Environmental Modelling & Software, 22(2), 248–258. https://doi.org/10.1016/j.envsoft.2005.07.024

Glaeser, B. (2019). Sustainable Coastal Management for Social-Ecological Systems—A Typology Approach in Indonesia. In Coastal Management (pp. 61–77). Elsevier. https://doi.org/10.1016/B978-0-12-810473-6.00006-6

Green, J., & Thorogood, N. (2018). Qualitative methods for health research. sage.

Green, K. M., Selgrath, J. C., Frawley, T. H., Oestreich, W. K., Mansfield, E. J., Urteaga, J., Swanson, S. S., Santana, F. N., Green, S. J., Naggea, J., & Crowder, L. B. (2021). How adaptive capacity shapes the Adapt, React, Cope response to climate impacts: Insights from small-scale fisheries. Climatic Change, 164(1), 15. https://doi.org/10.1007/s10584-021-02965-w

Guillemot, N., Leopold, M., Cuif, M., & Chabanet, P. (2009). Characterization and management of informal fisheries confronted with socio-economic changes in New Caledonia (South Pacific). Fisheries Research, 98, 51–61. https://doi.org/10.1016/j.fishres.2009.03.013

Guillotreau, P., Bundy, A., & Perry, R. I. (2018). Global change in marine systems: Societal and governing responses (p. 329). Scopus. https://doi.org/10.4324/9781315163765

Guillotreau, P., Bundy, A., & Perry, R. I. (2018a). Introduction: Societal and governing responses to global change in marine systems. Global Change in Marine Systems: Societal and Governing Responses, 1–12. Scopus. https://doi.org/10.4324/9781315163765

Halim, A., Wiryawan, B., Loneragan, N. R., Hordyk, A., Sondita, M. F. A., White, A. T., Koeshendrajana, S., Ruchimat, T., Pomeroy, R. S., & Yuni, C. (2019). Developing a functional definition of small-scale fisheries in support of marine capture fisheries management in Indonesia. Marine Policy, 100, 238–248. https://doi.org/10.1016/j.marpol.2018.11.044

Hammar, L., Molander, S., Pålsson, J., Schmidtbauer Crona, J., Carneiro, G., Johansson, T., Hume, D., Kågesten, G., Mattsson, D., Törnqvist, O., Zillén, L., Mattsson, M., Bergström, U., Perry, D., Caldow, C., & Andersen, J. H. (2020). Cumulative impact assessment for ecosystem-based marine spatial planning. Science of The Total Environment, 734, 139024. https://doi.org/10.1016/j.scitotenv.2020.139024

Hanh, T. T. H., & Boonstra, W. J. (2018). Can income diversification resolve social-ecological traps in small-scale fisheries and aquaculture in the global south? A case study of response diversity in the Tam Giang lagoon, central Vietnam. Ecology and Society, 23(3). http://www.jstor.org/stable/26799139

Hansen, H. S. (2019). Cumulative Impact of Societal Activities on Marine Ecosystems and Their Services. In S. Misra, O. Gervasi, B. Murgante, E. Stankova, V. Korkhov, C. Torre, A. M. A. C. Rocha, D. Taniar, B. O. Apduhan, & E. Tarantino (Eds.), Computational Science and Its Applications – ICCSA 2019 (pp. 577–590). Springer International Publishing. https://doi.org/10.1007/978-3-030-24302-9_41

Hardy, P.-Y., Béné, C., Doyen, L., & Mills, D. (2017). Strengthening the resilience of small-scale fisheries: A modeling approach to explore the use of in-shore pelagic resources in Melanesia. Environmental Modelling & Software, 96, 291–304. https://doi.org/10.1016/j.envsoft.2017.06.001

Hazard, L., Cerf, M., Lamine, C., Magda, D., & Steyaert, P. (2020). A tool for reflecting on research stances to support sustainability transitions. Nature Sustainability, 3(2), 89–95.

Hill, R., Grant, C., George, M., Robinson, C. J., Jackson, S., & Abel, N. (2012). A Typology of Indigenous Engagement in Australian Environmental Management: Implications for Knowledge Integration and Social-ecological System Sustainability. Ecology and Society, 17(1). http://www.jstor.org/stable/26269005

Hölscher, K., Wittmayer, J. M., & Loorbach, D. (2018). Transition versus transformation: What's the difference? Environmental Innovation and Societal Transitions, 27, 1–3. https://doi.org/10.1016/j.eist.2017.10.007

Holloway, I., & Todres, L. (2003). The Status of Method: Flexibility, Consistency and Coherence. Qualitative Research, 3(3), 345–357. https://doi.org/10.1177/1468794103033004

Hsieh, H.-F., & Shannon, S. E. (2005). Three Approaches to Qualitative Content Analysis. Qualitative Health Research, 15(9), 1277–1288. https://doi.org/10.1177/1049732305276687

Husson, F., Le, S., & Pagès, J. (2017). Exploratory Multivariate Analysis by Example Using R.

Huynh, P. T. A., Le, N. D., Le, S. T. H., & Tran, T. N. (2021). Adaptive livelihood strategies among small-scale fishing households to climate change-related stressors in Central Coast Vietnam. International Journal of Climate Change Strategies and Management, 13(4/5), 492–510. https://doi.org/10.1108/IJCCSM-04-2020-0034

Huynh, P. T. A., Le, N. D., Le, S. T. H., & Tran, T. N. (2021). Adaptive livelihood strategies among small-scale fishing households to climate change-related stressors in Central Coast Vietnam.

International Journal of Climate Change Strategies and Management, 13(4/5), 492–510. https://doi.org/10.1108/IJCCSM-04-2020-0034

Intergovernmental Panel on Climate Change (IPCC), Annex II: glossary, in: K.J. Mach, S. Planton, C. von Stechow (Eds.), Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, IPPC, Geneva, Switzerland, 2014, pp. 117_130 [core writing team, R.K. Pachauri and L.A. Meyer, editors].

Islam, M. M., & Chuenpagdee, R. (2022). Towards a classification of vulnerability of small-scale fisheries. Environmental Science & Policy, 134, 1–12. https://doi.org/10.1016/j.envsci.2022.03.023

Jadhav, A. (2018). Undefining Small-Scale Fisheries in India: Challenging Simplifications and Highlighting Diversity and Value. In D. S. Johnson, T. G. Acott, N. Stacey, & J. Urquhart (Eds.), Social Wellbeing and the Values of Small-scale Fisheries (pp. 147–173). Springer International Publishing. https://doi.org/10.1007/978-3-319-60750-4_7

Janßen, H., Göke, C., & Luttmann, A. (2019). Knowledge integration in Marine Spatial Planning: A practitioners' view on decision support tools with special focus on Marxan. Ocean & Coastal Management, 168, 130–138. https://doi.org/10.1016/j.ocecoaman.2018.11.006

Janssen, P., Walther, C., & Lüdeke, M. K. B. (2012). Cluster Analysis to Understand Socio-Ecological Systems: A Guideline. http://www.pik-potsdam.de/research/publications/pikreports/summary-report-no.-126

Jarre, A., Paterson, B., Moloney, C. L., Miller, D. C. M., Field, J. G., & Starfield, A. M. (2008). Knowledge-based systems as decision support tools in an ecosystem approach to fisheries: Comparing a fuzzy-logic and a rule-based approach. Progress in Oceanography, 79(2), 390–400. https://doi.org/10.1016/j.pocean.2008.10.010

Jentoft, S., & Chuenpagdee, R. (2015). The 'New' Marine Governance: Assessing Governability. In Governing Europe's Marine Environment. Routledge.

Johnson, D. S. (2018). The Values of Small-Scale Fisheries. In D. S. Johnson, T. G. Acott, N. Stacey, & J. Urquhart (Eds.), Social Wellbeing and the Values of Small-scale Fisheries (pp. 1–21). Springer International Publishing. https://doi.org/10.1007/978-3-319-60750-4_1

Josse, J., & Holmes, S. (2016). Measuring multivariate association and beyond. Statistics Surveys, 10, 132. https://doi.org/10.1214/16-SS116

Josse, J., & Husson, F. (2016). missMDA: A Package for Handling Missing Values in Multivariate Data Analysis. Journal of Statistical Software, 70, 1–31. https://doi.org/10.18637/jss.v070.i01

Kassambara, A. (2017). Practical guide to principal component methods in R: PCA, M (CA), FAMD, MFA, HCPC, factoextra (Vol. 2). Sthda.

Kearney, J., Berkes, F., Charles, A., Pinkerton, E., & Wiber, M. (2007). The Role of Participatory Governance and Community-Based Management in Integrated Coastal and Ocean Management in Canada. Coastal Management, 35(1), 79–104. https://doi.org/10.1080/10.1080/08920750600970511

Kelly, P. M., & Adger, W. N. (2000). Theory and Practice in Assessing Vulnerability to Climate Change andFacilitating Adaptation. Climatic Change, 47(4), 325–352. https://doi.org/10.1023/A:1005627828199

Kittinger, J. N., Finkbeiner, E. M., Ban, N. C., Broad, K., Carr, M. H., Cinner, J. E., Gelcich, S., Cornwell, M. L., Koehn, J. Z., Basurto, X., Fujita, R., Caldwell, M. R., & Crowder, L. B. (2013). Emerging frontiers in social-ecological systems research for sustainability of small-scale fisheries. Current Opinion in Environmental Sustainability, 5(3), 352–357. https://doi.org/10.1016/j.cosust.2013.06.008

Koh, K.-Y., Ahmad, S., Lee, J., Suh, G.-H., & Lee, C.-M. (2022). Hierarchical Clustering on Principal Components Analysis to Detect Clusters of Highly Pathogenic Avian Influenza Subtype H5N6 Epidemic across South Korean Poultry Farms. Symmetry, 14(3), 598. https://doi.org/10.3390/sym14030598

Kolding, J., Béné, C., & Bavinck, M. (2014). Small-scale fisheries: Importance, vulnerability and deficient knowledge. Governance of Marine Fisheries and Biodiversity Conservation: Interaction and Co-Evolution, 317–331. https://doi.org/10.1002/9781118392607.ch22

Komul Kalidin, B., Mattone, C., & Sheaves, M. (2020). Barriers to effective monitoring and evaluation of small-scale fisheries in small island developing states: An example from Mauritius. Marine Policy, 118, 103845. https://doi.org/10.1016/j.marpol.2020.103845

Kooiman, J. (2003). Governing as Governance. Sage Publications.

Kooiman, J., Bavinck, M., Chuenpagdee, R., Mahon, R., & Pullin, R. (2008). Interactive governance and governability: An introduction. Journal of Transdisciplinary Environmental Studies, 7. https://dare.uva.nl/search?identifier=ced27a4a-5fa1-41c9-b34a-63576058307e

Kostov, B., Becue-Bertaut, M., & Husson, F. (2013). Multiple Factor Analysis for Contingency Tables in FactoMineR Package. R Journal, 5. https://doi.org/10.32614/RJ-2013-003

Kotzé, L. J. (2019). Earth System Law for the Anthropocene. Sustainability, 11(23), 6796. https://doi.org/10.3390/su11236796

Krawczyk, J. B., & Pharo, A. S. (2013). Viability theory: An applied mathematics tool for achieving dynamic systems' sustainability. Mathematica Applicanda, 41(1), 97–126. https://doi.org/10.14708/ma.v41i1.409

Krueck, N., Abdurrahim, A., Adhuri, D., Mumby, P., & Ross, H. (2019). Quantitative decision support tools facilitate social-ecological alignment in community-based marine protected area design. Ecology and Society, 24(4). https://doi.org/10.5751/ES-11209-240406

Kull, C. A., Kueffer, C., Richardson, D. M., Vaz, A. S., Vicente, J. R., & Honrado, J. P. (2018). Using the "regime shift" concept in addressing social–ecological change. Geographical Research, 56(1), 26–41. https://doi.org/10.1111/1745-5871.12267

Kura, Y. (2004). Fishing for Answers. https://www.wri.org/research/fishing-answers

Lade, S. J., Tavoni, A., Levin, S. A., & Schlüter, M. (2013). Regime shifts in a social-ecological system. Theoretical Ecology, 6(3), 359–372. https://doi.org/10.1007/s12080-013-0187-3

Lalloué, B., Monnez, J.-M., Padilla, C., Kihal, W., Zmirou-Navier, D., & Deguen, S. (2015). Data analysis techniques: A tool for cumulative exposure assessment. Journal of Exposure Science & Environmental Epidemiology, 25(2), 222–230. https://doi.org/10.1038/jes.2014.66

Larkin, P. A. (1996). Concepts and issues in marine ecosystem management. Reviews in Fish Biology and Fisheries, 6(2), 139–164. https://doi.org/10.1007/BF00182341

Lê, S., & Worch, T. (2018). Analyzing Sensory Data with R. New York. Chapman and Hall/CRC. https://doi.org/10.1201/9781315373416

Lê, S., Josse, J., & Husson, F. (2008). FactoMineR: An R Package for Multivariate Analysis. Journal of Statistical Software, 25, 1–18. https://doi.org/10.18637/jss.v025.i01

Lewison, R. L., Rudd, M. A., Al-Hayek, W., Baldwin, C., Beger, M., Lieske, S. N., Jones, C., Satumanatpan, S., Junchompoo, C., & Hines, E. (2016). How the DPSIR framework can be used for structuring problems and facilitating empirical research in coastal systems. Environmental Science & Policy, 56, 110–119. https://doi.org/10.1016/j.envsci.2015.11.001

Limuwa, M. M., Sitaula, B. K., Njaya, F., & Storebakken, T. (2018). Evaluation of Small-Scale Fishers' Perceptions on Climate Change and Their Coping Strategies: Insights from Lake Malawi. Climate, 6(2), 34. https://doi.org/10.3390/cli6020034

Lopes, R., & Videira, N. (2013). Valuing marine and coastal ecosystem services: An integrated participatory framework. Ocean & Coastal Management, 84, 153–162. https://doi.org/10.1016/j.ocecoaman.2013.08.001

Lukens, L., & Zhan, S. (2011). 4.12—Plant Bioinformatics and Microarray Technologies. In M. Moo-Young (Ed.), Comprehensive Biotechnology (Second Edition) (pp. 149–163). Academic Press. https://doi.org/10.1016/B978-0-08-088504-9.00253-1

