

**Pathways to Social-Ecological Viability for Mangrove Dependent Small-Scale Fisheries in
the Bangladesh Sundarbans**

by

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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

It is well described in the literature that mangrove-dependent small-scale fisheries (MDSSF) are increasingly vulnerable to drivers of change. However, the survivability of many MDSSF communities indicates that there are strategies in place to cope and adapt to drivers of change. It is poorly understood what adaptive responses are used to achieve viability, and how the transition from vulnerability to viability can be mobilized. Given that it is not conceivable to eliminate the uncertainty associated with the vulnerabilities that MDSSF experience, it is important to understand how viability can be achieved.

In congruence with a transformative phenomenological research approach, this study will address viability in mangrove-dependent small-scale fisheries (MDSSF) using a social-ecological systems (SES) framework, with a broad goal of describing social-ecological viability in MDSSF and identifying pathways through which this can be achieved from the perspectives of the research participants. SES is an important framework for understanding the nature and dynamics of viability in MDSSF, and more specifically how it is rooted in interactions between social, political, institutional and ecological factors of a complex, multilevel system.

Two objectives guide this research: (1) to describe the magnitude and impacts of drivers of change and vulnerabilities and (2) to understand key response strategies and conceivable pathways to achieve viability in MDSSF. The study methods include three in-depth, qualitative case studies consisting of household surveys and a focus group discussion in the Bangladesh Sundarbans Forest. Key findings include identification of five components that contribute to social-ecological viability. Results support that bottom-up strategies rooted in the perspectives and knowledge of local resource users are critical for developing a management approach for mangrove fisheries that supports the long-term viability of dependent small-scale fishing communities. At a regional level, this research provides information to develop local and specific strategies towards building social-ecological viability in the case study locations. At a global level, this study will be applied to the I-ADApT Framework and contribute to the Vulnerability to Viability Global Partnership

database, providing a case for comparison of mangrove-dependent small-scale fishery viability which can be used in developing policy and management recommendations.

Keywords: Mangroves, Small-scale fisheries, Social-ecological resilience, Vulnerability, Viability, Phenomenology.

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Chapter 1

Introduction

1.1 Background

Mangrove forests are one of the most productive and biodiverse ecosystems on the planet that occur in the coastal tropics and subtropics worldwide, and provide ecosystem services that value at over \$250,000 CAD per hectare annually (Costanza et al. 2014). Mangroves once covered more than 200,000 square kilometers, contributing to two-thirds of global coastlines (Spalding et al. 1997). However, in the past several decades, over half of mangrove forests have been destroyed due to climate change and human development, with a loss rate three to five times greater than the global loss rates for other forests and coastal reefs (Valiela et al. 2001).

As these vital ecosystems continue to become smaller and more degraded, the mangrove species themselves are at risk for extinction along with the natural and human systems that rely on them for ecosystem services and resources (Valiela et al. 2001). Over 90% of the world's mangroves are located in developing communities, many of which are employed by small-scale fisheries (FAO 2015). Mangrove ecosystems are particularly important for small-scale fisheries, as millions of these communities are dependent on mangrove stands for their livelihoods and wellbeing (Robertson 1992, Mozumder et al. 2018).

Small-scale fisheries support the livelihoods of approximately 200 million people, which represent 95 percent of fishers worldwide, (McGoodwin 2001). However, despite global contributions of two-thirds of fish catches directed towards human consumption, small-scale fisheries are increasingly vulnerable to economic, political and environmental change (FAO 2015). Poverty and food security has been a long-standing issue in small-scale fisheries (Bene and Friend 2011), with an estimated 5.8 million fishers earning less than \$1 per day (FAO 2015), and these issues are fueled by political exclusion from decision making on fisheries management and poverty alleviation (Bene and Friend 2011). Additionally, due to marine location, dependent livelihoods and a lack of infrastructure caused by economic and political marginalization, small-scale fisheries are vulnerable to the impacts of climate change on the ocean such as sea level rise, natural disasters, erosion, and loss of marine life (Ruiz-Diaz et al. 2020, Ojea et al, 2017). Not

only does this have negative implications on food security and income, but also major impacts on ecological wellbeing (Ruiz-Diaz et al. 2020).

1.2 Research Problem

Mangrove ecosystems and small-scale fisheries interact in a dynamic and complex social-ecological system that is impacted by external drivers of change, as well as interactions between and within the social and ecological components of the system (Ostrom 2009, Mozumder et al. 2018). A major shortcoming of many conventional decision-making processes for natural resource management is a disregard for the strong and non-linear linkage between natural environments and the people who interact with them (Schluter et al. 2011). Thus, it is important to conceptualize the important feedbacks generated by and between the social and ecological components of a system (Berkes 2007). In the case of mangrove-dependent small-scale fisheries (MDSSF), the whole system must be able to cope and adapt to drivers of change, such as climate change or deforestation, to maintain both social and ecological wellbeing. This phenomenon is known as viability (Nayak 2019). However, despite well studied increasing vulnerabilities (Mozumder et al. 2018, Barrett et al. 2011, Hoq 2003), it is poorly understood how MDSSF communities can transition from vulnerability to viability. This research aims to address this gap by generating knowledge on the social-ecological dynamics that interplay with vulnerability and viability within MDSSF, and identifying a pathway from vulnerability to social-ecological viability.

1.3 Research Objectives and Questions

This research aims to first understand the social-ecological dynamics that shape vulnerability and viability in MDSSF, and then to assess how communities and mangrove ecosystems can transition from vulnerability to viability as a SES. To meet this goal, my first objective is to understand the current social-ecological state of the system from the participants' point of view by describing the magnitude and impacts of drivers of change and vulnerabilities in the SES, as

well as the significance of the mangroves to the fisherfolk. This objective will be guided by the following questions:

- 1) How does the mangrove ecosystem contribute to the wellbeing of the fisher community?
- 2) What is the (a) current level of vulnerability and (b) impact of vulnerabilities on ecological and social wellbeing?
- 3) How do these impacts interact to create outcomes at the SES level?

The second objective is to understand key response strategies and conceivable pathways to achieve viability in the SES, by asking:

- 1) What current coping strategies and adaptive responses are used to achieve viability in the SES?
- 2) What are the barriers to achieving viability in the SES, and what changes need to be made to address these barriers?
- 3) How can this information be conceptualized to mobilize a pathway from vulnerability to viability at a social-ecological level?

1.4 Phenomenology and Transformative Worldview

This research will employ a phenomenological approach by describing the lived experiences of individuals regarding the phenomenon of interest, social-ecological viability, from the perspective of the participants (Giorgi 2009, Moustakas 1994). Phenomenology is a powerful research strategy for working with marginalized communities, as it can help to shift power dynamics in the researcher-participant relationship and allow participants to guide the research process with their lived experiences and traditional bodies of knowledge (Moustakas 1994). Facilitating this dynamic in research with vulnerable populations is extremely important. The existing discourse on poverty and marginalization is largely shaped by the desires and interests of Western researchers instead of the people who are actually vulnerable and in the best position to identify both the factors contributing to this vulnerability and the possible solutions. (Beck et

al. 2020). Following a phenomenological strategy of inquiry, this research is consistent with a transformative philosophical worldview, which focuses on the needs of people experiencing marginalization and the strategies they utilize to withstand oppressive constraints (Mertens 2010). In congruence with a transformative paradigm, this research is interested in the lives and experiences of small-scale fishers in mangrove dependent communities, which are characteristically impoverished and marginalized (FAO 2015).

1.5 Transformative Justice Theory

Following a transformative paradigm, my research lens has been shaped by work done in the field of transformative justice, which can be defined as ‘justice practices that go all the way to the root of the problem and generate solutions and healing there, such that the conditions that create injustice are transformed’ (Brown 2017). Transformative justice theory (TJT) focuses on emancipatory peacebuilding that is context specific, participatory, and rooted in the lives of the people in a community experiencing broad social injustice, poverty and exclusion (Lederach 2002, Gready and Robins 2014). Conflict transformation is a concept at the core of TJT, which aims to address conflicts by developing capacity to support structural change that addresses the root causes of a conflict, rather than aiming to facilitate linear outcomes (Miall 2004). Overall, TJT is an emerging and important framework that is rooted in the perspectives and needs of a particular community, and aims to address the deep-rooted inequalities, exclusion and power dynamics underlying poverty to develop holistic, long-lasting solutions (Gready and Robins 2014). These concepts of TJT are important and relevant for this project because they provide a framework for understanding how a system works from a phenomenological perspective so that context-specific insights can be developed. For example, Grafton et al. (2022) investigated transformative actions in the context of water justice by asking research participants questions focused on understanding and amplifying the voices of those suffering from injustice and promoting their ‘truths’ in relation to injustice, with the goal of seeking reconciliation and meaningful pathways to overcome injustice.

1.6 Social Ecological Systems Theory

As addressed by transformative philosophy, the realities experienced by small-scale fishers are shaped by social, political, economic and cultural values (Mertens 2010). Thus, my research also draws from Social Ecological Systems (SES) Theory, which recognizes that social wellbeing cannot be separated from ecosystem wellbeing as they are integrated as a coupled, interdependent and co-evolutionary system (Berkes et al. 2011). SES indicates that there is a causal relationship between the wellbeing of the social subsystem and the wellbeing of the ecological subsystem due to interactions between and within the two components. The social or human component consists of interactions between the economy, cultures, institutions and politics, and the ecological component consists of biotic/ abiotic, food web, geological, hydrological and climatological interactions (Nayak 2014). Each subsystem is made up of multiple second-level variables, such as the level of governance or political interactions, which are further composed of deeper-level variables (Ostrom 2009). The two sub-systems interact through outputs of resource units and ecosystem services, such as lumber provisioning, and resource user actions, such as exploitation and governance systems (Ostrom 2009). Thus, the social and ecological subsystem can directly impact one another, which generates a cause-effect feedback loop of cascading impacts on social-ecological wellbeing. In the case of a conflicting feedback loop between the system components, this can lead to SES collapse (Ostrom 2009).

A SES framework is important for illuminating potential solutions to governance and management barriers, as it recognizes that the sub-systems and variables within a complex, non-linear system interact with one another as an interdependent and co-evolutionary system (Ostrom 2009, Berkes 2011). A SES approach has been most notably used to guide research for common-pool resources and marginalized populations, as a critical barrier to the effective governance in these systems is the inherent complexity that arises from the vulnerabilities and problems experienced being rooted in complex environmental, social, economic and political systems' interactions that can rarely be attributed to a single cause (Ostrom 2009, Berkes 2003, Folke et al. 2005).

1.7 Methodology and Methods

This research was comprised of a case study in Bangladesh, which is one of the global leading producers and exporters of fish (Mozumder et al. 2020). It has been acknowledged that small-scale fishers in Bangladesh face a myriad of vulnerabilities that are linked to social neglect and high exposure to the impacts of tropical cyclones (Deb and Haque 2016). The SSF population in Bangladesh faces poverty and helplessness, with a low literacy rate of about 14% and less than 1% of fishers obtaining a secondary education (Diba et al. 2022).

Within Bangladesh, a case study was conducted within three villages in the Sundarbans (Figure 1.1). The Sundarbans Forest is a UNESCO world heritage site that contains the largest



Figure 1.1 Map of the Bangladesh Sundarbans forest. The top left map shows a distanced view of where the study area (indicated by the red box) is in comparison to the countries of India and Bangladesh. The bottom right map shows a close-up of the Sundarbans region. The yellow tinted region to the left of the purple border is India, and the area to the right of the purple border is Bangladesh, with the Sundarbans highlighted in green. This map was created using *ArcGIS*.

continuous stretch of mangrove forest in the world, shared between Bangladesh and India (Chandra and Sagar 2003). Over 3.5 million people are dependent on the Sundarbans mangroves for their income, and are faced with a multitude of external threats, such as aquaculture encroachment and globalization processes (Hoq 2007, Chandra and Sagar 2003).

The mangrove ecological communities themselves are threatened by forest exploitation, habitat degradation and climate change (Sarker et al. 2016). Thus, this location presents an ideal opportunity to delve into the complex interactions that shape social-ecological viability in MDSSF.

This methodology of the research embraces a phenomenological and largely qualitative approach. Methods of inquiry include household surveys and a focus group discussion, with the intention of gathering data regarding people's beliefs, experiences, and knowledge of the dynamics in the social-ecological system that interact with viability. Consistent with qualitative methods, the data from the household surveys and focus groups is rich, dynamic and non-standardized, and thus was qualitatively coded using Nvivo software to categorize and identify patterns in the data in respect to the research objectives.

1.8 Study Significance

At a regional level, this research provides information to develop local and specific strategies towards building social-ecological viability in the case study location. At a global level, this study is part of the Vulnerability to Viability Global Partnership (V2V), which aims to generate knowledge to mobilize the transition of small-scale fisheries from vulnerability to viability and respond to the pressing need to develop solutions to combat food insecurity and poverty among vulnerable and marginalized SSF populations (FAO 2015). Through this partnership, my research will contribute to the V2V database and resource portal of information which will be utilized to integrate and mobilize knowledge generated and provide a case for comparison of MDSSF wellbeing and experiences which can be used in developing policy and management recommendations. Expected academic contributions include an increased understanding of

social-ecological viability, and insights on conceivable pathways to social-ecological viability in MDSSF.

1.9 Study Limitations

This research focuses on participants' voices and lived experiences in MDSSF. While there are several benefits to this approach, such as the rich and detailed understanding that comes from exploring a phenomenon from the perspective of those who have experienced it (Neubauer et al. 2019), there are also limitations that should be addressed. First, the research data is largely limited to the experiences of the research participants, and thus the subsequent findings may not be able to be generalized. Second, this study is limited by the time period of my two-year Master's degree. Phenomenological studies are characteristically in depth, and often take several years to complete (Neubauer et al. 2019). While this research contributes to the body of knowledge on social-ecological viability in MDSSF and offers insight to mobilize viability in case study communities, the temporal restrictions of data collection limit the richness and validity of findings.

1.10 Thesis Overview

This thesis comprises seven chapters in total: (1) Introduction, (2) Literature review, (3) Methods, (4), (5), and (6) Results, and (7) Conclusion.

Chapter 1 opens the thesis by discussing the background of the study, the research problem that is addressed, the philosophical approach and worldview shaping this work, the theories influencing the research approach, the research objectives and questions, as well as the importance and limitations of this study. This chapter also provides a summary of the research area, and the methodology and methods that were employed.

Chapter 2 provides a review of relevant literature, such as small-small fisheries, resilience, social wellbeing, and interactive governance, as well as the conceptual framework that informs this project.

Chapter 3 expands on the methods used to conduct this research and discusses the case study location, strategy of inquiry, study components, data analysis, limitations of the approach, and ethical considerations. Furthermore, this chapter provides a detailed explanation of how the data was analyzed and interpreted to generate results.

Chapter 4 and 5 present and discusses the results, each corresponding to one research objective. Chapter 4 describes the magnitude and impacts of drivers of change and vulnerabilities in the social-ecological system, as well as the significance of the mangroves to the fisherfolk communities. Chapter 5 explains key response strategies and conceivable pathways to achieve viability in the social-ecological system.

Finally, Chapter 6 concludes the thesis by summarizing the key findings and discussions presented throughout this thesis can inform how mangrove dependent small-scale fisheries can move from vulnerability to viability.

Chapter 2

Literature Review

2.1 Introduction

Although this thesis is largely focused on expressing the perspectives and expertise of mangrove dependent fishers who have lived experience in the phenomena being examined, it is also important to be informed by the work of previous researchers. This chapter will describe the following literature topics that are relevant to this research: (1) mangrove-dependent small-scale fisheries as a social-ecological system, (2) vulnerability and viability, (3) social-ecological resilience, (4) coping and adaptive strategies, (5) social wellbeing, and (6) interactive and multi-level governance. These areas of research provide definitions, examples, expertise and knowledge for understanding how viability can be analyzed, as well as demonstrate a gap in the existing research base that this thesis addresses.

2.2 Mangrove-dependent Small-scale Fisheries as a Social-ecological System

Mangroves are dominant coastal shoreline habitats of tropical and subtropical regions, and comprise of 80 flowering tree and shrub species present in a broad cross-section of 18 plant family lineages (Rivera-Monroy et al. 2017, Tomlinson 2016). Mangroves are characterized by their unique morphological and physiological adaptations for tidal conditions, high exposure, saturated soil and salt, which prior to human-driven deforestation, enabled them to dominate tropical coastlines worldwide (Duke et al. 1998). In tropical regions, mangrove stands are often positioned between coral reefs and tropical rainforests, and thus each of these ecosystems are linked by their roles in coastal and estuarine ecosystem processes (Rivera-Monroy et al. 2017, Duke et al. 2007).

Mangrove forests serve as fishing grounds for 38 percent of all small-scale fishers in over 100 countries, many of which live in the world's most vulnerable communities (Rivera-Monroy et al. 2017). These communities are completely dependent on mangroves for their livelihoods

and local economies (Hoq 2003), and thus are also heavily dependent on the health and resilience of mangrove ecosystems (Allison et al. 2009).

Although there is a relatively low species richness of mangroves, the richness of biota supported by mangrove ecosystems is approximately two orders of magnitude higher (Rivera-Monroy et al. 2017). For example, mangrove forests containing 39 tree species were reported to have 4011 species of bacteria, fungi, algae, plants and animals (Sandilyn and Kathiresan 2012). Mangroves provide high ecological value as nurseries for young fishes and invertebrates, thus facilitating marine diversity (Lefcheck 2019) and sustaining the livelihood of small-scale fishers by supporting the vast stocks of fish, shrimp and crab that are necessary for communities to have a stable income and food supply (Hoq 2003). Mangroves have additional value to fishers as a source of lumber, firewood, edible plant parts, charcoal, bark dyes, herbal remedies, and wax (Rivera-Monroy et al. 2017). These services have a variety of important functions for SSF, including cooking fuel, medicine, construction materials and support for alternative livelihoods (Mozumder et al. 2018).

Similar to species richness, mangroves have an intriguingly high level of functionality based on an overall low level of diversity and provide a number of valuable ecosystem services beyond provisioning that contribute to wellbeing in fishing communities. For instance, the unique entangled root systems of mangrove stands stabilize coastal areas through sediment capture and bio-filtration, thus reducing coastal erosion (Kathiresan 2012). Mangrove forests also serve as a barrier against natural disasters; Spalding et al. (2014) found that 100 yards of mangrove trees can reduce wave height by 66 percent, thus providing protection for coastal inhabitants. Additionally, mangrove forests provide global benefit by pulling massive amounts of greenhouse gases from the atmosphere and storing them in their rich, waterlogged soil, which helps to mitigate climate change (Rivera-Monroy et al. 2017). It is estimated that mangrove forests remove 6 billion tons of carbon from the atmosphere through photosynthesis per year, which is up to four times as much carbon compared to the sequestration of other tropical forests (Daniel 2011). Although this thesis is focused on mangroves and fisher communities as a SES, it is also important to emphasize that all humans are stakeholders in the ecosystem services

provided by mangroves, as many of the mangrove resources utilized by fishers and other coastal communities, such as fish catches, tourism and carbon sequestration serve global markets (Hein et al. 2006). Figure 2.1 from Rivera-Monroy et al. (2017) provides a useful summary of the key ecosystem services provided by mangrove forests in a spatial context.

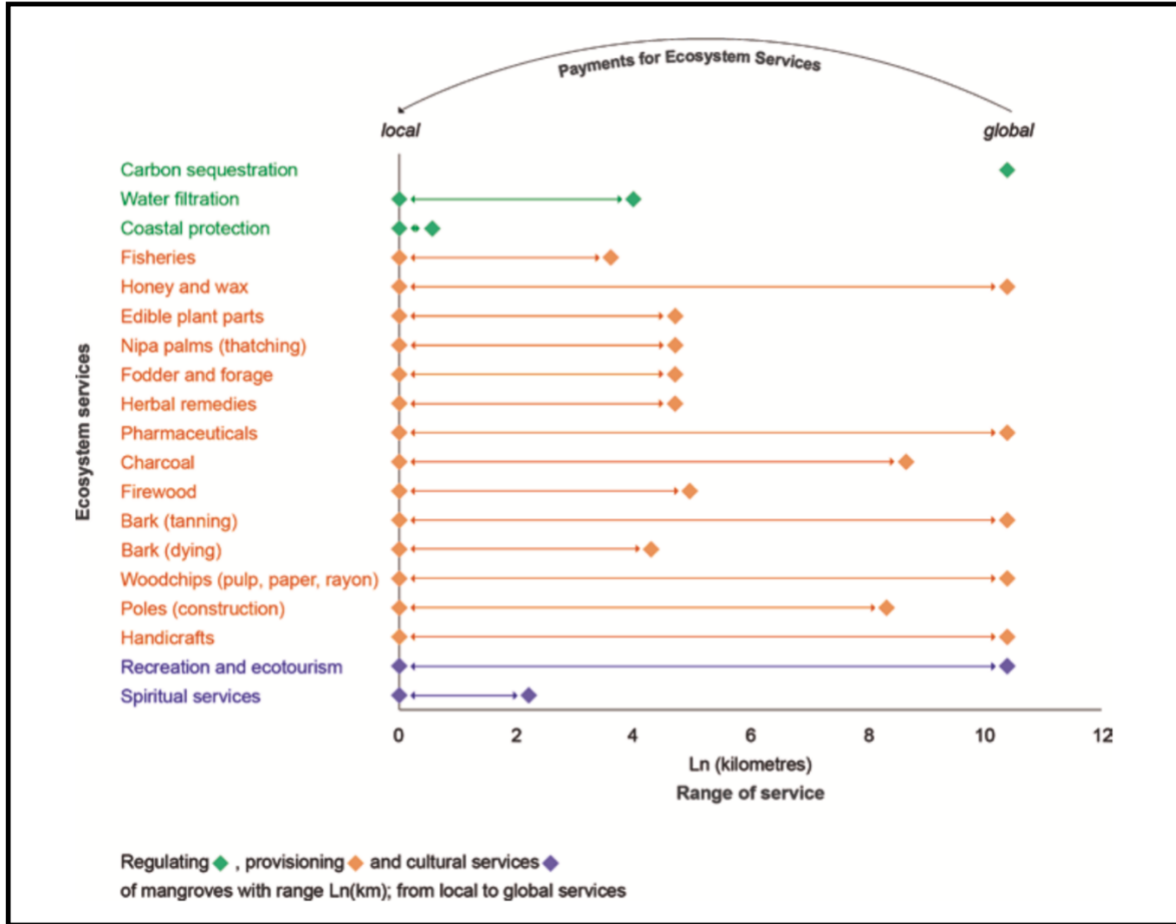


Figure 2.1. Mangrove ecosystem services categorized into (1) regulating, (2) provisioning and (3) cultural services. Range of service refers to the maximum distance over which the benefits are spread (Rivera-Monroy et al. 2017).

