

**Livelihood Vulnerability, and the Role of Agency in Adaptation: Evidence
from the Sundarbans
Fishing Communities of Bangladesh**

By

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Abstract

Climate change-induced disasters disproportionately impact livelihoods, particularly among coastal small-scale fishing communities in Bangladesh. Climatic hazards intersect deep-rooted socio-economic inequalities, marginalization, gender norms, and other triggers that create differential vulnerability among diverse groups. These issues highlight the importance of assessing and understanding the dynamic patterns of vulnerability and adaptation for effective policy interventions.

Using a mixed-method approach, this thesis research assesses the dynamics of intersectional livelihood vulnerability among small-scale fishing communities in the Sundarbans region of Bangladesh and examines how they mobilize individual and collective agency to craft locally grounded adaptation responses in the face of recurring climatic, environmental, and socio-political stressors. Field data were collected from April 2024 to June 2024 in two coastal *Unions* of Shyamnagar *Upazila*, Satkhira District, using multiple Participatory Rural Appraisal (PRA) tools. The study integrates numerical household survey data with qualitative insights from key informant interviews, focus group discussions, and participant observation conducted in the study area.

The results reveal that the interaction between spatial features and socio-economic processes generates uneven vulnerability of coastal fishing communities to extreme climate-related events. However, people demonstrate proactivity in addressing and adapting to these vulnerabilities, even amid constraints, by exercising their agency. Here, agency is largely deliberate and proactive rather than reactive; it evolves from past triggers and lived experiences and is typically reflected in adaptive actions to sustain livelihoods. The research findings underscore the need to integrate household heterogeneity and intersectionality perspectives into vulnerability assessments. By exploring adaptation actions in connection to various forms of agency, we infer that resilience outcomes depend not only on local adaptive capacities but also on enabling governance conditions that recognize and support meaningful application of agency. Finally, the need for locally grounded adaptation policies, stronger institutional arrangements targeting marginalized groups, and greater investment in women's capacities to support community resilience in hazard-prone coastal settings is emphasized.

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DEDICATION

This thesis is dedicated to the coastal communities of Shyamnagar, contributed to global scientific research by sharing their stories and experiences. It is also dedicated to my parents because they are my cheerleaders and to my late grandfather because he wished to read my thesis paper and watch me graduate and I stand here carrying his blessings.

Contribution of Authors Statement

This thesis written by Rukhser Ahmed, is also the result of the collective support and contributions of those mentioned in the Acknowledgement above, as well as many others who, though not explicitly named, have had a meaningful impact on her academic and personal journey.

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Chapter 1

Introduction

1.1 Background and Context

Climatic shocks have increased in frequency and intensity over recent decades, resulting in profound impacts that are disproportionately felt worldwide, particularly in developing countries and low-lying coastal regions that remain exposed to these hazards (World Economic Forum, 2018). Countries and small island states across South Asia face heightened risks of floods, cyclones, storm surges, and droughts, which collectively undermine livelihoods and exacerbate social inequalities (United Nations Office for Disaster Risk Reduction [UNDRR], 2019). Recurrent cyclonic events and weather-driven disasters have emerged as persistent threats to citizens' well-being, economic and ecological sustainability, and the achievement of global development priorities, creating and perpetuating cycles of chronic vulnerability in disaster-prone areas (Haque & Burton, 2005; Intergovernmental Panel on Climate Change [IPCC], 2022). In addition to environmental stressors, the cascading effects of intersecting factors like gender norms, limited assets, and social marginalization create additional differentiated vulnerability among varied groups and households. In the context of these emerging issues and problems, there is a growing need to examine the underlying factors of vulnerability, and to explore how different communities adopt innovative strategies and adaptation practices through their deliberate efforts and ideas to strengthen their adaptive capacity and reduce risks over time (Rana & Ilina, 2021; UNDRR, 2019).

Bangladesh is widely recognized as one of the most climate-vulnerable countries in the world due to its unique geographic location, low-lying topography, and limited infrastructure to withstand climatic extremes (The World Bank Group, 2021). Over the past five decades, the country has experienced numerous large-scale disasters, including devastating cyclones, tidal storm surges, floods, and salinity intrusions, which have repeatedly disrupted livelihoods (Dasgupta et al., 2011; Mirza, 2011). During the past half a century, the coastal belt stretching along the Bay of Bengal has experienced some of the deadliest cyclones, including the 1970 Bhola cyclone and the 1991 cyclone, both resulting in catastrophic loss of life and extensive economic damages (Haque, 1997; Paul, 2009). More recent events, such as Cyclone Sidr in 2007 and Cyclone Amphan in 2020, have left devastating loss of lives and assets, and multiple other livelihood challenges—demonstrating how climate-induced hazards continue to exacerbate poverty and deepen existing social and spatial inequalities across coastal regions (Rabbani, 2009; Roy et al., 2022).

The livelihoods of small-scale fishing communities in Bangladesh's Sundarbans mangrove coastal region are intricately linked to the fragile ecological and socio-economic dynamics of households in the face of disasters. These communities experience complex vulnerabilities driven by exposure to cyclones, often compounded by social inequalities related to gender, class, and access to resources (Choudhury & Haque, 2016; Kamal, 2013). These vulnerabilities are unevenly distributed across households due to variations in socio-economic status, gender, and spatial location, which influence exposure, sensitivity, and access to resources and mediate livelihood outcomes (Choudhury & Haque, 2016; Hahn et al., 2009).

Assessing these livelihood vulnerabilities is essential for identifying the differentiated risks faced within and between communities, and for a realistic understanding of people's strengths to reduce their vulnerabilities (assets, capitals, or resources) (Department for International Development [DFID], 1999). Given the heterogeneity of coastal populations, it is important to incorporate household-level characteristics into livelihood vulnerability assessments to more accurately capture how intersecting factors such as socio-economic class, gender roles, and occupational practices shape differential experiences of risk and capacity to adapt (Banerjee et al., 2019; Béné et al., 2016). For example, differences in income, occupation, and social status influence people's access to resources, health outcomes, and capacity to adapt to climate hazards (Conway et al., 2019).

Climate change intensifies intersectional gendered marginalisation, inequality, and vulnerability (Kaijser & Kronsell, 2014; MacGregor, 2010; Osborne, 2015; Sultana, 2014). People experience disproportionate impacts, shaped and exacerbated by existing social, historical, economic, and institutional inequalities—often described as the *differentiated impacts of climate change* (Field et al., 2014). These inequalities mean that some groups face greater exposure to and sensitivity to hazards, while also having more limited capacities to respond and recover, shaped not only by material assets but also by marginalization, social hierarchies, and socio-economic disadvantage. Understanding these differentiated vulnerabilities is therefore central to *climate justice scholarship*, which seeks to reduce marginalization and exploitation in order to enhance equity. Within climate justice approaches, intersectionality has increasingly been used to examine how multiple identities and power relations shape experiences of risk and exclusion (Kaijser & Kronsell, 2014). For example, while women are often excluded from international climate policymaking, indigenous women experience this exclusion disproportionately (Perkins, 2019). Feminist climate justice scholarship further draws on intersectionality to demonstrate how patriarchy compounds socio-

ecological crises, and studies in Bangladesh similarly show that gender, caste, class, religion, and age jointly shape vulnerability to floods (Sultana, 2010). These examples highlight the growing recognition that vulnerable communities are not homogeneous, and that vulnerability assessments should incorporate household-level characteristics—including socio-economic status and gender relations—to better reflect the diverse ways in which risks are experienced and negotiated across different segments of society. In particular, intersectional vulnerability assessments help better capture interconnected inequities (Sultana, 2021). Thus, these analyses must go beyond static accounts of vulnerability by examining the power relations, norms, and institutions that shape unequal outcomes (Malin & Ryder, 2018).

To better analyze the social impacts and outcomes of climate-related disasters, it is imperative to examine people's adaptive responses and the interventions undertaken within broader social, economic, and institutional structures that can both enable and constrain their actions (Cinner et al., 2018). Coastal fishing communities across South Asia frequently employ a range of adaptation strategies to cope with varied disaster impacts, thereby enhancing their resilience (Banerjee et al., 2019; Béné et al., 2016). In Bangladesh, small-scale fishers have combined local knowledge¹ with informal collective action to respond to increasing salinity and cyclonic hazards, illustrating how adaptation is embedded in everyday livelihood practices (Choudhury & Haque, 2016). Each household has a distinct set of capacities for negotiating its decisions. Therefore, understanding vulnerability remains incomplete without examining how fishing households actively navigate the complexities of disaster risk through diverse strategies.