Macher, C., Steins, N. A., Ballesteros, M., Kraan, M., Frangoudes, K., Bailly, D., Bertignac, M., Colloca, F., Fitzpatrick, M., Garcia, D., Little, R., Mardle, S., Murillas, A., Pawlowski, L., Philippe, M., Prellezo, R., Sabatella, E., Thébaud, O., & Ulrich, C. (2021). Towards transdisciplinary decision-support processes in fisheries: Experiences and recommendations from a multidisciplinary collective of researchers. Aquatic Living Resources, 34, 13. https://doi.org/10.1051/alr/2021010

Magliocca, N. R., Ellis, E. C., Allington, G. R. H., de Bremond, A., Dell'Angelo, J., Mertz, O., Messerli, P., Meyfroidt, P., Seppelt, R., & Verburg, P. H. (2018). Closing global knowledge gaps: Producing generalized knowledge from case studies of social-ecological systems. Global Environmental Change, 50, 1–14. https://doi.org/10.1016/j.gloenvcha.2018.03.003

March, A., & Failler, P. (2022). Small-scale fisheries development in Africa: Lessons learned and best practices for enhancing food security and livelihoods. Marine Policy, 136, 104925. https://doi.org/10.1016/j.marpol.2021.104925

Marín, A. (2019). Adaptive Capacity to Coastal Disasters: Challenges and Lessons from Small-Scale Fishing Communities in Central-Southern Chile. In S. Salas, M. J. Barragán-Paladines, & R. Chuenpagdee (Eds.), Viability and Sustainability of Small-Scale Fisheries in Latin America and The Caribbean (pp. 51–78). Springer International Publishing. https://doi.org/10.1007/978-3-319-76078-0_3

Marschke, M., & Berkes, F. (2006). Exploring Strategies that Build Livelihood Resilience: A Case from Cambodia. Ecology and Society, 11(1). https://doi.org/10.5751/ES-01730-110142

Martínez-Vázquez, R. M., Milán-García, J., & de Pablo Valenciano, J. (2021). Challenges of the Blue Economy: Evidence and research trends. Environmental Sciences Europe, 33(1), 61. https://doi.org/10.1186/s12302-021-00502-1

Mason, J. G., Eurich, J. G., Lau, J. D., Battista, W., Free, C. M., Mills, K. E., Tokunaga, K., Zhao, L. Z., Dickey-Collas, M., Valle, M., Pecl, G. T., Cinner, J. E., McClanahan, T. R., Allison, E. H., Friedman, W. R., Silva, C., Yáñez, E., Barbieri, M. Á., & Kleisner, K. M. (2022). Attributes of climate resilience in fisheries: From theory to practice. Fish and Fisheries, 23(3), 522–544. https://doi.org/10.1111/faf.12630

Mathias, J.-D., Anderies, J. M., Baggio, J., Hodbod, J., Huet, S., Janssen, M. A., Milkoreit, M., & Schoon, M. (2020). Exploring non-linear transition pathways in social-ecological systems. Scientific Reports, 10(1), 1–12. https://doi.org/10.1038/s41598-020-59713-w

Maunder, M. N. (2008). Maximum Sustainable Yield. In S. E. Jørgensen & B. D. Fath (Eds.), Encyclopedia of Ecology (pp. 2292–2296). Academic Press. https://doi.org/10.1016/B978-008045405-4.00522-X

Maynou, F., Recasens, L., & Lombarte, A. (2011). Fishing tactics dynamics of a Mediterranean small-scale coastal fishery. Aquatic Living Resources, 24(2), 149–159. https://doi.org/10.1051/alr/2011131

McClanahan, T. R., Castilla, J. C., White, A. T., & Defeo, O. (2009). Healing small-scale fisheries by facilitating complex socio-ecological systems. Reviews in Fish Biology and Fisheries, 19(1), 33–47. https://doi.org/10.1007/s11160-008-9088-8

McConney, P., Pereira Medeiros, R., Pascual-Fernández, J. J., & Pena, M. (2019). Stewardship and Sustainable Practices in Small-Scale Fisheries. In R. Chuenpagdee & S. Jentoft (Eds.), Transdisciplinarity for Small-Scale Fisheries Governance: Analysis and Practice (pp. 181–201). Springer International Publishing. https://doi.org/10.1007/978-3-319-94938-3_10

McGinnis, M. D., & Ostrom, E. (2014). Social-ecological system framework: Initial changes and continuing challenges. Ecology and Society, 19(2).

Menegon, S., Depellegrin, D., Farella, G., Sarretta, A., Venier, C., & Barbanti, A. (2018). Addressing cumulative effects, maritime conflicts and ecosystem services threats through MSP-oriented geospatial webtools. Ocean & Coastal Management, 163, 417–436. https://doi.org/10.1016/j.ocecoaman.2018.07.009

Milkoreit, M., Hodbod, J., Baggio, J., Benessaiah, K., Calderón-Contreras, R., Donges, J. F., Mathias, J.-D., Rocha, J. C., Schoon, M., & Werners, S. E. (2018). Defining tipping points for social-ecological systems scholarship—An interdisciplinary literature review. Environmental Research Letters, 13(3), 033005. https://doi.org/10.1088/1748-9326/aaaa75

Millennium ecosystem assessment, M. E. A. (2005). Ecosystems and human well-being (Vol. 5). Island press Washington, DC.

Mpomwenda, V., Tómasson, T., Pétursson, J. G., Taabu-Munyaho, A., Nakiyende, H., & Kristófersson, D. M. (2022). Adaptation Strategies to a Changing Resource Base: Case of the Gillnet Nile Perch Fishery on Lake Victoria in Uganda. Sustainability, 14(4), 2376. https://doi.org/10.3390/su14042376

Nayak, P. (2014). The Chilika Lagoon Social-Ecological System: An Historical Analysis. Ecology and Society, 19(1). https://doi.org/10.5751/ES-05978-190101

Nayak, P. K. (2017). Fisher communities in transition: Understanding change from a livelihood perspective in Chilika Lagoon, India. Maritime Studies, 16(1), 13. https://doi.org/10.1186/s40152-017-0067-3

Nayak, P. K. (2021). Vulnerability to Viability (V2V) Global Partnership for building strong small-scale fisheries communities. Inland Fisheries Society of India. http://epubs.icar.org.in/ejournal/index.php/JIFSI/article/view/109931

Nayak, P. K., & Berkes, F. (2010). Whose marginalisation? Politics around environmental injustices in India's Chilika lagoon. Local Environment, 15(6), 553–567. https://doi.org/10.1080/13549839.2010.487527

Nayak, P. K., & Berkes, F. (2014). Linking global drivers with local and regional change: A social-ecological system approach in Chilika Lagoon, Bay of Bengal. Regional Environmental Change, 14(6), 2067–2078. https://doi.org/10.1007/s10113-012-0369-3

Nayak, P. K., & Berkes, F. (2019). Interplay Between Local and Global: Change Processes and Small-Scale Fisheries. In R. Chuenpagdee & S. Jentoft (Eds.), Transdisciplinarity for Small-Scale Fisheries Governance: Analysis and Practice (pp. 203–220). Springer International Publishing. https://doi.org/10.1007/978-3-319-94938-3_11

Nayak, P. K., & Berkes, F. (2022). Evolutionary Perspectives on the Commons: A Model of Commonisation and Decommonisation. Sustainability, 14(7), 4300. https://doi.org/10.3390/su14074300

Nayak, P. K., Armitage, D., & Andrachuk, M. (2016). Power and politics of social–ecological regime shifts in the Chilika lagoon, India and Tam Giang lagoon, Vietnam. Regional Environmental Change, 16(2), 325–339. https://doi.org/10.1007/s10113-015-0775-4

Nayak, P. K., Dias, A. C. E., & Pradhan, S. K. (2020). Traditional Fishing Community and Sustainable Development. In W. Leal Filho, A. M. Azul, L. Brandli, A. Lange Salvia, & T. Wall

(Eds.), Life Below Water (pp. 1–18). Springer International Publishing. https://doi.org/10.1007/978-3-319-71064-8_88-1

Nayak, P., & Berkes, F. (2011). Commonisation and decommonisation: Understanding the processes of change in the Chilika Lagoon, India. Conservation and Society, 9, 132. https://doi.org/10.4103/0972-4923.83723

Neumann, B., Ott, K., & Kenchington, R. (2017). Strong sustainability in coastal areas: A conceptual interpretation of SDG 14. Sustainability Science, 12(6), 1019–1035. https://doi.org/10.1007/s11625-017-0472-y

Newton, A., & Elliott, M. (2016). A Typology of Stakeholders and Guidelines for Engagement in Transdisciplinary, Participatory Processes. Frontiers in Marine Science, 3. https://www.frontiersin.org/article/10.3389/fmars.2016.00230

Noman, M., Mohsin, M., Shah Bukhari, S., Hamid, Z., & Mehak, A. (2019). Small-scale fisheries: Overview, importance, vulnerabilities and management. Indian Journal of Geo-Marine Sciences, 48, 183–192.

Novaczek, I., Macfadyen, J., Bardati, D., & Maceachern, K. (2011). Social and Cultural Values Mapping as a decision-support tool for climate change adaptation.

Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic Analysis: Striving to Meet the Trustworthiness Criteria. International Journal of Qualitative Methods, 16(1), 1609406917733847. https://doi.org/10.1177/1609406917733847

Nygård, H., van Beest, F. M., Bergqvist, L., Carstensen, J., Gustafsson, B. G., Hasler, B., Schumacher, J., Schernewski, G., Sokolov, A., Zandersen, M., & Fleming, V. (2020). Decision-Support Tools Used in the Baltic Sea Area: Performance and End-User Preferences. Environmental Management, 66(6), 1024–1038. https://doi.org/10.1007/s00267-020-01356-8

Nygård, H., van Beest, F. M., Bergqvist, L., Carstensen, J., Gustafsson, B. G., Hasler, B., Schumacher, J., Schernewski, G., Sokolov, A., Zandersen, M., & Fleming, V. (2020). Decision-Support Tools Used in the Baltic Sea Area: Performance and End-User Preferences. Environmental Management, 66(6), 1024–1038. https://doi.org/10.1007/s00267-020-01356-8

Oestreich, W. K., Frawley, T. H., Mansfield, E. J., Green, K. M., Green, S. J., Naggea, J., Selgrath, J. C., Swanson, S. S., Urteaga, J., White, T. D., & Crowder, L. B. (2019). Chapter 26 - The impact of environmental change on small-scale fishing communities: Moving beyond adaptive capacity to community response. In A. M. Cisneros-Montemayor, W. W. L. Cheung, & Y. Ota (Eds.), Predicting Future Oceans (pp. 271–282). Elsevier. https://doi.org/10.1016/B978-0-12-817945-1.00027-7

Okafor-Yarwood, I., Kadagi, N. I., Belhabib, D., & Allison, E. H. (2022). Survival of the Richest, not the Fittest: How attempts to improve governance impact African small-scale marine fisheries. Marine Policy, 135, 104847. https://doi.org/10.1016/j.marpol.2021.104847

Olsson, P., Gunderson, L., Carpenter, S., Ryan, P., Lebel, L., Folke, C., & Holling, C. S. (2006). Shooting the Rapids: Navigating Transitions to Adaptive Governance of Social-Ecological Systems. Ecology and Society, 11(1). https://doi.org/10.5751/ES-01595-110118

Ommer, R., & Neis, B. (2014). Introduction to the Special Feature on rebuilding fisheries and threatened communities. Ecology and Society, 19(3). https://doi.org/10.5751/ES-06960-190349

Ostrom, E. (2009). A General Framework for Analyzing Sustainability of Social-Ecological Systems. Science, 325(5939), 419–422. https://doi.org/10.1126/science.1172133

Owen, L. A., Pickering, K. T., & Pickering, K. T. (2006). An introduction to global environmental issues. Routledge.

Pagès, J. (2014). Multiple Factor Analysis by Example Using R. CRC Press.

Palomares, M.-L. D., & Pauly, D. (2019). Chapter 32 - Coastal Fisheries: The Past, Present, and Possible Futures. In E. Wolanski, J. W. Day, M. Elliott, & R. Ramachandran (Eds.), Coasts and Estuaries (pp. 569–576). Elsevier. https://doi.org/10.1016/B978-0-12-814003-1.00032-0

Pamungkas, D. (2018). Social Networks Among Small-Scale Fishermen in Cilincing As a Strategy to Dealing With Uncertainty in Finding Fish Resources. KOMUNITAS: International Journal of Indonesian Society and Culture, 10(1), 34–43. https://doi.org/10.15294/komunitas.v10i1.12643

Parrott, L., Chion, C., Martins, C. C. A., Lamontagne, P., Turgeon, S., Landry, J. A., Zhens, B., Marceau, D. J., Michaud, R., Cantin, G., Ménard, N., & Dionne, S. (2011). A decision support system to assist the sustainable management of navigation activities in the St. Lawrence River Estuary, Canada. Environmental Modelling & Software, 26(12), 1403–1418. https://doi.org/10.1016/j.envsoft.2011.08.009

Pascoe, S., Brooks, K., Cannard, T., Dichmont, C. M., Jebreen, E., Schirmer, J., & Triantafillos, L. (2014). Social objectives of fisheries management: What are managers' priorities? Ocean & Coastal Management, 98, 1–10. https://doi.org/10.1016/j.ocecoaman.2014.05.014

Paterson, B., & Charles, A. (2019). Community-based responses to climate hazards: Typology and global analysis. Climatic Change, 152(3), 327–343. https://doi.org/10.1007/s10584-018-2345-5

Paterson, B., Isaacs, M., Hara, M., Jarre, A., & Moloney, C. L. (2010). Transdisciplinary co-operation for an ecosystem approach to fisheries: A case study from the South African sardine fishery. Marine Policy, 34(4), 782–794. https://doi.org/10.1016/j.marpol.2010.01.019

Patrício, J., Elliott, M., Mazik, K., Papadopoulou, K.-N., & Smith, C. J. (2016). DPSIR—Two Decades of Trying to Develop a Unifying Framework for Marine Environmental Management? Frontiers in Marine Science, 3. https://www.frontiersin.org/articles/10.3389/fmars.2016.00177

Pearson, K. (1902). Mathematical Contributions to the Theory of Evolution.—On Homotyposis in Homologous but Differentiated Organs. Proceedings of the Royal Society of London, 71, 288–313.

Peterson, D. P., Wenger, S. J., Rieman, B. E., & Isaak, D. J. (2013). Linking climate change and fish conservation efforts using spatially explicit decision support tools. Fisheries. 38(3): 112-127 + 58 Pages of Appendices., 112–127.