Despite the global importance and services provided by mangroves, these vital ecosystems and their dependent communities are being increasingly threatened by drivers of

change. Drivers of change are natural or anthropogenic induced actions or events that directly or indirectly cause change in a system (MEA 2003). Drivers can occur at a large scale, such as globalization processes and events induced by climate change, as well as events at the local and regional scales that create or propel change in the SES. As MDSSF are complex and non-linear systems, globally, regionally and locally generated drivers can interact with one another and trigger changes at the higher or lower scales (Nayak and Berkes 2014). Thus, drivers at higher levels can impact lower ones, and vice versa. Geist and Lambin (2002) have provided the terms ‘proximate’ and ‘underlying’ to explain the interaction between drivers of change. Proximate drivers are immediate sources of loss that directly cause declines in the mangrove ecosystem, such as climate change, infrastructure development, land use conversions linked to agriculture or aquaculture, and wood extraction (Geist and Lambin 2002, Rivera-Monroy et al. 2017). For example, research on the socioecological dynamics of SSF in Bamna Nil Dumor Village and Joymuni Gul in the Bangladesh Sundarbans found that shrimp farming, illegal logging and climate change issues such as increased salinity, temperatures, and natural disasters are the main drivers of mangrove deforestation. Hoq (2007) also recognized the explosion of aquaculture as a global process as a major proximate source of mangrove loss. Underlying sources of loss are fundamental, deeper or indirect anthropogenic drivers underpinning proximate mangrove loss that stem from demographic, economic, institutional, technological and cultural forces (Geist and Lambin 2002). The dynamics of poverty and livelihoods in MDSSF are one of the key underlying drivers of mangrove loss. Barrett et al. (2011) found that the poor’s dependence on mangroves for their livelihoods can lead to a poverty-environment trap, which is a vicious cycle between poverty and the environment that leads to unsustainable extraction of mangroves, subsequent reduction of ecosystem services, reduced productivity of labor, and greater vulnerability to coastal erosion and natural disasters. In SES theory, this phenomenon is also referred to as a rigidity trap, which reflects the equilibrium where a SES’s internal interactions lock the system into a feedback loop that produces a vicious cycle of undesirable outcomes (Stedman 2016). Overall, these studies illustrate the importance for first understanding the multi-scale and multi-level dynamics between drivers of change in the complex systems that MDSSF interact in before attempting to make insights and decisions for mangrove management.

2.3 Vulnerability and Viability

In the context of MDSSF, vulnerability can be defined as ‘a function of exposure, sensitivity and the capacity to respond to threats’ (Chuenpagdee 2011). It is well established through the previously described literature that MDSSF are highly vulnerable to climate, environmental, economic and political drivers at multiple scales. However, the survivability of many communities in the face of increasing vulnerability indicates that they have strategies and mechanisms in place to cope and adapt to drivers of change, which is referred to as viability (Nayak and Berkes 2019). It is poorly understood what strengths and resilience strategies are currently used to achieve viability, and how the transition from vulnerability to viability can be mobilized. Given that it is not conceivable to completely eliminate the uncertainty associated with the vulnerabilities that MDSSF experience (Berkes 2007), it is important to understand the dynamics that interplay with vulnerability and viability in these communities. The following concepts of (1) social-ecological resilience, (2) social wellbeing, and (3) multi-level and interactive governance are essential concepts necessary to understand vulnerability and viability in a given community.

2.3.1 Social-ecological Resilience

Humanity has witnessed a global shift towards a capitalist mindset that has a strong focus on the growth of systems. However, a SES is never in a static or linear state, and when the growth of a system is halted or reversed, deep uncertainty and unpredictability occur (Berkes et al. 2003). At these times, it is the interactions at the foundation of a system that build and sustain the capacity for humans and the environment to persist in the face of change (Berkes et al. 2003). The understanding of how these root-level interactions can influence a system’s capacity to respond to change is central to the concept of social-ecological resilience. Resilience is at the core of the SES approach to managing human-nature relations (Glaser et al. 2010). As described by the *Resilience Alliance*, resilience describes the degree to which a SES is ‘capable of self-organization, learning and adaptation’ so that it can reorganize and renew itself when disturbed (Holling 1973, Gunderson & Holling 2002, Walker *et al.* 2004, Alcorn et al. 2003). Enhancing

resilience in MDSSF is critical, as they face risks that are changing the nature of the communities themselves, and thus must build resilience so that they are able to persist despite uncertain drivers of change (Brown 2014). Small-scale fisheries can be described by three attributes that Norberg and Cumming (2008) describe as the fundamentals of resilience thinking: (1) a degree of irreducible uncertainty, (2) the prospect of non-linear dynamics, and (3) the property of emergence. These characteristics form what are considered the key dynamics that fundamentally change what decision makers do when managing for resilience (Norberg and Cumming 2008). Bene et al. (2011) used these fundamentals of resilience to develop management interventions in small-scale fisheries in the Niger River Basin by first defining system boundaries and interactions of drivers and disturbance events that threatened the system, and then identifying ecologically and socially desirable configurations, relevant thresholds and appropriate indicators that could be used to assess and monitor the system's states and trajectories. This approach is useful for assessing the resilience threats and opportunities that interplay with vulnerability and viability in MDSSF.

2.3.1.1 Coping and Adaptive Strategies

Central to the concept of resilience is the ability of a system to adapt to change. Coping and adaptive strategies describe the ways in which fisher communities respond to change when a threat occurs (Nayak 2017). The sustainable livelihood framework is useful for understanding how coping and adaptive strategies can contribute to, or deter from viability, as it emphasizes that strategies used to either enhance existing security and wealth or try to reduce vulnerability and poverty can have positive or negative outcomes, depending on the context, resources and institutions involved in the strategy being implemented (Ellis 2000). Thus, it is possible that strategies implemented by fishers in attempt to deal with livelihood crisis may not result in achieving sustainable livelihoods because there is extensive complexity in the SES that influences if the outcome of a strategy will contribute a to system that can retain long-term viability (Nayak 2017).

The distinction between adaptive and coping strategies is that coping strategies are the immediate, short-term responses to a stressor and adaptive strategies are long-term adjustments that produce more sustainable outcomes at the SES level (Nayak 2017). For example, a coping strategy that small-scale fishers may use respond to livelihood crisis is taking staggering amounts of loans that are higher than their income, which facilitates cycles of increasing debt (Karlsson and Mclean 2020, Nayak 2017). An example of an adaptive strategy that contributes to long-term sustainability in the SES from Karlsson and Mclean (2020) is implementing local forums and workshops to build the fishers' capacity to plan and adapt to extreme weather events.

Given the complexities involved in the processes and outcomes of strategies, it is often difficult to understand whether the outcome of a strategy will contribute to viability. A concept to help predict outcomes is adaptive capacity, which is defined as the ability of a system to “anticipate and respond to change and cope with and recover from perturbations, change and extreme events” (Cinner et al. 2013). The capacity of a system to produce adaptive strategies is influenced by social capital and community relationships, as well as physical, financial and natural assets (Coulthard 2012, Allison and Ellis 2001). External events and vulnerabilities can also create significant impacts on adaptive capacity. For instance, over the last 20 years, the severity and impacts of climate change events on fisher communities has increased, and the context of these events along with the interaction of climate changes with social and political processes influence a community's ability to adapt (Pelling 2010).

These concepts are important for understanding how social-ecological viability can be mobilized in a community, as they encourage questions that explore the root-level interactions that produce outcomes of coping and adaptive strategies such as: (1) what is the context in which a community is responding to a change?; (2) what interactions with resources and institutions are involved in this response?; and (3) does this community have access to social, financial, natural and physical capital to enable an adaptive response?

2.3.2 Social Wellbeing

Where social-ecological resilience is the ability of a SES to re-organize and renew in the presence of uncertainty, social wellbeing is an analytical lens to understand the strength of root-level interactions that are the foundation for supporting the resilience of a system when uncertainty occurs (Weeratunge et al. 2013). McGregor (2008) defined wellbeing 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’. Three key dimensions provide a framework for understanding wellbeing: material (e.g., economic yield, assets, resources), relational (e.g., access to markets, institutional, social capital) and subjective (e.g., self-identify, aspirations, happiness) (White 2009, McGregor 2008, Weeratunge et al. 2013).

As shown in Figure 2.2, aspects of wellbeing also occur at three scale levels: (1) micro-scale: the wellbeing of an individual or household, (2) meso-scale: the wellbeing of a community of group of fishers and (3) macro-scale: the wellbeing at the SES level (Weeratunge et al. 2013). These dimensions and scales provide parameters for understanding vulnerability and viability by highlighting the facets of wellbeing that are the basis of resilience and viability in small-scale fisheries (Gough and McGregor 2007, Fisher 2014).

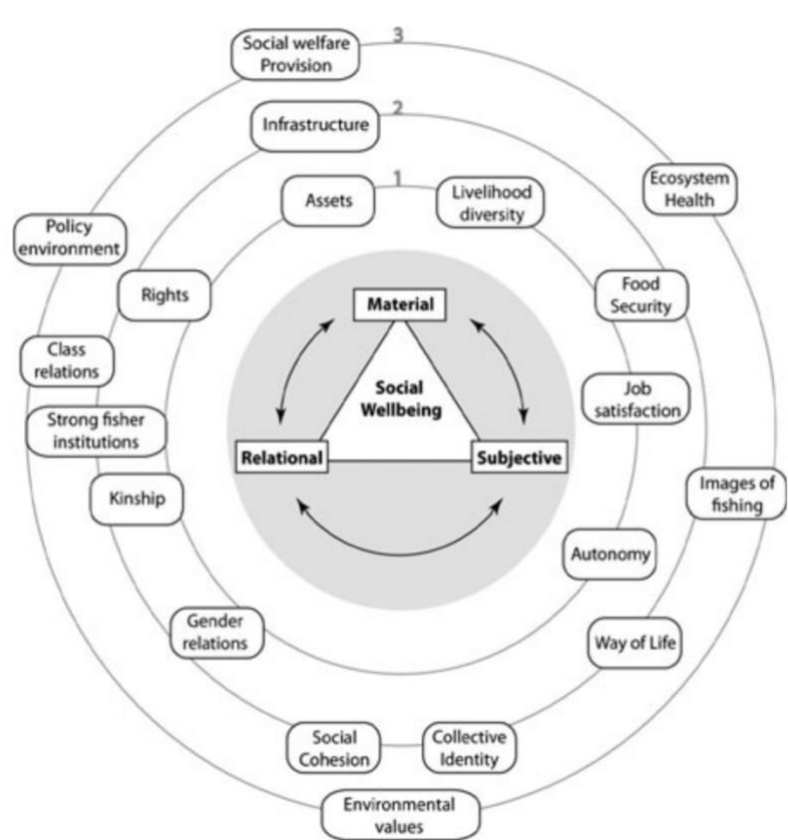


Figure 2.2 Facets of social wellbeing in small-scale fisheries, from Weeratunge et al. (2013).

2.3.3 Multi-level and Interactive Governance

A prominent concern in the governance of MDSSF is that the social-ecological dynamics interacting with resilience and wellbeing of communities are not accounted for in the current management systems (Berkes et al. 2011, Folke et al. 2005). Additionally, economic globalization presents a major challenge for good governance of MDSSF by placing the demands of markets in one location on vulnerable people in other parts of the world (Berkes 2006). For example, in response to global demands for cheap shrimp, governance systems in many parts of the developing world have facilitated the privatization and conversion of mangrove stands into aquaculture farms, resulting in more than half of global mangrove losses, and significantly contributing to the degradation of wellbeing and livelihoods in MDSSF (Das Gupta. and Shaw, 2013). Given the complexities involved in the globalization and SES processes that impact MDSSF viability, and the consequences that insufficient governance policies can have on mangrove ecosystem health and social wellbeing, it is essential to identify governance regimes that support SES viability in MDSSF communities. Governability is a concept that can be used to assess the overall quality of a governance system. It asks: (1) what are the inherent and constructed characteristics of a system that will contribute to making the system more or less governable?; (2) what is the capacity of the governing system's structure and function to address the concerned of the system-to-be governed?; and (3) how does the governing system interact to prohibit or facilitate sustainability? (Chuenpagdee and Jentoft 2015). Overall, governability focuses on understanding how the governing system interacts with the social-ecological system that it aims to govern.

This research draws on concepts from multi-level and interactive governance, to enhance understanding of the interactions between governance and social-ecological systems. Interactive governance can be defined as "the whole of interactions taken to solve societal problems and to create societal opportunities; including the formulation and application of principles guiding those interactions and care for institutions that enable and control them" (Kooiman et al. 2005). Interactive governance theory assumes that the overall capacity for governance of any societal entity or system is continuously changing in response to external or internal factors (Kooiman et

al. 2008). This is very applicable for SESs, as these systems are constantly co-evolving in response to the interactions between social, ecological and external components (Ostrom 2009, Berkes 2003, Folke et al. 2005). Similarly, multi-level governance acknowledges that effective governance of SESs is a complex process and requires arrangements that facilitate adaptation and the sharing of knowledge across institutional levels and bridges the gap between community-based management and governmental organizations (Armitage 2008). Thus, insights from these theories will help to inform my understanding of the institutional and governance processes vital for supporting viability in complex SESs.

2.4 Conceptual Framework

The previously described literature identifies important concepts and theories that provide a structure to guide my process as the researcher. I will utilize these concepts for understanding the phenomena that emerges from this study, and to analyze the data based on the research objectives. The synthesis of these concepts in reference to my research objectives forms the conceptual framework that will be used in this thesis to aid in understanding how MDSSF can transition from vulnerability to viability. Figure 2.3 visualizes the conceptual framework for this study.

This framework illustrates that in order to meet the research objectives of understanding how vulnerability and viability are shaped, it is essential to first acknowledge that MDSSF are a SES, and that the diverse interactions between and within the social and ecological sub-systems need to be explored to understand emergent phenomena. The first research objective – *“To describe the magnitude and impacts of drivers of change and vulnerabilities in the social-ecological system, as well as to understand the significance of the mangroves to the fisherfolk”* – aims to understand the social-ecological interactions shaping vulnerability, and the second research objective- *“To understand key response strategies and conceivable pathways to achieve viability in the social-ecological system”*- explores how viability can be mobilized on a social-ecological scale. Thus, the existing literature on MDSSF as a SES is a critical application to this work.

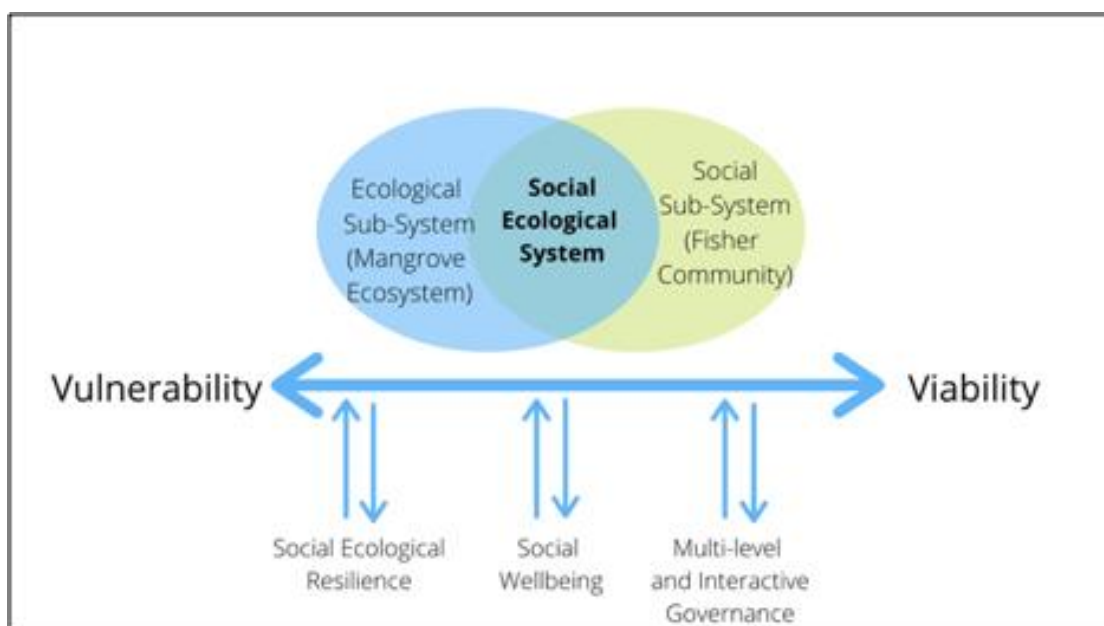


Figure 2.3. Conceptual Framework

Figure 2.3 shows that state of vulnerability or viability that MDSSF as a SES experience is not binary; systems are not simply viable OR vulnerable, as these phenomena occur on across a spectrum influenced by social-ecological resilience, social-wellbeing, and multi-level and interactive governance. It is important to note the two-way arrows in the framework that represent the iterative interactions between the concepts described in this chapter. These interactions emphasize that vulnerability and viability are not static states, and just as improving resilience, wellbeing and governance regimes can mobilize viability, the contrary can do the opposite and increase vulnerability.

The first research objective focuses on how vulnerability in the SES manifests as impacts on material, relational and subjective wellbeing, which are aspects core to social wellbeing. The conceptual understanding of social wellbeing is critical to examining how exactly MDSSF are affected by drivers at various scale, and for understanding how these impacts can interact to create culminating vulnerabilities on wellbeing. This initial research objective also focuses on

the contribution of mangrove ecosystems to dependent communities and draws from the existing literature on social wellbeing to examine how interactions between fishers and the mangroves relates to aspects of social wellbeing in the fisher community.

The second research objective aims to understand how viability can be mobilized at the SES level. To meet this objective, the current coping and adaptive strategies utilized by the case study communities in response to experiencing vulnerability were described, drawing from the existing literature on adaptive strategies and social-ecological resilience to understand *if* and *how* current strategies contribute to long-term viability. Additionally, to meet the second research objective, case study participants were asked to describe what changes are needed to mobilize viability in their community, and what barriers are present that prevent such changes. The concept of resilience was essential for examining participant responses to these questions to conceptualize what the pathway to viability looks like for MDSSF. Responses were analyzed to understand what root-level actions in the community can increase the adaptive capacity and resilience of MDSSF for current and future generations.

Existing scholarly knowledge of multi-level and interactive governance contributes to meeting the second research objective by comparing the elements that are needed in the community to increase wellbeing and resilience with the existing governance regime and proposing needed changes to the current management that will mobilize viability.

Chapter 3

Methodology and Methods

3.1 Introduction

The goal of this thesis is to understand how social-ecological viability can be mobilized in MDSSF based on the perspectives, opinions and expertise of research participants. This chapter will explain the steps and processes utilized to achieve this goal. I will discuss the methodology employed as the research approach, methods used for collecting data, data analysis, limitations, ethical considerations, and my reflection on this research process.

Overall, this thesis is based on a phenomenological case study in the Bangladesh Sundarbans, and in congruence with a transformative paradigm, a qualitative approach was embraced to provide a comprehensive understanding of the complex social-ecological interactions in MDSSF.

The results and conclusions gathered from the methodology and methods discussed in this chapter will be applied to the I-ADapt template, or ‘Assessment based on Description and responses and Appraisal for a Typology’, developed by the Integrated Marine Biosphere Research (IMBeR) and Human Dimensions Working Group (HDWG) to integrate knowledge from all stakeholders in MDSSF in a way that information can be compared and contrasted across case studies to effectively inform management decisions and identify pathways to viability (Bundy et al. 2016).

3.2 Case Study Locations

As discussed in Chapter 1, Section 7, the broad case study location is the Bangladesh Sundarbans Region. The Sundarbans are largest single block mangrove forest of the world and cover approximately 10,000 km² of land in both Bangladesh and India (Aziz and Paul 2015). Within Bangladesh, the Sundarbans forest is situated at 21°30" to 22°30" N and 89°00" and 89°55" E, covering a forest landmass of 6017 km² which represents 60% of the total land cover of the

Sundarbans and 23% of the total forested land in Bangladesh (Kamruzzaman et al. 2018, Roy 2016, Rahman et al. 2010).

Within the Bangladesh Sundarbans, three specific case study villages were selected after seeking recommendations and conversations with Dr. Samiya Selim, a V2V partner at the University of Liberal Arts Bangladesh. First, two cases study communities were selected based on the following criteria: (1) communities that are impacted by mangrove loss, (2) communities where the dominant occupation is small-scale fishing and (3) communities with approximately 150 households. Based on these criteria and recommendations from Dr. Selim, two villages in the Gabura Union in Satkhira district (Figure 3.1) were identified as study locations: Dumuria and Keyabunia.

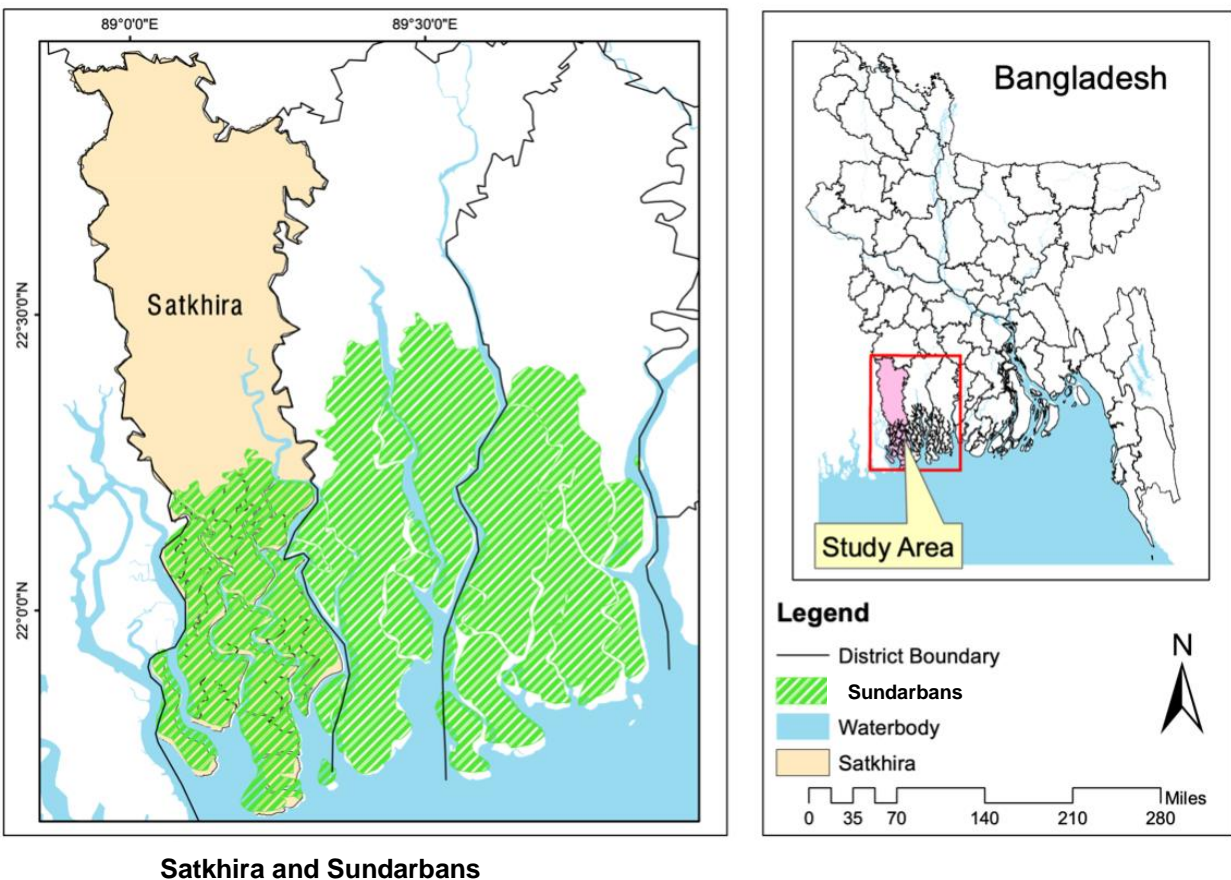


Figure 3.1 Map of Satkhira district, Bangladesh.