These practices reflect intentional decisions and the capacity to shape adaptive responses to recurrent hazards, commonly referred to as *agency* (Adger, 2003). Individuals and households channel these decisions within broader social, economic, and institutional structures that can both enable and constrain action (Cinner et al., 2018). For example, Cinner et al. (2018) demonstrate how market pressures, governance arrangements, and institutional dynamics influence the possibilities for small-scale fishers to adopt adaptive measures. Investigating the dynamics of agency within adaptation processes and its linkage to structural arrangements provides valuable insights into how vulnerable coastal communities negotiate

¹ *Local knowledge* refers to the understandings and skills developed by individuals and populations, specific to the places where they live—a key element of the social and cultural systems which influence observations of, and responses to, climate change. It also informs governance decisions. See IPCC 2023 Annex I: Glossary

their vulnerabilities, adapt meaningfully over time, and create opportunities to enhance livelihood security (Coulthard, 2012).

Recognizing that vulnerability is not only experienced but also actively negotiated, it becomes essential to explore how adaptation strategies reflect different forms of *agency*² and what factors enable or limit that agency in specific contexts (Coulthard, 2012; Ensor & Harvey, 2015). Understanding these dynamics of adaptation is therefore critical, not only for identifying who is most vulnerable but also for uncovering how and why people adapt and for revealing the existing drivers of adaptation that build resilience (Adger, 2003).

While the concept of agency is increasingly acknowledged as a central dimension of adaptive capacity (Cinner et al., 2018), there remains a notable dearth of empirical studies that explicitly position agency as a core analytical lens within vulnerability assessments (Tschakert & Clair, 2013). Much of the adaptation literature emphasizes structural determinants, such as institutional support, governance, and resource access, while paying less attention to how individual and collective agency mediates these factors in practice (Coulthard, 2012; Nightingale, 2015). As a result, there is limited understanding of the mechanisms by which agency shapes adaptive capacity, particularly in coastal fishing communities confronting recurrent climate-related disasters. Addressing this gap requires empirical research that not only documents adaptation strategies but also examines how agency is exercised, constrained, and negotiated within these strategies in the contexts of vulnerable livelihoods (Cinner et al., 2018).

In this context, the present study assesses the intersectional vulnerability and adaptive capacity of small-scale fishers in Bangladesh's coastal communities to climate-triggered hazards. In addition, this study examines how agency shapes adaptation among coastal fishers, with the aim of understanding why people pursue certain adaptive responses and the implications of these for building resilience.

1.1.1 Key Terms and Concepts

This section briefly explains the key terms and concepts used in this thesis, as follows:

Intersectional vulnerability: Intersectional vulnerability is conceptualized as the compounding condition of risk and insecurity produced by intersecting factors such as social

² *Agency* is used throughout this thesis to refer to the socially and institutionally embedded capacity of individuals and communities to act intentionally, reflectively, and purposefully in response to change and constraint.

identities, gendered roles, ethnicity, race, and unequal access to resources and institutional support within broader political–economic relations. It also aligns with a climate justice lens by emphasizing equity and the need to address unequal power relations in support of marginalized populations facing climate disasters.

Livelihood: Refers to the means through which fishers meet basic needs (e.g., food and income) as well as to the practices through which they mediate vulnerability and build the capability to cope with, recover from, and adapt to climatic uncertainty. Fishing livelihoods are conceptualized collectively within the social and institutional context of fishing communities.

Livelihood vulnerability: Livelihood vulnerability refers to the degree to which fishing households and communities are exposed to, and sensitive to, climatic shocks and stresses—and the extent to which they lack the adaptive capacity to cope with, recover from, and adjust over time. In this study, livelihood vulnerability is conceptualized as socially differentiated and shaped by intersecting socio-economic, gendered, institutional, and political conditions.

Adaptive capacity: The ability of individuals, communities, or systems to respond to, recover from, and adjust to climatic shocks and stresses, thereby reducing overall vulnerability. In this study, adaptive capacity is understood as socially embedded, shaped by broader political, institutional, and governance contexts that enable or constrain adaptation.

Adaptive response: The broad range of actions, decisions, and intentional and behavioural adjustments through which individuals and communities cope with, recover from, and respond to climatic shocks and stresses to reduce exposure and sensitivity. In this study, adaptive responses are understood as adaptive practices that may be material (e.g., livelihood shifts, infrastructure repair) or non-material (e.g., behavioural change, planning, and social coordination), and are shaped by agency and structural constraints.

Resilience: In the present study, resilience is not regarded as a transformation into a new socio-ecological state or a full return to the original state, but as a negotiated and adaptive process through which communities maintain viable livelihoods amid recurring hazards.

Agency: Conceptualized as the socially and institutionally embedded capacity of individuals and communities (not limited to cognitive capacity) to make decisions, exercise *free will* and *proactive* initiative, and take adaptive action under constraints in response to climatic shocks and stressors. Agency is examined through its expressions in everyday

adaptation practices rather than assumed as an abstract system property or a static domain of adaptive capacity.

Agency-triggered responses: Understood as the adaptation strategies, practices, or adjustments that emerge from intentional individual or collective decision-making to respond to climatic stressors. In this study, the term emphasizes that adaptive responses are not isolated reactions to vulnerabilities, but are shaped by agency operating within structural and institutional constraints.

1.2 Objectives and Research Questions

In consideration of the above backdrop, the overall purpose of this study is to assess the livelihood vulnerability of small-scale fishing communities in the face of multiple climatic and non-climatic stressors, and to understand their adaptation mechanisms that contribute to increasing their adaptive capacity and enhance community resilience. In addition, improving our understanding of the agency pathways within adaptive strategies of the communities, in enhancing their adaptive capacity and community resilience, is a goal.

This research has been guided by the following two specific objectives:

- i) To assess the livelihood vulnerability of small-scale fishing communities in the Sundarbans mangrove coastal region; and
- ii) to explore how agency is exercised in adaptation strategies and to identify the drivers of agency contributing to building resilience.

The primary objectives of the thesis have been expanded to associate with five research questions. Based on Objective One, two research questions were formulated and are presented in Chapter Two. Objective Two was also disaggregated into three research questions. These research questions are described in Chapter Three of this thesis. Table 1 represents the objectives of the thesis and the associated research questions:

Table 1. *Objectives and Sub-objectives of This Study*

No.	Objectives	Sub-objectives
1.	To assess the livelihood vulnerability of small-scale fishing communities in the Sundarbans mangrove coastal region.	i) What are the patterns and dynamics of livelihood vulnerability-based intersectional aspects (socio-economic and gender) of small-scale fishing communities in the <i>Sundarbans</i> coastal region of Bangladesh? ii) Do spatial disparities of place-based livelihood vulnerability exist between two coastal fishing communities in Bangladesh?
2.	To explore how agency is exercised in adaptation strategies and to identify the drivers of agency contributing to building resilience.	i) How do small-scale fishing communities exercise agency in adaptation strategies? ii) What are the drivers of agency, and how do they enhance resilience through shaping adaptation actions? iii) What are the barriers against, and opportunities for, undertaking adaptive actions?

1.3 Methodological Approaches

To achieve the above-stated two objectives of the present study, a mixed-method study design was developed. A combination of structured questions designed to gather quantitative data, and open-ended inquiries intended for qualitative data collection, were incorporated within the questionnaire survey, interviews, and discussions in a participatory setting. Both qualitative and quantitative data were merged in a complementary manner, providing a comprehensive analysis of the results.

A quantitative design was employed to assess the livelihood vulnerability of small-scale fishing communities (Objective 1), as it allowed for systematic measurement and comparison across socio-economic class, gender, and spatial settings (Creswell & Plano Clark, 2011). Quantitative methods facilitated the development of a context-specific livelihood vulnerability

index, enabling examination of how vulnerability varies within and between communities in a structured, replicable manner (Hahn et al., 2009). The use of quantitative tools thus provided a robust foundation for identifying patterns and disparities in livelihood risks across the study area.