Pezoulas, V. C., Exarchos, T. P., & Fotiadis, D. I. (2020). Chapter 7—Machine learning and data analytics. In V. C. Pezoulas, T. P. Exarchos, & D. I. Fotiadis (Eds.), Medical Data Sharing, Harmonization and Analytics (pp. 227–309). Academic Press. https://doi.org/10.1016/B978-0-12-816507-2.00007-4

Pimentel, D., Westra, L., & Noss, R. F. (2013). Ecological Integrity: Integrating Environment, Conservation, and Health. Island Press.

Pınarbaşı, K., Galparsoro, I., Borja, Á., Stelzenmüller, V., Ehler, C. N., & Gimpel, A. (2017). Decision support tools in marine spatial planning: Present applications, gaps and future perspectives. Marine Policy, 83, 83–91. https://doi.org/10.1016/j.marpol.2017.05.031

Pita, C., Villasante, S., & Pascual-Fernández, J. J. (2019). Managing small-scale fisheries under data poor scenarios: Lessons from around the world. Marine Policy, 101, 154–157. https://doi.org/10.1016/j.marpol.2019.02.008

Poloczanska, E. S., Smith, S., Fauconnet, L., Healy, J., Tibbetts, I. R., Burrows, M. T., & Richardson, A. J. (2011). Little change in the distribution of rocky shore faunal communities on the Australian east coast after 50years of rapid warming. Journal of Experimental Marine Biology and Ecology, 400(1), 145–154. https://doi.org/10.1016/j.jembe.2011.02.018

Pomeroy, R. S. (2012). Managing overcapacity in small-scale fisheries in Southeast Asia. Marine Policy, 36(2), 520–527. https://doi.org/10.1016/j.marpol.2011.10.002

Pomeroy, R. S., & Andrew, N. (2011). Small-scale Fisheries Management: Frameworks and Approaches for the Developing World. CABI.

Pörtner, H. O., Roberts, D. C., Adams, H., Adler, C., Aldunce, P., Ali, E., Begum, R. A., Betts, R., Kerr, R. B., Biesbroek, R., Birkmann, J., Bowen, K., Castellanos, E., Cissé, G., Constable, A., Cramer, W., Dodman, D., Eriksen, S. H., Fischlin, A., … Ibrahim, Z. Z. (2022). Climate change 2022: Impacts, adaptation and vulnerability. https://research.wur.nl/en/publications/climate-change-2022-impacts-adaptation-and-vulnerability

Powers, B. A., & Knapp, T. R. (2010). Dictionary of Nursing Theory and Research: Fourth Edition. Springer Publishing Company.

Purcell, S. W., & Pomeroy, R. S. (2015). Driving small-scale fisheries in developing countries. Frontiers in Marine Science, 2. https://www.frontiersin.org/article/10.3389/fmars.2015.00044

Purcell, S. W., Lovatelli, A., & Pakoa, K. (2014). Constraints and solutions for managing Pacific Island sea cucumber fisheries with an ecosystem approach. Marine Policy, 45, 240–250. https://doi.org/10.1016/j.marpol.2013.11.005

Purcell, S. W., Mercier, A., Conand, C., Hamel, J.-F., Toral-Granda, M. V., Lovatelli, A., & Uthicke, S. (2013). Sea cucumber fisheries: Global analysis of stocks, management measures and drivers of overfishing. Fish and Fisheries, 14(1), 34–59. https://doi.org/10.1111/j.1467-2979.2011.00443.x

Putten, I. van, Breckwoldt, A., Bundy, A., Guillotreau, P., Nayak, P. K., Österblom, H., & Perry, R. I. (2018). Conclusion: Lessons from global change responses to advance governance and sustainable use of marine systems. In Global Change in Marine Systems. Routledge.

QSR International. (2022). How are cluster analysis diagrams generated? http://help-nv.qsrinternational.com/12/win/v12.1.98-d3ea61/Content/vizualizations/how-cluster-analysis-generated.htm

Refulio-Coronado, S., Lacasse, K., Dalton, T., Humphries, A., Basu, S., Uchida, H., & Uchida, E. (2021). Coastal and Marine Socio-Ecological Systems: A Systematic Review of the Literature. Frontiers in Marine Science, 8. https://www.frontiersin.org/article/10.3389/fmars.2021.648006

Reyers, B., Moore, M.-L., Haider, L. J., & Schlüter, M. (2022). The contributions of resilience to reshaping sustainable development. Nature Sustainability, 1–8. https://doi.org/10.1038/s41893-022-00889-6

Richardson, J. T. E. (2011). Eta squared and partial eta squared as measures of effect size in educational research. Educational Research Review, 6(2), 135–147. https://doi.org/10.1016/j.edurev.2010.12.001

Richmond, L., & Casali, L. (2022). The role of social capital in fishing community sustainability: Spiraling down and up in a rural California port. Marine Policy, 137, 104934. https://doi.org/10.1016/j.marpol.2021.104934

Robert, P., & Escoufier, Y. (1976). A Unifying Tool for Linear Multivariate Statistical Methods: The RV- Coefficient. Journal of the Royal Statistical Society. Series C (Applied Statistics), 25(3), 257–265. https://doi.org/10.2307/2347233

Roscher, M. B., Eriksson, H., Harohau, D., Mauli, S., Kaltavara, J., Boonstra, W. J., & van der Ploeg, J. (2022). Unpacking pathways to diversified livelihoods from projects in Pacific Island coastal fisheries. Ambio. https://doi.org/10.1007/s13280-022-01727-x

Rousseau, R., Egghe, L., & Guns, R. (2018). Chapter 4—Statistics. In R. Rousseau, L. Egghe, & R. Guns (Eds.), Becoming Metric-Wise (pp. 67–97). Chandos Publishing. https://doi.org/10.1016/B978-0-08-102474-4.00004-2

Ruiz-Díaz, R., Liu, X., Aguión, A., Macho, G., deCastro, M., Gómez-Gesteira, M., & Ojea, E. (2020). Social-ecological vulnerability to climate change in small-scale fisheries managed under spatial property rights systems. Marine Policy, 121, 104192. https://doi.org/10.1016/j.marpol.2020.104192

Said, A., Pascual-Fernández, J., Amorim, V. I., Autzen, M. H., Hegland, T. J., Pita, C., Ferretti, J., & Penca, J. (2020). Small-scale fisheries access to fishing opportunities in the European Union: Is the

Common Fisheries Policy the right step to SDG14b? Marine Policy, 118, 104009. https://doi.org/10.1016/j.marpol.2020.104009

Salas, S., Chuenpagdee, R., & Barragán-Paladines, M. J. (2019). Drivers and Prospects for the Sustainability and Viability of Small-Scale Fisheries in Latin America and the Caribbean. In S. Salas, M. J. Barragán-Paladines, & R. Chuenpagdee (Eds.), Viability and Sustainability of Small-Scale Fisheries in Latin America and The Caribbean (pp. 543–559). Springer International Publishing. https://doi.org/10.1007/978-3-319-76078-0_23

Salgueiro-Otero, D., & Ojea, E. (2020). A better understanding of social-ecological systems is needed for adapting fisheries to climate change. Marine Policy, 122, 104123. https://doi.org/10.1016/j.marpol.2020.104123

Savit, R., Riolo, M., & Riolo, R. (2013). Co-Adaptation and the Emergence of Structure. PLOS ONE, 8(9), e71828. https://doi.org/10.1371/journal.pone.0071828

Schemmel, E. M., & Friedlander, A. M. (2017). Participatory fishery monitoring is successful for understanding the reproductive biology needed for local fisheries management. Environmental Biology of Fishes, 100(2), 171–185. https://doi.org/10.1007/s10641-016-0566-x

Schober, P., Boer, C., & Schwarte, L. A. (2018). Correlation Coefficients: Appropriate Use and Interpretation. Anesthesia & Analgesia, 126(5), 1763–1768. https://doi.org/10.1213/ANE.0000000000002864

Schlüter, M., Lindkvist, E., & Basurto, X. (2021). The interplay between top-down interventions and bottom-up self-organization shapes opportunities for transforming self-governance in small-scale fisheries. Marine Policy, 128, 104485. https://doi.org/10.1016/j.marpol.2021.104485

Schreiber, M., Niquen, M., & Bouchon, M. (2011). Coping Strategies to Deal with Environmental Variability and Extreme Climatic Events in the Peruvian Anchovy Fishery. Sustainability, 3, 823–846. https://doi.org/10.3390/su3060823

Schuhbauer, A., & Sumaila, U. (2016). Economic viability and small-scale fisheries—A review. Ecological Economics, 124(C), 69–75.

Schuhbauer, A., Cisneros-Montemayor, A., Chuenpagdee, R., & Sumaila, U. (2019). Assessing the economic viability of small-scale fisheries: An example from Mexico. Marine Ecology Progress Series, 617. https://doi.org/10.3354/meps12942

Seddon, N., Chausson, A., Berry, P., Girardin, C. A. J., Smith, A., & Turner, B. (2020). Understanding the value and limits of nature-based solutions to climate change and other global challenges. Philosophical Transactions of the Royal Society B: Biological Sciences, 375(1794), 20190120. https://doi.org/10.1098/rstb.2019.0120

Selig, E. R., Hole, D. G., Allison, E. H., Arkema, K. K., McKinnon, M. C., Chu, J., Sherbinin, A. de, Fisher, B., Glew, L., Holland, M. B., Ingram, J. C., Rao, N. S., Russell, R. B., Srebotnjak, T., Teh, L.

C. L., Troëng, S., Turner, W. R., & Zvoleff, A. (2019). Mapping global human dependence on marine ecosystems. Conservation Letters, 12(2), e12617. https://doi.org/10.1111/conl.12617

Selig, E. R., Kleisner, K. M., Ahoobim, O., Arocha, F., Cruz-Trinidad, A., Fujita, R., Hara, M., Katz, L., McConney, P., Ratner, B. D., Saavedra-Díaz, L. M., Schwarz, A.-M., Thiao, D., Torell, E., Troëng, S., & Villasante, S. (2017). A typology of fisheries management tools: Using experience to catalyse greater success. Fish and Fisheries, 18(3), 543–570. https://doi.org/10.1111/faf.12192

Sguotti, C., & Cormon, X. (2018). Regime Shifts – A Global Challenge for the Sustainable Use of Our Marine Resources. In S. Jungblut, V. Liebich, & M. Bode (Eds.), YOUMARES 8 – Oceans Across Boundaries: Learning from each other (pp. 155–166). Springer International Publishing. https://doi.org/10.1007/978-3-319-93284-2_11

Sharma, C. (2011). Securing economic, social and cultural rights of small-scale and artisanal fisherworkers and fishing communities. 21.

Silas, M. O., Mgeleka, S. S., Polte, P., Sköld, M., Lindborg, R., de la Torre-Castro, M., & Gullström, M. (2020). Adaptive capacity and coping strategies of small-scale coastal fisheries to declining fish catches: Insights from Tanzanian communities. Environmental Science & Policy, 108, 67–76. https://doi.org/10.1016/j.envsci.2020.03.012

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. Global Environmental Change, 16(3), 282–292. https://doi.org/10.1016/j.gloenvcha.2006.03.008

Smith, H., & Basurto, X. (2019). Defining Small-Scale Fisheries and Examining the Role of Science in Shaping Perceptions of Who and What Counts: A Systematic Review. Frontiers in Marine Science, 6. https://www.frontiersin.org/article/10.3389/fmars.2019.00236

Smith, S. L., Pollnac, R. B., Colburn, L. L., & Olson, J. (2011). Classification of Coastal Communities Reporting Commercial Fish Landings in the U.S. Northeast Region: Developing and Testing a Methodology. Http://Aquaticcommons.Org/Id/Eprint/9664. https://aquadocs.org/handle/1834/26272

Sowman, M. (2020). Participatory and rapid vulnerability assessments to support adaptation planning in small-scale fishing communities of the Benguela Current Large Marine Ecosystem. Environmental Development, 36, 100578. https://doi.org/10.1016/j.envdev.2020.100578

Sparker, A., & Holloway, I. (2005). Qualitative research in health care. Ed. Holloway, Immy. McGraw-Hill Education: Berkshire.

Stanners, D., & Bourdeau, P. (1995). Europes environment: The Dobris assessment.

Stern, P. C. (1993). A Second Environmental Science: Human-Environment Interactions. Science. https://doi.org/10.1126/science.260.5116.1897

Stott, P. A., Christidis, N., Otto, F. E. L., Sun, Y., Vanderlinden, J.-P., van Oldenborgh, G. J., Vautard, R., von Storch, H., Walton, P., Yiou, P., & Zwiers, F. W. (2016). Attribution of extreme

weather and climate-related events. Wiley Interdisciplinary Reviews. Climate Change, 7(1), 23–41. https://doi.org/10.1002/wcc.380

Sundler, A. J., Lindberg, E., Nilsson, C., & Palmér, L. (2019). Qualitative thematic analysis based on descriptive phenomenology. Nursing Open, 6(3), 733–739. https://doi.org/10.1002/nop2.275

Susilo, E., Purwanti, P., Fattah, M., Qurrata, V. A., & Narmaditya, B. S. (2021). Adaptive coping strategies towards seasonal change impacts: Indonesian small-scale fisherman household. Heliyon, 7(4), e06919. https://doi.org/10.1016/j.heliyon.2021.e06919

Teh, L. C. L., & Pauly, D. (2018). Who Brings in the Fish? The Relative Contribution of Small-Scale and Industrial Fisheries to Food Security in Southeast Asia. Frontiers in Marine Science, 5. https://www.frontiersin.org/article/10.3389/fmars.2018.00044

Teh, L. C. L., & Sumaila, U. R. (2013). Contribution of marine fisheries to worldwide employment. Fish and Fisheries, 14(1), 77–88. https://doi.org/10.1111/j.1467-2979.2011.00450.x

Thurstan, R. H. (2022). The potential of historical ecology to aid understanding of human–ocean interactions throughout the Anthropocene. Journal of Fish Biology, n/a(n/a). https://doi.org/10.1111/jfb.15000

Tress, G., Tress, B., & Fry, G. (2005). Clarifying Integrative Research Concepts in Landscape Ecology. Landscape Ecology, 20(4), 479–493. https://doi.org/10.1007/s10980-004-3290-4

Tscherning, K., Helming, K., Krippner, B., Sieber, S., & Paloma, S. G. y. (2012). Does research applying the DPSIR framework support decision making? Land Use Policy, 29(1), 102–110. https://doi.org/10.1016/j.landusepol.2011.05.009

Tuffour, I. (2017). A critical overview of interpretative phenomenological analysis: A contemporary qualitative research approach. Journal of Healthcare Communications, 2(4), 52.