Gabura Union (population of ~32000) is situated south of Padmapukur Union, east of the Kholpetua River, west of Kapotakhha River and Khulna district, and north of the Sundarbans and Kholpetua River (Figure 3.2). Given the proximity of the region to the Sundarbans, many of the people living here depend on the mangrove resources for their livelihoods. Gabura Union consists of 15-16 villages and among them Dumuria and Chakbara hold the highest percentage of small-scale fishers (SSFs). In Dumuria village, approximately 95-98% people are SSFs, and in the second case study village, Chakbara, approximately 90-95% of the population are SSFs.

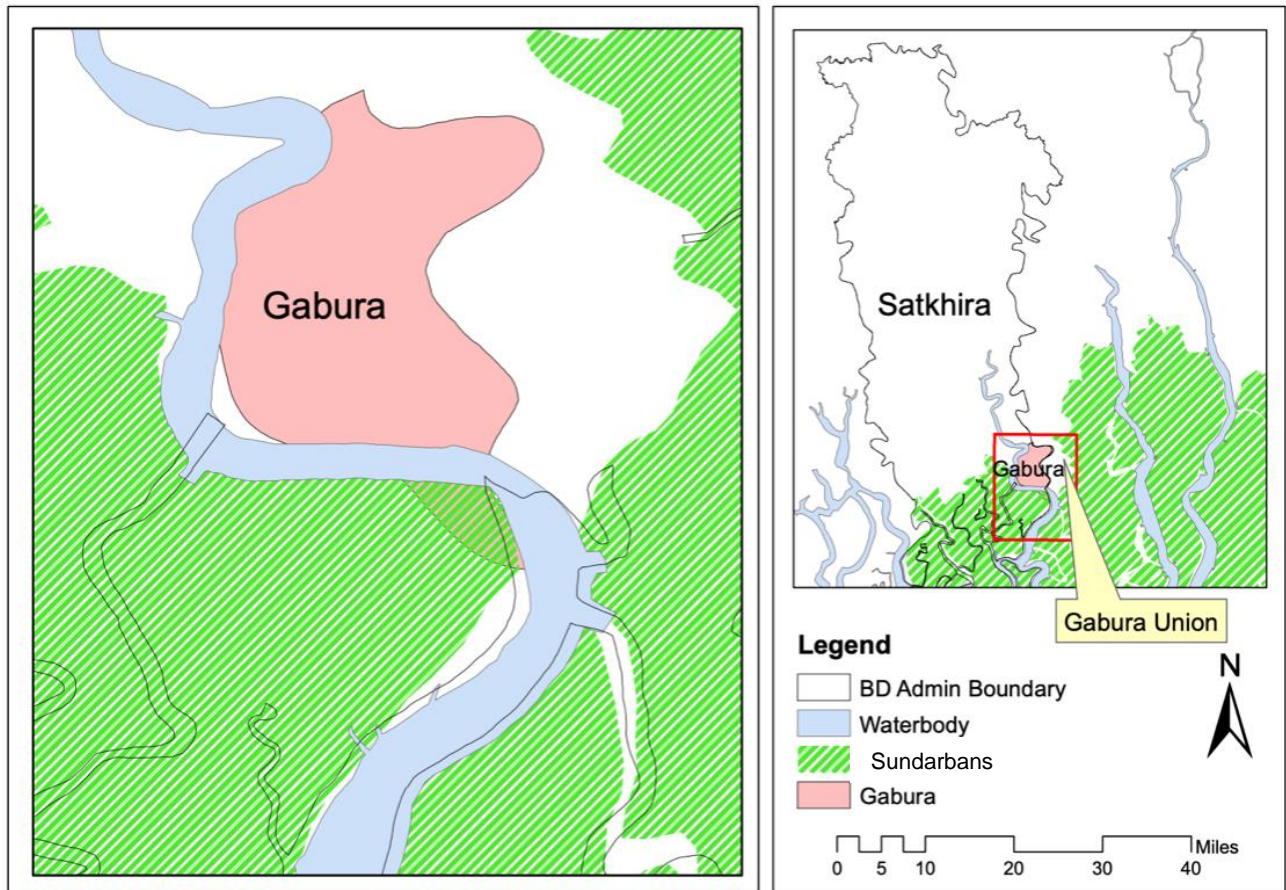


Figure 3.2 Map of Gabura Union, Satkhira district, Bangladesh.

95-99% of the Gabura population follow the rules and practices of Islamic religion. The minority religion is Hinduism. The people's ethics are informed by their religion, and they try to help one another and work together for the betterment of the community. There is a strong sense of respect, and community members celebrate their religion and culture together. One aspect of the local culture is the market day, locally called 'hut day', which is held every week. On this day, most of the villagers sell their products and make their necessary purchases for the week.

The first case-study village in Gabura Union is Dumuria, which is approximately 8km from the union 'parishad', or assembly, and is 3-4km in length. There are approximately 200 households in this village. The village is at the bank of the Kholpetua river and ~98% of the households have a SSF based livelihood. There is a mosque and madrasa, as well as primary school located in the village. The condition of transportation infrastructure inside the village is very poor. There is an embankment that has been heavily damaged by floods and is becoming more degraded each day. This is a major threat to the villagers because when the embankment breaks down, the whole village will be flooded with salt water.

The second case-study village in Gabura Union is Chakbara. It is 12km from the union 'parishad' and is 2- 2.5km in length. This village has a smaller population than Dumuria, with 150-180 households. 90-95% of households are dependent on SSF. This village is considered to be less vulnerable than Dumuria for four reasons: (1) the roads are better quality, and transportation is more accessible, (2) the village is less populated, so there are less resource users, (3) a new embankment is currently being built, and (4) women contribute to their family income by catching juvenile shrimp from the bank of the river.

A theme that emerged during surveys in Gabura Union is that the formation of a community-based organization (CBO) would be beneficial for improving community wellbeing. I was interested in exploring this further and decided to conduct additional surveys in a third MDSSF that had a CBO to understand the role that CBO's can play in mobilizing viability. Therefore, a third village was identified based on the following criteria: (1) a community that are impacted by mangrove loss, (2) a community where the dominant occupation is small-scale fishing, (3) a community with approximately 150 households and (4) a community that has an

active CBO. Based on these criteria and consultations with Dr. Selim, Keyabunia village in Chila, Mongla Upazila was selected as the third study site. Chila is a union of Mongla Upazila in the Bagerhat district in Khulna division of Bangladesh (Figure 3.3). It has an area of 78.06 km² and a population of approximately 19,000. Keyabunia is a village in Chila Union that is directly east of the Posur River. There is an estimate of 200 households, of which at least 90% are SSFs. There are two main religions in Keyabunia village: Islam (60%) and Hindu (40%), and there is a strong sense of community and respect between and within the two religious groups. The village has a CBO called ‘Jele Shomiti’, which was formed by fishers in the community approximately three years ago, with the goal of promoting wellbeing of the fishers.

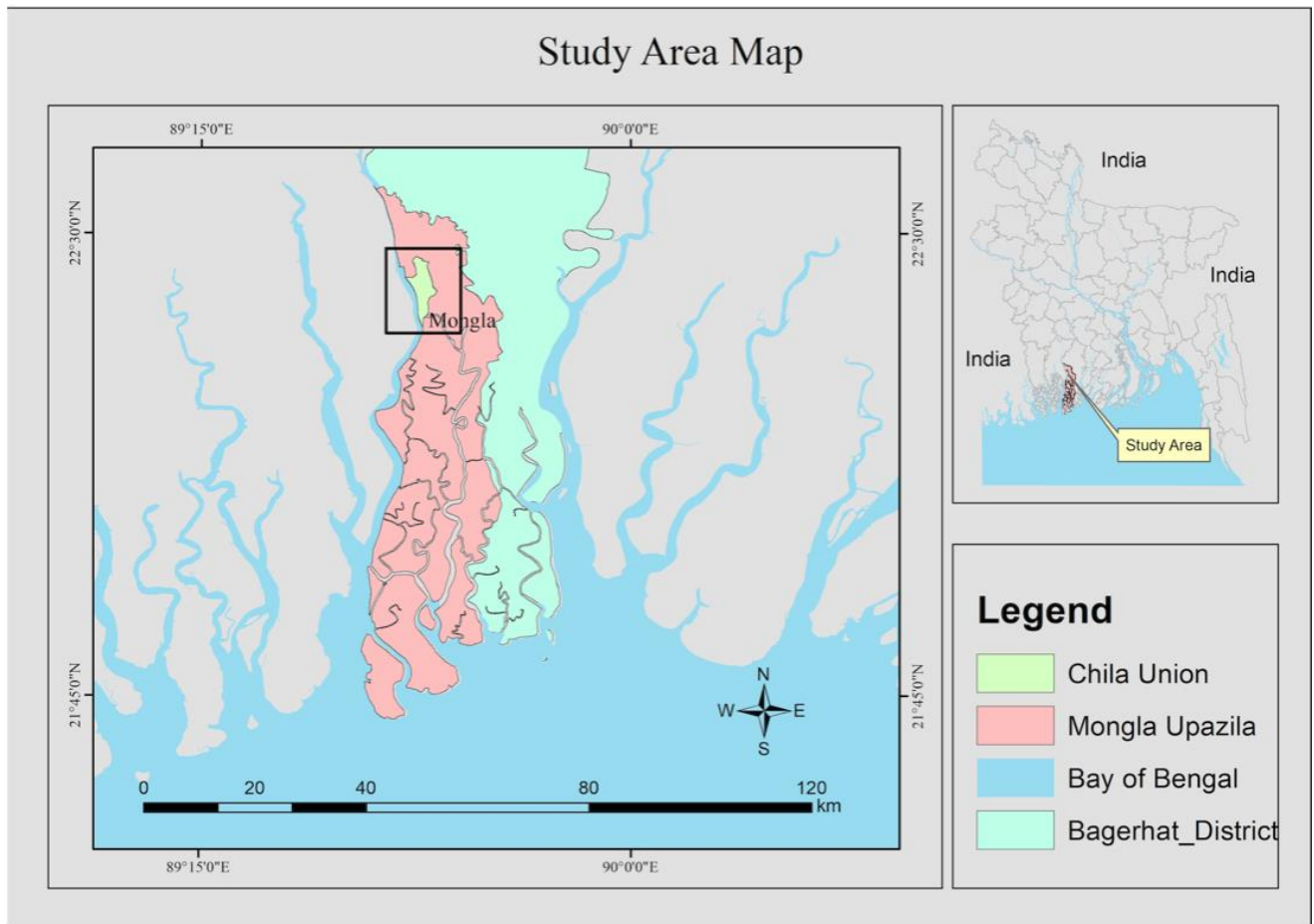


Figure 3.3 Map of Chila Union, the location of the third case study village ‘Keyabunia’.

3.3 Methodology

The methodology employed for this thesis draws from both phenomenology (Chapter 1) and a case study research approach. Both case studies and phenomenology are qualitative research approaches. Case study research provides an in-depth description and analysis of cases, and phenomenology emphasizes understanding the essence of participants' experiences (Creswell 2007). My research approach combined the two to follow a case study from a phenomenological perspective. This approach is suitable for the context of this thesis because the research goal is to understand the depth and richness of research participants' perspectives and bodies of knowledge, which is in congruence with phenomenology. A case study approach is appropriate to address this goal, as it is 'a research approach that is used to generate an in-depth, multi-faceted understanding of a complex issue in its real-life context' (Crowe et al. 2011). Furthermore, case studies are recognized for their ability to capture answers to explanatory 'how', 'what', and 'why' questions which help to explain, describe, and explore how links and pathways occur in their particular context (Crowe et al. 2011). Given that this research is exploring social-ecological interactions, using a case study approach rooted in phenomenology to understand the processes in such interactions is extremely useful for meeting the research objectives. Although phenomenological work typically involves the principal researcher being present during data collection, I could not be physically in the field due to COVID-19 restrictions and instead hired two research assistants to collect data, which I will further explain in the following sections. However, I still believe it is possible to follow a phenomenological approach, as the essence of phenomenology pertains to understanding the lived experiences of the people who have experienced the phenomena (Cresswell 2007), rather than focusing on the experience of the researcher. In fact, several projects following a phenomenological design have been conducted without the principal researcher being present 'in-person' (Collado-Boira et al. 2020, Sumnall et al. 2011). In the context of this thesis, collaboration with local researchers allowed for participants to still be able to share their lived experience regarding the research phenomena and engage with the interviewer.

I implemented a collective case study approach, which involves studying multiple cases, either sequentially or simultaneously, to generate a broader perspective of the research phenomenon (Crowe et al. 2011). In the context of my research, the three case study villages (Dumuria, Chakbara and Keyabunia) were surveyed sequentially. One limitation that the case study approach has been criticized for is a lack of transferability of the research findings to a broader context (Yin 2009). While this is a valid concern, the results from the case studies in this project will be applied to the I-ADapt template, which aims to provide an ‘integrated assessment framework that builds on knowledge learned from past experience of responses to the to global change in marine systems, to enable decision- makers, researchers, managers and local stakeholders to: (i) make decisions efficiently; (ii) triage and improve their responses; and (iii) evaluate where to most effectively allocate resources to reduce vulnerability and enhance resilience of coastal people’ (Bundy et al. 2016).

Given the realities of the COVID-19 pandemic, this thesis was completed remotely and did not involve any in-person data collection. The research approach greatly transformed over the course of preparing for data collection, and thus the methodology is emergent and sequential, as the methods utilized at one point in the research were informed by knowledge generated from the processes taking place prior to that point. The plan for the research process was to conduct a remote qualitative global survey to gain insight into the social-ecological interactions that underly vulnerability and viability on a global scale, and a remote case study in two MDSSF communities in the Sundarbans Forest. However, recruitment for the global survey yielded surprisingly low participation, and I made the decision to instead focus on the rich and community-specific data generated from the two case-study villages, and to further explore developing themes in a third case-study village in the Bangladesh Sundarbans. This overall strategy of inquiry is shown in Figure 3.4.

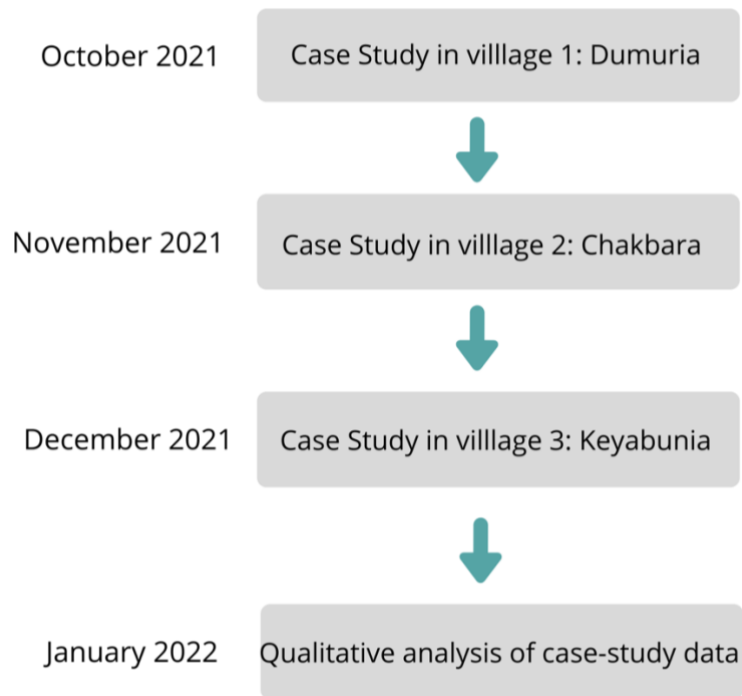


Figure 3.4 Strategy of inquiry and timeline for data collection methods.

3.4 Methods

Methods for data collection consisted of household surveys and a focus group discussion. The purpose of the household surveys was to develop a rich understanding of peoples' values, experiences, positionalities and bodies of knowledge in relation to my research objectives, while also maintaining structure that would accommodate the remote nature of this research. As this research was conducted remotely due to COVID-19 restrictions, two students from Bangladesh were hired as RAs to collect case study data. In each of the villages (Dumuria, Chakbara and Keyabunia), 25 individuals from different households were surveyed by the RAs, cumulating in a total of 75 respondents the three case study locations. The inclusion criteria for survey respondents were that each participant needed to be (1) over 18 years of age and (2) involved (either themselves or their spouse) in small-scale fisheries, whether that be fishing, trading, or processing fish. The surveys followed snowball sampling (Ghaljaie 2017), which is a method of

purposefully identifying key participants by asking an informant or participant to recommend others for interviewing. The interviewers identified initial informants by contacting a local fisherman group, who provided connections to other potential key informants. The survey included questions that were very structured (ex. yes or no questions), as well as open-ended questions to capture the depth of participant's responses (ex. 'What is your impression of current resource management?'). There were three sets of questions in the household surveys. The first section asked demographic questions, such as the participants' annual income and occupations, with the goal of gaining background information to help understand the respondent's perspectives and experiences of vulnerability and viability in their community. The second section corresponded to the first objective of this thesis and focused on understanding the respondent's experiences and point of view regarding the vulnerabilities that they have experienced, and what the impacts of such vulnerabilities have been on their community. The third section corresponded to the second research objective and focused on gaining understanding on how the participant has responded to vulnerability and drivers of change, and what changes they think are necessary in their community to improve the wellbeing of themselves, their community, and the mangrove ecosystem. At the end of the survey, the participant was asked to offer any additional information and insights that they believe would be useful to mobilize viability. Appendix A shows the household survey guide for conducting this aspect of the case study.

There are important gender dimensions to consider when studying vulnerability and viability, and my goal was to fully represent female perspectives in this research. In the first case study location- Dumuria- a dynamic emerged where female respondents did not want to be included in the research because they were uncomfortable speaking alone with male interviewers. As both the RAs were male, it was very difficult to include women's perspectives in the data using only household surveys. To adjust to this, I decided to conduct a focus group with ten women from the community, as facilitating a group dynamic where women would not be speaking one-on-one with a male interviewer would create a more approachable and appropriate way for women to be included in the project. The questions asked were influenced by themes emerging in the household surveys but focused on women's perspectives of what a

pathway to viability could look like for their community (Appendix B). The inclusion criteria for focus group participants were that they needed to be (1) female, (2) over 18 years of age and (3) involved (either themselves or their spouse) in small-scale fisheries, whether that be fishing, trading or processing fish. Recruitment for the focus group discussion also involved snowball sampling, where the participants were identified by recommendations from previous household survey participants in Dumuria.

Table 3.1 provides a summary of the female and male participants who participated in the household surveys and focus group discussion in the three study locations.

Table 3.1 Female and male participants included in each of the three case study locations: Dumuria, Chakbara and Keyabunia.

	Dumuria	Chakbara	Keyabunia
Female Participants	10 (focus group)	11 (household surveys)	12 (household surveys)
Male Participants	25 (household surveys)	14 (household surveys)	13 (household surveys)
Total	35	25	25

3.5 Data Analysis

Data analysis describes the ‘systematic procedures to identify essential features and relationships’ (Coffey and Atkinson 1996) and is a method for investigating and understanding the constituents and context of the phenomena of interest. In this section, I will describe how the data collected from the methods described in this chapter were analyzed to obtain results, which are presented in Chapters 4-6.

3.5.1 Data Collection as a Step Towards Analysis

Data collection for the household surveys and focus group consisted of the RAs physically writing participants’ responses during interviews. It is important to note that these ‘field notes’ involved some level of interpretation from the RA recording the responses. RAs received

training on how to take notes in a manner that did not prematurely code or categorize data by placing their bias regarding the phenomena of interest, but it is important to acknowledge that the writing of field notes is a step towards data analysis (Groenewald 2004, Morgan 1997).

3.5.2 Case Study Qualitative Data Analysis

The data from the household surveys and focus group was rich, dynamic and descriptive. Thus, this data was analyzed qualitatively to fully explore the meanings and perspectives expressed in the dataset. Contrary to quantitative methods, which adhere to statistical methods, qualitative methods prioritize the exploration of the values, beliefs and experiences characteristic to the phenomenon being studied (Tashakkori and Teddlie 2003).

Following a phenomenological research approach, data analysis was guided by the four stages of phenomenological analysis:(1) Epoche, (2) Phenomenological Reduction, (3) Imaginative Variation and (4) Essence of the Experience.

The first stage, 'epoche', is a Greek word that translates to 'stay away from' or 'abstain' (Moustakas 1994) and describes a process the researcher must engage in to acknowledge and block their own biases and assumptions about the research so that the phenomenon being analyzed (social-ecological viability) can be explained by participant's voices rather than by personal biases. This is a critical step in phenomenology, as it is believed that as the researcher, I cannot be detached from my own presuppositions, and to account for that, the research process should not pretend otherwise (Hammersley 2000). Although I recognize that it is likely impossible to fully suspend all of my biases from the research process (Zahavi 2021), I still feel this is a meaningful step to engage in to represent participants' perspectives to the fullest extent. To engage in epoche, I reflected on my positionality, background and biases related to the research project, and made a list of all my presumptions that could impact the analysis process. While engaging in data analysis, I was able to reference this list to remind myself of my biases and consciously put them aside to reduce the impact of my presumptions on the results emerging from the data.

The second stage is phenomenological reduction, which aims to attain the core meanings of the participants' experiences (Moustakas 1994). To do this, I repeatedly read over the survey and focus group responses to develop a holistic sense of the data and become familiar with the words of the participants, while also continuing to consciously prevent my preconceived ideas from influencing the 'meaning-making process'. After reading through the field notes, I used Nvivo software to 'open-code' the data into inductive themes that addressed the research objectives. Open coding is an initial step involved in the analysis process to create larger categories within the data set that describe the core experiences of participants (Cresswell 2007, Moustakas 1994).