In contrast, a qualitative research design was adopted to investigate how agency operates within adaptation strategies and the drivers and barriers against it (Objective 2). Qualitative inquiry was appropriate for capturing the subjective experiences, perceptions, and decision-making processes that underlie adaptation practices (Maxwell, 2013; Patton, 2015). Through participant narratives and detailed accounts of local realities, this approach offered nuanced insights into the ways individuals and collectives navigate structural opportunities and constraints to shape adaptive responses. The integration of both quantitative and qualitative approaches enabled a more comprehensive understanding of the differentiated vulnerabilities and adaptive capacities of coastal fishing communities (Creswell & Plano Clark, 2011), yielding a richer, more holistic analysis.

1.3.1 Study Area

The research was conducted in Shyamnagar Upazila, Satkhira District, in southwestern Bangladesh. It is situated at approximately 21.55° N latitude and 89.11° E longitude (See Figure 2). Shyamnagar lies at the interface between the Bay of Bengal and the expansive Sundarbans mangrove forest, forming an ecologically sensitive coastal zone shaped by the interplay of freshwater and marine influences. Livelihoods in this region are largely dependent on small-scale fishing, subsistence crop production, and seasonal harvesting of forest resources. The area's geographic characteristics, such as low-lying terrain and proximity to tidal rivers, make it physically exposed and vulnerable to cyclones, storm surges, and salinity intrusion. These environmental pressures are intensified by limited access to basic services such as health care, education, and disaster preparedness infrastructure in the region, as well as limited employment, contributing to entrenched social and economic precarity (Ahmed et al., 2021).

Historically, between 1877 and 2017, the coastal regions of Bangladesh experienced 168 cyclones, of which 52 were accompanied by severe storm surges. Increased cyclonic storm surges, along with coastal flooding and salinity intrusion—at the intersection of limited economic and institutional supports—reproduce and reinforce poverty, gender violence, and unemployment in the coastal communities of Bangladesh (Azad et al., 2013; Hossain et al.,

2019). The recent (1995–2020) major cyclone tracks are shown in Figure 1, illustrating the region's physical exposure to climate-related cyclones. Two major cyclones severely affected the District of Satkhira in 2007 and 2009—Cyclone Sidr and Cyclone Aila, respectively—causing catastrophic loss and damage to lives, properties, and livelihoods. The Cyclone Sidr affected 2.3 million households with physical damage and a loss of approximately US \$1.1

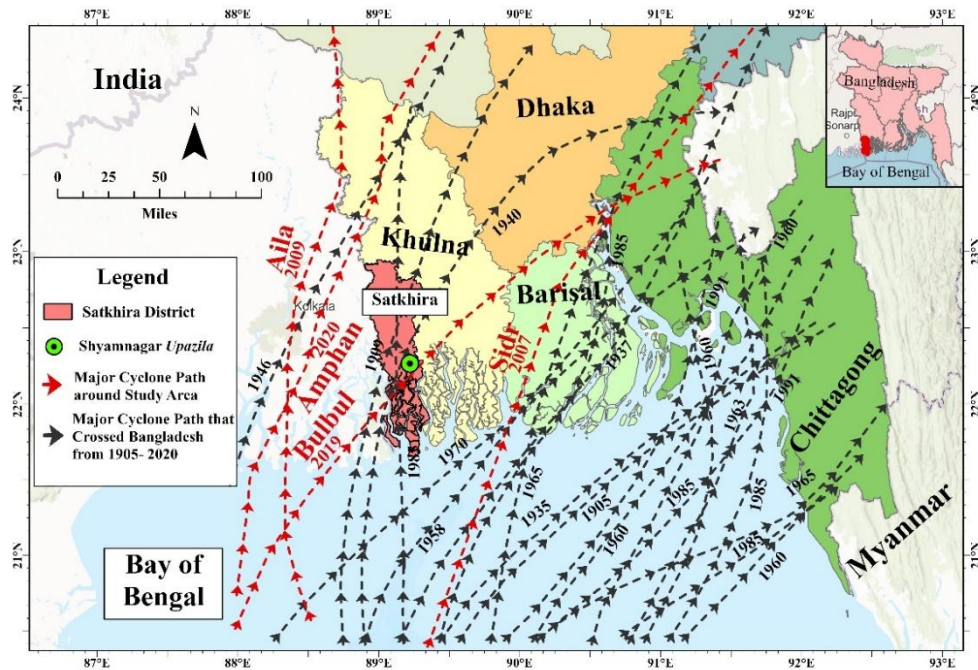


Figure 1. Major Cyclone Paths on the Coastal Region of Bangladesh (1995–2020) and the Physical Exposure of Study Area to Cyclones

Compiled from Ahmed et al., 2022; Badarinath et al., 2012; IFRC, 2020; Islam, Md. M. et al., 2014; Tamim & Islam, 2025.

billion; the Cyclone Aila affected 3.9 million people, with an estimated loss and damage of US \$240 million (Azad & Khan, 2015; Islam & Hassan, 2016; Moniruzzaman, 2019; Tajrin & Hossain, 2017). Shyamnagar Upazila³ within Satkhira District has experienced numerous severe cyclones that have left a lasting impact on local livelihoods. For instance, Cyclone Sidr in 2007 and Cyclone Aila in 2009 both caused extensive damage to homes, fishing gear, and farmland, as well as large-scale displacement.

³ Upazila is the second lowest administrative unit of Bangladesh, with the Union Parishad (UP) being the lowest. Upazilas are sub-districts within a district, further divided into unions.

Subsequently, the District of Satkhira experienced two major horrific cyclones: Cyclone Bulbul in 2019 and Cyclone Amphan in 2020 (see Figure 1 for the cyclone paths). Cyclone Bulbul, which passed directly over the Sundarbans, generated high storm surges, inundation, and heavy rainfall, causing substantial damage to the fisheries sector (approximately US\$5.5 million in losses). It submerged over 11,223 ha of ponds and *ghers*⁴ (Iqbal, 2019). Similarly, Cyclone Amphan damaged more than 176,000 ha of productive land and numerous established fish/shrimp farms, resulting in total damage of approximately US\$ 130 million (Iqbal, 2020). Recently, cyclonic events have increased in the region: 12 cyclones affected the Bay of Bengal over the past 6 years (2019–2024), leaving little time for communities to recover from successive cyclone-induced losses.

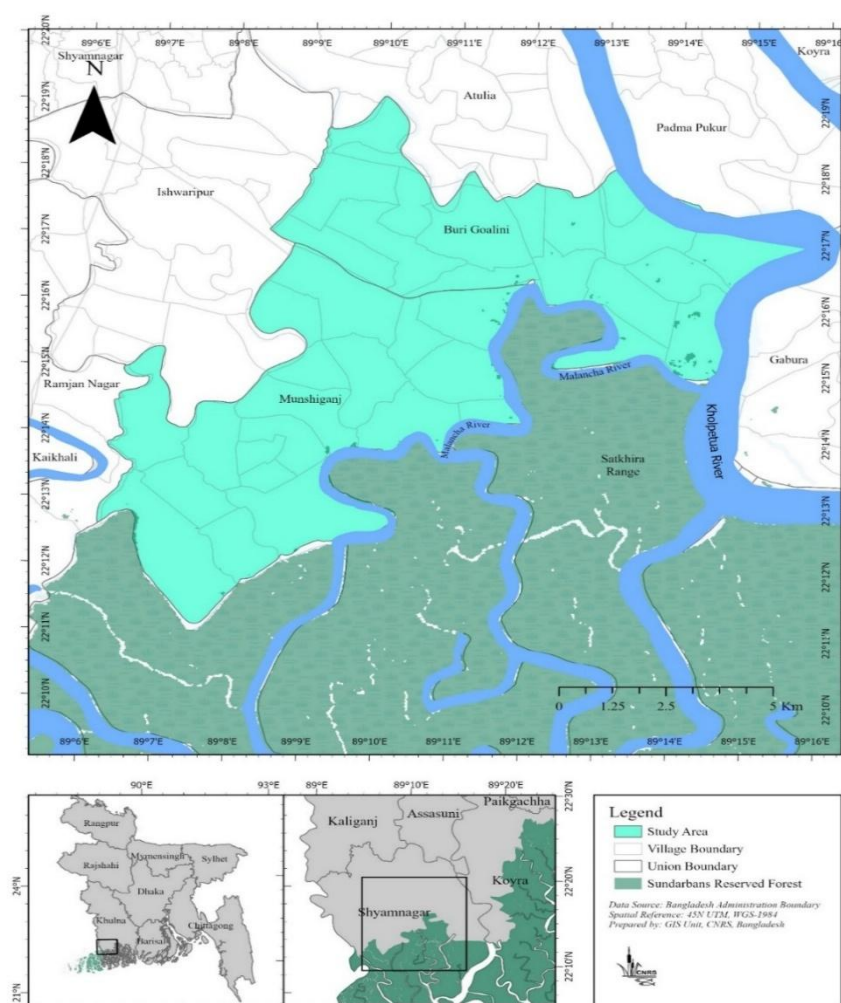


Figure 2. Map of Shyamnagar Upazilla, Satkhira District

Source: Bangladesh Administration Boundary, 2022 and Field Assessment, 2025

⁴ *Ghers* in southern Bangladesh refer to modified rice fields used for an integrated farming system that combines freshwater prawn/shrimp and fish aquaculture with HYV rice cultivation. This unique indigenous innovation is a primary source of income and food security here