Tuler, S. P., Webler, T., & Polsky, C. (2013). A rapid impact and vulnerability assessment approach for commercial fisheries management. Ocean & Coastal Management, 71, 131–140. https://doi.org/10.1016/j.ocecoaman.2012.09.013

Turner II, B. L., Kasperson, R. E., Meyer, W. B., Dow, K. M., Golding, D., Kasperson, J. X., Mitchell, R. C., & Ratick, S. J. (1990). Two types of global environmental change: Definitional and spatial-scale issues in their human dimensions. Global Environmental Change, 1(1), 14–22.

Tzanatos, E., Dimitriou, E., Katselis, G., Georgiadis, M., & Koutsikopoulos, C. (2005). Composition, temporal dynamics and regional characteristics of small-scale fisheries in Greece. Fisheries Research, 73(1), 147–158. https://doi.org/10.1016/j.fishres.2004.12.006

Tzanatos, E., Georgiadis, M., & Peristeraki, P. (2020). Small-Scale Fisheries in Greece: Status, Problems, and Management. In J. J. Pascual-Fernández, C. Pita, & M. Bavinck (Eds.), Small-Scale Fisheries in Europe: Status, Resilience and Governance (pp. 125–150). Springer International Publishing. https://doi.org/10.1007/978-3-030-37371-9_7

Vaismoradi, M., Turunen, H., & Bondas, T. (2013). Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. Nursing & Health Sciences, 15(3), 398–405. https://doi.org/10.1111/nhs.12048

VanWey, L. K., Ostrom, E., & Meretsky, V. (2005). Theories underlying the study of human-environment interactions. Seeing the Forest and the Trees: Human-Environment Interactions in Forest Ecosystems, 23–56.

VanWey, L. K., Ostrom, E., & Meretsky, V. (2005). Theories underlying the study of human-environment interactions. Seeing the Forest and the Trees: Human-Environment Interactions in Forest Ecosystems, 23–56.

Visbal-Cadavid, D., Martínez-Gómez, M., & Escorcia-Caballero, R. (2020). Exploring University Performance through Multiple Factor Analysis: A Case Study. Sustainability, 12(3), 924. https://doi.org/10.3390/su12030924

Vos, A. de, Maciejewski, K., Bodin, Ö., Norström, A., Schlüter, M., & Tengö, M. (2021). The practice and design of social-ecological systems research. In The Routledge Handbook of Research Methods for Social-Ecological Systems. Routledge.

Walshe, T., Dempster, F., Pascoe, S., and Jennings. S. (2019). Review of decision support tools and their potential application in the management of Australian Marine Parks. Report to the National Environmental Science Program, Marine Biodiversity Hub. Australian Institute of Marine Science.

Weeratunge, N., Béné, C., Siriwardane, R., Charles, A., Johnson, D., Allison, E. H., Nayak, P. K., & Badjeck, M.-C. (2014). Small-scale fisheries through the wellbeing lens. Fish and Fisheries, 15(2), 255–279. https://doi.org/10.1111/faf.12016

Weiand, L., Schmitz, S., Becker, S., Niehoff, N., Schwartzbach, F., & Schneidemesser, E. von. (2019). Climate change and air pollution: The connection between traffic intervention policies and public acceptance in a local context. Environmental Research Letters, 14(8), 085008. https://doi.org/10.1088/1748-9326/ab299b

Werners, S. E., Wise, R. M., Butler, J. R. A., Totin, E., & Vincent, K. (2021). Adaptation pathways: A review of approaches and a learning framework. Environmental Science & Policy, 116, 266–275. https://doi.org/10.1016/j.envsci.2020.11.003

White, S. B., & Scheld, A. M. (2022). Characterizing Changes in Participation and Diversification in Small-Scale Fisheries of Virginia, USA. Coastal Management, 50(1), 3–28. https://doi.org/10.1080/08920753.2022.2006874

Wise, R. M., Fazey, I., Stafford Smith, M., Park, S. E., Eakin, H. C., Archer Van Garderen, E. R. M., & Campbell, B. (2014). Reconceptualising adaptation to climate change as part of pathways of change and response. Global Environmental Change, 28, 325–336. https://doi.org/10.1016/j.gloenvcha.2013.12.002

Woodall, L. C., Talma, S., Steeds, O., Stefanoudis, P., Jeremie-Muzungaile, M.-M., & de Comarmond, A. (2021). Co-development, co-production and co-dissemination of scientific research:

A case study to demonstrate mutual benefits. Biology Letters, 17(4), 20200699. https://doi.org/10.1098/rsbl.2020.0699

Yajie, L., Zhengdong, L., & Maonan, W. (2017). Visualization Investigation on the Marine Data with Multivariate Statistical Analysis Methods. Polish Maritime Research, 24(s2), 89–94. https://doi.org/10.1515/pomr-2017-0069

Yin, R. K. (2009). Case study research: Design and methods (Vol. 5). sage.

Young, O. R. (2002). The Institutional Dimensions of Environmental Change: Fit, Interplay, and Scale. MIT Press.

Zeller, D., & Pauly, D. (2019). Viewpoint: Back to the future for fisheries, where will we choose to go? Global Sustainability, 2. https://doi.org/10.1017/sus.2019.8

Zhang, Z., Murtagh, F., Van Poucke, S., Lin, S., & Lan, P. (2017). Hierarchical cluster analysis in clinical research with heterogeneous study population: Highlighting its visualization with R. Annals of Translational Medicine, 5(4).

Zolfaghari, F., Khosravi, H., Shahriyari, A., Jabbari, M., & Abolhasani, A. (2019). Hierarchical cluster analysis to identify the homogeneous desertification management units. PLOS ONE, 14(12), e0226355. https://doi.org/10.1371/journal.pone.0226355

Appendices

Appendix A

Related definitions and key concepts
SSF communities: SSF communities refer to the group of fishers (usually smaller) who have been physically, socially-ecologically, culturally, and historically connected to the oceans (Armitage et al., 2017) over the years as primary resource users and who depend, operate on the ocean for their survival and livelihood. The large-scale industrial fisheries are not considered as SSF communities because they are rarely tied to a community (Berkes & Nayak, 2018).
Driver in the context of social-ecological change: "A driver is any natural or human-induced factor that directly or indirectly causes a change in an ecosystem. A direct driver unequivocally influences ecosystem processes. An indirect driver operates more diffusely, by altering one or more direct drivers" (Millennium ecosystem assessment, 2005).
Vulnerability to climate change: "Vulnerability is defined as the characteristic of a system and as a function of exposure, sensitivity and adaptive capacity" (Adger, 2006). It is also understood in terms "of the ability or inability of individuals and social groupings to respond to, in the sense of cope with, recover from or adapt to, any external stress placed on their livelihoods and well-being" (Kelly & Adger, 2000). In a broad context, "Vulnerability is a socially constructed phenomenon influenced by institutional and economic dynamics" (Adger et al., 2003).
Adaptation in the context of global change: "Adaptation refers to a process, action or outcome in a system (household, community, group, sector, region, country) for the system to better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity" (Smit & Wandel, 2006).
The adaptive capacity of SSF communities: Adaptive capacity of the SSF communities refers to the ability to adapt to social-ecological changes. In the context of the global change "adaptive capacity is a critical system property, for it describes the ability to mobilize scarce resources to anticipate or respond to perceived or current stresses" (Engle, 2011).
Coping response: Immediate response to abrupt challenges to reduce the effect of the global change stressors (Schreiber et al., 2011). Coping responses are the temporary responses followed

at the individual, household and community level which helps to develop the adaptive capacity of the SSF communities. Coping responses become adaptive responses if they are followed for long time to develop the resilience (Marschke & Berkes, 2006).
Ecosystem based management: "An ecosystem approach to management is management that is adaptive, specified geographically, takes into account ecosystem knowledge and uncertainties, considers multiple external influences, and strives to balance diverse social objectives" (Burgess et al., 2005). Ecosystem based management approach falls within nature-based solution concept which incorporates "wide range of actions, such as the protection and management of natural and semi-natural ecosystems, the incorporation of green and blue infrastructure in urban areas, and the application of ecosystem-based principles to natural systems" (Seddon et al., 2020).
Governance: "Governance refers to the processes (e.g., decision making, planning, political alliances) and institutions (e.g., rules, rule- making, rights, practices) through which societies make decisions" (Armitage et al., 2021).
Common-pool resources: "Defined as those resources in which exclusion of beneficiaries through physical and institutional means is especially costly, and exploitation by one user reduces resource availability for others" (Adapted from: Nayak & Berkes, 2022)
Excludability: "Defined as the difficulty of excluding potential users through physical and institutional means. It pertains to the question of who is and who is not a legitimate user of a resource" (Adapted from: Nayak & Berkes, 2022)
Subtractability: "Defined as the idea that exploitation by one user reduces resource availability for others, and deals with the rules of resource distribution and allocation among users" (Adapted from: Nayak & Berkes, 2022)
Evidenced based management approach: "Defined as the approach where indigenous, local and scientific knowledge systems are viewed together to generate new knowledge" (Berkes, 2021).
Community-based management (CBM): "CBM is the widespread form of participatory type of governance applied to SSF management problems which involves fisheries communities in the design, implementation and monitoring of the management measures" (Kearney et al., 2007)
Participatory governance: "Refers to the effort to achieve change through actions that are more effective and equitable than normally possible through representative government and bureaucratic administration by inviting citizens to a deep and sustained participation in decision

making. Participatory governance focuses on tangible problems, involves all the people affected by those problems, and comes up with practical solutions" (Kearney et al., 2007).
Multi-disciplinarity in SSF research: 'Refers to research efforts of different disciplines carried out towards a shared goal for the SSF sustainability but with multiple disciplinary objectives and without integration between the disciplines' (Tress et al., 2005; Macher et al., 2021).
Inter-disciplinarity in SSF research: 'Refers to research efforts crossing boundaries to integrate different academic disciplines and create new knowledge and theory towards a common goal for the SSF sustainability' (Tress et al., 2005; Macher et al., 2021).
Trans-disciplinarity in SSF research: 'Refers to integration of academic and non-academic knowledge (local fishers and professional scientists knowledge) to create new knowledge and theory towards a common goal for the SSF sustainability' (Tress et al., 2005; Macher et al., 2021).
Common-pool resource theory: Common-pool resource (CPR) theory explains that the fisheries communities (resource users) are self-sufficient in sustainably managing marine resources which they depend on for their survival and existence such as fish, mangroves, and coral reefs (Ostrom, 1990). Several past studies support this hypothesis by Ostrom (1990) (e.g., Basurto, 2008; Cox et al., 2010). The self-organizing capability of the social-ecological system highly depends on social-ecological factors including institutional factors (Nenadovic & Epstein, 2016). However, social-ecological system properties of the fisheries commons such as cross-scale dynamics and feedback, self-organization, numerous domains of attraction, emergence, uncertainty, and change (Berkes et al. 2003) make it challenging to shape commons governance (Nenadovic & Epstein, 2016).
Co-management and co-governance: Co-management is defined as "a management partnership in which the SSF communities and other stakeholders share power and responsibility with the government agencies – it becomes adaptive co-management if there is social learning involved" (Berkes, 2021). Co-management has different faces such as co-management as power-sharing, co-management as governance, co-management as institution building, co-management as problem-solving, co-management as a process, and co-management as knowledge innovation (Berkes, 2021). Jentoft & Chuenpagdee, (2015) mentioned that "co-governance is synonymous with co-management" where the term 'management' involves institutional factors. Co-governance enables better stakeholder participation, power-sharing, and democracy and also

enhances the governability of issues in fisheries (Jentoft & Chuenpagdee, 2015a).
Social learning: is defined as a self-organized learning process "of iterative reflection that occurs when experiences and ideas are shared with others" (Berkes, 2021).
Adaptive governance: is mostly related to untangling the self-organizing capability of the SSF SES and building resilience mainly through the adaptation measures suitable for all the principal actors of the society (Serrao-Neumann et al., 2016). Self-organizing characteristics of SSF SES lead to uncertainty in decision-making that grows with time (Folke et al., 2005), in this context, the adaptative co-governance approach provides an opportunity for the stakeholders to learn, adjust and adapt themselves to the change.
Adaptive co-governance: follows the basic logic of adaptative management (Pomeroy & Andrew, 2011) and collaborative environmental governance (Bodin, 2017). However, it is distinguished by its focus on decision-making and power-sharing in the broader social context (Karpouzoglou et al., 2016), which involves horizontal and vertical linkages for learning-by-doing (Armitage et al., 2010). Building networks, participation, collaborations, and partnerships (Armitage et al., 2010) are the core features informed by adaptive co-governance allowing societal actors to engage in cross-scale interactions and multi-level engagements.

CASE STUDY TEMPLATE FOR I-ADApT

Integrated Marine Biogeochemistry and Ecosystem Research

www.imber.info

Appendix B

The purpose of this case study template is to collect case studies to develop a decision support tool to enable managers, researchers and local stakeholders to: (1) make decisions efficiently, (2) improve their response and (3) evaluate where to most effectively allocate resources to "reduce" vulnerability and enhance the capacity of coastal peoples to adapt to global change. This decision tool, I(MBER)-ADApT (Assessment based on Description and responses and Appraisal for a Typology), will build on knowledge learned from existing marine case studies, where some action was taken to counteract the environmental, social or other impacts of global change. The case studies should take into account the highly interconnected natural and human systems of today. Here we explicitly ask what can be learned from existing responses that were taken to global change generally and how this information can be used to decide how best to respond to current and future global change. Thus, the information that you will provide is key to the development of this decision support tool.

I-ADApT has been developed by the Human Dimensions Working Group of IMBER (Integrated Marine Biogeochemistry and Ecosystem Research project, www.imber.info). I-ADApT has the capacity to be applied to a wide range of global change issues in the terrestrial and marine realms, but our current focus is on marine social and ecological systems related to fisheries and aquaculture with respect to global change. By taking a broad perspective on human-ocean interactions, from biogeochemistry to governance, and recognising the interconnections and feedbacks, we address the complex nature of both the marine ecosystems and of the human interactions. As marine ecosystems are subjected to a

complex set of natural, social and/or governance drivers, with responses and interactions occurring at multiple levels and scales, focusing on understanding how humans interact with the marine environment can help us address issues threatening security of food, shelter, livelihoods, and human health.

The development of such a framework necessarily requires an interdisciplinary approach. The case study template is comprised of six sections (A-F in "Contents" below) with a total of 30 questions, which will probably require input from several people. We encourage you to consult with your colleagues in order to complete the case study template. The case study template is designed around an "Issue" affecting fisheries and aquaculture that links the natural properties of the marine ecosystem with the social and governance systems. In completing this case study template, please focus on only the most prominent **issue** (e.g. over-fishing, invasive species, ocean acidification, globalised markets, tourism etc.). If there are other relevant issues, please note these in the background section and where appropriate in the case study template. Sections A-F should be completed in full and Section G is a glossary of terms.