The third stage is imaginative variation, which examines the possible interpretations of participants' responses and experiences (Moustakas 1994). For instance, if a general theme of 'unsustainable fishing practices as drivers of change' emerged in open coding, I axially coded this individual theme to understand the dynamics, events and relationships between 'unsustainable fishing practices as drivers of change' and other themes in the data to understand how exactly this was experienced. For example, 'unsustainable fishing practices as drivers of change' was linked with 'resource access restrictions' and 'governmental corruption', which provided a greater depth of context on the dynamics shaping these experiences. I also extracted anonymized quotes from the data to provide evidence supportive of the results. Furthermore, to add additional evidence to my findings, I used excel to quantitatively estimate the prevalence of a theme in each community. For example, I calculated the number of participants identifying 'tropical cyclones as a driver of change' in each location to provide some context for comparison between study sites in the results chapters.

The fourth stage in phenomenological analysis is synthesis of meanings, which combines the understanding of the 'what was experienced' that was gained in phenomenological reduction with the understanding of the 'how it was experienced' that was gained in imaginative variation, to generate a holistic understanding of the essence of participants' experiences regarding the research objectives (Moerer-Urdahl and Creswell 2007). After obtaining this full understanding of what the household survey and focus group respondents experienced, I then used the

conceptual framework (Figure 2.3) to transform the expressions of the participants into expressions that are relevant to the concepts of social-ecological resilience, social wellbeing and multi-level and interactive governance.

3.6 Ethical Considerations

This study involved collecting data from marginalized communities who are ethically vulnerable, and therefore precautions were taken to protect participants from any ethics issues that may have arisen. Participants were informed about the purpose of the study, provided straight-forward consent forms, and were assured that their participation was completely optional. Conversations about how the social and cultural needs of participants could be respected during data collection were prioritized before and during the study. Information shared during data collection did not contain the names of participants, maintaining anonymity. Interviews were carried out in a non-intrusive and honest manner so that participants felt that they could safely act as collaborators in the research project. Overall, the goal was for the research methods to be a collaboration with MDSSF communities, and within the research process I prioritized honoring and respecting participants' voices and traditional ways of knowing. I strived to build meaningful partnerships and hope to make contributions that support specific strategies for social-ecological viability in the local case study communities.

This study has been reviewed and received ethics clearance through the University of Waterloo Research Ethics Board (REB #43509). Please see Appendix C for notice of ethics clearance.

3.7 Limitations

The limitation of this thesis are categorized here into (1) researcher limitations, (2) sampling limitations and (3) respondent limitations.

3.7.1 Researcher Limitations

The unstructured nature of phenomenological research generates a diversity of responses, and although bias was limited through the 'epoche' process, it is important to acknowledge that as a researcher, I may have limited the validity of findings by placing personal biases when analyzing coding responses (Creswell 2007).

The inclusion of RAs in data collection placed additional possibilities of creating a bias on findings. As discussed in section 3.6.1, the RAs were responsible for recording the survey responses and focus group discussions. RAs were trained on recording qualitative data and acknowledging their biases, but there is a risk that unconscious bias influenced how responses were recorded.

The RAs placed an additional limitation on the research because the relationships they fostered with participants and their ability to communicate respectfully and thoughtfully influenced the richness of data that was collected from interviews with community members.

3.7.2 Sampling Limitations

First, validity issues may have arisen due to sampling bias. For instance, snowball sampling may create bias towards people with certain personalities, such as those who are friendly and well known in the community. However, this is a consideration that went into the criteria for selecting case study communities, as a smaller population size will allow for a more accurate representation of the community, and for the research team to become aware of the diversity of personalities within the community and actively avoid sampling bias.

Second, this study was temporally restricted to the length of my Masters degree, and thus the short duration may have limited the depth of research findings. For example, it was not possible to conduct additional focus group discussions in the study locations due to time restrictions.

Third, all sampling and data collection occurred remotely due to COVID-19 restrictions, which certainly placed limitations on the research. Not being able to interact with and observe

participants in their environment is a disadvantage of remote research, as cultivating a sense of trust and comfortability with participants, and thus generating a greater depth of responses, is significantly more attainable during face-to-face interactions.

3.7.3 Respondent Limitations

This is a largely qualitative study, and the information gathered largely came from personal interactions with participants. Therefore, the validity of this information may be limited by acquiescence bias, which is the tendency of respondents to agree with a statement regardless of its content, and social desirability bias, which is the tendency for respondents to give answers that are socially acceptable (Byrman et al. 2009).

Both of the RAs were male, which may have limited the transparency and comfortability of female respondents. For example, in the first study location- Dumuria- female participants were not comfortable speaking directly to an unknown man, so we facilitated a women's focus group discussion to adjust to this cultural norm. However, it is important to acknowledge that the presence of a male facilitator in the discussion group may have influences the responses that participants felt comfortable providing.

3.8 Researcher's Reflection

One unique aspect of the research approach in this thesis is that data collection occurred remotely due to COVID-19 restrictions preventing in-person research. The experience of completing a Masters research project amidst COVID-19 posed many challenges and frustrations, as I developed multiple research plans that had to be abandoned and re-conceptualized in response to travel restrictions and unforeseen circumstances. However, the pandemic also provided opportunities for collaboration with other researchers. The original research plans were for myself to be physically present as the researcher in the case study locations and build a foundational understanding of the community dynamics and settings in the case study locations through informal interactions, which would have made my subsequent

methods more relevant to the experiences and specific interactions or concerns of the communities. However, due to restrictions surrounding the COVID-19 pandemic, it was not feasible for myself to physically collect data in the study locations. To adjust to this, two research assistants (RAs) were recruited and hired to conduct the data collection for the case study. The well-established relationships of the V2V partnership and collaborations with the University of Liberal Arts Bangladesh were crucial to identifying these research assistants. This adjustment made the process of conducting phenomenological data collection more challenging, as a critical aspect of phenomenology is the inclusion of participant's voices in the research, and as the researcher, I was only able to receive secondhand feedback and opinions from participants through the RAs, which was often temporally delayed due to the study locations having poor cellular connection. However, there are also some major advantages to including RAs in data collection. First, the RAs in this study are highly qualified Masters students working in the field of environmental science, and local to Bangladesh. Thus, they have a large knowledge base of the local customs and politics in the case study communities and are also knowledgeable about the environmental and social interactions in SSF that this thesis aims to describe. Additionally, they are fluent in both Bangla and English, and were able to communicate with both myself and the research participants without the need for a third-party translator. Overall, the inclusion of RAs in this project was a huge asset. They provided helpful feedback before and during data collection on how the research methods and survey questionnaire could be tailored to best suit the data emerging from participants in each case-study community. After being hired, the RA's and myself engaged in several remote meetings to discuss the research approach. I provided training on ethical considerations and protocols, obtaining consent, documenting participant responses and on the context and goals of this thesis. We worked together to clarify what the goal of each question was and how each question in the survey should be framed so that it would center the perspectives of the respondent. We discussed how to record survey responses and made a communication plan for how we would remain in contact over the course of the data collection period.

In conclusion, conducting this research during a global pandemic was certainly challenging at times, but with the support and guidance of my supervisor, as well as the

collaborations with the RAs, I hope this thesis will provide high quality insight that can be useful and relevant for the V2V global partnership.

Chapter 4

A Case Study Examination of Social-ecological Dynamics of Vulnerability in Mangrove-dependent Small-scale Fisheries

4.1 Introduction

To meet the broad goal of this thesis, which is to define what social-ecological viability is in the context of mangrove-dependent small-scale fisheries (MDSSF), it is essential to first capture the social-ecological dimensions of vulnerability. As explained by Elinor Ostrom's SES theory (Ostrom 2009), the human and ecological components of a SES interact through outputs of ecosystem services and resource user actions, which generates a cause-effect relationship between the wellbeing of the social and ecological subsystems. Within each subsystem, there are many deeper level variables, such as governance regimes, that contribute additional levels of complexity to SES interactions (Ostrom 2009). When attempting to understand how vulnerability and viability interact at an SES level, it is critical to begin by comprehensively examining the interactions between and within the human and environmental components in a given community. This examination is the focus of this chapter, which addresses the first research objective (Box 4.1) by describing the social-ecological interactions and dynamics shaping

- 1) Describe the magnitude and impacts of drivers of change and vulnerabilities in the social-ecological system, as well as to understand the significance of the mangroves to the fisherfolk.**
- 2) Understand key response strategies and conceivable pathways to achieve viability in the social-ecological system.

Box 4.1 Review of research objectives.

vulnerability, as experienced by the women and men in the fishing villages of Dumuria, Chakbara and Keyabunia. First, I will describe the relationship between the mangrove forest and the fisher community by explaining how this vital ecosystem contributes to the material,

relational and subjective wellbeing of dependent communities. Second, I will describe the multi-level drivers of change that contribute to vulnerability in the case study communities. Third, I will explain how these drivers of change manifest as impacts on the SES. Finally, I will discuss the complexity of interactions between impacts and drivers of change at multiple levels in the SES.

4.2 The Contributions of Mangrove Fisheries to Wellbeing

This section details the contributions and importance of mangrove fisheries' resources to the wellbeing of the fisherfolk. In order to understand how MDSSF can transition from vulnerability to viability, it is important to start from the ground up and first understand the relationship between the mangrove fisheries and the people dependent on the resources that this ecosystem provides. Here, I explain how the mangroves contribute to the three dimensions of wellbeing: subjective, material and relational (Section 2.2.2).

4.2.1 Subjective Wellbeing

Subjective wellbeing is how an individual thinks and feels about their life; it is a person's own reflection on what they have and what they do (Coulthard 2012). In this context of MDSSF, the participants identified that the mangrove resources provided a strong sense of identity and purpose for their life. One fisherfolk respondent voiced:

'I feel the most comfortable and safe in this mangrove. This is like my second home. This forest gives me inner peace. I know this place more than anything of the world'

Another shared:

'From the time of my ancestor till now, we have depended on fishing and crab hunting in the mangroves. This place holds our identity'

This strong sense of identity that the mangroves bring to the fisherfolk can be described as place-identity, which is a sub-dimension of overall self-identity that refers to how a place contributes to identity and creates feelings of belonging and purpose (Fresque-Baxter & Armitage 2012). The

generational relationship that the fisherfolk hold with the mangroves has developed a strong emotional bonding to place. One respondent shared:

'Since the beginning of my childhood, I have grown up going to the mangroves with my grandfather and father. Fishing in the mangroves is the way of life for my family; it continues from generation to generation. Our people think that we are born to be fishing in the mangroves. It means everything to us.'

The emotional connection that the fisherfolk have with the mangrove fisheries is a defining aspect of their identity. Being associated with the mangroves provides self-worth and a sense of belonging. When respondents were asked to describe their relationship with the mangrove fisheries, it was incredibly clear that there is no separation between the mangroves and the fisherfolk. They identify as 'mangrove fisherfolk', and experience a deep, generational rootedness to place.

4.2.2 Material Wellbeing

Material wellbeing is viewed through an objective lens that examines what a person actually has that contributes to their overall wellbeing (Coulthard 2012). This refers to the resources which one has access to meet their needs, such as food, employment, natural capital and assets (Coulthard 2012). The mangrove fisheries are crucial to the material wellbeing of mangrove-dependent fisherfolk because the resources provided by the mangroves generate their main source of income. All survey respondents were mangrove resource users (N=75): 83% collecting fish, 45% collecting crab, 36% collecting honey, 16% collecting shrimp, and 3% collecting wood, with 68% of users collecting more than one resource. These resources are collected for selling into the market, which provides income. As described above (Sec. 4.2.1), mangrove-dependent fisherfolk are place-based people and over the course of several generations have developed the ability to use their 'place'- the mangrove fisheries- to meet their needs. The survey respondents expressed how they have spent their entire lives in the mangroves and have a heightened awareness of the ecological landscape. They feel competent in the mangroves and have acquired the specialized skills to harvest resources that can support their livelihood. For example, one respondent expressed:

‘The mangrove resources are the main source of my livelihood for supporting my family. I am an expert in this sector; I have been collecting these resources with my father since childhood. Our ancestors have built a community where this (the mangroves) is what we live on.’

4.2.3 Relational Wellbeing

Coulthard (2012) defines relational well-being as what a person does through social relationships that enable the pursuit of wellbeing. This includes interactions with individuals, groups and institutions internal or external to their community. This section explains how the mangrove fisheries contribute to relationships that improve the wellbeing of mangrove-dependent fisherfolk.

4.2.3.1 Community relationships

As >90% of the population in all three case study villages are small-scale fisherfolk, the people depend on the same resources for earning their livelihoods and have developed strong relationships with each other. For example, one survey respondent from Keyabunia shared:

‘We have all grown up together from our childhood, going to the forest together, eating together, sleeping together. We are bonded like family. We support each other no matter the circumstance.’

The mangrove resources are integral to building these strong community relationships. Generations of collecting the same resources with neighbors has built a strong bond. Not only does this social value contribute to a sense of belonging and greater wellbeing, but it also provides a support system for fishers to help one another through loaning money or fishing equipment in times of necessity.

4.2.3.2 Markets

The mangrove fisheries contribute to relationships and connections with markets and institutions outside the community. In the three case study villages, there are two types of market systems.

One is that fisherfolk sell their collected resources directly in the local market. The second, and the most common way of selling, is that they sell to the traders through a bidding system. The traders work as a middleman, which is locally called “*mohajon*”. The *mohajon* buys fish by bidding from the fisherfolk and then supplies the fish to the city area and receives a huge profit; much more than the fisherfolk. Although the fisherfolk receive substantially less of a profit than the *mohajon* in this transaction, they have good relationship with the traders and are able to generate some income to support their families. The more impoverished fisherfolk can take loans from the *mohajon* of the village to prepare for going to the mangrove forest. After fishing, they sell their fish to the *mohajon* at a reduced price. In the case of honey, the *mohajon* gives a money advance to the honey collector to prepare themselves for going to the mangrove forest and then the honey collector will give honey to the *mohajon* and be paid based on how much they collect. The mangrove resources are the backbone of these relationships between fisherfolk, fish traders and markets. By selling these resources, fisherfolk can earn their livelihoods.

4.3 Drivers of Change

The previous section described how the ecological system (the mangrove fisheries) supports the social system (the fisherfolk community). Here, I will explain the drivers of change that impact the wellbeing of both the social and ecological subsystems, as well as the whole SES in the three case study communities. Drivers of change are defined as internal or external stressors that create movement in the social-ecological system, thus generating impacts. I will explain the drivers identified by respondents in two sub-sections: (1) natural drivers of change, which are stressors that directly come from the natural environment, and (2) anthropogenic drivers of change, which are stressors that are a result of human actions.

4.3.1 Natural Drivers of Change

The natural drivers of change identified in the three case studies are all linked to climate change. Table 4.1 shows the breakdown of the drivers that were identified by participants in the three villages.

Table 4.1 The natural drivers of change identified by each of the three case study villages: Dumuria, Chakbara and Keyabunia.

	Village 1: Dumuria	Village 2: Chakbara	Village 3: Keyabunia
1	Tropical cyclones (23)	Tropical cyclones (22)	Tropical cyclones (25)
2	Changes to monsoon season (9)	River erosion (8)	River erosion (5)
3	River erosion (3)	Changes to monsoon season (5)	Changes to monsoon season (4)

Notes: Each column pertains to the respective village, and the rows show which driver is most to least common in each village. The numbers in brackets show how many participants identified that driver in each village. N=25 for each village, with some participants identifying more than one driver.

Tropical cyclones are by far the most frequent and severe natural driver of change identified by respondents. Tropical cyclones are defined as ‘intense, rotating vortices of air that sustain themselves on the energy that is released when water condenses in clouds’ (Bushra and Rohli 2021). Respondents acknowledged that cyclones are historically common in the Sundarbans, but that in the last ten years the impacts of cyclones on the villages have become more severe (Figure 4.1). An important ecosystem service that mangroves provide to nearby communities is protection from natural disasters. However, the amount of mangrove deforestation has increasingly become more and more in the case study locations, and thus there are less mature, established mangrove stands that can physically protect communities from the extensive damage that cyclones cause. Additionally, respondents identified that the amount and intensity of cyclones has increased in the past decade, and therefore there is not enough time for mangroves to re-establish themselves between cyclone events to provide protection to the communities. Cyclones Sidr in 2007, Aila in 2009 and Amphan in 2020 had particularly extensive damage to the mangrove forests and significantly degraded the ecosystem. Many

people died during these disasters, and infrastructures, embankments and cultivated lands were severely impacted. In particular, the village Dumuria has an embankment that was very damaged and is falling apart more day by day. There is no initiative or action to build a new embankment, and the people of the village are scared because if the embankment breaks down, the whole village will have flooded with saline water. Livelihoods have also been very negatively impacted by these cyclones; fishing infrastructure was damaged, fisherfolk were not able to safely go fishing due to cyclone warnings, and people were unable to collect wood and honey because trees were uprooted, and honeycombs were destroyed.



Figure 4.1 Photo of flooding caused by Cyclone Amphan (2020) in Gabura Union, where case study villages Dumuria and Chakbara are located. This photo was externally sourced from Dhaka Tribune, a Bangladeshi news organization, and was taken by Kazi Fazla Rabbi.

Several respondents noted that changes to the monsoon season were drivers of unwanted impacts on their community. The region receives approximately 80% of its yearly rainfall during

the monsoon season, which is typically between June and October. Due to climate change, the monsoons season is changing and it is becoming more unpredictable. The unpredictability is directly related to the occurrence of tropical cyclones, which happen during monsoon season. Participants in the three villages described how monsoon seasons have become longer and more severe over the last decade, which has resulted in flooding, river erosion and livelihood impacts. River erosion is a driver predominantly mentioned by the women in the community, as women collect shrimp from the rivers behind their homes to supplement their family income. Riverbank erosion is associated with the floods that occur during monsoon season. When severe, river erosion can damage homes and displace people, but the impact most discussed by respondents is that the increased water turbidity that results from river erosion leads to higher shrimp mortality, and therefore a reduction in shrimp collection.

4.3.2 Anthropogenic Drivers of Change

Respondents from the three case study villages were very much in unanimity when discussing threats to their communities and experienced the same major threats (Table 4.2). Five major anthropogenic drivers of change were identified from response, which will be described in this section: (1) government actions, (2) corruption, (3) unsustainable fishing practices, (4) more resource users and (5) the corona pandemic. One fisherman in Chakbara shared that there is an increasing amount of aquaculture hatcheries that are encroaching on the mangrove forests and contributing to degradation of biodiversity, but this driver was only identified by one participant in the entire case study, and there is not enough data to thoroughly describe aquaculture as a driver of change in this section.

Table 4.2 The anthropogenic drivers of change identified by each of the three case study villages: Dumuria, Chakbara and Keyabunia.

	Village 1: Dumuria	Village 2: Chakbara	Village 3: Keyabunia
1	Government actions (25)	Government actions (25)	Government actions (25)
2	Unsustainable fishing practices (25)	Corruption (23)	Unsustainable fishing practices (25)

3	Increase in resource users (20)	Unsustainable fishing practices (21)	Corruption (25)
4	Corona pandemic (18)	Corona pandemic (16)	Increase in resource users (14)
5	Corruption (16)	Increase in resource users (3)	Corona pandemic (11)
6		Increase in aquaculture (1)	

Notes: Each column pertains to the respective village, and the rows show which driver is most to least common in each village. The numbers in brackets show how many participants identified that driver in each village. N=25 in each village, with some respondents identifying more than one driver.

4.3.2.1 Government Actions

Since independence in 1971, the management of all state-owned forests in Bangladesh is controlled by the Forest Department, which currently works under the Ministry of Environment and Forests. The organizational structure (Fig 4.2) of the Forest Department includes Divisional Forest Officers at the highest level, which are the key persons of forest administration. At the lower organizational level, there is a beat officer who is a forest guard in charge of a ‘beat’, which is the smallest area of administration in the department. Within each forest beat, there are forest guards who are responsible for enforcing policies, protecting forests from thefts, and executing field operations.

In response to degradation of mangrove resources, the Forest Department has reduced the forest area that fisherfolk are able to access to collect resources, as well as the amount of time that they can spend in the forest. Previously, fisherfolk were able to freely enter the mangroves, so this has been a big change to peoples’ livelihoods. Every single respondent from all three case study villages voiced that the governmental policies enforced by the Forest Department are a major threat to their wellbeing and livelihoods. For example, one fisherman in Chakbara expressed:

“The government is the main reason why we are struggling. They have reduced the (fish) catchment area. There are fish but we have lost access. Because of this, my income has

suffered. I can't meet the demands of my family. Sometimes I have to go to the forest without permission, but then if I get caught I have to give a fine to the forest officers. Sometimes they take people to prison for entering without permission."

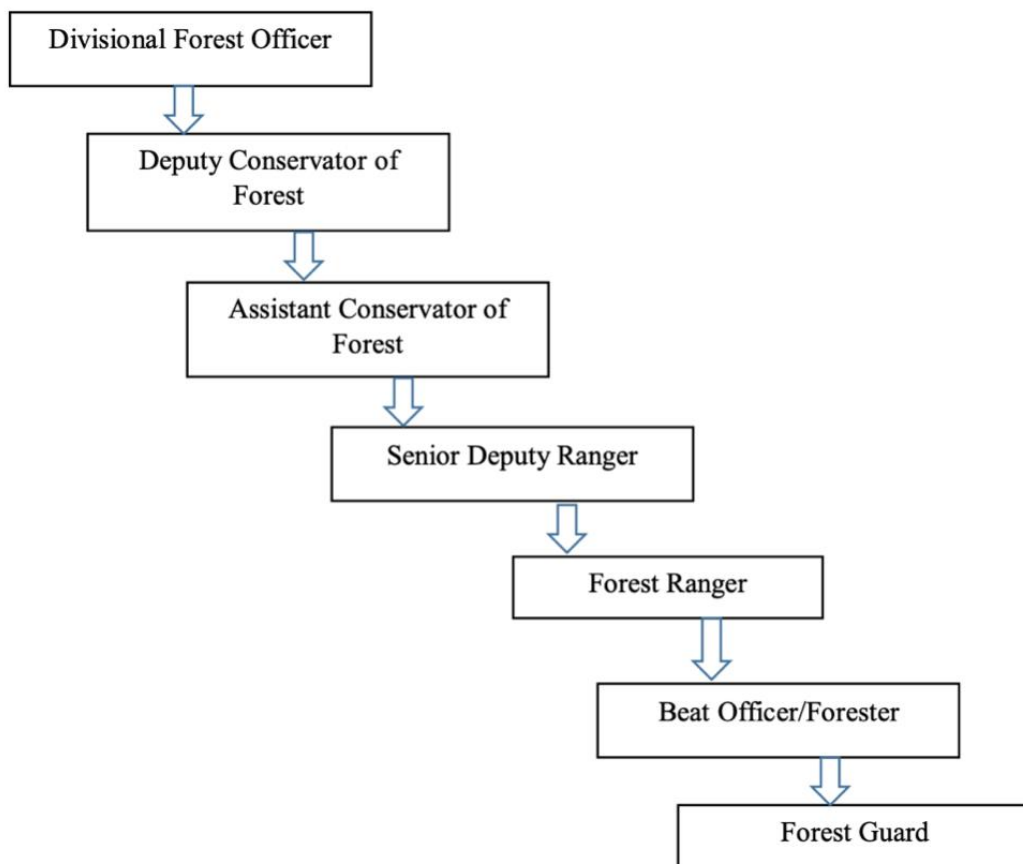


Figure 4.2 Hierarchical Structure of the Bangladesh Forest Department. This figure was created by research assistants Ashiqur Tamim and Zahid Hassan.