Using a multi-stage study design, we first randomly selected the Shyamnagar *Upazila* as our study area, out of a total of seven *Upazilas* (sub-district) in the District (Fig. 1). Second, out of 12 Unions (the lowest level administrative unit), we selected two Unions (17%)—namely Burigoalini and Munshiganj—using a simple random sampling procedure. These two Unions are predominantly homes of small-scale fishers, comprising 10,965 households (BBS, 2016). The repeated occurrence of such high-impact disasters, combined with heightened poverty and other social disparities, makes this coastal region a significant context for studying the drivers of vulnerability and how fishing communities exercise their human agency in adaptation mechanisms that build resilience. This study site was chosen based on several key considerations:

- (i) the area experiences frequent exposure to heavy rainfall, tidal surges, strong winds, and salinity intrusion, as well as extreme climatic events, such as cyclones and very high storm surges;
- (ii) heavy reliance on fishing and natural resource-based livelihoods for subsistence and income;
- (iii) persistence of high poverty levels among fishing households; and
- (iv) the existence of structural inequalities that constrain adaptive choices (Alam et al., 2015).

To allow for in-depth analysis, this research was conducted in focus on the two selected Unions of Shyamnagar *Upazila*—Munshiganj and Burigoalini—both of which exemplify communities where fishing households experience severe livelihood disruptions due to climatic disasters. These Unions were chosen in recognition that, here, adaptation is shaped by local socio-ecological contexts, and that even neighbouring communities can demonstrate different adaptive pathways and capacities. Studying adaptive mechanisms within these communities was thought to be helpful in formulating context-specific programs to reduce disaster impacts, thereby crediting local-level adaptation strategies.

1.3.2 Data Collection Methods

This research was part of an international partnership project, funded by the Social Sciences and Humanities Research Council (SSHRC) of Canada, titled “*Vulnerability to Viability (V2V): A Global Partnership to Build Strong Small-Scale Fisheries Communities*”. The present study was guided by the ‘pragmatic worldview’, which enabled a critical understanding of the study's objectives and facilitated a comprehensive analysis (Creswell & Creswell, 2018).

Primary data were collected using multiple Participatory Rural Appraisal (PRA) data collection tools and methods, which emphasize the “bottom-up” technique, prioritizing the perspectives and priorities specified within the local context (Cornwall & Jewkes, 1995). Data collection was conducted from March 2024 to June 2024. The tools used in the study were: key informant interviews (KII), household surveys, and focus group discussions (FGD).

For Objective One, a total of 100 households were surveyed using a structured questionnaire (see Chapter 2 and Appendix C), along with 9 KIIs using a set of guiding questions (see Chapter 2 and Appendix D) and 6 FGDs in both the study Unions (see Chapter 2 and Appendix E).

For Objective Two, 12 KIIs, 6 FGDs, and participant observation were used as data collection tools (See Chapter 3 and Appendix D, E) as shown in Table 2.

Table 2. *Data Collection Methods*

Objectives	Data collection tools
To assess the livelihood vulnerability of small-scale fishing communities in the Sundarbans mangrove coastal region.	Household Survey (100) Key Informant Interviews (9) Focus Group Discussion (6)
To explore how agency is exercised in adaptation strategies and to identify the drivers of agency that contribute to building resilience and the barriers against it.	Key Informant Interviews (12) Focus Group Discussion (6) Participant Observation

This study received ethics approval from the Research Ethics Board at the University of Manitoba, Fort Garry campus (Protocol Number: HE2023-0314). Following the consent protocol, the household survey, key informant interviews, and focus group discussions were conducted in Bengali, the mother tongue in Bangladesh. The procedures used in this study adhere to the principles outlined in the Declaration of Helsinki. Information about the study's scope and objectives was provided prior to data collection. Written consent was obtained, respondents were informed of their right to withdraw at any time, and a debriefing session was conducted regarding the preliminary research results.

1.3.2.1 Household Surveys. Household heads were interviewed using a structured questionnaire (see Chapter 2 and Appendix C). Only fishing households were considered under the scope of this study. To generate household survey data, a baseline census was conducted among 497 households. The baseline census collected data on basic demographic information for all households in the selected study communities. The purpose of the baseline census was to ensure representativeness and to avoid bias in selecting the final sample households. Categorical variables, such as land ownership, family structure, household size, occupation, and dependency ratio were used to classify households into Strata groups, such as small fishers, marginal fishers, and large fishers. Finally, a stratified random sampling procedure was used to ensure the representativeness of the sample households in each community. A total of 100 households were selected for this study. Of these households, 44 households were selected from Munshiganj Union, and 56 households were selected from Burigoalini Union.

A structured questionnaire was developed to procure data from households. The head of households was selected for this survey questionnaire. The structured questionnaire was designed based on variables identified in the existing literature and the authors' observations (see Appendix C). The questionnaire included indicators derived from Hahn et al. (2009). An Open Data Kit (ODK) data collection toolkit was used to obtain primary field data. The toolkit was designed for real-time data production, enabling it to operate both offline and online.

1.3.2.2 Key Informant Interviews. To substantiate the data collected in the household surveys in Chapter 2, we conducted nine Key Informant Interviews (KIIs) with key stakeholders, using a set of guiding questions (see Chapters 2 and 3 and Appendix D). The key informants were representatives of local government organizations, non-governmental organizations (NGOs), community-based organizations (CBOs), microfinance institutions (MFIs), volunteers, and community leaders. The relevant stakeholders were selected based on their institutional roles and long-standing engagement with community resilience initiatives, as elaborated in Chapters 2 and 3.

For Chapter 3, a total of 12 in-depth, face-to-face KIIs were conducted with a range of relevant stakeholders, including six NGO representatives, a Project Implementation Officer (PIO), a *Union Parishad* member from each Union, Union Parishad Chairman(s) from each Union, and a community member demonstrating leadership in local collective efforts (see Appendix D). These interviews offered insights into underlying factors influencing local-level adaptation practices. The KIIs were conducted until data saturation, aiming for a comprehensive analysis of locally adopted adaptation measures, barriers to exercising agency,

and the driving forces behind it. Each interview was a discussion that ensured the full breadth of the participants' views, experiences, and understanding of the issues was covered.

1.3.2.3 Focus Group Discussions. I applied purposive sampling to select participants for data collection. For focus group discussions, we selected participants with firsthand experience of disaster impacts and involvement in fishing-related adaptation decisions to obtain rich, context-specific insights into agency and resilience, relevant to the research objectives.

A total of 6 FGDs were conducted for the study in both the Munshiganj and Burigoalini Unions (see Chapters 2, 3, and Appendix E). I employed purposive sampling to select participants who were directly engaged in fishing-related livelihoods or who relied on the Sundarbans for subsistence. Priority was given to individuals involved in small-scale fishing, fish processing, and related market activities, as well as those who regularly access forest resources for income or household needs. Each session involved six to eight participants and lasted 35–45 minutes.

For attaining the objectives of Chapter 2, we organized and conducted 6 Focus Group Discussion (FGD) sessions. The FGDs included individuals who were directly affected by past climate-related disasters. Four FGD sessions were organized with mixed groups (including both males and females) engaged in fisheries (two from each Union). Additionally, to capture gender-specific experiences and intersectional vulnerabilities, an FGD session was organized with women only in each study Union. Each FGD session comprised six to eight participants and lasted 80–90 minutes.