Our longer term intention is to develop a database of global case studies as an open-access web site to help decision makers, researchers and stakeholders decide how to respond when faced with difficult choices and trade-offs. This means that some of the information and data that you provide will be made accessible to other users. By returning the completed case study template to us, it is understood that we have your permission to include this information on-line. If you do not agree to this, please let us know by returning a completed non-consent form (Section I).

We are currently publishing a book that will describe I-ADApT and synthesise lessons learned from its application to specific case studies. We intend to continue to publish collections of case study and extend our analyses and would like to invite you to join us and contribute a chapter about your case study. Please let us know if this is of interest to you, and we will be in touch with further details.

Thank you once more for agreeing to complete this case study template. This case study template is downloadable from our website (http://www.imber.info/index.php/Science/Working-Groups/Human-Dimensions/IMBER-ADApT). We have also provided an example of a completed case study template for a case study from Uruguay for your guidance. Please submit your completed case study template to IMBER

HDWG at: imber@imr.no . We will keep you informed of progress and in the meantime please visit our website http://www.imber.info/index.php/Science/Working-Groups/Human-Dimensions

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If you have any questions, please contact us at imber@imr.no

Many thanks for agreeing to complete this case study template!

CASE STUDY TEMPLATE SECTIONS

A. BACKGROUND INFORMATION

B. DESCRIPTION OF THE STRESSORS AND THEIR IMPACTS

C. VULNERABILITY (6 questions)

D. GOVERNANCE AND GOVERNABILITY (8 questions)

E. RESPONSE (2 questions)

F. APPRAISAL (7 questions)

G. GLOSSARY

I. NON-CONSENT FORM

BACKGROUND INFORMATION

In this section, please provide background information about yourself and your case study, as well as a clear description of the Main Issue affecting fishing or aquaculture in your case study. Please provide as much information as necessary to understand the Main Issue. If required, use an extra page and feel free to provide references where relevant.

INFORMATION	**DETAILS**		
CASE STUDY CONTRIBUTORS **(please include all contributors)**	**NAME:** **AFFILIATION:** **Email:**	**NAME:** **AFFILIATION:** **Email:**	**NAME:** **AFFILIATION:** **Email:**
NAME OF STUDY AREA			
COUNTRY/COUNTRIES WITH JURSIDICTION			
GEOGRAPHIC LOCATION (Temperate, Tropical or High Latitude)			
ECOSYSTEM TYPE (Coastal, Lagoon, Shelf or Open Ocean, other)			

MAIN ISSUE (a) Provide a concise, detailed description of the Main Issue affecting the case study. Include the following information to show the extent of the effect of the Main Issue:	**Description of Main Issue** **location** **size of marine area in your case study (km^2)** **main species** **main habitats** **size of area inhabited by people in your case study (km^2)** **key stakeholders** **number of people affected by the Main Issue** **total number of people in your case study area**
(b) When did the Main Issue occur?	
(c) Are there other geographical areas that are also affected by this issue, but not included in this case study? If so, please indicate what they are.	

Please insert a map of the area of your case study here

DESCRIPTION OF THE STRESSORS AND THEIR IMPACTS

This section aims to gather information about the scale of the affected natural and social systems, and the governing systems, the main stressors affecting these systems, the consequent changes that these cause, and their impacts. Please provide as much information as necessary, but in no more than 200-300 words for each question. Please provide references where relevant.

Questions	Natural system	Social system	Governing system
1. What are the boundaries of the natural, social and governing systems?			
2. Which of the following levels is the Main Issue related to? Please describe for each system and level, where appropriate.	A. LOCAL B. REGIONAL (within country) C. NATIONAL D. INTERNATIONAL/GLOBAL	A. LOCAL B. REGIONAL C. NATIONAL D. INTERNATIONAL	A. LOCAL B. REGIONAL C. NATIONAL D. INTERNATIONAL
3. What are the main natural, social and/or governance stressors that affect this system?			
4. What changes in the natural, social and governing systems			

do these stressors cause and where?			
5. What are the impacts or consequences of this change on the natural, social and governing systems?			

VULNERABILITY (6 questions)

Please provide as much information as necessary in no more than 200-300 words for each question, and provide references where relevant.

NB: These questions refer to the period PRIOR to the Main Issue

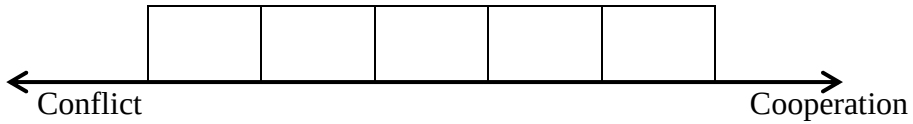
QUESTION	Details
6. What was the ecological status of the ecosystem (e.g., eutrophication, changes in size and/or trophic level, loss of key species, habitat quality, invasive species structure, dead zones) prior to the main issue?	
7. What was the productivity of the system (low, medium or high) prior to the main issue?	
8. What were the main livelihood activities (e.g., fishing, tourism, etc.) directly affected by the Main Issue?	
9. What other livelihood opportunities (e.g., farming, manufacturing, forestry, etc.) were there in the affected area prior to the main issue?	
10. What % of the total catch/production from fisheries and or aquaculture was used for own household consumption (not sold) prior to the main issue?	
11. What proportion of household income came from fish caught or produced locally (including post-harvesting activities) prior to the main issue?	

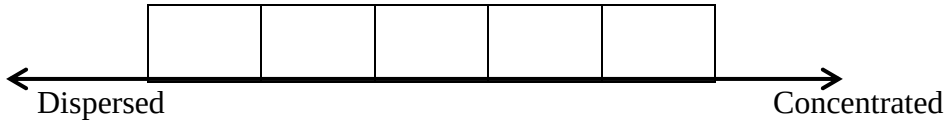
GOVERNANCE AND GOVERNABILITY (8 questions)

Please provide as much information as necessary, but in no more than 200-300 words for each question, and provide references where relevant.

NB: These questions refer to the period <u>PRIOR</u> to the Main Issue

QUESTION	Details
12. What were the relevant organisation(s) or individual(s) (including state, market and civil society) responsible for governance of fisheries and aquaculture at local, regional and national levels in this area prior to the main issue?	LOCAL: REGIONAL: NATIONAL:
13. What was the mode of governance (e.g., self-, co-, hierarchical (local), hierarchical (larger scale), mixture) prior to the main issue. Please describe.	
14. What were the long-term management objectives prior to the main issue?	

15. What were the key rules, regulations, instruments and measures employed to achieve the management objectives prior to the main issue?	
16. Were there any informal rules, regulations, instruments and measures that play an important role in the governance of fisheries and aquaculture prior to the main issue? Please describe.	
17. What was the nature of the relationship between the different sectors or livelihood occupations in this system prior to the main issue? (i.e., was there conflict or cooperation) Were there any special circumstances in their relationships that should be noted?	Please tick the box corresponding to the most appropriate situation 
18. Who dominated or wielded the most social power in the area prior to the main issue? (e.g., fishers' associations, unions, corporations, governments, business owners, etc.)	

19. How concentrated was social power in the area prior to the main issue? (ie., was power held by a few people/1 organisation (concentrated) or was it dispersed over several organisations)	Please tick the box corresponding to the most appropriate situation of the social system 
20. Were there any structural changes in the governing system or individuals prior to the main issue? Please describe the changes and why they occurred?	
21. Were there any changes to the key rules, regulations, instruments and measures, or have any new ones been introduced prior to the main issue? Please describe the changes and why they were introduced	

RESPONSE (2 questions)

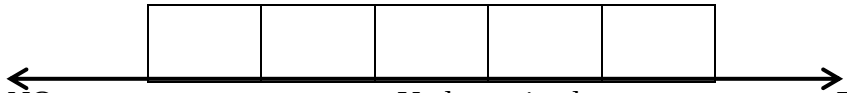
The objective of this section is to evaluate the response of the natural, social and governing systems to the Main Issue. We ask for information about Short Term (within 2-5 years) and Long Term responses for the natural, social and governing systems. Please provide as much information as necessary, but in no more than 200-300 words for each question. Please provide references where relevant.

	Natural	**Social**	**Governing**
22. a. What were the **short term** responses of the social and governing systems to the main issue? (Include structural changes in the governing system(s) or individuals, or the changes in key rules, regulations, instruments and measures etc.)	NA	TYPE OF RESPONSE (eg behavioural change, exit of actors) LEVEL OF RESPONSE (national, regional, local) of response))	TYPE OF RESPONSE (eg management measure, technological change, $ aid) LEVEL OF RESPONSE (national, regional, local) of response)
b. What were the **long term** responses of the social and governing systems to the main issue?		TYPE OF RESPONSE (eg behavioural change, exit of actors)	TYPE OF RESPONSE (eg management measure, technological change, $ aid)

(Include structural changes in the governing system(s) or individuals, or the changes in key rules, regulations, instruments and measures etc.)		LEVEL OF RESPONSE (national, regional, local) of response	LEVEL OF RESPONSE (national, regional, local) of response
23. a. What were the objectives of the **short term** social and governing responses for the natural, social and governing systems?			
b. What were the objectives of the **long term** social and governing responses for the natural, social and governing systems?			

APPRAISAL (7 questions)

The objective of this section is to evaluate the response of the natural, social and governing systems to the Main Issue. We ask for information about Short Term (within 2-5 years) and Long Term responses for the natural, social and governing systems. Please provide as much information as necessary, but in no more than 200-300 words for each question. Please provide references where relevant.

	Natural	Social	Governing
24. a. What were the results of the s**hort term** response for the natural, social and governing systems (ie were the objectives in Q.23.a achieved)?			
b. What were the results of the **long term** response for the natural, social and governing systems (ie were the objectives in Q. 23.b achieved)?			
25. Was the Main Issue addressed (Section A)? Please describe			
Please describe			

26. a. What factors contributed to the successful **short term** results described in Q 24.a (e.g., enabling policy, government funding)			
b. What factors contributed to the successful **long term** results described in Q 24.b (e.g., enabling policy, government funding)			
27. a. What factors (if any) prevented the **short term** objectives from being fully achieved? (e.g., regulatory barrier, lack of social cohesion, costs too high, climate variability, judicial decisions).			
b. What factors (if any) prevented the **long term** objectives from being fully achieved? (e.g., regulatory barrier, lack of social cohesion, costs too high, climate variability, judicial decisions).			

28. Has there been a formal evaluation of the responses? If so, how was this done and when?			
29. a. What were the benefits related to costs of the **short term** response?			
b. What were the benefits related to costs of the **long term** response?			
30. Were other options considered for the short and/or long term responses? Why were these not selected?			

GLOSSARY

Driver

Any natural or human-induced factor that directly or indirectly causes a change. (http://www.greenfacts.org/glossary/def/driver.htm)

Ecosystem

A discrete unit that consists of living (e.g. assemblage of plant and animal species) and non-living parts (e.g. the physical environment), interacting to form a stable system.[1,2]

Eutrophication (Q#6)

The process of nutrient enrichment (usually by nitrates and phosphates) in aquatic ecosystems, such that the productivity of the system ceases to be limited by the availability of nutrients. The increased growth of plants and algae depletes the dissolved oxygen content of the water and often causes a die-off of other organisms. It occurs naturally over geological time, but may be accelerated by human activities (e.g. sewage disposal or land drainage); such activities are sometimes termed 'cultural eutrophication'.[1]

Governance

Governance refers to groups of people coming together to achieve a particular outcome. It involves all interactions among government, private firms, civil society, citizens as well as any other relevant stakeholder groups to solve societal or environmental problems and to create opportunities. In addition to the day-to-day management tasks, the boundary of governance includes the formulation and application of principles and visions guiding those interactions and care for institutions that enable and structure them.[4,6]

Governance refers to mechanisms, processes and institutions through which public and private sectors articulate their interests, exercise their rights, meet their obligations and mediate their differences in order to make decisions affecting society (Rosenau, 1999).

Habitat (Main Issue)

The natural environment, characterized by its physical features (e.g., temperature range, availability of light, food availability or dominant plant types) in which an organism or population normally lives. Marine habitats include, for example, mangroves, intertidal zones, coral reefs, deep sea.

Household (Q#10, 11)

A household is a domestic unit consisting of the members of a family, as well as any non-relatives who live together in the same dwelling.

Instruments (or measures) (Q#15, 16, 21, 22)

Instruments are tools used in governance to overcome problems or obtain a desired effect. They are usually of a regulatory or economic nature. There is a large variety of instruments including 'soft' ones, like information and advice, and 'hard' ones such as taxes and regulations. Laws, treaties and appointments are formal instruments, while oral agreements, visits, or making a speech are more informal.[4]

Invasive species (Q# 6)

A species that is not native to an area that it colonizes and that is capable of causing harm to native species or the natural environment, and incur economic damage, or injury to human health.[1]

Mode of governance (Q#13)

There are three forms of governance: hierarchical, co-governance or self-governance. Hierarchical governance is a top-down 'steering and control 'style of intervention, that uses policies and in law. Co-governance requires involvement from various parties with a common purpose (e.g. fisheries co-management). In self-governance (e.g., community- or market-based) the actors take care of themselves, outside the purview of government. While self-governance may be initiated by governments through deregulation or devolution, it can also come about of its own accord.[5,6]

Power (relations) (Q#18)

Power is the ability to influence the behaviour of others and in social relationships is determined by the actors' access to power resources. Besides obvious power resources such as wealth and control over jobs, many others exist, for example, organizational capacity, expert knowledge, control of information, being in certain social positions, and even having a reputation of being powerful. Power has a reciprocal nature: A acts, B reacts, A reacts to B's reaction, and so on.[7]. This can manifest as power to exclude, power to influence markets or power to influence decision-making

Primary Productivity (Q#7)

The photosynthetic fixation of carbon by chlorophyll containing organisms, such as phytoplankton, macroalgae, mangroves, sea grasses and other sea plants. It is measured as the weight of carbon fixed per unit area per time, usually as $g.C.^{m-2}.yr^{-1}$

Rules (formal and informal) (Q# 15, 16, 21, 22)

Formal rules (e.g., constitutions, laws and regulations) are consciously designed and often codified in written form. They are often enforced by an external authority such as the police and the courts. Informal rules evolve spontaneously and unintentionally over time through human interaction, and take the form of unwritten conventions, routines, customs, and behavioural norms. Informal rules are often self-enforced, because all (or most) actors find it beneficial to adhere to them (as long as others do too). Those who do not abide by the informal rules of society can expect the other actors to show their disapproval even to the extent of expelling them from the group.[3]

Social system

Organisation of individuals into groups or structures that have different functions, characteristics, origin or status. http://www.businessdictionary.com/definition/social-system.html. Characteristic pattern of interrelationships between individuals, groups, and institutions to form a coherent whole http://www.merriam-webster.com/dictionary/social system

Stressor (Section B, Q# 3, 4)

An event, condition, individual, or other stimulus that causes stress to a system.[9]

Structural changes (Q#20, 22)

Changes to the structure of an organization to achieve its goals. These can be either a partial adjustment or a total overhaul of the duties, tasks, and responsibilities of individuals and departments, as well as reporting relationships and the number of levels in the organization's hierarchy.[8]

Trophic level (Q#6)

The position that an organism occupies in a food chain. For example, green plants (which obtain their energy directly from sunlight) are the primary producers, and herbivores are primary consumers (and secondary producers). A carnivore that eats only herbivores is a secondary consumer and a tertiary producer. Many animals feed at several different trophic levels.[2]

References

[1] Allaby, M. 2010. A dictionary of ecology, 4th ed. Oxford: Oxford University Press.