4.3.2.2 Corruption

Following the discussion from the previous section on the threat that government actions pose to MDSSF, a common theme that emerged in the data is the amount of corruption that is present in how the mangroves are managed by the government. According to the people of the villages, the

mangrove fisheries are not restricted for the sole purpose of allowing the forest to ecologically regenerate. There are NGOs, international organizations and other countries that represent competing commercial uses of coastal areas who give the Bangladeshi government money to restrict the Sundarbans.

There is also corruption present in the lower units of the Forest Department. Forest officers take bribes from the wealthier fisherfolk in turn for letting them access the mangroves without a permit, or for turning a blind eye to illegal fishing activities, such as using fish poison. This creates a huge inequity in fishers being able to access the forest, because the officers favor the richer fishers and then not grant access to the poorer fishers, which amplifies and drives the financial disparities and conflicts between people of different income levels. Some respondents also voiced that the forest officers will refuse fisherfolk access to the forest, and then over-harvest fish resources for themselves.

4.3.2.3 Increase in Resource Users

This driver is directly related to governmental actions. Even though the government has decreased the fish catchment area, there are still the same amount of fisherfolk, so there are more resource users dependent on a smaller resource unit. This spatial concentration of small-scale fishery activity is coupled with an increase in population and businesses that are dependent on the mangrove resources, thus leading to over-harvesting.

4.3.2.4 Unsustainable Fishing Practices

In the previous drivers that have been discussed, we can see the emerging realities of MDSSF in the case study village that, simply put, lead to not enough resources available for people to support their livelihoods. This driver- unsustainable fishing practices- is both a coping response and a driver of change, as many fishers feel that engaging in such practices is their only option to maintain their income. 100% of respondents in Dumuria and Keyabunia, and 84% of respondents in Chakbara identified unsustainable practices as a major driver of vulnerability in their communities (Table 4.2). Additionally, participants in the women's focus group session in Dumuria collectively voiced that unsustainable fishing practices have detrimental impacts on

their community. In the following subsections, I describe the unsustainable fishing practices that the study respondents identified.

4.3.2.4.1 Fish Poison

76%, 44% and 84% of respondents in Dumuria, Chakbara and Keyabunia (N=25 in each village) respectively identified the use of fish poison as an unsustainable fishing practice. In all three study sites, the use of fish poison as a means to improve catch efficiency has increased drastically in recent years. When a fisher uses poison, they are able to harvest a very large amount of fish in a short time. However, this heavily pollutes the water and harms biodiversity. After poison is used, fishers cannot harvest from that area for a month. This practice is harmful to the small-scale fishing community and decreases the fish resources in the long run; respondents noted that there are significantly less fish and crab in the rivers because of poison.

4.3.2.4.2 Use of Non-standardized Fishing Nets

Respondents (4% in Dumuria, 20% in Chakbara and 16% in Keyabunia; N=25 in each village) identified that some fishers are also using large nets to catch bigger volumes of fish, or nets with a smaller mesh size that catch immature or undersized species. Small-scale fishing is often characterized by the use of traditional, low-tech gear that leads to sustainable practices. According to participants, this shift that some fishers are making to use non-standardized nets is resulting in over harvesting and is diverging away from the ecologically harmonious practices associated with small-scale fishing operations.

4.3.2.4.3 Over-harvesting of Resources

Respondents (24% in Dumuria, 20% in Chakbara and 16% in Keyabunia; N=25 in each village) identified over-harvesting of resources as an unsustainable practice that is driving unwanted change. Rich fishermen with higher quality boats are able to go to the ocean for six months at a time. They fish near the connecting point of the ocean and the river, which decreases the number of fish entering the river that most fisherfolk access for resource collection. Some of these wealthier fisherfolk are also catching the mother fish. The mangrove forest functions as a nursery

for marine species, and mother fish come to the river to lay eggs. When pregnant fish are caught in the ocean, this decreases the reproductive activity and abundance of fish in the mangrove rivers.

Respondents, particularly in villages Dumuria and Chakbara, also noted that some people are illegally entering the forest at night to cut trees for wood and steal fish. One fisherman from Dumuria said:

“The people are treating the Sundarbans resources badly and are being dishonest with one another. This is the biggest threat of all. The stealing and poaching has become very bad since the government restrictions.”

4.3.2.5 Corona Pandemic

Although the corona pandemic can be argued as a natural driver of change, I chose to present it as an anthropogenic driver based on the data that emerged from the case studies, which supports that it is the human actions surrounding the corona pandemic that have caused stress to the case study communities in several ways, rather than the virus itself. For instance, the government increased the restrictions for accessing the mangrove forest in response to the pandemic. Fisherfolk were already unable to collect the amount of resources needed to support their livelihoods, and these further restrictions exacerbated their financial stresses. Additionally, the reduction in fish, crab and shrimp exports resulted an absence of markets for fisherfolk to sell their collected resources. When they were able to source a buyer, the prices were much lower than before the pandemic. Furthermore, many fisherfolk engage in secondary occupations, such as working in agriculture or brick kilns. Due to the pandemic, the about of day laborer jobs significantly decreased, and fisherfolk were unable to find work to supplement their income.

4.4 Impacts as Vulnerabilities

This section explains how the anthropogenic and natural drivers of change discussed in section 4.3 have manifested as impacts that increase vulnerability in the three communities in this study. Impacts will be discussed in three subsections on the specific impacts on (1) material wellbeing,

(2) relational wellbeing and (3) subjective wellbeing. These impacts are summarized below in Table 4.3.

Table 4.3 Summary of impacts discussed in Section 4.3.

Type of Impact	Description of Impact
Material Wellbeing	<ul style="list-style-type: none"> ○ Decrease in market prices ○ Less resources available ○ Loss of livelihood and financial security ○ Cycles of debt ○ Fear over future material wellbeing
Relational Wellbeing	<ul style="list-style-type: none"> ○ Increase in social conflict ○ Shift in gendered roles in the family ○ Decreased social relations between fisherman
Subjective Wellbeing	<ul style="list-style-type: none"> ○ Loss of identity

4.4.1 Impacts on Material Wellbeing

Impacts on the material wellbeing (i.e., livelihoods, resources, income, assets) were by far the most discussed by research participants in all case study sites. Largely due to the restrictions imposed by the government, small-scale fishers have experienced a major decrease in income. This has been further exasperated by the decrease of market prices due the corona pandemic, as well as the damage inflicted by recent tropical cyclones. When asked if their income was sufficient for their annual expenditures, 78.7% of respondents said no. Many fisherfolk have been forced to take loans from NGOs, which has initiated cycles of increasing debt. One respondent from Dumuria said:

“As our community is completely dependent on the mangroves and fisheries, these changes have impacted our livelihood. My income is decreasing and I can’t afford to live. I had to take loans and now I have to sell my cattle, land and other assets to pay the loans.”

Another respondent from Keyabunia said:

“These changes have reduced our income and some days we are starving. We have more financial problems and I cannot afford education for my children.”

In addition to relying on the mangroves for access to able to resources that support their livelihoods, fisherfolk also collect food and firewood from the mangroves for their family’s personal consumption. The lack of access to the forest has impacted the ability of people to access food and other necessary goods for survival. A respondent from Chakbara expressed:

“Before the restrictions, we could collect fish and Kewra (a mangrove fruit), which was meeting the needs of food in our family. But now, we cannot go to the forest, so we cannot collect food, or even wood for fuel.”

There is a strong feeling of insecurity and fear regarding material wellbeing in the three villages. People do not know whether they will be able to eat the next day or make enough money to pay off their loan debts. Respondents shared that they were scared for their future, and the future of their children. One fisherman from Chakbara said:

“I worry about the future and being unable to provide for my family. Can you picture the condition of our community when we will inevitably be hit by another tropical cyclone? The height of the water from the riverside will break the embankment. We have no way to make income, no way to access food. We are so insecure. Of course we are scared.”

4.4.1.1 Ecological Impacts

This subsection falls within the broader category of impacts on material wellbeing because the ecological state of the mangroves and fisheries is directly related to the social state of material wellbeing; the ecosystem represents natural capital and resources that fisherfolk need to support their livelihoods. Tropical cyclones are a major driver of ecological degradation. The mangrove forests provide a natural barrier to coastal disasters, and many are uprooted or destroyed when a cyclone hits. According to the study respondents, mangroves require approximately two years to

reach a mature size. As tropical cyclones are becoming more frequent and intense, the mangrove stands are not able to restore themselves between cyclonic events. Additional, anthropogenic drivers, such as deforestation and unsustainable wood harvesting are further degrading the mangrove ecosystem. On the other hand, fishers in the village Keyabunia explained that sustainable harvesting of wood in the mangroves is helpful for the forest and removes old wood, allowing for more growth and diversity. However, the government has made strict decisions without consulting the fisherfolk, and this practice of sustainable wood harvesting is not considered or permitted, which is also contributing to the decline of ecosystem wellbeing.

4.4.2 Impacts on Relational Wellbeing

Due to being restricted from accessing the mangroves, the men in the communities have been forced to step away from their ancestral occupation of small-scale fishing and pursue secondary occupations such as working as day labourers in agricultural fields, or at a brick kiln. They have to leave their communities and families for months at a time to do so. Prior to restrictions, the fishermen would be able to go fishing together, but now since many are switching occupations, the social relations and connection in the communities are decreasing.

Similarly, women are working as a shrimp collector in the river to make up for their family's income deficit. In the women's focus group session conducted in Dumuria, participants discussed how this affects their families- they feel their role as a woman in to work in the household and some are unhappy that they need to work outside of their home; they are now giving more time to working in the river than to their children and homes.

Another impact on relational wellbeing is an increase in social conflict. There is a major conflict between the fisherfolk and the forest officers who look after the management of the mangrove. According to the fishers, they are restricted to go for fishing, and are upset that they cannot collect resources for their livelihoods. When they express frustrations to the forest department, the officers say that they are just doing their job and implementing the government policy, rules and regulations. However, there is also corruption within the forest department that

is contributing to this conflict. As previously discussed (sec 4.2.2.2), some of the richer fisherfolk are bribing the forest officers for permits or for letting them use illegal fishing practices. Not only does this further engage conflict between the government and fisher communities, but it also is creating a sense of distrust among the fisherfolk because some people are using unsustainable practices that degrade the mangroves or are using their higher economic position to bribe the government.

4.4.3 Impacts on Subjective Wellbeing

As discussed in section 4.2.1, the mangrove-dependent fisherfolk's identities are very strongly linked to the mangroves. Due to the restrictions and resource degradation, fisherfolk are not able to access the mangrove and are experiencing a loss of identity. For example, one respondent stated:

“Without the mangroves I am nothing. This mangrove is my only identity. In the past days my whole year was spent into the forest. The forest is everything to me. But now I can barely go there. I feel like I am losing my identity.”

A loss of identity is also a result of people diversifying their livelihoods away from small-scale fishing. Many fishermen are spending more time pursuing secondary occupations, and less time in the mangrove fisheries, reducing their emotional connection with the forest. A relevant quote from one respondent that reflects this theme is:

“This mangrove is my identity. This mangrove is part of me. But, nowadays I feel that this forest is betraying me. This forest feeds me. But I cannot get what I need from the mangroves now. The current situation forces me to work as a day laborer.”

4.5 Discussion: Feedback Loop Between Driver and Impacts

As discussed in Chapter 2, there are two types of drivers of change: (1) proximate drivers and (2) underlying drivers. Proximate drivers are threats that directly impact a system, whereas underlying drivers are deeper or indirect anthropogenic drivers underpinning proximate drivers

that are rooted in demographic, economic, institutional, technological and cultural interactions (Geist and Lambin 2002). For example, a proximate driver of change in this study is tropical cyclones, which are events that directly impact the system. An impact of cyclones is that mangrove resources are destroyed, and fisherfolk are not able to harvest resources to support their livelihoods. In response to this, some fishers use unsustainable fishing practices, which in turn creates impacts on relational wellbeing and degrades the ecosystem, furthering the actions that the government takes in restricting the mangrove forest. Therefore, unsustainable fishing practices are a good example of an underlying driver, which is rooted in social interaction. There is some overlap between impacts and drivers, because some impacts, such as unsustainable fishing practices, are themselves drivers of further impacts. Before proceeding to the next chapter, which looks at plausible strategy for mobilizing viability in MDSSF, it is important to discuss the full, dynamic picture of how drivers of change and impacts interact. As this project follows a social-ecological framework, I will explain the drivers of change that emerged from the data in a feedback loop that included the human and environmental interactions.

Figure 4.3 shows a diagram of how all the drivers and impacts previously discussed in this chapter relate with one another. The legend describes how each text box is categorized into different types of drivers or impacts. The circle at the top right of the diagram contains 3 natural proximate drivers of change: (1) cyclones, (2) climate change and (3) river erosion. The arrow shows that these drivers cause 'ecological degradation', which in turn feeds back into the social system as 'less resource available' for users. 'Ecological degradation' also leads to 'government actions' and restrictions on resource access, making even fewer resources available to users. Due to 'less resources available', some resource users started engaging in unsustainable fishing practices. This drives more 'ecological degradation', thus promoting more 'government actions' and creating a positive feedback loop between these underlying drivers and impacts. The cumulation of 'less resources available' and the 'decrease in market prices' caused by the 'corona pandemic' has manifested into material impacts on wellbeing by creating a 'loss of livelihood and financial security', which in turn leads to 'cycles of debt' and a 'fear over future material wellbeing'. Due to 'less resources

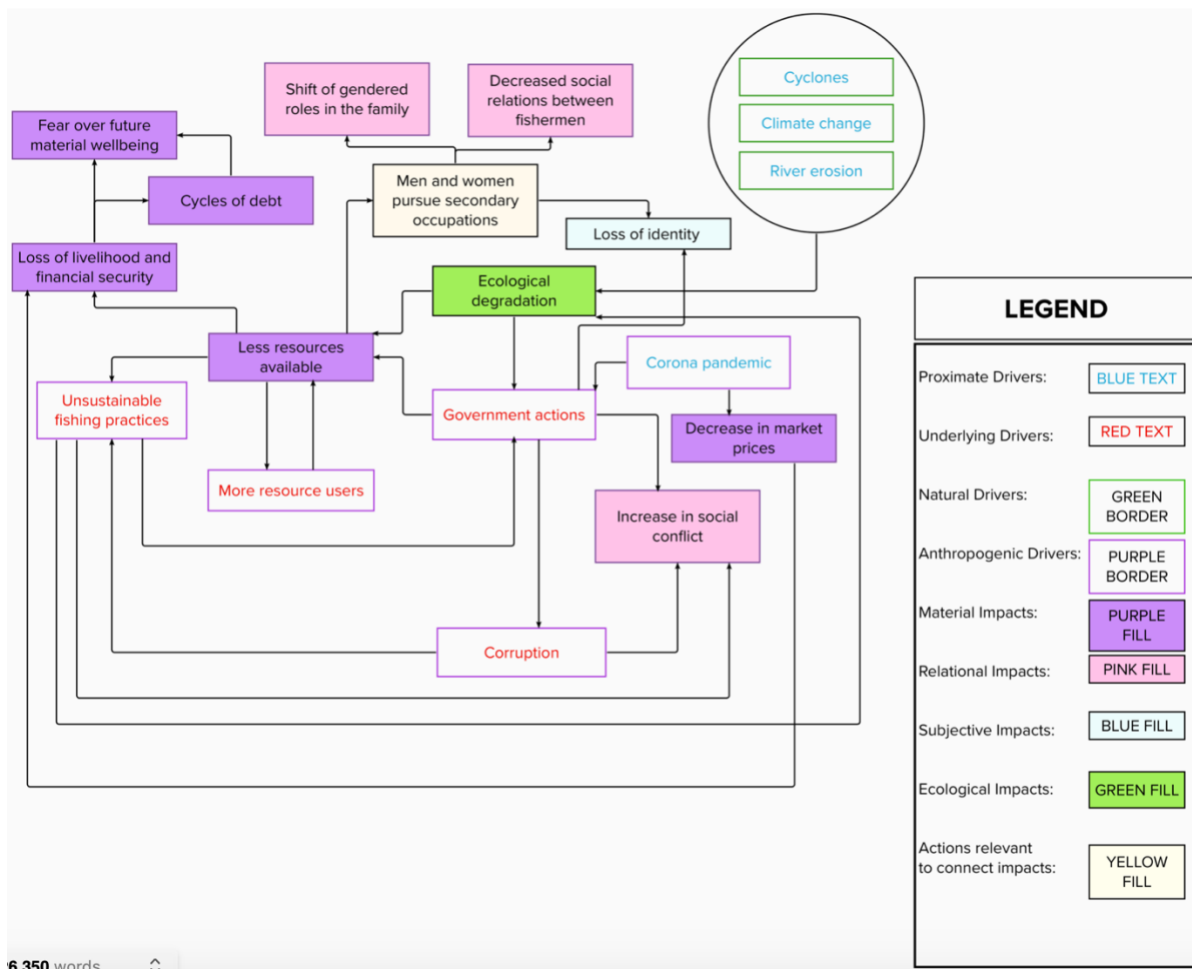


Figure 4.3 Diagram of the social-ecological interactions between drivers of change and impacts that contribute to vulnerability.

available’, fisherfolk pursue secondary occupations, which along with the governmental access restrictions, impacts subjective wellbeing by creating a ‘loss of identity’. Additionally, this impacts relational wellbeing by creating ‘shifts of gendered roles in the family’ and ‘decreased social relations between fishermen’. Finally, the figure shows how ‘government actions’ fuel ‘corruption’, which then facilitates unsustainable fishing practices. All three underlying impacts then cause an ‘increase in social conflict’. This figure aims to capture and communicate some of the intricate and dynamic feedback patterns that contribute to the vulnerability of the case study communities. It is important to acknowledge how these impacts and drivers interact with one

another, so that when discussing pathways from vulnerability to viability in the next chapter, it can be fully understood how an action can have cascading impacts on the whole social-ecological system.

4.6 Conclusion

In this chapter, the social-ecological interactions of drivers of change and the resulting impacts that contribute to vulnerability are described. As discussed in Chapter 2, vulnerability can be defined as ‘a function of exposure, sensitivity and the capacity to respond to threats’ (Chuenpagdee 2011). In Section 4.4, it was described that the case study communities have a high exposure to anthropogenic and natural drivers of change. For example, the Bangladesh Sundarbans are in a geographical region where there is a high frequency of tropical cyclones, and the impacts of climate change and mangrove loss have made MDSSF increasingly exposed to cyclones and extreme weather events. Furthermore, these communities are very sensitive to vulnerability, as demonstrated by the magnitude of the impacts that drivers of change have on the SES (Section 4.4), as well as the positive feedback loop that creates cumulating impacts on social wellbeing (Section 4.5). However, the third indicator of vulnerability- the capacity to respond- has not yet been examined. It is evident that the three case studies experience significant vulnerabilities that stem from complex social-ecological interactions at multiple levels, but the current survivability of these communities indicates that there is much to learn about how they have managed to persist despite these detrimental impacts to material, relational and subjective wellbeing. Overall, this chapter has mapped out the current state of the SES to provide understanding of how vulnerability is experienced in MDSSF. Next, in chapter 5, this information will lay the foundation to then understand how, despite these vulnerabilities, MDSSF can adapt to these impacts and improve social-ecological viability.

Chapter 5

A Case Study Examination of Pathways to Social-ecological Viability in MDSSF

5.1 Introduction

In Chapter 4, I discussed the current state of the social-ecological dynamics shaping vulnerabilities in the three case study communities by examining the relationships between the fisherfolk community and the mangroves, and how natural and anthropogenic drivers interact with the system to create impacts on social and ecological wellbeing.

1. Describe the magnitude and impacts of drivers of change and vulnerabilities in the social-ecological system, as well as to understand the significance of the mangroves to the fisherfolk.
2. **Understand key response strategies and conceivable pathways to achieve viability in the social-ecological system.**

Box 5.1 Review of research objectives.

Now, after gaining understanding of how vulnerability is experienced in the communities, I will focus on the second objective of this research (Box 5.1), which is to understand key response strategies and conceivable pathways to achieving viability in the social-ecological system. This work is built on the understanding that MDSSF are communities with strong survivability and have persisted despite generations of experiencing vulnerability. The goal of conducting the household surveys and focus groups (described in chapter 3) is to gain understanding of plausible coping strategies from the participant's point of view. The strategies and lived experiences of research participants guide the conversation in this chapter, of which the overall goal is to identify a pathway from vulnerability to viability for MDSSF. The results that emerged from the participants' responses will be explained in subsections that respectively address the following questions:

- A. What current strategies are used in the communities? Which of these strategies are adaptive responses that can help to mobilize viability?
- B. What changes need to be made in the community to mobilize viability?
- C. How can this information be conceptualized to visualize a pathway to social-ecological viability?

5.2 Coping and Adaptive Strategies

As discussed in Chapter 2, coping and adaptive strategies describe how individuals and communities respond to change when a threat occurs, and the difference between the two is that coping strategies are the immediate, short-term responses to a stressor, whereas adaptive strategies are long-term adjustments that produce sustainable outcomes at the SES level (Nayak 2017).

During the household surveys that were conducted in each village, after being asked about the financial deficits and vulnerabilities that they experience, participants were asked how they cope and adapt to these described impacts (Chapter 4, Section 4). Four main strategies emerged from these responses (Table 5.1). Respondents expressed these strategies as their response to the collective vulnerabilities that they experienced, rather than as in response to a single vulnerability. As described in Chapter 4, Section 5, drivers of change do not create vulnerability through individual impacts. Rather, the interactions between drivers of change and impacts manifest as vulnerabilities that can not necessarily be attributed to an individual impact. In the first two case study villages, Dumuria and Chakbara, participants respond to vulnerability by (1) seeking secondary occupations, (2) taking loans from NGOs and (3) taking loans from individuals in the community. The third case study village, Keyabunia, also utilized these strategies, but the difference between Keyabunia and the other two villages is that fisherfolk in Keyabunia take less loans from NGOs and individuals and rely more on support from a community-based organization called 'Jele Shomiti'. The following subsections will discuss each of these strategies, and whether they are coping or adaptive in nature.