Similarly, to achieve the objectives of Chapter 3, we conducted the six FGDs described above: two with male fishers from each union, two with female fishers/household heads, and two mixed-gender FGDs, thereby capturing diverse experiences and perspectives. Discussions focused on how adaptation strategies were enacted at both household and community levels, particularly in response to recurrent cyclonic events, and what factors (social, political, institutional) help or constrain exercising their capacities through these strategies. We were aware of factors that could affect the results, such as participants' age, gender, and the location of the discussion. We limited homogeneous group discussions to women-centric issues, as women in rural areas do not feel comfortable discussing such issues in front of male community members. We kept participants within a similar age range (35–55); however, some retired or older members participated in the discussion and could provide valuable insights from their experience. Each FGD session comprised six to eight participants and lasted 80–90 minutes.

1.3.2.4 Participant Observation. Participant observation was employed to complement the data collected through interviews and focus group discussions (see chapter 3), enabling a deeper understanding of informal practices, local knowledge, and community dynamics that shape adaptive responses. As an ideal observation technique (Patton, 2015), it helped me gain critical insights into human interactions and the study's appropriate contexts. Informal interactions were observed in public spaces such as tea stalls, local shops, and social hubs where daily livelihood concerns are commonly discussed in rural Bangladesh. These interactions not only offered rich contextual insights but also facilitated trust-building and community acceptance of the researcher's presence. In addition, informal conversations with key stakeholders helped elicit the underlying values and philosophical orientations that inform their actions in disaster risk reduction. Field notes from these observations served to triangulate and enrich the primary data, offering additional depth and nuance to participants' reported experiences.

All interviews and discussions were audio-recorded with consent and transcribed manually. Transcripts were analyzed using thematic content analysis, involving a data reduction process to identify key themes aligned with the study's objectives. Particular attention was paid to how agency was expressed and shaped within the broader socio-ecological and institutional context of the communities.

1.4 Data Analysis

To address Objective 1, an index-based vulnerability assessment was conducted to develop a Modified Livelihood Vulnerability Index (MLVI) to enable in-depth analysis of intersectional socio-economic and gender vulnerabilities. The index was developed by drawing on the Livelihood Vulnerability Index (LVI) framework of Hahn et al. (2009), which is grounded in the Sustainable Livelihoods Framework (SLF). This approach enabled an examination of the overall vulnerability of small-scale fishing households in the study area, with particular attention to differences across socio-economic classes and gender. A spatial comparative analysis was also performed to illustrate variation in vulnerability scores between two unions within Shyamnagar *Upazila*. To generate or categorize households by income thresholds, 26 variables pertaining to occupation, annual income, housing structure, social relations, and access to institutions were selected (see Appendix G for the variables used in Principal Component Analysis (PCA)). Principal Component Analysis (PCA) was used to classify households into low-, medium-, and high-socio-economic status (SES) groups. In determining overall and comparative scores, two phases of analysis were conducted: (i) a calculation of a

balanced weighted average method, and (ii) the application of the IPCC framework (Hahn et al., 2009; IPCC, 2007). Statistical T-tests and F-tests were conducted to examine the association between socio-economic variables and vulnerability components, including exposure, sensitivity, and adaptive capacity.

For Objective 2, qualitative data were analyzed using a Data Reduction Approach (Miles & Huberman, 1994). Transcripts were systematically reviewed to identify key themes, sub-themes, and patterns relevant to the research objectives. Particular attention was given to recurring ideas and the contextual factors shaping adaptation practices and expressions of agency (DeWalt & DeWalt, 2011). A paper-based system was used to trace and organize the main findings from each transcript. Once themes were identified, the data were synthesized into analytical narratives that illustrated how individual and collective agency shaped adaptation strategies. These findings were interpreted in light of the existing literature to deepen understanding of how coastal fishing communities negotiate vulnerability and pursue viable livelihoods.

1.5 Organization of Thesis

The thesis is organized into four chapters. Chapter 1 is the introduction, which starts with a brief background, outlines objectives and methodological approaches, and then describes the organization of the thesis. In accordance with the study's two objectives, Chapters 2 and 3 were prepared as manuscripts for potential publication in academic journals. Chapter 2 (Manuscript 1) assesses the dynamics of livelihood vulnerability and adaptive capacity in response to multifaceted climate change impacts in coastal communities in Bangladesh. In Chapter 3 (Manuscript 2), the focus shifts to the role of human agency in adaptation, the drivers of agency, and its implications for building resilience at the local level, highlighting how agency-led local adaptive strategies contribute to resilience amid recurrent climatic hazards. Chapter 4 presents a discussion of my findings and concludes with remarks on the overall research.

1.6 Contribution of Authors

This thesis follows a grouped manuscript-based format and includes four chapters. I am the sole author of Chapters 1 and 4, which were completed under the direct supervision of Dr. C. Emdad Haque.

Chapters 2 and 3 were prepared as manuscripts for publication in peer-reviewed academic journals. Below are the descriptions of the co-authorship and their contributions:

Chapter 2: *Assessing the vulnerability and adaptive capacity of small-scale fishers to climate change in Bangladesh: A case study of the Sundarbans coastal communities.*

I conducted the fieldwork, performed data analysis, and wrote the manuscript as the lead author. Dr. C. Emdad Haque provided overall supervision and scholarly guidance throughout the study's development. Dr. Mokhlesur Rahman and M. Abul Kalam Azad further contributed to shaping the analytical framework. This manuscript has been prepared to be submitted to the *Journal of Environmental Management*.

Chapter 3: *Agency, collective action, and adaptation to climate-related disasters: Evidence from the Sundarbans coastal communities of Bangladesh.*

As the lead author, I carried out the fieldwork for data collection, analyzed the data, and prepared the manuscript under the direct supervision of Dr. C. Emdad Haque. Dr. Prateep Nayak contributed to critical theoretical aspects and provided editorial feedback. The manuscript has been submitted to the journal *Global Environmental Change*.

It is important to note that there is no conflict of interest to declare among any of the contributors. All co-authors are appropriately acknowledged for their respective contributions to the research and manuscript preparation. The findings and narratives reflect the authentic voices of participants and my direct engagement with the study context, ensuring the integrity and originality of the research process.

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Chapter 2

Assessing the Intersectional Vulnerability and Adaptive Capacity of Small-scale Fishers to Climate Change in Bangladesh: A Case Study of the Sundarbans Coastal Communities

Abstract

While climate vulnerability assessment has advanced our understanding of the differential nature of vulnerability, a comprehensive understanding of how the intersection of socio-economic status, gender, and climate-triggered events compounds these differentiated vulnerabilities and adaptive capacity to climate variability and shocks remains limited. To this end, we formulated a Modified Livelihood Vulnerability Index (MLVI) using an intersectional approach, building on Hahn's LVI and LVI-IPCC frameworks, to assess the intersectional dynamics of vulnerability and the adaptive capacities of fishing households in coastal communities in Bangladesh to climate-related disasters. Using a mixed-method research design, we selected two coastal communities in the District of Satkhira to collect empirical data from a survey of 100 households, nine key informants, and six focus group discussions. Our results reveal that low-socio-economic status (SES) households were the most vulnerable to environmental stressors among SES groups. The cascading intersections of limited assets, income inequality, social marginalization, and low recoverability were key drivers of their unsafe conditions. These intersectional factors (i.e., a confluence of gender norms, gender roles, lack of asset endowments, and institutional supports) generated additional gender differentiated vulnerability, revealing an enhanced vulnerability of female-headed households. However, the results revealed that impoverished groups (e.g., low-SES fishers and female-headed households) reduce their vulnerabilities, indicating local adaptive responses within external structures that enhance adaptive capacity to climate perturbations, such as cyclones. Introducing intersectional approaches in understanding place-based vulnerabilities and adaptive capacities within broader structures is recommended for policy formulations.

Keywords: Climate change, disasters, intersectionality, vulnerability, adaptive capacity, fishers

2.1 Introduction

Small-scale fisheries (SSFs) play a vital role in global food systems and the livelihoods of coastal and rural communities. This sector accounts for approximately 90% of total capture fisheries and is a major source of employment, engaging around 60.2 million people and supporting the livelihoods of over 500 million individuals globally (Food and Agriculture Organization of the United Nations [FAO], 2023). SSFs are highly labour-intensive, characterized by small vessels, nearshore fishing, modest catches, and limited capital investment (Perry et al., 2010). They are not only vital tools for food and income security but are also deeply embedded in cultural traditions, local knowledge systems, and socio-economic networks. This is because culturally rooted fishing practices offer significant opportunities to strengthen resilience to environmental uncertainty (FAO, 2015; Islam et al., 2021).