[2] Martin, E., Hine, R. 2008. A dictionary of biology, 6th ed. Oxford: Oxford University Press.

[3] Skoog, G.E. 2005. Supporting the development of institutions – formal and informal rules. UTV Working Paper No. 3. Stockholm: Swedish International Development Corporation Agency.

[4] Kooiman, J. 2003. Governing as governance. London: Sage Publications.

[5] Chuenpagdee, R. 2011. Interactive governance for marine conservation: an illustration. Bulletin of Marine Science 87(2): 197-211.

[6] Kooiman J., Bavinck, M., Jentoft, S., Pullin, R.S.V., eds. 2005. Fish for life: interactive governance for fisheries. Amsterdam: Amsterdam University Press.

[7] Scott, J., Marshall, G. 2009. A dictionary of sociology, 3rd ed. Oxford: Oxford University Press.

[8] Law, J., ed. 2009. A dictionary of business and management, 5th ed. Oxford: Oxford University Press.

[9] "Stressor" Merriam-Webster online: dictionary and thesaurus, accessed August 14, 2013, http://www.merriam-webster.com/dictionary/stressor

NON-CONSENT FORM

Purpose

The Human Dimensions Working Group of the Integrated Marine Biogeochemistry and Ecosystem Research project (IMBER) is developing a decision support tool known as IMBER-ADApT (Assessment based on Description, Responses and Appraisal for a Typology). It will be built from lessons learned from case studies collected from around the world, dealing with issues relating to global change impacts on marine fisheries and aquaculture, and the people who depend on them. Its aim is to provide managers, decision makers and other stakeholders faced with difficult decisions with considered options on how to respond effectively.

Information and data

Once developed, the IMBER-ADApT will be made available as an open-access web application available to all stakeholders. This means that some or all of the information that you provide in the ADApT Case study template will be available on-line. By signing this form, you have indicated that you do not agree to having the information that you have provided made available on-line.

If you have questions regarding this study, contact:

Dr. Alida Bundy, Chair Human Dimensions Working Group

Alida.Bundy@dfo-mpo.gc.ca

Statement:

The nature and purpose of this project have been adequately explained to me but I do not agree to the use of my data and research as indicated above.

Signature: _____ Date: _____

NAME:

ADDRESS:

Email:

Please send this form with your completed case study to imber@imr.no. You will receive a copy of this form for your records.

Appendix C

Note (1): This scoring has been done by members of the IMBeR HD Working Group, and not by the respondents.

A. VULNERABILITY

Vulnerability assesses how 'vulnerable' or susceptible the system (comprising natural, social, and governance components) is to shocks or pressures.

QB - BACKGROUND INFORMATION- Main Issue Question

The number of people affected by the Main Issue (from Background section) expressed as a ratio to the total number of people in your case study area (also from Background Section), ie, size of affected population/total population:

(QBA) less than 5%
(QBB) between 5% and 10%
(QBC) between 10% and 15%
(QBD) between 15% and 20%
(QBE) greater than 20%

Q3. What are the main stressors that affect this ecological system?

(Q3A) eutrophication, and/or other water quality issues
(Q3B) fishing, e.g. causing changes in structure (e.g., reduced size structure), species composition, etc.
(Q3C) loss of key-habitat or major habitat changes including invasive species
(Q3D) environmental changes (e.g. freshwater flows, climate change, etc.)
(Q3E) mix of above responses (plus other responses?)

Q6. What is the ecological status of the affected ecosystem at the ecosystem level prior to the main issue?

(Q6A) severely degraded (Q6B) degraded (Q6C) some concerns
(Q6D) improving (Q6E) good

Q7. What is the productivity of the system (low, medium or high)?

(Q7A) very low (Q7B) low (Q7C) medium (Q7D) high (Q7E) very high

Q8. What are the main livelihood activities (e.g., fishing, tourism, etc.) directly affected by the Main Issue?

(Q8A) fishing
(Q8B) aquaculture
(Q8C) industrial activities (eg. shipping)
(Q8D) tourism
(Q8E) mixture of 2 or more of the above

Q9. What other livelihood opportunities (e.g., farming, manufacturing, forestry, etc.) are there in the affected area?

(Q9A) none
(Q9B) limited (1–2)
(Q9C) some (3–4)
(Q9D) several (5–6)
(Q9E) lots (7+)

Q10. What % of the total catch/production is used for household consumption (not sold)?

(Q10A) less than 20%
(Q10B) between 20% and 40%
(Q10C) between 40% and 60%
(Q10D) between 60% and 80%
(Q10E) greater than 80%

Q11. What proportion of household income comes from local sales of fish catches, processing, and wholesaling?

(Q11A) less than 20%
(Q11B) between 20% and 40%
(Q11C) between 40% and 60%
(Q11D) between 60% and 80%
(Q11E) greater than 80%

D. GOVERNANCE AND GOVERNABILITY

Governability: Governability refers to the 'overall quality' for governance. It is affected by the "capacity" of the governing system, the characteristics of the systems that are being governed, and the interactions between them.

Q2. Which of the following levels is the Main Issue related to? Please describe for each system and level

a. Local, b. Regional, c. National, d. International - repeated for Natural, Social, Governing Systems

Q2N. Natural System

(Q2NA) Local (Q2NB) Regional (Q2NC) National
(Q2ND) International (Q2NE) ALL

Q2S. Social System

(Q2SA) Local (Q2SB) Regional (Q2SC) National
(Q2SD) International (Q2SE) ALL

Q2G. Governing System

(Q2GA) Local (Q2GB) Regional (Q2GC) National
(Q2GD) multi-level (domestic) (Q2GE) International

Q13. What is the mode of governance

(Q13A) self-governance
(Q13B) co-governance
(Q13C) hierarchical governance - local
(Q13D) hierarchical governance – regional/national/international
(Q13E) mixture

Q15. What are the key rules, regulations, instruments and measures employed to achieve the management objectives?

(Q15A) none
(Q15B) input measures (e.g. effort limitation, spatial and seasonal closures, gear limitations, limits on feed/chemical additions, stock enhancement, etc.)
(Q15C) output measures (e.g. quotas, etc.)
(Q15D) both input and output measures
(Q15E) formal co-management

Q16. Are there any informal rules, regulations, instruments and measures that play an important role in the governance of fisheries and aquaculture?

(Q16A) none
(Q16B) some – primarily fisher-based
(Q16C) some – primarily corporation-based
(Q16D) some – primarily government-based
(Q16E) many

Q17. What is the nature of the relationship between the different sectors or livelihood occupations in this system (i.e., ranging from conflict to

cooperation)? Please tick the box corresponding to the most appropriate situation between conflict (Q17A) and cooperation (Q17E) in the system:

Q18. Who dominates or wields the most social power in the area (e.g., fishers' associations, unions, corporations, governments, business owners, etc.)?

(Q18A) village/community leaders
(Q18B) trade unions/fishers' associations/cooperatives
(Q18C) business owners/corporations
(Q18D) governments
(Q18E) NGOs

Q19. How concentrated is social power in the area. Please tick the box corresponding to the most appropriate situation of the social system, between dispersed social power (Q19A) and concentrated social power (Q19E):

Q20. Were there any structural changes in the governing system or individuals prior to the main issue? Please describe the changes and why they occurred?

(Q20A) large change in structure of organisation and or/reduction in number of organisations or personnel;
(Q20B) some change in structure of organisation and or/reduction in number of organisations or personnel;
(Q20C) no change,
(Q20D) some change in structure of organisation and or increase in number of organisations or personnel
(Q20E) large change in structure of organisation and/or increase in number of organisations or personnel.

Q21. Were there any changes to the key rules, regulations, instruments and measures, or have any new ones been introduced prior to the main issue? Please describe the changes and why they were introduced

(Q21A) removal of rules entirely
(Q21B) reduction in numbers of key rules or diversity of key rules
(Q21C) no change

(Q21D) some increase in number or diversity of key rules
(Q21E) addition of new sets of rules (e.g. introduction of output controls to a system previously having only input controls)

E. RESPONSE

Q22S. What were the **short term** responses of the social and governing systems to the main issue? (Include structural changes in the governing system(s) or individuals, or the changes in key rules, regulations, instruments and measures etc.)

(Q22SA) no responses
(Q22SB) one key response in the social or governing response at one level
(Q22SC) a few (2–4) key responses within one of social and/or governing responses at more than one level (local, regional, national)
(Q22SD) a variety of short term responses in social or governing system at more than one level (local, regional, national)
(Q22SE) a variety of short term responses in both social and governing systems at more than one level (local, regional, national)

Q22L. What were the **long term** responses of the social and governing systems to the main issue? (Include structural changes in the governing system(s) or individuals, or the changes in key rules, regulations, instruments and measures etc.)

(Q22LA) no responses
(Q22LB) either limited social or governing response at local level
(Q22LC) limited social and governing response at more than one level (local, regional, national)
(Q22LD) variety of responses in social or governing system at more than one level (local, regional, national)
(Q22LE) variety of responses in both social and governing systems at more than one level (local, regional, national)

Q26S. What factors contributed to the successful **short term** results described in Q24S (e.g., enabling policy, government funding)

(Q26SA) no factors
(Q26SB) one key factor in the natural, social or governing system
(Q26SC) a few (2–4) key factors within one or two of natural, social or governing systems
(Q26SD) a variety of short term factors within one or two of natural, social or governing systems
(Q26SE) a variety of short term factors within all three of natural, social and governing systems

F. APPRAISAL

Appraisal – coded, but not used for the initial numerical classification. Instead, used to evaluate whether clusters of case studies were deemed to have been a success, or not.

Q24S. What were the results of the **short term** response for the natural, social and governing systems (ie were the objectives in Q23S achieved)?

Q26L. What factors contributed to the successful **long term** results described in Q24L (e.g., enabling policy, government funding)

(Q26LA) no factors
(Q26LB) one key factor in the natural, social or governing system
(Q26LC) a few (2–4) key factors within one or two of natural, social or governing systems
(Q26LD) a variety of long term factors within one or two of natural, social or governing systems
(Q26LE) a variety of long term factors within all three of natural, social and governing systems

Q27S. What factors (if any) prevented the **short term** objectives from being fully achieved? (e.g., regulatory barrier, lack of social cohesion, costs too high, climate variability, judicial decisions).

(Q27SA) a variety of short term factors within all three of natural, social and governing systems
(Q27SB) a variety of short term factors within one or two of natural, social or governing systems
(Q27SC) a few (2–4) key factors within one or two of natural, social or governing systems
(Q27SD) one key factor in the natural, social or governing system
(Q27SE) no factors

Q27L. What factors (if any) prevented the **long term** objectives from being fully achieved? (e.g., regulatory barrier, lack of social cohesion, costs too high, climate variability, judicial decisions).

(Q27LA) a variety of long term factors within all three of natural, social and governing systems
(Q27LB) a variety of long term factors within one or two of natural, social or governing systems
(Q27LC) a few (2–4) key factors within one or two of natural, social or governing systems
(Q27LD) one key factor in the natural, social or governing system
(Q27LE) no factors

(Q24SA) Objectives not achieved in N, S or G
(Q24SB) Some objectives met in one of N, S, or G
(Q24SC) Some objectives met in more than 1 subsystem N and/or S and/or G
(Q24SD) Most objectives met in 1 or more of N, S and G
(Q24SE) Most/all objectives met in N, S and G.

Q24L. What were the results of the long term response for the natural, social and governing systems (ie were the objective in Q23L achieved)?

(Q24LA) Objectives not achieved in N, S or G
(Q24LB) Some objectives met in one of N, S, or G
(Q24LC) Some objectives met in more than 1 subsystem N and/or S and/or G
(Q24LD) Most objectives met in 1 or more of N, S and G
(Q24LE) Most/all objectives met in N, S and G.

Q25. Was the Main Issue addressed? Please describe from failure (Q25A) to success (Q25E).

Q28. Has there been a formal evaluation of the response (how and when)?

(Q28A) no (Q28B) yes, partially (Q28C) yes, fully
(Q28D) ongoing (Q28E) undetermined

Q29S. What were the benefits related to costs of the short term response?

(Q29SA) costs exceeded benefits
(Q29SB) costs equaled benefits
(Q29SC) benefits exceeded costs
(Q29SD) still being assessed
(Q29SE) unknown

Q29L. What were the benefits related to costs of the long term response?

(Q29LA) costs exceeded benefits
(Q29LB) costs equaled benefits
(Q29LC) benefits exceeded costs
(Q29LD) still being assessed
(Q29LE) unknown

Q30. Were other options considered for the short and/or long term responses? Why were these not selected?