Table 5.1 Strategies identified by each of the three case study villages: Dumuria, Chakbara and Keyabunia.

	Village 1: Dumuria	Village 2: Chakbara	Village 3: Keyabunia
1	Secondary occupation (25)	Secondary occupation (23)	Secondary occupation (25)
2	Taking loans from NGOs (23)	Taking loans from NGOs (19)	Support from community-based organization (19)
3	Taking loans from individuals in the community (12)	Taking loans from individuals in the community (7)	Taking loans from individuals in the community (11) AND Taking loans from NGOs (11)

Note: Each column pertains to the respective village, and the rows show which strategy is most to least common in each village. The numbers in brackets show how many participants identified that strategy in each village. N=25 in each village, with some participants identifying more than one strategy.

5.2.1 Secondary Occupations

The most common strategy in response to undesirable impacts in all three villages is pursuing a secondary occupation. Out of 25 household survey participants in each village, 95% of respondents in Chakbara and 100% of respondents in Dumuria and Keyabunia reported that either they and/or their spouse are coping with livelihood loss by spending more time working in one or more secondary occupations (Figure 5.1).

It is worthwhile to note that while many respondents reported honey collecting (N=17 in Dumuria, 3 in Chakbara) and crab hunting (N=17 in Dumuria, 2 in Chakbara, 8 in Keyabunia) as

secondary occupations, these are not being pursued as a strategy, and thus will not be discussed in the context of this section. Honey and crab are mangrove forest resources that are integral to the livelihood of many small-scale fishers and generate income that contributes to livelihoods. However, these strategies are in response to fisherfolk being cut off from accessing the mangrove forests, which includes fish, crab, wood and honey resources. Therefore, in this section I will discuss livelihoods that are pursued as responses to the previously discussed impacts on social and ecological wellbeing.

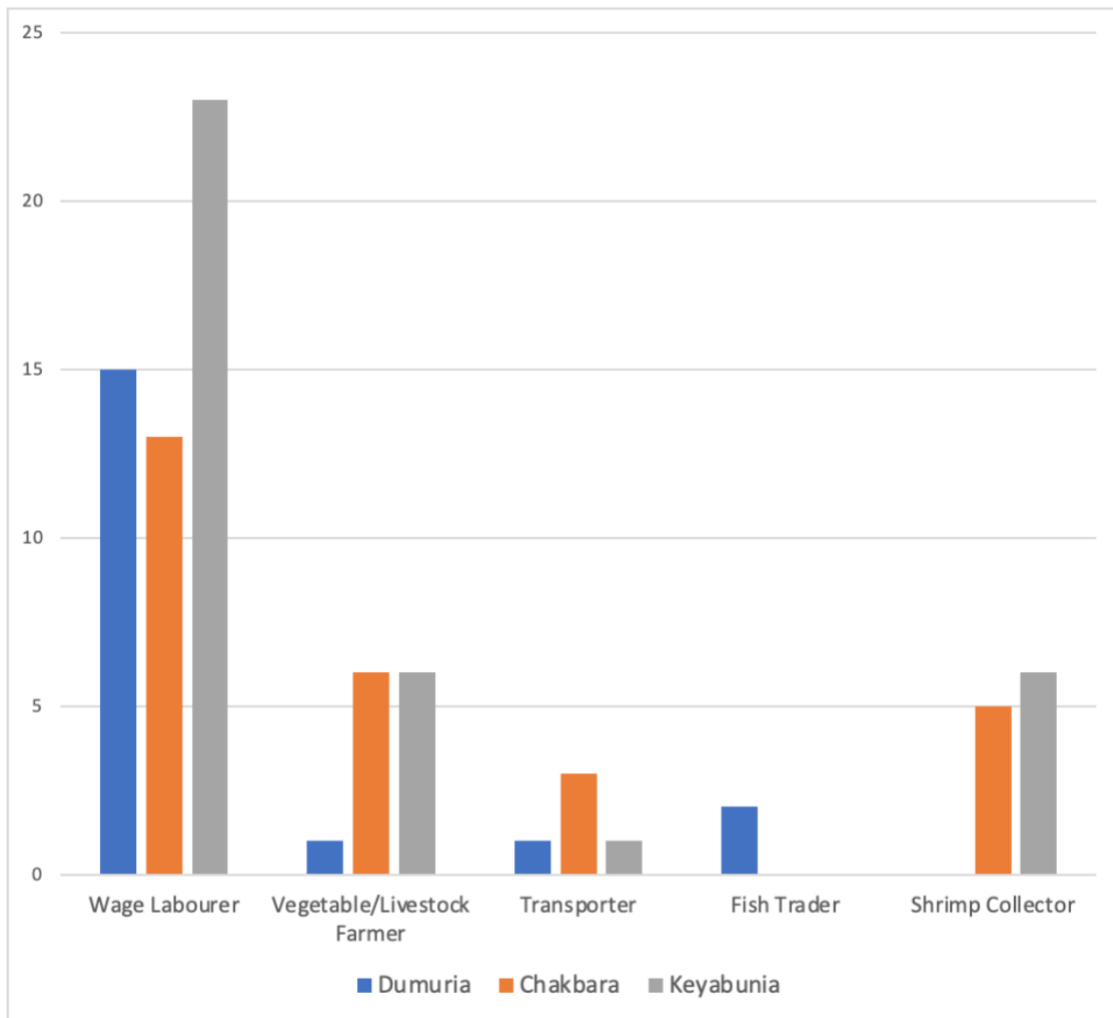


Figure 5.1 Dispersal of secondary occupations in the three case study villages: Dumuria, Chakbara and Keyabunia (N=25 in each village). Note: some respondents reported more than one secondary occupation.

The most frequently reported secondary occupation pursued as a coping strategy is working as wage laborer (N=15 in Dumuria, 13 in Chakbara, 23 in Keyabunia). A wage laborer is low-income work that often involves extended time away from one's community. In Dumuria and Chakbara, some people are able to work as a daily laborer in Gabura Union, but most resort to going to work in brick kilns for six months of the year to bring income home for their families. Respondents reported that six months of labor in the brick kiln equates to a total of approximately 100,000-150,000 taka. In Dumuria, two respondents shared that they are forced to send their children to work instead of going to school to cope with recent financial impacts. During the women's focus group discussion in Dumuria, participants also reported that their sons are working in brick kilns for six months at a time instead of going to school. Fisherfolk in Keyabunia reported either working as a day laborer in the village or at the Khulna-Mongla railway construction site and earning between 5000-12000 taka every month.

Some respondents reported working as vegetable or livestock farmers (N=1 in Dumuria, 6 in Chakbara, 6 in Keyabunia). This occupation allows fisherfolk to remain in their community while pursuing an alternative livelihood. Vegetable and livestock farmers can farm on their land and then sell their products at the local market. One male respondent shared:

“Because we bought some chickens, goats, and one cow, we can raise these animals and generate income when there is no other way to make money in our community because of these mangrove restrictions.”

In Keyabunia, a community-based organization called Jele Shomiti, provides some training to women in the community on vegetable farming and livestock farming. The role of this organization in mobilizing viability will be discussed in more detail in Sec 5.2.4, but it is important to note here that community members involved in Jele Shomiti have identified that pursuing livestock and vegetable farming is considered positive to the wellbeing of fisherfolk, unlike labor work, which forces fisherfolk to leave their communities and encourages youth to work instead of pursuing education.

Female respondents reported that women are working as shrimp collectors in the river to contribute income to their families. 5 of the 10 women surveyed in Chakbara, and 6 of the 10 women surveyed in Keyabunia voiced that women collect and sell juvenile shrimp from the river located around their village to supplement their family income. One respondent from Chakbara shared:

"Because my husband is not allowed into the mangroves, I have to work as a shrimp collector to help my family. The status of a woman in our community is to work in the household and this is where I want to be, but to cope with these changes I have to spend more time working in the river than with my family."

As explained in chapter 3, female respondents in Dumuria were uncomfortable with speaking one-on-one to a male interviewer, so to adjust to this, we invited 10 women in the community to participate in a communal focus group session. When asked how they have been coping with impacts to their income, the participants shared that they have been working in the river behind their homes as shrimp collectors to support their families. Due to the corona pandemic, the selling price of shrimp has decreased from 1000 taka per 1000 shrimp to 300-400 taka per 1000 shrimp, so women have been spending more and more time working in the rivers to meet the basis financial needs of their family. Some participants also shared that they occasionally help their husbands catch fish in the river near their house to support their income.

In addition to working as a day laborer, farmer and shrimp collector, a few respondents reported that they recently have started working as a vehicle or boat driver to generate some supplementary income (N=1 in Dumuria, 3 in Chakbara, 1 in Keyabunia). For example, a fisherman from Chakbara said:

"I took loans from the NGO and bought a boat. Now I can work as a boatman to transport people from one side of the river to the other. But the income is still much less than before."

5.2.2 Loans as a Coping Strategy

As shown in table 5.1, loans are a major coping strategy that emerged from the household survey data. Respondents in Dumuria reported taking the most loans, with 92% loaning from an NGO and 48% loaning from another community member (N=25). The surveys conducted in Chakbara showed 76% of respondents loaning from an NGO and 28% of respondents loaning from another community member (N=25). In Keyabunia, the number of respondents taking loans as a coping strategy is relatively less, with 44% loaning from both community members and NGOs (N=25).

Fisherfolk in the three villages are able to get some support from local non-governmental organizations (NGOs), which are mainly micro-financing organization. The most popular local NGO that provides loans to fisherfolk is the Nowabenki Gonomukhi Foundation (NGF). There are other NGOs in the villages, such as Brac and Barsha, but villagers prefer NGF because they can take loans with shorter notice. They repay the loans in weekly payments, with 13% interest. The fisherfolk, especially in Dumuria and Chakbara, are very dependent on these loans. One respondent from Dumuria articulates this dependency very well:

“There is no choice; I must take loans if I am to cope with this economical condition and feed my family. The whole community is facing the same problem. Especially when there is no available work. It is risky, because there is high interest and if I can’t earn enough to repay the loan I have to sell our assets.”

It is important to understand that while loans have apparently become crucial to the coping strategies of fisherfolk, the dynamics of taking loans can lead to positive feedback loops that cause fisherfolk to fall into cycles of debt. A common theme that emerged when participants were discussing loans, is that they have to use most of the money that they earn to repay the loans and end up equally or more financially insecure than before they took out a loan. When fisherfolk cannot repay the full loan, they have to sell their assets, such as cattle, jewelry and land, which reduces material wellbeing and forces them to require taking yet another loan. This can lead to cascading cycles of loaning, debt accumulation, and increased financial vulnerability. When asked what their major heads of annual expenditure are, 20% of respondents in Dumuria, 32% of respondents in Chakbara, and 24% of respondents in Keyabunia identified loan repayments as their main expenditure (N=25 in each village).

Aside from micro-financing organizations such as NGF and Brac, participants did not identify that they receive substantial external support to cope with vulnerabilities. Participants explained that there are some other NGOs working to protect the mangrove ecosystem, but those organizations also work with the forest officers to restrict the villagers to go to the forest. This has generated some conflict between fisherfolk and these types of NGOs that work for the management of the forest, as the current mangrove management strategy has severe impacts on the livelihoods and wellbeing of the fisherfolk. During the focus group discussion in Dumuria, participants shared that there is another NGO called ‘Leaders’ that has provided some training on climate change, but the women who took part in this did not have a positive experience and did not understand the terms being discussed during the training. Overall, the external support that mangrove-dependent fisherfolk receive is largely limited to the short-term financial relief of taking loans from micro-financing organizations, despite the risks and long-term negative consequences of falling into cycles of loan repayments and debt.

Some fisherfolk also cope by taking loans from members in their community. 48% of respondents in Dumuria, 28% of respondents in Chakbara and 44% of respondents in Keyabunia (N=25 in each village) identified that they take loans from neighbors, relatives and other individuals in their community (Table 5.1). These fisherfolk have chosen to loan from community members instead of, or in addition to taking NGO loans, because there is generally a lower interest rate and no time limit to repay the loan. However, with the whole community facing the same problem of economic vulnerability, it is important to consider that the capacity of community members to provide money for others to borrow may decrease.

5.2.3 Community-based Organization

In the third case study village, Keyabunia, 76% of survey participants (N=25) identified that they are receiving support from a community-based organization (CBO) that was in itself formed as a strategy to collectively adapt to unwanted impacts and vulnerabilities experienced by the village. This CBO is called ‘Jele Shomiti’, which translates to ‘Fisherman Association’. Jele Shomiti was created by community members of Keyabunia village approximately 3 to 4 years ago, with the

goal of improving the wellbeing of small-scale fishers in the community. The structure of the organization is shown in figure 5.2. The Functioning Committee includes the presidents (male

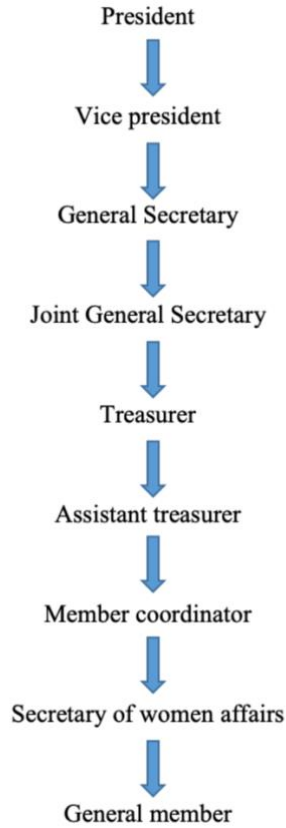


Figure 5.2 Organizational structure of the CBO, Jele Shomiti, in Keyabunia.

and female), vice-presidents, general secretary, joint general secretary, treasurer, assistant treasurer, member coordinator and secretary of women's affairs. As a relatively new organization, the current electoral process of choosing the committee is informal and based on the opinions of the members, but the organization is planning a structural election system for the next committee election. The decision-making process in the organization is led by the presidents and secretary and includes the feedback and opinions of all members.

The membership has slowly grown since Jele Shomiti was established. As of December 2021, there were 133 members in the organization. Survey participants estimated that

approximately 75% of people in Keyabunia village are currently members. To join the organization, members must pay 20 taka twice a month, which is pooled into a fund that provides loans. Members then receive a 'Jele Card', which allows them to participate in the following trainings and opportunities that are offered to members:

- A. Training on vegetable and livestock farming. Mostly women partake in these training sessions. This training allows for community members, particularly women, to make money when fishing and accessing the mangroves is restricted.
- B. Training on how to sustainably use and manage the mangroves as a community. The organization uses these training sessions to raise awareness on the negative impacts of poaching and using fish poison.
- C. Training on how to respond to cyclones and natural disasters.
- D. Members have access to receiving loans with 8% interest, which is significantly lower than the 13-17% interest rates required from external organizations.
- E. Enforcing rules that ban using fish poison and poaching wood. If a Jele Shomiti member is caught breaking these rules, they are fined by the organization.
- F. The organization advocates for its members to receive support from the government. Many fisherfolk in Bangladesh depend on catching hilsa fish, but the government has banned catching hilsa during the breeding season. The government is supposed to provide a 'BLC card' to the fisherman who depend on hilsa fish, so that they can use this card to receive food and financial support from the government. However, many fisherman said they are being forced to provide money to government officials to receive a BLC card, which is supposed to be free. Jele Shomiti has provided support to its members by communicating with the government for provisions of rice and food for hilsa fishers during the restricted season.

These activities provide both short-term and long-term adaptive strategies. By providing loans, fishers can afford some expenditures when fishing is restricted. By providing training on vegetable and livestock farming, community members can learn to earn an alternative livelihood source during the times that they are not allowed in the mangroves. By providing training on

sustainable fishing methods, community members are educated on the consequences of unsustainable practices, and how they can contribute to protect the mangroves for future generations of small-scale fishers. By creating and enforcing rules on mangrove resource harvesting, Jele Shomiti is helping to create a healthy ecosystem where fishers can have equal access to harvesting. Finally, by acting as a communication linkage between government officials and fisherfolk, the organization can help advocate for villagers to receive subsidies.

Overall, the community has a very positive opinion on this organization's work. There is a consensus within the responses from survey participants that Jele Shomiti is becoming more impactful to the fisherfolk as the organization grows. However, this is a young organization that is slowly developing, and not all fisherfolk in Keyabunia are able to join. One respondent shared:

“Jele Shomiti is doing great things. This is a very good organization that works for the people of the fisher community and helps to raise up our voices from the root level to the government. One hinderance is that they are not giving membership ID to all the fisherfolk. If we could all enter the organization, we could all be benefited.”

5.2.4 Summary of Coping and Adaptive Strategies

The previous sections discussed the strategies that participants identified that they implement in response to unwanted impacts. In Table 5.2, I compare these strategies as discussed by with the conceptual understanding of coping and adaptive strategies. It is important to define whether a strategy implemented by a MDSSF is adaptive or coping to understand if that strategy can contribute to long-term viability in the SES. However, it is also important to understand that coping strategies are not 'bad' or necessarily harmful. In fact, when combined with capacity building, coping strategies can be integral to building viability. For example, in the organization 'Jele Shomiti', members are provided loans in addition to being provided training that builds long term adaptive capacity. These loans offer immediate relief that can allow community members to engage in long-term strategies. Thus, coping and adaptive strategies can occur simultaneously and complement one another in the mobilization of viability.

Table 5.2 Summary of coping and adaptive strategies currently used by fisherfolk, as discussed in section 5.2.

Strategy	Type of Strategy	Explanation
Secondary occupations	Coping or adaptive, depending on the context of the occupation	<p>Secondary occupations that deter from long-term sustainability are coping strategies. For example, working as a wage laborer provides one with short term financial relief, but creates further impacts on the SES by forcing people to leave their community for long-periods of time, and can involve children being taken out of school and sent to work as a laborer to cope with financial deficits.</p> <p>On the contrary, secondary occupations that contribute to long-term sustainability are adaptive strategies. For example, working as a vegetable or livestock farmer allows for fishers to earn income within their community during times of the year when fishing is restricted, thus increasing their ability to adapt and support their livelihood to some extent despite limited resource access.</p>
Taking loans	Coping	<p>Taking high interest loans from NGOs facilitates cycles of debt that have negative impacts on fishers' wellbeing, thus moving the SES away from viability.</p> <p>Taking loans from community members has fewer negative impacts on the wellbeing of fishers due to lower interest rates and more flexibility on loan repayment, but it is unclear from the data whether this could contribute to long-term viability. Taking loans as a sole strategy in response to impacts is a short-term solution, because unless this strategy is coupled with an initiative to increase the long-term income of an individual, the loan will only provide the borrower with short-term relief until the repayment and interest rate of the loan increases their debt-to-income ratio.</p>

Support from community-based organization	Adaptive	The organization, ‘Jele Shomiti’ provides members with a combination of strategies and tools (e.g., training, low-interest loans, formation and enforcement of rules and advocacy for governmental support) that improve the capacity of the community to cope with and recover from impacts on a long-term scale, thus contributing to viability.
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5.3 Barriers and Opportunities for Increasing Viability

In the previous section, I explained what strategies are currently used by the case study communities to cope and adapt to impacts and drivers of change. Here, I will examine what changes need to be made to address barriers to building viability in MDSSF. In the household survey, participants were asked (1) what they think is needed in their community to improve the wellbeing of their family, the mangroves and their overall community and (2) how they think the management of mangrove resources can be improved. The goal of these questions is to understand WHAT changes fishers want to see in their community. Then, we asked fishers to identify the barriers are to implementing these changes, with the goal of understanding HOW these needed changes can be mobilized into actionable and operational movement.

In the following three sub-sections, I will describe each of the needed key changes (what needs to happen?) and the barriers to implementing each change (what is preventing this change?). Then, in section 5.4, I will explain what actions need to be taken to address these barriers (what are the underlying changes that need to be made to build a foundational, rooted system in which this larger change can be mobilized?).

Table 5.3 Needed changes identified by each of the three case study villages: Dumuria, Chakbara and Keyabunia.

	Village 1: Dumuria	Village 2: Chakbara	Village 3: Keyabunia
1	Reform of management system (18)	Reform of management system (12)	Reform of management system (13)

2	Stop unsustainable fishing practices (4)	Stop unsustainable fishing practices (5)	Stop unsustainable fishing practices (15)
3	Better alternative livelihoods (4)		

Note: Each column pertains to the respective village, and the rows show which change is most to least commonly identified in each village. The numbers in brackets show how many participants identified that change in each village. N=25 in each village, with some respondents identifying multiple needed changes.

5.3.1 Reform of Management System

The most widely identified change is that the current management system for the mangrove fisheries needs to be deconstructed and reconstructed. When asked for their opinion on the current resource management, 100% of survey respondents (N=75) and the focus group participants in Dumuria (N=10) voiced a negative impression. As discussed in chapter 4, the government is currently managing the mangroves in a way that has cumulated in several unwanted impacts on the fisherfolk who live and work in this ecosystem. 72% of survey respondents in Dumuria, 48% of respondents in Chakbara and 52% of respondents in Keyabunia described how the current management is inappropriate and harmful to the wellbeing of fishers and needs to be changed (Table 5.3). Two common themes emerged from the data for the three villages on what specific changes need to be made to the management:

1. Consider the social dimensions of resource management.

Currently, fishers feel that the management is only focused on the ecological system and does not have enough consideration for the wellbeing of the communities that depend on the mangroves. The access restrictions that have been placed on the mangroves have improved the condition of the mangroves but have heavily impacted the fisher community. As described in chapter 4, the fishers and the mangrove ecosystem interact in a social-ecological system, where impacts that affect the social community will feedback into the ecological system. For example, when the mangroves are heavily restricted, some

fishers start to illegally poach from the forest to survive, which has negative impacts on the mangrove ecosystem. Appropriate management of the mangrove fisheries would acknowledge that the people and the ecosystem are interconnected and supporting one system without the other is unsustainable and will not produce desirable outcomes in the long-term. Resource management needs to be reformed so that it can simultaneously support both the mangrove forest and the people who are dependent on this ecosystem for their livelihoods.

2. Management should be informed based off the knowledge of community members.

The previous point described that the social dimension of management needs to be considered. For this to happen, the social dimension and the interactions between the mangroves and the fishers *needs to be understood in the context specific to that community*. To be understood, the people need to be listened to and considered. One respondent from Chakbara voiced:

“The government should come to us and hear what we have to say before making policies. This is the proper way to make sure people can live and the mangroves will also be alive.”

Another participant from Keyabunia said:

“The management of the mangroves needs to be given to the community. The mangrove-based people know better than the government on how to protect this mangrove. But the government should help to take action for illegal activity in the Sundarbans. We can then extract resources that we need for our livelihoods and also manage the mangrove.”