Despite practicing culturally led, locally knowledge-driven fishing practices, diverse socio-economic and institutional constraints, along with persistent climatic variability, force many SSF communities to live amid uncertainty. Such a precarious situation becomes worse when socio-economic barriers (e.g., limited resources) and social marginalization (e.g., less access to information and networks), are compounded with the impacts of climate-related disasters, such as cyclones, storm surges, and flooding (Islam et al., 2021; Perry et al., 2010). For example, small-scale fishers in developing countries, such as Bangladesh and Malaysia, are experiencing declining fish stocks and incomes, particularly due to increased social disparities (e.g., unequal access to resources) and climatic perturbations. The compounded effects of social disparity and climate change further exacerbate these coastal communities' susceptibility to future climate hazards (Islam et al., 2021).

Recent studies have shown that climate change-triggered perturbations, particularly cyclones and storm surges, adversely impact the livelihoods of diverse groups, including women, people with disabilities, low-income farming and fishing communities, and communities dependent on natural resources (Birkmann, 2007; Hossain et al., 2019; Hsiang et al., 2017). Among these groups, fisheries-based communities consistently face fragile living conditions, food insecurity, limited adaptive capacity, and malnutrition (Islam et al., 2022). In this respect, several studies have cited that fisheries-based communities' vulnerability and withstanding capacity to climatic variability are mediated by the level of differences in access to resources, decision-making power, political relations, and local institutional dynamics (Chambers & Conway, 1992; Wisner et al., 2004; Yin et al., 2019). It is therefore argued that an assessment is required to understand how the dynamic patterns of interaction mediate

vulnerability and capacity of small-scale fishing communities to environmental stresses. Additionally, an improved understanding of socio-spatial disparities is necessary to develop effective intervention plans and policies (Amegavi et al., 2021).

In Bangladesh, fishing communities are actively engaged in SSFs for their livelihoods, adopting various strategies to mitigate vulnerability to climatic storms and foster adaptive capacity (Deb & Haque, 2017; Folke, 2006; Nelson, 2007). In this country, this sector spans the Sundarbans mangrove forests and the lower Ganges Delta, supporting the livelihoods of 18.5 million people and contributing to nearly 90% of coastal-marine capture production (Islam et al., 2014; Rahman et al., 2018). Notably, 10–12% of SSFs are women (Hossain et al., 2019).

While vulnerability assessment has been a major area of research in climate change impact studies, it remains largely fragmented. The focus of these assessments has primarily been on the extent of vulnerability and distribution of fishing sectors along with industrial fisheries (Glantz, 1992; Hu et al., 2023), assessing the fish production and the supply chain, physical exposure of communities reliant on the fisheries sector, or livelihood-related stresses (Badjeck et al., 2010). Notably, studies on climate adaptation practices have generally overlooked the roles of human agency and local social capital in mitigating vulnerability to disaster events (Galappaththi et al., 2019; Sarker et al., 2019). Additionally, as Cutter et al. (2008) noted, limited efforts have been made thus far to examine the spatial disparities of vulnerability and the role of resource bases, such as social and human capital, in reducing vulnerability (Adger, 2006; Cutter et al., 2008; Islam et al., 2022).

It has been asserted that any vulnerability assessment of climatic hazards would remain incomplete without recognizing and integrating social dynamics, such as socio-economic characteristics, risk perceptions, political dimensions, social relations, and coping capacities (Cinner, 2018). Accordingly, we posit that place-based vulnerability analysis must extend beyond examining physical hazards and geographic conditions to incorporate social dynamics and community-specific characteristics that evolve through experiencing climate-induced disturbances and social interactions. A comparative analysis of the Global South and North by Galappaththi et al. (2021) indicates that small-scale fishing communities employ context-specific knowledge systems, diverse learning practices, cultural attributes, community-based norms and values, social networks, and human agency. The localized attributes ensure flexibility and foster adaptive mechanisms, enabling individuals to thrive amid climate

vulnerability and reshape social structures (Brown & Westaway, 2011; Cinner et al., 2018; Giddens, 1984). In this study, we posit that human capacities and socio-economic realities should be regarded as foundational elements in shaping how vulnerability is experienced in a local fishers' community. We assert that the variation in spatial and livelihood vulnerabilities is a product of households' engagement with diverse social resources, shaped by the knowledge and perceptions of climate risks (e.g., cyclones), socio-political and institutional relations, social networks, and human agency. Adopting a holistic perspective on vulnerability assessment that incorporates both spatiotemporal dimensions and socio-political processes is critically important.

The primary purpose of this study is to assess the intersectional vulnerability and adaptive capacity of small-scale fishers in coastal communities of Bangladesh to climate-triggered hazards. Drawing on the existing literature (Adger et al., 2006; Choudhury & Haque, 2016; Wisner et al., 2004), we consider intersectional vulnerability to climate change as a condition of unsafe exposure resulting from the intersection of gender roles, social identity, social relations, access to institutional support, and existing economic and political relations. The specific objectives of the study are twofold: (i) to examine the patterns and dynamics of livelihood vulnerability of small-scale fishing communities in the *Sundarban* coastal region of Bangladesh based on socio-economic position and gender; and ii) to evaluate the spatial disparities of place-based livelihood vulnerability between two coastal fishing communities in Bangladesh.

2.1.1 Vulnerability Assessment: Key Concepts and Conceptual Considerations

2.1.1.1 Key Terms and Concepts. The concept of vulnerability has long been applied in climate change research, initially from a hazard-oriented perspective emphasizing biophysical risks (Adger, 1996; Bohle et al., 1994). Over time, the vulnerability scholarship expanded to include social science perspectives, incorporating socio-economic, political, cultural, and institutional dimensions (Adger, 2006; Hewitt, 1997; O'Brien et al., 2007). For instance, Cutter (1996) emphasizes both biophysical and social factors—such as geographical location, economic conditions, demographic profiles, and infrastructural characteristics—interact to shape place-based vulnerability. Nonetheless, research on the intersections of socio-economic factors and climatic hazards, and their roles in shaping vulnerability, has largely been overlooked (Choudhury & Haque, 2016; Cutter et al., 2003). Under more integrative approaches that have evolved since the late 2000s, a consensus has emerged that vulnerability

reflects the outcome of interacting disparities rather than a single, uniform state (Cutter et al., 2003; Intergovernmental Panel on Climate Change [IPCC], 2007, 2014).

In this research, consistent with the conceptualization of vulnerability in the IPCC Assessment Report (2007), *vulnerability* is defined as “The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt” (IPCC, 2023). Taking into consideration a system’s (in particular, social system) sensitivity and capability to cope with the dire climatic disasters–induced consequences, we formulated a comprehensive conceptual framework that integrates three interlinked components of vulnerability: *exposure*, *sensitivity*, and *adaptive capacity* (Choudhury & Haque, 2016; Hahn et al., 2009) (See Figure 3). Here, *exposure* refers to the extent to which local communities are exposed to climatic hazards, such as cyclones, sea-level rise, or rainfall variability (Cardona et al., 2012). *Sensitivity* measures the degree to which systems (i.e., human society) are affected, particularly when livelihoods depend on climate-sensitive resources or sectors, such as fisheries, health, and food security (Ngu et al., 2023; Nunn & Kumar, 2017). As illustrated in Figure 3, while both exposure and sensitivity increase overall vulnerability, adaptive capacity, by contrast, reflects the ability of communities (and systems) to respond, recover, and adjust, thereby reducing overall vulnerability.