(Q30A) no
(Q30B) yes, but too expensive
(Q30C) yes, but too complicated
(Q30D) yes, but no social support
(Q30E) No answer/don't know

Appendix D

Table 1A: Variable categories (dim 1 to dim 3) (Est: Estimate)

Dim 1.			Dim 2.			Dim 3.		
	Est.	P.value		Est.	P.value		Est.	P.value
Q2G_E	2.16	1.44E-05	QB_E	1.82	6.34E-08	Q8_A	0.97	1.37E-04
Q22S_B	1.79	2.78E-05	Q19_A	2.24	3.05E-04	Q20_C	1.46	1.01E-03
Q2S_E	1.95	3.00E-04	Q6_E	1.69	6.63E-04	Q19_E	1.86	1.06E-03
Q2N_E	1.76	3.00E-04	Q9_B	1.02	6.66E-04	Q2N_C	2.33	2.24E-03
Q26L_E	2.34	7.98E-04	Q7_D	0.82	1.12E-03	Q16_A	1.41	2.64E-03
Q26S_E	2.13	8.59E-04	Q15_B	1.14	2.23E-03	Q27L_D	1.82	2.95E-03
Q11_E	1.44	1.55E-03	Q22S_A	2.15	4.17E-03	Q22L_A	2.80	3.92E-03
Q21_E	1.95	4.79E-03	Q27S_E	1.80	9.16E-03	Q17_A	2.67	3.92E-03
Q19_E	1.25	1.38E-02	Q11_D	1.11	1.01E-02	Q10_E	1.78	1.35E-02
Q13_D	1.00	2.62E-02	Q26S_E	1.22	2.10E-02	Q27S_D	1.23	1.54E-02
Q9_E	1.70	2.67E-02	Q26S_A	0.89	2.28E-02	Q2S_C	1.43	3.13E-02
Q20_A	2.10	3.96E-02	Q19_E	1.15	2.75E-02	Q3_B	1.97	4.09E-02
Q20_D	-1.49	4.84E-02	Q22S_C	-1.21	4.74E-02	Q9_E	-1.53	4.72E-02
Q11_B	-1.05	4.71E-02	Q26L_A	-1.03	4.15E-02	Q16_B	-0.24	3.34E-02
Q26L_D	-1.85	2.26E-02	Q17_D	-1.32	1.87E-02	Q19_A	-1.54	2.00E-02
Q19_D	-0.96	1.47E-02	Q15_D	-0.62	1.60E-02	Q18_B	-0.86	1.05E-02
Q27S_E	-1.72	8.06E-03	Q19_B	-1.85	7.64E-03	Q2S_E	-1.30	4.00E-03
Q26S_A	-1.29	7.27E-03	Q7_C	-1.18	6.32E-03	Q2N_E	-1.81	4.00E-03
Q13_B	-0.92	6.88E-03	Q26S_C	-1.25	4.05E-03	Q8_E	-0.78	4.88E-04
Q6_B	-0.98	6.42E-03	QB_A	-0.55	1.13E-03			
Q18_C	-1.44	2.98E-03	Q9_C	-1.70	7.72E-07			
Q2N_A	-1.28	2.75E-03						
Q27L_E	-1.38	2.49E-03						
Q2S_A	-1.01	1.71E-03						
Q17_C	-1.34	1.55E-03						

Table 1B: variable categories (dim 4 to dim 5) (Est: Estimate)

Dim 4.			Dim 5.		
	Est.	P.value		Est.	P.value
Q6_D	1.72	5.32E-03	QB_D	1.97	2.76E-03
Q3_B	2.86	6.09E-03	Q2S_D	2.17	9.71E-03
Q11_A	1.24	6.17E-03	Q22L_A	2.34	1.22E-02
Q18_D	1.19	6.56E-03	Q17_A	2.16	1.22E-02
Q2G_A	1.11	1.01E-02	Q27S_C	1.26	2.10E-02
Q27L_D	1.40	1.87E-02	Q2N_D	0.97	2.52E-02
Q13_C	0.41	2.07E-02	Q27L_C	0.90	3.83E-02
Q22L_B	1.07	3.11E-02	Q10_A	0.97	4.01E-02
Q26S_B	1.12	3.42E-02	Q2S_C	0.25	4.53E-02
Q6_E	0.38	3.42E-02	Q3_D	0.99	4.86E-02
Q21_C	0.41	3.59E-02	Q9_B	0.99	4.96E-02
Q16_D	0.93	4.68E-02	Q2N_C	1.12	4.98E-02
Q3_C	-1.82	3.99E-02	Q22L_C	-1.13	4.42E-02
Q22L_E	-1.06	3.08E-02	Q17_B	-1.46	6.51E-03
Q2S_C	-1.04	3.05E-02	Q2S_A	-1.25	4.97E-03
Q18_C	-1.03	2.54E-02	Q9_D	-1.31	1.07E-04
Q13_D	-1.04	2.23E-02			
Q21_D	-0.84	1.07E-02			
Q16_A	-0.88	7.06E-03			
Q26S_D	-1.71	2.83E-03			
Q27L_A	-1.49	7.94E-04			
Q22S_E	-1.78	6.85E-04			
Q6_C	-1.58	2.56E-04			

Appendix D: Table 2: Individual partial coordinate

	Dim.1	Dim.2	Dim.3	Dim.4	Dim.5
BB_oyst.Vulnerability	0.7	-2.41	-0.12	-2.26	-0.73
BB_oyst.Governability	-0.71	-0.55	0.11	-1.25	1.06
BB_oyst.Response	0.4	-0.98	-0.05	-1.05	-1.26
UR_clam.Vulnerability	-0.74	0.58	-0.75	-0.04	0.85
UR_clam.Governability	-1.49	-0.45	-1.36	0.83	-0.21
UR_clam.Response	0.41	-1.96	-1.56	-0.24	1.22
US_oyst.Vulnerability	1.56	-2.52	-0.91	-1.89	1.36
US_oyst.Governability	0.38	-0.54	-0.28	-0.01	0.28
US_oyst.Response	-0.35	-1.87	-0.59	-1.42	0.87
BU_pela.Vulnerability	-0.46	0.38	0.25	-1.51	2.08
BU_pela.Governability	-1.33	-0.19	1.13	-2.44	1.72
BU_pela.Response	-2.58	0.37	0.64	-2.73	1.13
TB_shrm.Vulnerability	-1	-0.46	0.18	-0.61	-2.12
TB_shrm.Governability	-1.16	0.03	-0.9	-1.37	-0.93
TB_shrm.Response	-1.64	0.17	0.1	0.68	-2.38
IN_reef.Vulnerability	0.71	-1.46	-0.91	-1	0.79
IN_reef.Governability	0.58	-0.72	0.2	-1.04	-0.41
IN_reef.Response	0.5	-0.77	-0.16	0.65	0.79
VL_clam.Vulnerability	-0.43	-2.38	-0.89	1.14	0.33
VL_clam.Governability	-0.57	-1.63	0.53	1.37	0.05
VL_clam.Response	0.52	-1.06	0.12	0.59	0.44
PH_poll.Vulnerability	-0.82	-1.34	-1.16	0.2	0.74
PH_poll.Governability	-2.51	-0.25	-0.05	-0.13	-0.74
PH_poll.Response	-2.04	0.15	0.38	-4.12	0.56
CB_oyst.Vulnerability	-0.18	-1.85	1.31	0.93	-0.81
CB_oyst.Governability	-0.55	-1.31	0.59	0.13	-0.67
CB_oyst.Response	-0.72	-1.13	0.12	-0.24	0.18
MB_oyst.Vulnerability	0.59	-2.5	-0.53	-1.12	-0.08
MB_oyst.Governability	-0.35	-0.56	-0.63	-0.23	0.75
MB_oyst.Response	-0.06	-0.77	0.64	-0.55	0.15
GR_Amv.Vulnerability	-0.03	-1.35	-0.32	0.72	0.22
GR_Amv.Governability	-0.85	-0.68	0.68	1.39	-0.73
GR_Amv.Response	0.15	-0.61	0.53	1.48	0.43
GR_Mal.Vulnerability	-1.77	-1.57	0.34	2.26	-1.68
GR_Mal.Governability	-1.15	-0.16	0.13	0.8	-0.49
GR_Mal.Response	0.88	0	0.58	0.95	-0.19
YB_clam.Vulnerability	0.7	-3.89	4.37	4.62	-2.44
YB_clam.Governability	-0.71	-1.56	0.79	2.71	-0.19
YB_clam.Response	0.77	-1.36	2.46	2.5	0.65
BA_mang.Vulnerability	-1.03	1.13	1.13	-2.15	-2.16
BA_mang.Governability	-1.03	0.05	1.15	-1.35	-0.99
BA_mang.Response	-1.54	-0.11	0.76	-3.4	0.47
ON_tour.Vulnerability	-0.24	3.61	-0.43	0.74	1.36
ON_tour.Governability	-1.94	1.32	-1.55	1.49	-0.2

ON_tour.Response	-3.87	3.25	-1.95	0.06	0.26
SH_poll.Vulnerability	-3.2	0.44	-0.93	1.47	-2.38
SH_poll.Governability	-2.46	-0.21	-0.53	-0.18	-1.17
SH_poll.Response	-1.89	1.41	-1.68	0.67	-0.54
SL-cora.Vulnerability	-1.01	2.67	-0.6	0.23	0.99
SL-cora.Governability	-0.49	1.3	-1.31	0.94	0.2
SL-cora.Response	-2.94	3.12	-1.88	1.43	0.26
OB_poll.Vulnerability	-0.93	2.64	0.43	1.69	1
OB_poll.Governability	-2.02	0.81	0.35	2.65	0.18
OB_poll.Response	-0.25	0.51	0.39	1.18	-0.34
BS_fish.Vulnerability	-1.39	-1.22	-1.67	-0.09	2.41
BS_fish.Governability	-1.05	-1.75	-0.33	0.12	3.31
BS_fish.Response	-0.51	-1.21	-0.79	0.81	2.85
CM_mang.Vulnerability	-1.71	0.6	1.39	-0.98	-2.27
CM_mang.Governability	-0.66	-0.42	1.51	-0.49	-1.36
CM_mang.Response	-0.42	0.4	0	0.26	-2.76
BGD.Vulnerability	0.7	1.97	2.94	-1.51	-2.4
BGD.Governability	1.56	1.14	1.94	-1.47	-1.75
BGD.Response	1.33	-0.02	0.06	-1.46	-1.4
ESP_G.Vulnerability	1.35	-1.77	-1.24	-1.07	1.27
ESP_G.Governability	2.58	-0.29	-2.15	-1.05	0.02
ESP_G.Response	2.2	-0.11	-0.37	0.16	0.44
VIC.Vulnerability	1.57	1.97	-0.44	0.8	1.06
VIC.Governability	1.43	-0.58	-2.56	1.06	0.47
VIC.Response	1.19	-1.11	-0.71	1	0.13
VEN.Vulnerability	1.63	1.95	1.48	-1.82	0.49
VEN.Governability	1.73	1.74	3.3	-2.37	1.12
VEN.Response	1.98	0.85	-0.03	-0.53	-0.68
KAR.Vulnerability	0.2	3.32	0.95	0.47	1.64
KAR.Governability	1.79	2.4	5.26	-1.41	3.17
KAR.Response	0.99	0.48	4.14	2.32	3.53
TAN.Vulnerability	1.64	2.8	-2.05	0.79	0.65
TAN.Governability	4.2	2.72	-3.84	1.23	-1.29
TAN.Response	2.77	1.38	-0.7	0.27	-1.13
ARG.Vulnerability	1.09	-1.41	-1.62	-1.04	0.76
ARG.Governability	4.76	-1.55	-3.32	-0.59	-1.33
ARG.Response	1.63	-0.41	-0.52	0.2	-1.14
ESP_M.Vulnerability	1.35	0.34	0.72	1.63	-0.89
ESP_M.Governability	2.76	1.36	0.79	0.8	-0.37
ESP_M.Response	3.13	0.95	0.2	0.55	-1.2
GRC.Vulnerability	1.14	1.75	-0.9	-0.62	-0.04
GRC.Governability	-0.73	0.53	0.34	-0.15	0.49
GRC.Response	-0.06	0.43	-0.15	-0.02	-1.33

Appendix E

The Codebook - Description of the major and minor themes

Theme	Description	Files	References
Vulnerability (Parent theme)		28	511
Ecological (Major theme)		26	214
Anthropogenic activities	Growing human population, and consequently, overexploitation of resources including the developmental activities and other types of the industries. Urbanization, aquaculture, rice cultivation, salt mining and grazing, responsible for the large-scale destruction of natural ecosystem. Environmentally irresponsible land development, enclosure of certain coastal area for private use, damages on coral reefs and fishing ground etc. High population density in the coastal areas; increased land-use; lack of appropriate and efficient wastewater treatment systems	11	17
Biodiversity loss	Changes in species abundance, loss of species. Continuous encroachment of forest areas and illegal poaching of wildlife, disappearing mangroves, siltation, decrease in breeding and nursery grounds of mangrove fisheries, pollution. Modification of the coastline, increase in water temperature, coastal erosion, increased salinity.	14	24

Theme	Description	Files	References
Climate change	Climate change induced negative effects on the natural environment of fishery system, rising sea levels, flooding, tsunamis, rise in sea water temperature, climate variability, meteorological anomalies delimited fishing activities, and global warming.	13	26
Disease outbreak	Changes in the natural system likely unrelated to anthropogenic causes: abundance of Pelagic fish was dramatically reduced in 90's without any anthropogenic influence. Mass mortality due to disease outbreak. Appearance of parasite in the early 1960s. E. coli presence	8	11
Environmental degradation	Sedimentation, changes in physio-chemical and environmental parameters, ecosystem degradation, environmental variability, changes in hydrological regimes	22	36
Extreme weather	Extreme weather events such as cyclones, hurricanes, and tidal surges. Changes in rainfall pattern, wind direction, wind speed, sea water current	8	14
Overfishing	Reduction in stock, small-scale fishers moved to commercialized methods, caught undersized fish by reducing the mesh size of nets, and used mechanized equipment's	10	16
Pollution	Eutrophication, oil spills and agricultural effluents, industrial toxic pollutants, fertilizers, and pesticides used by agro-industrial companies, mass nutrient loadings from agriculture and sewages, degradation of water including oxygen deficient water, metal pollution, ocean acidification, low pH levels	17	32

Theme	Description	Files	References
Resource depletion	Over-exploitation of resources (uncontrolled exploitation, commercial exploitation, destructive fishing such as bombing, use of chemicals), changes in distribution and availability of natural resource	18	38
Economic (Major theme)		24	103
Corruption	Fishers complain that they need to pay bribe to forest officials during fishing in the forest. Fishers also need to pay ransom to pirates in forest. Corrupted officials as well as leaders of fisher's associations.	4	8
High production cost	High permit fees to get the access to the resource	2	2
Lack credit	Many fishers failed to pay back previous loans due to losses following cyclone, micro-credit providing NGOs did not provided further loans to support livelihood re-establishment of small-scale fishers. Lack of informal credit system.	3	4
Lack income	Lack of fish catch following cyclones and other natural disasters, bankruptcies due to lack of income, decreased employments limited harvest	15	26
Lack investment	Lack of different capitals in community livelihoods, Lack of investments for alternative income generating activities; lack of "feeling" for traditional fisheries management as many fishing grounds were occupied by fishers	5	5
Lack market	Syndicate controls the price of fish catch where fishers end up getting paid lesser, fishers live far from the city	6	6