Fisherfolk are currently excluded from any decision-making on mangrove resource management, and yet they are the people who are most impacted by these decisions. As discussed in Chapter 4, the current resource management and governmental restriction was the most frequently identified driver of anthropogenic change in all three case study communities; when the social dimensions and community knowledge are absent from management decision-making processes, the implications on the community are severe. Thus, the consideration and

involvement of small-scale fishers in mangrove resource management is crucial to forming a system that mobilizes viability.

While these changes may sound reasonable, there are significant barriers to building a better resource management system. Respondents identified two main barriers: (1) an institutional gap between the community and the government and (2) systemic exclusion of fisherfolk from decision making on resource management. When asked if they felt they were able to communicate with individuals and/or institutions that manage the mangrove resources, 40% of survey respondents from Dumuria, 36% of respondents from Chakbara and 24% of respondents from Keyabunia said no (N=25 in each village). 60% of survey respondents from Dumuria, 32% of respondents from Chakbara and 16% of respondents from Keyabunia said yes, they can physically go and talk to the forest officers to get their permit for entering the mangroves, but the corruption and the forest officer's disregard for the opinion of the fisherfolk prevents them from being able to effectively voice their concerns and insights on the management. Respondents from Keyabunia indicated that because they have formed a community-based organization, this has helped them to raise their opinions in a more structural way.

5.3.2 Stop Unsustainable Fishing Practices

The mitigation of unsustainable fishing practices is the needed change that was most commonly identified by participants in Keyabunia and was also identified to a slightly lesser extent by participants in Dumuria and Chakbara (Table 5.3). During the women's focus group session in Dumuria, the presentation and monitoring of unsustainable and illegal practices was discussed as an important change that need to occur. Specifically, respondents explained that rules and regulations on resource extraction practices need to be created and effectively enforced in the community. This includes a ban on fish poison, a ban on harvesting fish that are young or pregnant, rules for harvest limits, a regulation for a standardized net size to be used for fishing, and an effective monitoring system that will enforce these rules. There are three barriers to mitigating such unsustainable practices. Firstly, there is a lack of trust and accountability at the community level. For example, a respondent from Dumuria said:

“The greediness and corruption of some people has broken the trust of our community. There is no integrity among the people.”

As discussed in chapter 4, one of the impacts on the relational wellbeing of fisher communities is a decrease in social capital and connection among the people. This impact itself has created a barrier to building viability in the community, as the strength and integrity of relationships in a community are building blocks that support the entire system. The wellbeing of a community is grounded in the process of cultivating and sustaining healthy relationships. As discussed in chapter 2, a restorative justice-based approach to supporting communities should prioritize trust and connection so that when conflict and unwanted impacts inevitably arise, there are solid relationships as the foundation to support the community (Vaandering 2010, Grafton et al. 2021). Thus, we must ‘move at the speed of trust’ and focus on critical connections to build resilience (Brown 2017).

The question that may be asked following this is, how can trust be repaired within the community? This directly leads to the second barrier identified by participants: governmental corruption. Participants explained that corruption within the government facilitates unsustainable practices, as government officials accept money from villagers in exchange for allowing them to use fish poison or collect from restricted areas. One fisherman from Dumuria said:

‘There is not proper monitoring from the government. The political organizations working in the forest use their power in a bad way. Occurrences of corruption have broken the trust of the community people.’

Thus, this misuse of political power fuels a sense of dis-trust in the community, and is a significant barrier to first, restoring trust in the community and second, mitigating unsustainable practices.

The third barrier identified by respondents is that there is a lack of awareness in the community regarding the impacts of unsustainable practices on the mangroves, which prevents people from taking action to abandon these practices.

5.3.3 Offer Better Alternative Livelihoods

32% of survey respondents in Dumuria shared that there needs to be better alternative livelihoods offered to fisherfolk during the times that they are unable to access the mangroves (Table 5.3). As explained in chapter 4, mangrove-dependent fishers have highly specialized skills on mangrove resource harvesting that have been passed down from generation to generation, but outside of small-scale fishing, they do not have expertise in other occupations, so it is difficult to find fair work. As a result, many fishers have to work in poor conditions making very little money, such as in brick kilns or as agricultural labourers. Training on how to maintain an alternative occupation in the community is a necessity for fishers maintaining wellbeing during times where it is not feasible to access the fisheries. Examples of such occupations identified by participants are farming livestock and vegetables. One fisherman from Dumuria also added that if the government provided proper subsidies during times of restricted resource access, he and his neighbors would be able to buy cows and goats to sell milk, improving their financial situation.

5.4 Turning Barriers into Opportunities

In the previous section I discussed what changes are needed in the case-study communities to mobilized viability and what barriers there are that prevent these changes. Here, I will examine the underlying actions that need to occur to address these barriers. As explained in chapter 2, a social-ecological system (SES) that is managed top-down from a place of crisis, rushed decision making, and emphasis on achieving short term goals will likely collapse under its top-heavy weight and is characteristically unsustainable. When attempting to approach a SES from a restorative justice framework, it is important to shift from ‘mile-wide, inch-deep’ thinking to ‘inch-wide, mile-deep’ thinking that prioritizes deep, strengthening work at the community level, rather than surface-level, widespread work. In this section, I ask, how can these barriers be addressed to mobilize needed changes ‘radically’, which means ‘from the root up’? To answer this question, participant responses from the three villages were examined and five root-level actions, as well as one governmental-level action was identified (Table 5.4), which will be explained in the following sub-sections.

5.4.1 Education at the Community Level

Although mangrove-dependent fishers have an extensive and ancestral knowledge of the mangrove fisheries, there have been a lot of external changes in the past decade that have altered the state of the SES that the fisherfolk live and work in, such as an increase in cyclones and an increase in the amount of people and institutions extracting from the mangroves. Study participants identified that context specific education and awareness building would be helpful for providing fishers the tools to understand and contribute to mangrove resource management:

“If the educated people of the community give training to the uneducated people, this can be helpful” - Male respondent from Dumuria

“Education for the villages needs to be implemented so that they we can also contribute to the management of the mangroves” - Male respondent from Chakbara

“Awareness among the fisherfolk about the importance of the mangroves can be the best management of the mangroves and its resources” - Female respondent from Keyabunia

Based on the descriptions that respondents provided on how education would be beneficial for their community, four key elements emerged:

- A. Education should be led by community members so that it is context specific for that particular community.
- B. Education should include awareness building on the impacts of unsustainable fishing practices.
- C. Education should include training on alternative livelihoods that allow fisherfolk to remain in their communities, such as training for how to farm livestock and vegetables.
- D. Education should include training on how to respond to impacts of drivers of change that the community experiences, such as tropical cyclones and more mangrove resource users.

5.4.2 Establishment of Boundaries and Rules

There should be clear rules and boundaries within the community on how fishers can harvest the mangrove resources. These rules and boundaries should be created by the people of the community, based on their extensive knowledge of the mangrove ecosystem. For example, during the women's focus group session in Dumuria, participants voiced that there should be a ban on fish poison and a rule that only allow one size of net to be used by fishers. A fisherman from Dumuria echoed this same sentiment:

“Rules and regulations need to be introduced in the community. We need to decrease the role of fish poisoning in our community and take proper action from the root level.”

Similarly, there also needs to be boundaries on how fishers can access the mangrove resources. For example, a fisherman in Chakbara expressed:

“Fisherfolk who have money go to the ocean for 6 months to catch fish, so there are less fish entering the river that flows through the mangroves. The mother fish are being caught and cannot come to the river to give birth to the juvenile fish.”

Having clear boundaries on where fishers can access resources in the mangroves would establish areas from which resource users can harvest from the ecosystem. Establishing rules and boundaries within the community would also make it clearer who is and is not following such rules, making monitoring within the community more feasible.

5.4.3 Communal Monitoring and Rule Enforcement

Following from Sec. 5.4.2, it is important that established rules and boundaries are effectively enforced and monitored within the community. Currently, the individuals responsible for monitoring resource access and use are Forest Officers, who work for the Bangladesh Government. As previously addressed, there is a significant amount of corruption within the operations of the governmental representatives that fuels unsustainable fishing practices. Many survey respondents indicated that having monitoring within the community would be a more effective way to address unsustainable practices. Considering that the wellbeing of mangrove-

dependent fisherfolk is deeply rooted in the mangrove ecosystem, there are strong incentives for fishers to effectively monitor the mangroves, as they are the people who are most impacted by rule-breaking. Similarly, there should be conflict-resolution strategies within the community that can be implemented when someone breaks a rule. These strategies would depend on the context of each community but would include a simple mechanism for addressing and resolving conflicts quickly.

5.4.4 Formation of Local Institutions Within the Community

The community-based group, Jele Shomiti, in Keyabunia is a good example of how an organization created by community members can be an effective strategy to implement the above changes. Currently, the organization has initiatives that provide education to the community, rules and monitoring on harvesting from the mangrove forest, as well as a platform for fishers to voice their opinions. Responses from fishers in Dumuria and Chakbara also indicate that forming a local group would be useful to address some of the needed changes in their communities. However, the majority of fishers (96% in Dumuria, 68% in Chakbara, N=25) expressed that there is no value in organizing a community group because the government does not give any importance to their opinions.

5.4.5 Support and Collaboration from Government

Following from sec. 5.4.5, there needs to be some support from governmental institutions to support the previously described changes that are needed to mobilize viability for small-scale fishers. As just discussed, even if communities are able to come together to increase education and establish and enforce rules to mitigate unsustainable fishing practices, there can only be so much progress made to mobilizing viability if the forest department continues to operate in the same way. Many survey respondents (32% in Dumuria, 24% in Chakbara, and 36% in Keyabunia, N=25) stated that community members need to be included in decision making on the management of mangrove resources. Currently, all the power regarding mangrove resource management is held by the forest department. There is no effective linkage between communities

and the government for fisherfolk to fully express their opinions and insights on how the mangroves can be managed in a way that preserves and restores both ecological and social wellbeing. To address this, the following changes need to be made to facilitate an engagement and collaboration between the government and local resource users. First, the power dynamics of mangrove resource management need to be decentralized. The decision-making regarding how the mangroves are managed should be dispersed and distributed among the local fisherfolk who have ancestral and deep knowledge on how the mangrove ecosystem functions. Second, there needs to be institutional linkages and communication between the government and MDSSF communities; there needs to be a mechanism for fishers and government officials to work together and collaborate on mangrove resource management. Third, there needs to be monitoring and mitigation of corruption at the governmental level to address the institutional facilitation of unsustainable fishing practices that have serious consequences on both the social and ecological system.

Table 5.4 Summary of needed changes in the community, the barriers to making such changes, and what actions need to be taken to disarm and mitigate these barriers.

<u>Needed Changes</u>	<u>Barriers to Changes</u>	<u>Actions to Address Barriers</u>
Reform of management system	<ul style="list-style-type: none"> • Institutional gap • Exclusion of fisherfolk from decision making on resource management 	<ul style="list-style-type: none"> • Decentralization of resource management • Formation of local institution(s) that can lead management • Institutional linkages • Establish access rules and boundaries for fishers
Better alternative livelihoods	<ul style="list-style-type: none"> • Lack of expertise in occupations other than mangrove/fishery resource collection 	<ul style="list-style-type: none"> • Education at the community level
Stop unsustainable fishing practices	<ul style="list-style-type: none"> • Lack of trust and accountability at the community level 	<ul style="list-style-type: none"> • Education at the community level • Communal monitoring and rule enforcement

	<ul style="list-style-type: none"> • Lack of awareness within the community on impacts of unsustainable fishing • Facilitation of unsustainable practices through corruption at the government level 	<ul style="list-style-type: none"> • Supportive government that monitors and mitigates corruption at the government level
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5.5 Discussion: Social-Ecological Viability

In this section, I ask the question: how we learn from the perspectives and knowledges of small-scale fishers from Dumuria, Chakbara and Keyabunia to understand how MDSSF can transition from vulnerability to viability?

First, it is important to conceptualize and understand what viability looks like. As defined in chapter 2, viability is how a system can adapt and cope to drivers of change (Nayak 2019). When I refer to viability, I am specifically referring to *social-ecological* viability, because true, long-term viability cannot exist without acknowledging that it must be applied to the social system, ecological system, and the interactions between the two. Understanding the nature-human nexus is critical for mobilizing viability. Different ecosystems and their dependent communities face different challenges and threats in the light of their particular circumstances and acknowledging the intricate dynamics of social-ecological systems is a crucial step to understanding the pathway to viability. As articulated by (Behnassi et al. 2021), “The failure to perceive human societies as integral parts of the Earth system and the tendency to predate resources accordingly lead to a wide variety of mutually reinforcing and unprecedented complex risks. They tend to destabilize the security, viability, and resilience of social and ecological systems at all levels”.

In chapter 2, three concepts from the literature were drawn on to explore how social-ecological viability can be understood: (1) resilience, (2) social wellbeing and (3) multi-level and interactive governance. These concepts illustrate that a social-ecologically viable system will (1) be able to persist during non-linear disturbances (Alcorn et al. 2003, Norberg and Cumming 2008), (2) maintain a state in the social system where human needs are met, where one can act meaningfully to pursue one’s goals and where one enjoys a satisfactory quality of life (McGregor

2008), and (3) have an interactive and multi-level governance model that facilitates adaptation and the sharing of knowledge across institutional levels, and bridges the gap between community based management and high-level institutions (Armitage 2008). In sec 5.4, five components were identified to mobilize the pathway to social-ecological viability:

- (1) Community led education, which includes:
 - (A) Awareness building on the impacts of unsustainable fishing practices
 - (B) Training on alternative livelihoods
 - (C) Training on how to respond to impacts of drivers of change
- (2) Establishment of clear rules and boundaries
- (3) Communal monitoring and rule enforcement
- (4) Formation of community-based institutions
- (5) Support and collaboration from the government, which includes:
 - (A) Decentralization of resource management
 - (B) Formation of institutional linkages
 - (C) Mitigation of governmental corruption

Comparing these community-identified components to the conceptual components of social-ecological viability integrates conceptual and empirical knowledge of what the pathway to a viable system is for MDSSF (Figure 5.3). First, resilience would be built by (1) educating fishers on how to sustain secondary livelihoods during times that their access to the mangroves is compromised by an external driver, and (2) providing community-led training on how fishers can respond to external threats or drivers, such as instructions on what to do and where to go when a cyclone hits. A multi-level and interactive governance model would be initiated by arrangements at the community level being strengthened by (1) establishing rules and boundaries, (2) communal monitoring and rule enforcement and (3) the formation of a community-based organization. An appropriate governance regime would also be developed by the (1) formation of linkages that facilitate communication between communities and top-level institutions, and (2) the decentralization of resource management to develop involvement and participation in governance across multiple levels. Wellbeing would be directly improved by implementing

strategies to reduce unsustainable fishing and the impacts that it has on both ecological and fisher communities. These strategies include: (1) providing community-led training on the impacts of unsustainable fishing and (2) mitigating the facilitation of unsustainable and illegal practices by governmental corruption. Furthermore, similar to how the dynamics contributing to vulnerability are interacting and can generate cascading impacts on the social-ecological system, the dynamics shaping viability can also behave in this same complex and co-evolving pattern that generate a positive feedback loop. For example, community-led training for secondary occupations that are helpful for a specific community during periods of restricted mangrove access would build resilience by increasing the capacity by which fisher community can adapt and retain material well-being when a driver of change, such as a cyclone or governmental restriction, prevents access to the mangroves. Additionally, as demonstrated by the CBO 'Jele Shomiti' in Keyabunia, this training could promote long-term wellbeing by increasing financial stability and by allowing fishers to pursue work that is in their community where they can remain connected with family and neighbors. This is an important concept to acknowledge because the connections between the components of viability identified in this study and the conceptual components identified in external literature, as well as the connections between each component, can be easily interpreted as linear relationships, but social-ecological systems behave in a non-linear, interactive and iterative nature that cannot be contained by simplistic relationships.

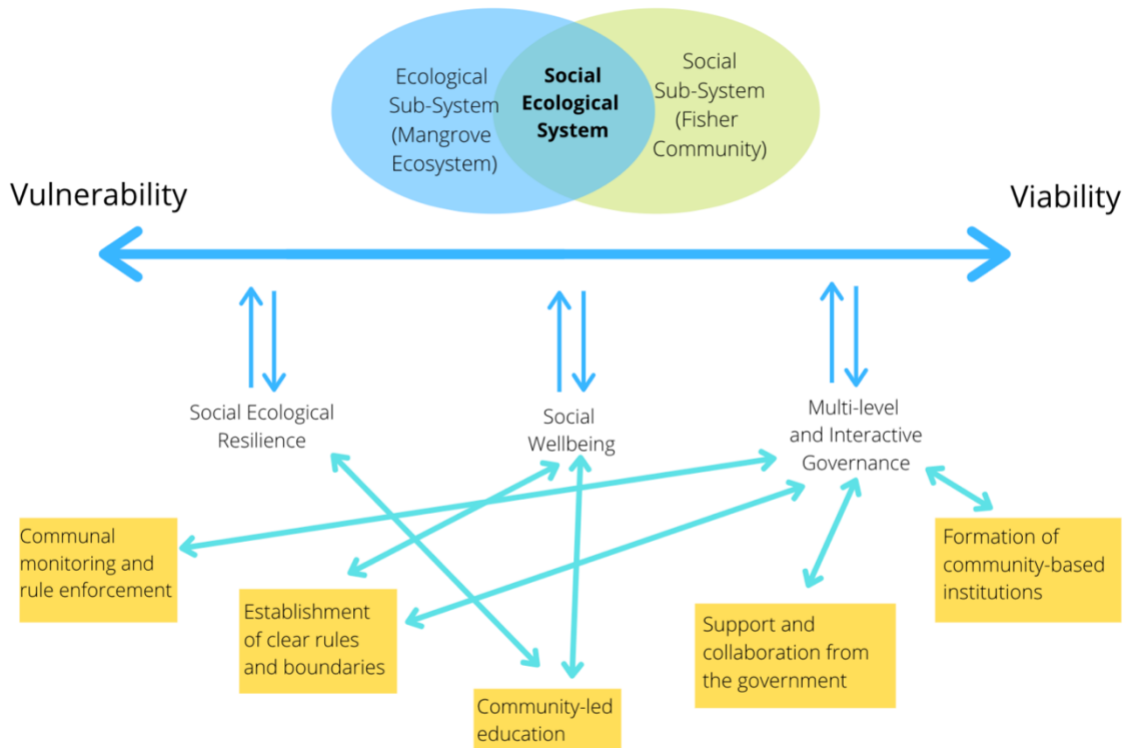


Figure 5.3 Integration of the conceptual and empirical elements of the pathway to social-ecological viability for MDSSF. The yellow boxes show the five elements of social-ecological viability.

The results that emerged from this data support that the formation and activities of community-based organizations can mobilize pathways for social-ecological viability. Jele Shomiti is a young organization, but in the few years since formation, it has provided community-led training and awareness building, created a low interest loaning system so that members can borrow money with less risk of falling into cycles of debt, created and enforced rules on using fish poison and over harvesting trees, and facilitated some communication with government officials. These initiatives are rooted in a bottom-up system that is built on community strengthening, and provides support based on the specific needs of the community. As discussed in this chapter, these are the building blocks of social-ecological viability. Although this organization has done important work, it is critical to not view this with an idyllic

lens, which is easily done from an external perspective. Despite Jele Shomiti having a positive impact on the community, Keyabunia village still faces significant drivers of change and impacts on ecological and social wellbeing (chapter 4). One major component of viability missing in Keyabunia is that there is insignificant support or collaboration from the government. There has been some communication between CBO leaders and government officials to advocate for Hilsha fishers receiving subsidies, but the magnitude and depth of this communication between the institutional levels is not significant for having long-term impacts on facilitating viability. The forest department needs to be willing and open to listening to the perspectives of fishers on how the resource which they depend upon. As identified by participants, the power to make and contribute to decision making on resource management needs to be distributed to the resource users so that fair rules and boundaries that are both ecologically and socially appropriate can be created and monitored by resource users. Keyabunia, along with the Dumuria and Chakbara, still faces major issues regarding unsustainable fishing practices. If government officials continue to facilitate these practices by accepting bribes, there is only so much that can be done at the community level; there needs to be action within the government to effectively mitigate this corruption.

The findings from this chapter specifically offer evidence in support of community-based conservation that uses commons principles. Commons- or common pool resources- are defined by two characteristics: exclusion: “exclusion of beneficiaries through physical and institutional means is especially costly”, and subtractability: “exploitation by one user reduces resource availability for others” (Ostrom et al. 1999). Fisheries are an excellent example of a commons, as it is their characteristics of exclusion and subtractability that make them exceedingly difficult to manage and conserve. Commons management requires a social-ecological approach that recognizes the intertwinement of resources and their users (Berkes 2021). Table 5.5 shows a summary of Ostrom’s (2009) collective-action design principles that characterizes the best practices or factors under which the governance of commons is sustainable at a social-ecological scale. When comparing these principles to the five elements of the pathway to social-ecological viability identified in this research, there is an evident linkage between these design principles of commons governance, and aspects of viability. Similar to the findings from this study, commons

theory acknowledges that serious problems can face community-based conservation in two critical ways: (1) once a resource is managed in a way that neglects local needs, this can lead to vicious cycles of poaching and further reinforcement of conflict between the local and authoritative levels, and (2) a lack of capacity at the local level to address conservation problems can prevent community institutions from effectively and sustainably managing resources (Berkes 2021). A solution to this is what commons theory refers to as adaptive co-management, which is a flexible, long-term resource management process by which institutional arrangements and ecological knowledge are tested and revised in a multi-level, ongoing process of learning by doing that involves a polycentric collaboration between a network of actors (Olson et al. 2004). This includes distributing authority and power across the local scale (Berkes 2021), relating to the fifth empirical aspect of viability that involves decentralization of resource management with the formation of institutional linkages (Berkes 2021). Additionally, this calls for the creation of incentives to link the conservation of ecological resources with the improvement of livelihoods. This relates to several of the empirical aspects of social-ecological viability defined here, such as community led education that provides training on sustainable harvesting and building skills for alternative livelihoods, as well as the establishment monitoring of clear rules and boundaries on resource access to ensure there is an equity across those receiving benefit.

A worthwhile question to ask here is, what role does community-based conservation utilizing commons principles in the pathway to social-ecological viability for MDSSF? Although this question cannot be definitively answered within the constraints of thesis, the findings from this research certainly support that further work should be done to identify the role that commons governance plays in mobilizing viability.

Table 5.5 Elinor Ostrom’s (2009) updated collective-action design principles for commons use (Cox et.al 2010) in comparison to the five elements of the pathway to social-ecological viability identified in this chapter.