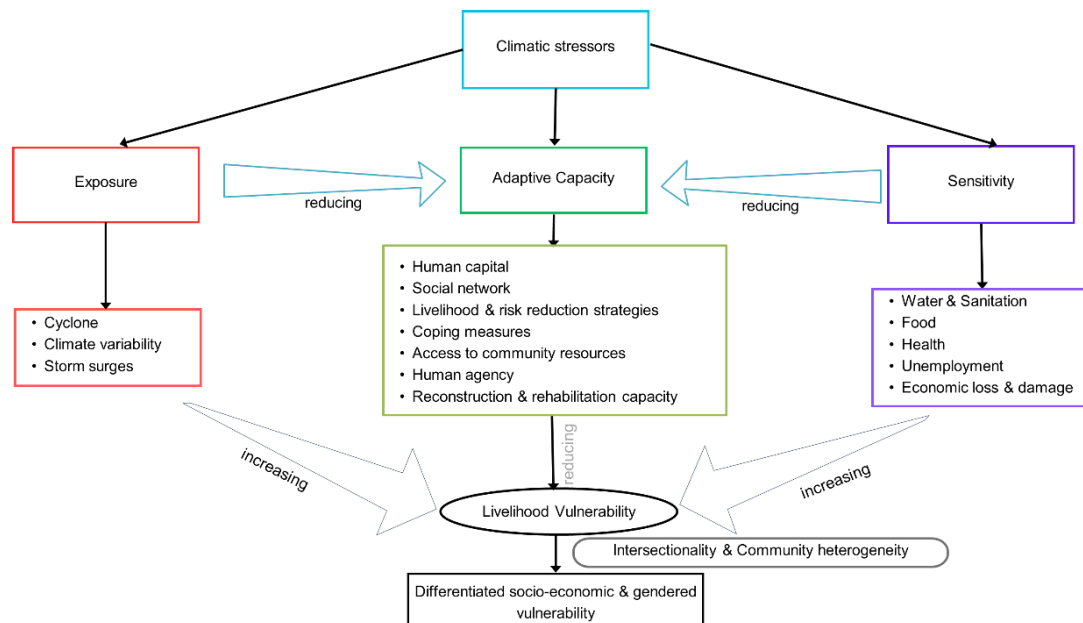


Figure 3. *Conceptual Framework of Climatic Vulnerability, Associated Components, and the Outcomes*

The combination of various factors produces adaptive capacity. As Klein et al. (2003) highlighted, in the face of climatic disasters, access to financial, institutional, technological, and social resources is a major determinant of adaptive capacity. Additionally, it has been noted that demographic factors (e.g., age, sex, ethnicity, and race) and livelihood factors (e.g., occupations) intersecting with socio-economic and political factors shape the adaptive capacity of a unit or system (Choudhury & Haque, 2016; IPCC, 2007).

Contrary to conventional thought, recent studies have shown that social disparities and uneven⁵ exposure can catalyze local innovation, as was evident during the 2010 floods in Ladakh (India), where community institutions and knowledge enabled prompt responses (Le Masson, 2015). Therefore, it is asserted that vulnerability assessment must situate exposure, sensitivity, and adaptive capacity within broader social, political, and institutional contexts (e.g., local and regional government rules and regulations). Human ingenuity and agency in overcoming environmental and socio-economic constraints should be considered in such efforts.

In understanding adaptive capacity for addressing climate-related stresses and shocks, scholarly work draws on the concept of human agency within social-ecological systems. Human agency, as a central dimension of adaptive capacity, is understood as the socially embedded capacity of individuals, households or communities to exercise their independent choices and proactive abilities (e.g., use skills, knowledge, aspirations, motivation, decision-making ability) to act, shaped by institutional arrangements, power relations, social norms, and governance structures—with the goal to have control over resources to perform meaningful functions toward sustainable livelihood outcomes (i.e., securing well-being and reducing risk) (Choudhury & Haque, 2016; Giddens, 1984; Sen, 1994). In the context of Bangladesh's coastal communities, we argue that human agency can turn communities from passive victims into active agents of change, as reflected in local knowledge, innovation, and collective action. For example, coastal communities in Bangladesh use local knowledge (e.g., predicting storms based on wind intensity, duration, and direction) and often triangulate it with institutional early warning systems to strengthen disaster preparedness measures (Choudhury et al., 2021). This stresses the importance of integrating agency elements within adaptive capacity, for a holistic understanding of vulnerability.

⁵ *Uneven vulnerability* is understood as the differing levels of risks faced by impacted population, to disasters

Climate-related disasters also produce and reinforce intersectional vulnerability. *Intersectionality* in the context of climate change explains how vulnerability is produced by the existing systems of inequalities and privileges based on factors such as gender, age, race, ethnicity, and socio-economic class (Collins, 1990; Kaijser & Kronsell, 2014; Ravera et al., 2016; Thomas et al., 2021). Although intersectionality thinking has historically grown as a critique of feminist theory and anti-racist politics by exposing intersectional oppression of Black women (Crenshaw 1989), it has been largely circumscribed to social vulnerability, including environmental change literature. Theoretical advancement of intersectionality is further found in relation to climate justice, often bringing a spatiality lens in the debate of Global North and Global South (Sultana, 2021). Further, the concept has been increasingly deployed at lower scales and across scales, such as spatial (e.g, communities and countries) and temporal (historical and intergenerational) (Fisher 2015; Forsyth, 2014; Robinson & Shine, 2018).

The commonality between intersectionality and climate justice is the aim of advancing equity in climate governance and redressing climate-related harms. Therefore, this approach emphasizes an empirically grounded spatial investigation of differentiated vulnerabilities, incorporating feminist insights to reveal barriers and opportunities in the climate justice pathway. For example, a recent study in the Indian Himalayas found that caste and gender intersect with income and education to influence households' access to institutional supports. Female-headed and lower-caste households are required to rely heavily on ecosystem-based strategies compared to other higher social groups, as they lack access to formal and technological supports, which, in turn, reinforces their intersectional vulnerability (Choudhury et al., 2025). Without accounting for intersectionality, an analysis is likely to overlook critical differences in the capabilities of different groups and in how they generate opportunities and constraints for building resilience (Adger, 2006; Le Masson, 2015). Thus, incorporating intersectionality-based analysis through a climate justice lens, this study examines the socio-economic and gendered intersectional vulnerabilities within fishing households and communities, which overlap and compound within broader social, political, and institutional contexts, with the aim of recognizing these harms and promoting critical reflexivity in planning interventions.

2.1.2 Differentiated Modified Livelihood Vulnerability Index (MLVI)

Vulnerability assessment provides a systematic means of capturing its multidimensional nature. Approaches vary across physical and built-environment vulnerability (Mileti & Henry, 1999),

social vulnerability (Cutter et al., 2003; Davis et al., 2004; Singh et al., 2019), and economic vulnerability (Deepak et al., 2020). The importance of embedded socio-economic, spatial, and institutional contexts in vulnerability assessments is increasingly being recognized (Hahn et al., 2009). Embedding context is crucial because vulnerability is spatially dependent and dynamic, and it emerges from interactions among these dimensions.

Notably, the usage of vulnerability assessments focuses on the intended goals of this approach (Gentle et al., 2014; Hahn et al., 2009). In a disaster vulnerability context, for example, Sarker et al. (2022) applied a context-specific composite flood vulnerability index (FVI) for evaluating the vulnerability of riverine communities in northern Bangladesh. Focusing on the individual context, Pandey et al. (2018) assessed household-level vulnerability, drawing on its major components. Similarly, applying a Gender-based Livelihood Index (GLVI) in northern Bangladesh, Jerin et al. (2023) explained how multiple factors produce livelihood vulnerability. Nonetheless, intersectional and socio-economic class-based vulnerability analyses have been largely ignored or understudied.

In efforts to evaluate livelihood risks resulting from climate change impacts, index-based assessments have emerged as a popular tool that integrates multiple indicators, such as health, water, and education, which often serve as proxies for multidimensional issues of vulnerability (Hahn et al., 2009). As Eakin & Bojórquez-Tapia (2008) emphasized, accurate measurement requires weighing each of these indicators to reflect their relative contributions. The usage of vulnerability assessments also varies by scale (i.e., local to regional or national). Studies that focus on the spatial unit (e.g., administrative district or community level) apply vulnerability assessment methods particularly to capture livelihood vulnerability with a focus on living conditions, resources, and strategies for sustaining livelihood in the face of climate risks and crisis (Chambers & Conway, 1992; Hahn et al., 2009). For example, Hahn et al. (2009) used the Livelihood Vulnerability Index (LVI) approach to demonstrate how differences in food shortage experiences and management practices in Mozambique contributed to reducing vulnerability among *Moma* households compared to *Mabote* households, despite both regions facing similar levels of food insecurity. This highlights how variations in skills, local management practices, and living conditions can lead to differentiated vulnerability outcomes.