Theme	Description	Files	References
	where they don't get good market of their catch		
Poor value chain	Conventional approach, lengthy value chain process, small-sized pelagic fishery has also changed with women and youths involved in all value-chain segments	4	5
Poverty & Illiteracy	Fishers are illiterate, poor, with limited economic capacity to buy productive assets. Most of the fishers are below the poverty line. Poverty in small-scale fisheries is further propagated due to low level of literacy. In most fishing hamlets, there are no schools; the nearest school were inaccessible because of distance or poor road communication. Illiteracy is widespread among elders and children seem to follow the elders. Several families cannot send their children to school because of poverty.	6	11
Productivity decrease	Decrease in fish catch, decrease in economic yields from fisheries, impact of fish stock fluctuation	19	36
Institutional (Major theme)		20	82
Centralized management	Poor participation in the decision-making process, no proper connection between various levels of management, bureaucracy in implementation of management decision (top-down management system), centralized management of hierarchical type, government welded most of the social power, absence of common fishery right.	11	16
Fragile institutions	No or fragile social institutions	2	3

Theme	Description	Files	References
Inappropriate management	Uncoordinated developmental activities, lack of management measures, strong lobbying groups are politically favoured, no area-based management measures	7	11
Lack accountability	Lack of transparency, accountability in management decisions. Unfair subsidies, compliance has been a key challenge in fisheries, but the problem with non-compliance has been substantially reduced.	6	6
Poor legislation	Poor law enforcement, rules, regulations, instruments, policies, and measures.	10	17
Unsuitable governance	Weak, poor governance, usually hierarchical (top-down). The administration legislates and fishermen must comply with these rules, state regulates entry into the fishery grounds.	9	16
Weak property rights	Encroachment of marine resources by external parties, open-access nature of property rights, lack of defined ownership and established rights in management of fisheries commons, property rights are always contested in context of small-scale fisheries management.	9	13
Social (Major theme)		24	108
Behaviour issues	Opportunistic behaviour of the fishermen	5	8
Catch uncertainty	Uncertainties were the common feature of the fishery management leading the fishermen to decide to catch what becomes abundant or what can be loaded to the markets. Continuous increases on fishing costs (fuel,	7	10

Theme	Description	Files	References
	taxation, declining demand) have been forcing the fishers' income downwards		
Illegal activities	Illegal fishing, unauthorized fishing, unsustainable fishing methods, illegal fishing gears, unlicensed fishermen	6	9
Intersectoral conflict	Conflict between artisanal fishermen and oil companies located in the coastal area, conflict among stakeholders, particularly between fishers and tourism industry, conflict in use of coastal resources, conflicts between sectoral interests (heavy industry vs fisheries)	12	18
Intrasectoral conflict	Conflict between the fishermen group, conflicts between new entrants' small holder fishermen and the fishing companies, conflict between aquaculture and the small-scale fishers, Intra-sectoral conflicts are mainly between the pelagic (commercial) and the inshore (artisanal) fishery.	14	23
Lack wellbeing	Social frustration due to lack of job, income, and mental wellbeing	5	5
Low environmental concern	Less concern for environmental issue and lack of the knowledge about the ecological value of various species	3	4
Newcomers in fisheries	"New" fishermen managed to make a living and didn't return to their original employment/businesses.	6	7
Outward	There is extensive disagreement among the small-scale fisheries, especially between those born and raised in	6	9

Theme	Description	Files	References
migration	different villages around the bay, regarding fishing methods and attitudes. Youths migrate in search of new opportunities leaving the historical profession followed by their parents or the older generation.		
Political instability	Political pressures to the local administrators to decisions based in favor of their closed ones, frequently changing government caused frequent changes to the fisheries policies, acts, and rules.	2	2
Unemployment	Lack of alternative livelihood	9	13
Technological (Major theme)		3	4
Destructive technology	heavy mechanization of the fishing boats leading to unequal fish catches within the fishing communities	3	3
Poor connectivity	Use of digital technologies, digital connectivity to market	1	1
Towards Viability (Parent theme)			
Governing responses (Major theme)		28	269
Appropriate legislation	Legislation for development planning, prohibit use of small mesh, oyster harvest rotation plan to attem2pt to	14	30

Theme	Description	Files	References
	satisfy harvester pressure to capture oysters before they die, restrict harvest by dredging		
Co-management	Co-management structure of governance, moving from a hierarchical system to a co-management model, the participation of the fishing sector in the Co-management of this fishery allows a greater involvement of the main actors, the fishermen, in the management of the resource, co-existence, co-prosperity relationship	16	38
Decentralization	Decentralization process to grant more administrative and economic autonomy to the regions (“autonomous communities”). Transfer of power and authority from the central to provincial and regional government agencies.	5	5
Evidenced-based management	Backing up the industry through its research programs and large subsidies. Scientific support (ecosystem models) implemented to support and speed up political decision-making processes. Coordination between the scientific working groups and resource management working groups. Research, investigation into finding disease tolerant or resistant oysters, research and the establishment of financing mechanisms that ensure the sustainability of the actions undertaken.	13	16
Extended collaboration	Collaboration between fishermen, NGOs, INGOs, and the governments. Horizontal and vertical interactions.	12	20
Good governance	Formal governance system, governance incorporating all the stakeholders yielding successful results, organizational role to all stakeholders	5	8

Theme	Description	Files	References
Institutional framework	Appropriate legal and institutional framework to assist in developing the management plans, acts, and policies.	7	15
Management systems	Management systems such as master management plan, water quality management system, strategic plans, and organizational vision	18	31
Participatory management	Participation of the fishers in the process of creating standards, policy, and community-based management.	11	15
Policies & regulations	Clear property rights, legal regulations, policies (long term and short term), acts, law amendment, resolutions, legal agreements.	21	42
Proper funding	Allocation of funding to kick start the management plans.	10	16
Relief & subsidies	Subsidy and relief distribution (usually temporary).	9	16
Revisions & Inspections	Surveys, inspections, monitoring, and inspection systems	13	17
Social responses (Major theme)		28	161
Capacity development	Mechanization of the fishing equipment's; promotion of sustainable fishing practices, new technologies, giving autonomous rights to fishers make their own rules, livelihood diversification	16	22
Community-based	Fisheries cooperatives, combined efforts towards implementation of plans, and programs, and knowledge	7	19

Theme	Description	Files	References
management	mobilization		
Habitat conservation	Ecosystem restoration and rehabilitation programs to restore health of degraded resource, environmental assessment and planning based on lagoon type and habitat conservation activities	6	6
Informal local practices	Includes low price trading, self-compromising and eating unhealthy diet to save money for family and children; child labour without sending them to school	12	20
Livelihood diversification	Change of the occupations or practice aquaculture or involve in food processing industries	14	28
Malpractices	Violation of rules, fishers did not obey with all management measures, illegal activities	8	16
Multi-level collaboration	Collaboration of the fishing communities with the government stakeholders and other cooperative agencies and the volunteering works	12	22
Nature-based solutions	Sustainable solutions to restore fishing grounds, traditional methods of construction using locally available materials	5	5
Partnership development	Partnerships through associations, councils with other stakeholders	8	13
Temporary migration	Temporary migration to find alternative employment during low catch period	6	10
Enabling governing responses		22	87

Theme	Description	Files	References
(Major theme)			
By-catch limit	Setting the bycatch limit	2	2
Control exploitation	Controlling the overexploitation of the natural resource. For example, banning the extraction of wood to protect the mangroves in Sundarbans, seasonal ban on exploitation of commercially important fish species.	7	12
Empowerment	Empowerment of the local communities at the local level through trainings and workshops to re-engage in fisheries. Introduction and promotion of the commercially viable fisheries among the communities. Fishers can express their opinions on any proposed or implemented management measure to regional regulators and/or to the government through a standard process by which fishermen's associations and guilds. Empowerment of not only the fishers but the social and government institutions through democratic election of the leaders and council members.	4	6
Expansion of fishing ground	Expanding the harvesting grounds, development of the fishing village	3	3
Experimental fishing	Establishment of labs/factories for testing and assessment, assessment of the impact on the ecosystem of the fishing gear used in this fishery: accessory species and impact on the seabed	5	5
Government incentives	Government support for immediate survival of the fishing communities, tax subsidies.	7	10
Implementation	Focus on execution of the plans, implementation of the development plans, MPAs, effective execution,	10	13

Theme	Description	Files	References
of plans	optimization and adjustment as required to execute the fisheries management plans, crisis management plan		
Licence system	Provisioning of the fishing licences to limit the no. of the resource users	8	8
Quota system	Prohibition or management restrictions: fishing quotas. Somewhere set by the regional government, and somewhere thorough local institutions.	7	11
Restore fish stock	Rebuild the fish stock by implementing the sustainable practices through collaborative activities	9	12
Restrict access	Administrative restrictions such as no fishing without the permit and during no fishing period, harvest restrictions to allow stock rejuvenation.	5	5
Enabling social responses (Major theme)		24	72
Active involvement	Willingness of fisher communities to work jointly, involvement of fishers in decision making and policy formulation	8	15
Awareness	Through public hearing, public campaigns educating local populations about the importance of mangroves and the need to conserve, trainings on good Agri-farming practices, consumer awareness	9	11
Control invasive species	Control invasive species to reduce the mortality rates	2	2

Theme	Description	Files	References
Media outreach	Media was found to be powerful tool to express the voices and opinions through interviews in TV/Radio, reporting of illegal fishing activities and resource depletion issues	3	5
Permanent migration	Fishers who were worst affected by the changes left the fishing profession permanently, the ones who migrated temporarily never returned, fishers perceived there was limited opportunities in fisheries, and they decided to quit the profession	2	4
Social campaigns	Social campaigns targeting youths, educating them get involved in fishing activities, lobbying for more research funding and potential subsidies, fishers putting pressure on the government to fulfill their demands	4	5
Social unity	Fishers remain united to achieve the common goal such as to reduce economic crisis. Common acceptance to the leadership decision. Unity through involvements in the fisheries associations	8	14
Switch target species	Decrease in productivity caused the fishers to switch the target species, Abundance of some of their target species was not economically viable any longer. Fluctuating market of fish species influenced switching the target species	4	5
Valuing fishers	Fishing communities being valued as a part of the governing system. Participation of the fishermen in regional advisory councils and coastal action groups (with other stakeholders) contributed to further social recognition of fishing activity. Fishermen have realized that it is much better to participate in the management	6	8

Theme	Description	Files	References
	of the fishery (co-management) than to be simple compliers with the regulations imposed on them.		
Youth engagement	Some of the young youths are interested in fishing as an occupation	2	3
Preventing governing response (Major theme)		25	147
Communication problem	Lack of risk communication	2	2
Conflicting agendas	Lack of coherent plans, management measures and regulation change constantly	4	4
Delayed responses	Sluggish response from the government agencies (e.g., delayed reconstruction of damaged embankments, parts of which were broken during cyclone Aila. There were no clear responses from the managers, who were not prepared for “surprises”, The slow implementation of effort reduction has hampered successful implementation, delayed restoration of sewage treatment facility after Tsunami.	6	8
Distrust government	Mistrust the political governance, mistrust towards the system, mistrust between the fisher groups and the municipal agricultural office.	5	5
Fund mismanagement	Corruption	4	5
Hierarchical	No involvement of fisheries communities in decision	5	5

Theme	Description	Files	References
decision-making	making, highly centralized governance does not allow for local action. Leadership became too dictatorial and hypocritical in the governance of the resources. In that, they were involved in illegalities as individuals while barring other fishers.		
Ignoring climate change	Governing response does not explicitly address the sustainability of fisheries resources in respect of climate change impacts. Legislation and policies incorporate climate change to a much lesser extent also because authorities think this is a problem of global proportion. The government by itself was unable to find mitigation measures to cope with these unusual changes in the system due to climate change. The government institutions did not consider any proactive and preventive plan against the climatic variability that delimited fishing activities.	6	6
Ignoring science	Ignoring scientific evidence and increasing total allowable catch limit just to satisfy the fishers need to improve government statistics	8	11
Insufficient funding	Monitoring, control, and surveillance (MCS) costs are too high for a developing country, shortage of the Budget for the monitoring system. Limited funding and. Management plans were not implemented due to the increased operational cost.	9	11
Lack coherent strategy	Lack of coherency in development of frameworks, policies, rules, act balancing all the sectors (e.g., coastal area development and small-scale fisheries fishing ground management)	11	14

Theme	Description	Files	References
Lack management plans	Lack of operational management plans with performance indicators to manage the fishing grounds, markets, fishing zones. No guided risk management plan.	16	28
Lack monitoring	Lack of monitoring due to capital and technical expertise issues.	11	14
Lack resource	Manpower and other physical resources	3	6
Political interference	Co-management initiatives interrupted by political interests	6	7
Poor enforcement	Due to several reasons such as negligence of government to operationalize its plans or lack of the community support in some cases; not following the permit system or the rules; strict regulations. Weak enforcement of regulatory measures, limited action from the central public administration and a lot of approval process to implement plans at the local level. Inability to enforce research findings in real action.	11	16
Revenue oriented policy	The government objectives strongly shifted towards operationalizing only profit aimed strategies.	5	5
Preventing social response (Major theme)		15	63
Dependency on state	Relying too much on the government agencies to fulfill all expectations	3	3

Theme	Description	Files	References
Excludability	Exclusion of some members of the community from decision making. Lack of fairness while distributing subsidies, reliefs, funds, and other incentives.	7	10
Lack fishing knowledge	Newcomers lacked fishing knowledge, did not value customary fishing groups.	3	4
Lack social cohesion	Lack of organization of fishing communities, limited cooperation. Lack of cohesion between government officials and between the small scale fisheries communities. Trust, and willingness issue to improve collective actions.	10	16
Lack social institution	Lack of social infrastructures including lack of common property rights	4	5
Opportunistic behaviour	Individualism and opportunistic behaviour of fishermen and stakeholders, fishers themselves were concerned about their own well-being with less concern about resources sustainability	8	10
Short-term measures	Most of the rehabilitation activities were short-term basis. There were very few initiatives that focus on the long-term resilience of the communities.	5	7
Social un-rest	Social unrest due to difference in political ideology, culture, traditions affected the new co-management formula negatively, unfair social divisions, social cohesion is threatened due to violence and threats among fishers.	7	8