Design Principles	Description	Related Empirical Element of Viability
1A. Clearly defined user boundaries	Clear boundaries that define which individuals or households have rights to access and withdraw from the resource.	Establishment of clear rules and boundaries
1B. Clearly defined resource boundaries	Clear boundaries that define the resource to eliminate open-access conditions.	Establishment of clear rules and boundaries
2A. Congruence between rules and local conditions	Clear, context-appropriate rules and the recognition that no one set of rules will be suitable for all situations.	Establishment of clear rules and boundaries
2B. Proportional equivalence between costs and benefits	The benefits that users obtain from the resource are proportional to the cost of their inputs (ex: labor, materials).	Establishment of clear rules and boundaries
3. Collective-choice arrangements	Practices and arrangements through which users can become participants and stakeholders in the formation of rules and governance structures.	Formation of community-based organizations and community-led education
4A. Monitoring rule enforcement	Presence of individuals who are members of the community or are accountable to members of the community to monitor and address rule enforcement.	Communal monitoring and rule enforcement
4B. Monitoring the resources	Monitoring of the status and condition of the resources to address issues of subtractability.	Communal monitoring and rule enforcement
5. Graduated sanctions	Appropriate sanctions based on the severity of infraction to deter participants from	Communal monitoring and rule enforcement

	excessive violation of community rules.	
6. Conflict-resolution mechanism	Platforms for effective conflict resolution mechanisms to address conflicts between users and officials.	Communal monitoring and rule enforcement
7. Minimal recognition of rights to organize	External authorities do not challenge the right of resource users to devise their own institutions.	Support and collaboration from the government
8. Nested enterprises	Governance structures and activities are organized in multiple layers of nested institutions.	Support and collaboration from the government, and formation of community-based institutions

5.6 Conclusions

In conclusion, this chapter discussed (1) how the current coping and adaptive strategies utilized by fishers in the case study communities in response to drivers of change can contribute to or deter from social-ecological viability, (2) the barriers to further mobilizing viability, (3) five actions that need to be taken to address these barriers, and finally (4) how the empirical contributions of respondents to identifying a pathway to social-ecological viability can be integrated with the conceptual framework to describe the interactions and components that are necessary for mobilizing this pathway.

Overall, the information discussed in this chapter is important and applicable for developing a pathway to social-ecological viability. However, with community based organizing emerging as a major component of this pathway, it is also important to acknowledge that this case-study was limited to only one village with a CBO, and further examining in other MDSSF should be initiated to understand the role of community organizations more comprehensively in mobilizing a path from vulnerability to viability.

Chapter 6

Conclusions

6.1 Introduction

MDSSF are a characteristically neglected group on political, practical and academic fronts. Despite the significant contributions that fisherfolk make to providing food security and resources on a global context, they have received inadequate governmental support, insufficient advocacy from high power players in the fisheries sector and a deficit in attention from researchers and academics. However, securing a sustainable approach to fisheries management is critical not only to improve human rights and quality of living for small-scale fishers, but also for securing food access and mitigating climate impacts at an international scale. If one thing is evident from this research, it is that the current management approach is not sufficient for the complex dynamics present in MDSSF, as it is based on top-down governmental regulations that enforce policing and restrictions as solutions to ecological degradation of the mangrove forests. It has been highly regarded by many institutions and academics that these conventional approaches to conservation management that are punishment-driven and top-down do not provide positive outcomes in the long-term because there is little or no involvement of the local communities who are the resource users (Berkes 2021, Foucault 1991, Ostrom 1990). Therefore, this research aimed to listen and learn from the people who are actually interacting with and extracting from the mangrove forests in the Bangladesh Sundarbans and investigate how both human and environmental viability can be built based on the perspectives of participants.

In this chapter, I provide a summary of research objectives, methods, key findings and recommendations for practice, policy and theory. I also describe gaps in the study and opportunities for further research.

6.2 Objectives and Conceptual Position (Chapters 1 and 2)

The broad goal of this thesis is to understand what the pathway from vulnerability to social-ecological viability looks like, and what elements and actions are needed to mobilize such a pathway. This goal was addressed by two research objectives:

- 1. Describe the magnitude and impacts of drivers of change and vulnerabilities in the SES, as well as the significance of the mangroves to the fisherfolk**
- 2. Understand key response strategies and conceivable pathways to achieve viability in the social-ecological system.**

Objective one was developed to comprehensively understand the current state of the SES by (1) exploring how the mangrove ecosystem contributes to the wellbeing of the fisher community, (2) identifying the (a) current level of vulnerability and (b) impacts of vulnerabilities on ecological and social wellbeing, and (3) understanding how such impacts interact to create outcomes at the SES level.

Objective two was formulated to understand how viability can be mobilized, based on the social-ecological dynamics identified in objective one. This objective was guided by (1) investigating what current coping strategies and adaptive responses are used to achieve viability in the SES, (2) identifying barriers to achieving viability in the SES, and the changes that need to be made to mitigate these barriers, and (3) applying this information to understand how a pathway from vulnerability to viability at a social-ecological level can be mobilized.

As described in Chapter 2, the concepts and theories of MDSSF as a SES, vulnerability and viability, resilience, coping and adaptive strategies, social wellbeing, and multi-level and interactive governance were utilized to further understand the research objectives, and to frame findings in a manner that is relevant for current academic discourse and discussion.

6.3 Methodology and Methods (Chapter 3)

Using a phenomenological research approach to prioritize the voices of participants in research findings, three case studies were conducted in MDSSF villages in the Bangladesh Sundarbans. Due to COVID-19 restrictions, two students were hired from the University of Liberal Arts Bangladesh to conduct the case studies. Each case study consisted of 25 household surveys that aimed to generate data on participants' beliefs, experiences, and knowledge of the dynamics in

the SES that interact with vulnerability and viability. Additionally, one focus group session for ten female respondents was conducted in Dumuria, the first case study location, to explore women's perspectives and insights for mobilizing social-ecological viability. Data from the case studies was largely qualitatively coded using Nvivo software to discover emerging themes and concepts from the data that address the research objectives.

6.4 Key Findings: Objective One (Chapter 4)

Chapter 4 explained the social-ecological dimensions of vulnerability in the case study locations, following insights from Elinor Ostrom's SES theory (Ostrom 2009). The chapter focused on the first research objective of describing the magnitude and impacts of drivers of change and vulnerabilities in the social-ecological system, as well as the significance of the mangroves to the fisherfolk. The key finding from this chapter are listed below:

- The contributions of mangroves to subjective wellbeing of dependent communities include strong place-based identity and a sense of life purpose and belonging.
- Mangroves contribute to material wellbeing of SSF communities by providing the resources upon which fishers are completely dependent for their livelihoods and income.
- The mangrove ecosystem facilitates relational wellbeing by strengthening community relationships and social value by providing a common resource and physical space for people to gather together and earn their livelihoods and contributing to fishers' relationships with markets and external institutions.
- Key natural drivers of change that impact case study villages are tropical cyclones, changes to monsoon season and river erosion
- Key anthropogenic drivers of change are governmental actions, unsustainable fishing practices, corruption, increase in resource users, and the corona pandemic.
- Drivers of change impact material wellbeing by significantly reducing resource availability, degrading livelihoods and financial security, facilitating cycles of debt, decreasing market prices, and instigating fear and dread over future finances.

- Drivers of change impact relational wellbeing by increasing social conflict, shifting the gendered roles within a family structure and weakening relationships between community members.
- Drivers of change impact subjective wellbeing by creating a loss of identity among the fisherfolk.
- Drivers of change and the subsequent impacts can interact in a positive feedback loop to generate cascading negative impacts at the social, ecological, and whole system level.
- Government actions that ignore social dynamics lead to a vicious cycle of negative impact: current restrictions harm the livelihoods of fishers, leading to unsustainable harvesting that degrades resources, which reinforces the view that communities cannot manage resources from the local level.

6.5 Key Findings: Objective Two (Chapter 5)

After describing how vulnerability is experienced at a social ecological level in Chapter 4, Chapter 5 continued the conversation by addressing the second research objective if understanding key response strategies and conceivable pathways to achieve viability in the SES. Key insights include:

- The majority of responses strategies implemented by participants in response to vulnerability are coping strategies, meaning that they are only short-term solutions that deter from long-term viability.
- Two adaptive strategies are currently used to improve social-ecological resilience on a long-term scale: (1) pursual of secondary occupations, such as vegetable farming, that increase fishers' ability to adapt and maintain finances during time of resource restriction, and (2) the formation of a community-based organization in Keyabunia, which implements several initiatives to increase the adaptive capacity and wellbeing of the community.

- Participants identified that a reform of the current management system, formation of better alternative livelihoods, and the mitigation of unsustainable fishing practices all need to be implemented in their community.
- Barriers to these changes include an institutional communication gap, political exclusion of fisherfolks, lack of education and awareness at the community level, lack of social value, and governmental corruption.
- Five key components were identified to address these barriers and mobilize a pathway to social-ecological viability: (1) community led education, (2) establishment of clear rules and boundaries, (3) communal monitoring and rule enforcement, (4) formation of community-based institutions and (5) support and collaboration from the government.
- The five empirical aspects of the pathway to social-ecological viability identified in this study along with the classification of fisheries as a common-pool resource support that community-based conservation informed by commons principles is core to viability.

6.6 Recommendations for Policy and Theory

Here I ask, how can these findings be applied to a real-world context? First, this research offers strong evidence in support of a political space that prioritizes the perspectives and knowledge of local resource users. The assumption that communities cannot conserve resources is simply inaccurate, and reflects the impacts that commercialism, globalization and colonial processes have inflicted upon marginalized populations. The solution to resource degradation is not top-down policing and infliction of power; it is investing in the long-term processes that are necessary to thoughtfully address many of the urgent crises that both environmental and human systems face. These processes to deconstruct a governing system that is ineffectively addressing the complex interactions shaping such crises and reconstructing a governing system that is viable and flexible across temporal scales, begins with the prioritization and understanding of needs at

the community level. As discussed in Chapter 5.5, policies regarding mangrove resource management need to be developed with a polycentric approach that involves actors at different levels and supports the specific needs and actions of local resource users.

In this work, I recognize that change is a constant, and I ask how MDSSF can mobilize viability in the face of ongoing external drivers of change. However, this research supports that core to long-term viability is institutional support and collaboration. Of the five core elements of social-ecological viability identified in Chapter 5, one describes that local communities need support and communication across governance levels to effectively mobilize viability. Although root-level action within the community, such as seen in Keyabunia with the formation of Jele Somiti, is critical to improving wellbeing and adaptive capacity within the community, I believe that action also needs to be taken at multiple scales to fully mobilize viability. For the systemic issues that underly impacts to be solved, it is first important to address that colonial and post-colonial processes set the agenda for centralist institutional control over common pool resources, and there needs to be a reform to political system and a prioritization of solidarity, reconciliation, and respect for local resource users' rights.

This research also supports that community-led initiatives and the formation of commons governance regimes share the critical elements of the pathway to social ecological viability. Future research should explore the role of such root-level governance in the viability of MDSSF.

In conclusion, appropriate protection for mangrove forests and dependent SSF communities faces a multitude of challenges and given the urgency of the threats that these ecosystems are facing, it is easy to make quick decisions that come from a place of short-termism and panic. However, the dynamics shaping the outcomes of any management decision are intricate, and it is essential to understand these dynamics by listening to resource users and collaborating with a diversity of actors in the decision-making process to ensure a viable outcome at the social-ecological scale.

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Appendix A

Household Survey Guide

Participant Code: _____

Interviewer Initials: _____

These survey questions will follow the brief introduction and verbal consent script.

The interviewer should provide a succinct preamble and explain the following points to the participant:

- *This survey consists of 3 sections, which approximately 10 questions each.*
- *The first section asks demographic questions, for example: your gender, annual income, and occupations. The purpose of these questions is to gain background information that can help us to understand your perspectives and experiences of vulnerability and viability in your community.*
- *The next 2 sections ask questions focused on understanding your experiences and point of view regarding the vulnerabilities that your community has experienced, how you and your community have responded to such vulnerabilities, and what changes need to be implemented to improve the livelihoods of yourself and your community.*
- *At the end of the survey, you may be asked an additional question or two to clarify or follow up on a previous answer. You will also be prompted to add anything that you think is important.*
- *Again, as a reminder, you can choose to skip any question, and can end the interview at any time.*
- *Do you have any questions before we begin?*

SECTION 1: Demographic Questions

1. What is the gender of the survey respondent?
 - A. Male
 - B. Female
 - C. Unsure
2. What caste do you belong to? *If there is no caste system in the village, ask about ethnicity and ethnic group.*
3. What does small scale fishing mean to you? How do you describe small-scale fishing?
4. How many months in a year do you receive income for this occupation?
5. What is your total annual income from fishing alone?
6. Does your family have any secondary occupations?

- A. Yes
 - B. No
7. (*If answer to question 6 is yes*), what are the other occupations of your family?
 - a. Vegetable Farming
 - b. Raising Animals (chickens, cows, other)
 - c. Large-scale aquaculture
 - d. Business (shops, fish selling, others)
 - e. Wage laborer
 - f. Forestry
 - g. Honey Production
 - h. Fish trader
 - i. Others (specify):
 8. (*If answer to question 6 is yes*), how many months in a year do you receive income for each secondary occupation?
 9. What are your major heads of expenditure in a whole year? (*mention in reference to last two years*)?
 - a. Consumption
 - b. Education
 - c. Loan repayment
 - d. Social ceremonies of relatives
 - e. Healthy problems/Hospitalization
 - f. Marriage
 - g. Others (specify):
 10. Is your total income sufficient for your annual expenditures?
 - a. Yes
 - b. No
 11. (*if answer to 10 is no*) what are the main reasons for the insufficiency? How do you cope with the deficit?
 12. What is the educational qualification of the members of your household?
 - a. Male adults:
 - b. Female adults:
 - c. Male children, and if they are currently in school:
 - d. Female children, and if they are currently in school:

SECTION 2 : *Note these questions are intended to address the objective of describing the magnitude and impacts of drivers of change and vulnerabilities in the SES, and to understand the significance of the mangroves to the people.*

1. What resources (such as honey, wood, fish) from the mangroves do you use for your livelihood?
2. What is the importance of these resources for your income?

3. Do these resources contribute to your relationships with markets and external institutions? *If so, how?*
4. What are the main contributions of the mangroves to your relationships with your community? *For example, does the harvesting of mangrove resources contribute to a sense of community? If so, how?*
5. What are the main contributions of the mangroves to your self-identity and sense of belonging?
6. In the last 20 years, what are the major changes that you have seen occurring in the mangrove forests?
 - A. What do you think are the main factors responsible for these changes? *(try to capture anthropogenic, natural and other drivers such as policy changes).*
7. In the last 20 years, what are the major changes that you have seen occurring in the fisheries?
 - A. What do you think are the main factors responsible for these changes? *(try to capture anthropogenic, natural and other drivers such as policy changes).*
13. Have these changes to the mangroves and fisheries impacted your community? *If the answer is yes, how so?*
14. Have these changes impacted ability to connect and work together with others in your community? *If the answer is yes, how so?*
15. Have these changes impacted your livelihood? *If the answer is yes, how so?*
16. Have these changes impacted your ability to connect with others outside of your community? *For example, has your access to external markets and institutions been compromised? If the answer is yes, how so?*
17. Have these changes impacted your feeling of safety and security? *If the answer is yes, how so?*
18. Have these changes impacted your sense of belonging/self-identity? *If the answer is yes, how so?*
19. Have these changes impacted your (cultural) connection with the mangroves? *If the answer is yes, how so?*
20. Currently, what do you think are the biggest threats to the mangroves? *If possible, ask respondent to rank the threats.*

SECTION 3: *Note these questions are intended to address the objective of understanding key response strategies and conceivable pathways to achieve viability in the SES.*

1. What are the ways that you and your community have coped with and/or are coping with the changes that you described? Please describe each coping strategy you/your community are using.

2. What do you think is needed in your community to improve the wellbeing of your family, the mangroves, and your overall community? Please describe in as much detail as possible what exact changes should be made.
3. What do you think prevents these changes from happening?
4. Can you please describe how the mangroves and fisheries are currently managed? (*who are the people and/or institutions who make decisions regarding resource management? What are the rules and boundaries of the management system?*)
5. How has the management of the mangroves and fisheries changed in the last 10 years?
6. How have aspects of mangrove and fishery resource management impacted yourself and your community?
7. How do you think the management of mangrove resources can be improved?
8. What is your impression of the current management?
9. Do you feel that you are able to communicate with the individuals and institutions who manage mangrove resources?
 - A. If answer to 9 is no, what do you think are the reasons for lack of communication?
 - B. If answer to 9 is yes, how do you communicate with the individuals/institutions who manage mangrove resources? Who are the people involved in the communication?
10. Please describe the community-based organization in your village in as much detail as possible (*how and why it was created, the organization's structure, who makes the rules, how many people there are, how decisions are made*).
11. How does the organization participate in mangrove management? (*How do they interact with higher level institutions*)
12. What is your impression of this organization? (*What do you like about it/what do you think could be improved*)

SECTION 4: Concluding thoughts

1. Is there anything else that you would like to add? is there something important that we should know to better understand how mangroves, fisheries and the communities dependent on them can all become more resilient together?
2.ask any follow up questions that emerged based on the survey responses....

Appendix B

Household Survey Guide

INTRODUCTION:

Hello, my name is (name of research assistant). Thank you for agreeing to participate in this focus group meeting. Just to remind everyone, I'm looking at opinions about understanding various social-ecological and economic aspects of small-scale fisheries in your community and the status of the mangrove forests in your area. The project is under the supervision of Dr. Prateep Nayak at the University of Waterloo's School of Environment, Enterprise and Design. Thank you for your interest in participating in this focus group. A focus group is an interactive group discussion where we can gain several perspectives about a topic and members of the group can think about and comment on what others have said in the group. Have you had time to read the Letter of Information that was sent you? [If the participants responds that they have read the letter of information]

Great, then I would like to take a moment to review some main points from the Letter of Information before we continue. [Proceed to review the highlights of the letter of information, be sure to include risks and what will happen with their data and confirm the important points about voluntary participation and listed below and confidentiality.]

Confidentiality: Before we begin our discussion, I want to spend a few moments talking about confidentiality and to go over some basic ground rules for our focus group discussion today:

- Everyone's views are welcomed and important.

- The information which we will collect today will be attributable (connected or associated) to you as a group. This means that we will be identifying themes and interpretations from the group as a whole.
- Your names will not be recorded. We will not identify quotes or ideas with any one person of this group. Because of the nature of small communities or groups, it is possible that people could link participants in this room to quotes in the report.
- The researchers will keep your identity confidential in reports etc. and we are asking that all focus group participants treat our discussion as confidential. However, we cannot guarantee that this will be done. Please make only comments that you would be comfortable making in a public setting; and to hold back making comments that you would not say publicly.
- If you want to stop being in the focus group you can leave or stay and simply stop talking, but it will not be possible for you to pull out your data from the flow of the conversation because of the interconnected nature of the group discussion where one person's comments can stimulate the sharing of comments made by others in the group.
- Anything heard in the room should stay in the room.
- All voices are to be heard, so I will step in if too many people are speaking at once or to make sure that everyone has a chance to speak.
- I may also step in if I feel the conversation is straying off topic.
- You can expect this discussion group to last about 60-90 minutes.

II. INTERVIEW

The broad questions aim to understand the magnitude and impacts of drivers of change and vulnerabilities in the community, understand the significance of the mangroves to the people, and understand key response strategies to achieve viability in the social-ecological system from a gendered perspective.

For example, the key questions include:

- 1) Please describe your relationship with the fisheries/mangroves. (Prompts: Do you ever go to the mangroves? If so, in what capacity? Are you involved with the fisheries? If so, in what capacity (shrimp collection, etc.)?)
- 2) What is the importance of the local ecosystem for your household's financial security and livelihoods (for example, the financial importance of shrimp collection)?
- 3) As a group, please come up with a list of the biggest changes that your community has faced over the last ten years.
- 4) Have these changes impacted men and women differently? If so, how? Discuss how men and women adapt in different ways to the changes.
- 5) Have these changes impacted your everyday life? If so, how?
- 6) Have these changes impacted your household? If so, how?
- 7) Have these changes impacted your relationship with community members? If so, how?
- 8) Please describe the current management/governance of the fisheries and mangroves.
- 9) Are women involved/given leadership roles in resource management?
- 10) Do you believe that it would be beneficial for all members of the community to be included in managing the mangroves/fisheries?
- 11) Please describe what the ideal management of the mangroves/fisheries would look like to you. What do you think prevents this 'ideal management' from happening?
- 12) Have you ever received any support of help from government, NGOs or any other organization? If so, please describe.

III. WRAP-UP: The discussion will be summarized in front of all the participants by the facilitator. We will then close the discussion with a thank you and asking if anyone has any questions or comments.

Appendix C

Ethics Approval

Friday, April 8, 2022 at 17:24:53 Eastern Daylight Time

Subject: Research Ethics - Amendment application # 43509 has ethics clearance
Date: Friday, November 5, 2021 at 10:19:44 AM Eastern Daylight Time
From: no-reply=kuali.co@mx3.kuali.co on behalf of Kuali Notifications
To: Alyssa Robinson

Dear Prateep Nayak and other members of the research team:

Your application has been reviewed by Delegated Reviewers. We are pleased to inform you the **Amendment application for 43509 Pathways to Social-Ecological Viability for Mangrove-Dependent Small-Scale Fisheries** has been given ethics clearance.

***Note:** Due to the current COVID-19 situation, research activities that require face-to-face/in-person interactions cannot be conducted until all procedures for research re-start (including safety plan approval) have been completed. For on campus research, all research team members and participants must complete the [campus check in](#) before coming to campus and be full fully vaccinated or have received an accommodation as per the [University of Waterloo's vaccination policy](#). Please review [Frequently Asked Questions](#), [processes and forms](#), [vaccination confirmation guidance](#), and [restart guidance](#). Direct any inquires to researchethics@uwaterloo.ca.*

This research must be conducted in accordance with the most recent version of the application in the research ethics system and the most recent versions of all supporting materials.

Ethics clearance for this study is valid until Saturday, September 3rd 2022.

The research team is responsible for obtaining any additional institutional approvals that might be required to complete this Expedited study.

University of Waterloo Research Ethics Boards operate in compliance with the institution's guidelines for research with human participants, the [Tri-Council Policy Statement for the Ethical Conduct for Research Involving Humans](#) (TCPS, 2nd edition), [Internalization Conference on Harmonization: Good Clinical Practice](#) (ICH-GCP), the [Ontario Personal Health Information Protection Act](#) (PHIPA), and the applicable laws and regulations of the province of Ontario. Both Boards are registered with the [U.S. Department of Health and Human Services](#) under the [Federal Wide Assurance](#), FWA00021410, and IRB registration number IRB00002419 (Human Research Ethics Board) and IRB00007409 (Clinical Research Ethics Board).