The significance of assessing livelihood vulnerability has received wider policy attention since the early 1990s. In their seminal work, Chambers and Conway (1992) introduced the Sustainable Livelihood Approach (SLA) as a conceptual framework for assessing how precarious and marginal groups enhance their resilience to climate shocks by leveraging various

household assets (i.e., social, human, natural, economic, and physical) (Department for International Development [DFID], 1999). In the present study, we conceptualize *livelihood* as not only a means by which fishers meet their basic needs (i.e., food) but also an embodiment of such actions by which they mediate vulnerability and enhance their capabilities to cope with, recover from, and adapt to uncertain climatic stress (Shah et al., 2013). Fishing livelihoods are viewed collectively within the context of fishing communities. As Allison and Ellis (2001) argue, vulnerability and adaptive responses are not solely household-based but emerge from a broader social and institutional context. Concurring with this notion, we contend that the livelihoods of SSF communities encompass not only subsistence but also their capacity to recover and adapt to climate and socio-economic risks (Shah et al., 2013).

To assess the livelihood vulnerability of SSF communities to disasters, this study draws on the DFID Sustainable Livelihoods Framework to understand livelihood vulnerability as shaped by differential access to and mobilization of livelihood resources under climatic shocks (DFID, 1999). Drawing upon Hahn et al.'s (2009) approach to vulnerability assessment, we have formulated a Modified Livelihood Vulnerability Index (MLVI). While Hahn et al.'s (2009) approach to vulnerability assessment using household-level data addresses vulnerability and facilitates strategic planning for climate risk reduction, it overlooks crucial aspects of intersectional dimensions (e.g., gender and socio-economic class). Similarly, the regional comparative studies (e.g., Brown & Westaway, 2011; Mandal et al., 2025; Pandey et al., 2018) which have applied LVI, also emphasized the estimation of spatial disparities and gendered vulnerability (Jerin et al., 2023), but they largely failed to explain how differences in gender and socio-economic class interact to shape the overall vulnerability landscape.

Recognizing the above-stated gaps and further drawing on the IPCC Vulnerability Index Approach, we have formulated i) a Modified Livelihood Vulnerability Index (MLVI) that addresses the intersectionality of the studied communities, focusing on socio-economic status and gender; and (ii) the MLVI-IPCC framework that aims to integrate values of all components for determining the extent of vulnerability of coastal fishing communities in Bangladesh. Our modified index (MLVI) further incorporates the vital aspects associated with human agency, socio-economic factors, and institutional and political relations—all of which are key to determining exposure, sensitivity, and adaptive capacity.

2.2 Methods and Materials

2.2.1 Study Area

Given their extreme socio-economic and physical vulnerability, the empirical investigation in this study was conducted among local small-scale fishers in the District of Satkhira, located in the southwestern region of Bangladesh (between 21.55° N and 89.11° E). Shyamnagar *Upazila* was purposively selected for the present study, with a focus on the two Unions, namely Munshiganj and Burigoalini, for our empirical investigations. Detailed descriptions of the study area, including its socio-ecological and climatic context and relevance to the research objectives, are provided in Chapter 1 and Appendix H to avoid duplication.

2.2.2 Sample Size and Data Collection

Our study employed a mixed-methods research design, combining quantitative and qualitative methods. Primary data were procured between March and June 2024 using Participatory Rural Appraisal (PRA) tools, including household surveys, focus group discussions (FGDs), and key informant interviews (KIIs). An explanatory sequential design guided the analysis (Creswell & Plano Clark, 2018), whereby quantitative results from household surveys were contextualized and supported by qualitative insights. This approach enabled the systematic generation of numerical data while drawing on the lived experiences of small-scale fishing communities to inform the interpretation of findings and identify recurring themes (Ivankova et al., 2006).

A baseline census was conducted with 497 households to create a comprehensive sampling frame and to facilitate sampling for the household survey. The collected household data were categorized into strata based on land ownership, family structure, household size, and occupation. A stratified random sampling procedure was used to ensure that each stratum was represented in the sample. Applying the probability proportional sampling (PPS) procedure, a total of 44 household units from Munshiganj Union and 56 household units from Burigoalini Union were randomly selected, resulting in a total of 100 household units for the study. Primary household-level data were procured using both structured and semi-structured questionnaires. Household heads were chosen to represent their respective units. The questionnaire was developed based on variables identified in the existing literature, the authors' observations, and the indicators used in Hahn et al. (2009) (see Appendix C).

To substantiate the data collected in the household survey, we conducted nine Key Informant Interviews (KIIs) and six Focus Group Discussion sessions (FGDs). Key informant interviews were conducted with representatives of local government, NGOs, and community

leaders, selected for their professional and leadership affiliations with disaster management organizations and their involvement in community livelihood security and resilience-building initiatives. The FGDs included individuals who had been directly affected by past climate-related disasters. Four FGD sessions were organized with mixed groups (including both males and females) engaged in fisheries (two from each Union). Additionally, to capture gender-specific experiences and intersectional vulnerabilities, an FGD session was organized with women only in each study Union. Each FGD session comprised six to eight participants and lasted 80–90 minutes.

2.2.3 Formulation of the Modified Livelihood Vulnerability Index (MLVI)

A Modified Livelihood Vulnerability Index (MLVI) was developed to support an in-depth analysis of intersectional socio-economic and gender vulnerabilities. For this purpose, we categorized households into income groups based on 26 variables pertaining to occupation, annual income, housing structure, social relations, and access to institutions (see Appendix G) for use in Principal Component Analysis (PCA). We performed a principal component analysis, and factors 1–10 had eigenvalues greater than or equal to 1, accounting for 98% of the total variance. Using the total aggregate score of all loaded factors, small-scale fishing households were categorized into three socio-economic classes: Low SES (i.e., socio-economic status), Medium SES, and High SES.

To conduct an in-depth vulnerability analysis, a comparative study was conducted between the fishing communities of the Burigoalini Union and the Munshiganj Union. Incorporating socio-economic and gender perspectives, a Modified Livelihood Vulnerability Index (MLVI) was formulated using two key approaches: (i) a balanced weighted average method, and (ii) the IPCC framework (Hahn et al., 2009; IPCC, 2007; Schneider et al., 2007). Statistical tests, including T-tests and F-tests, were used to examine associations between socio-economic variables and vulnerability components—exposure, sensitivity, and adaptive capacity.

For MLVI, a composite indicator method was employed by applying a balanced weighted average approach, where three major contributing factors (e.g., exposure, sensitivity, and adaptive capacity) were ultimately combined to generate the MLVI-IPCC index (Hahn, 2009). The balanced weighted approach ensured that each component contributed equally to the overall vulnerability index (Sullivan, 2002). These contributing factors were grouped into 16 major components and further subdivided into 81 subcomponents, collectively constituting the index.

Exposure comprised climate-variability variables, such as rainfall, temperature extremes, frequency and intensity of cyclones, and salinity intrusion. Sensitivity included components reflecting dependence on natural resources and infrastructure, such as unemployment, access to water and sanitation, institutional relations, and the degree of loss and damage. Adaptive capacity captured elements such as access to disaster-related information, recovery and coping mechanisms, social networks, human agency, and reconstruction efforts. After categorization of the indicators, the following equation was used to standardize each component using the normalization technique:

$$Index_S = \frac{S - S_{min}}{S_{max} - S_{min}} \dots\dots\dots (1)$$

Here, Index_S indicates the value of a subcomponent after standardization. S implies the original sub-component value; S_{min} and S_{max} express the minimum and the maximum value for each sub-component, respectively. After standardization, the value of each major component (M) was calculated as shown in equation (2) below:

$$M_B = \frac{\sum index_{S_B i}}{n} \dots\dots\dots (2)$$

Where M_B is one of the major components for region B, and index B_i represents the sub-components indexed by i, which make up each major component, and n is the total number of sub-components in each major component. These numerical values (between 0 and 1) for major components represented household status with respect to these components and, therefore, indicated the community's relative vulnerability, as derived from aggregated household responses. After calculating the values of each major component, the values were averaged using equation (3) to obtain the MLVI contributing factors.

$$CF_B = \frac{\sum_{i=1}^n W_{Mi} M_{Bi}}{\sum_{i=1}^n W_{Mi}} \dots\dots\dots (3)$$

Here, CFB is a major component of region B, indexed by i; W_{Mi} denotes the weight of each subcomponent; M_{Bi} denotes the major components for each household and community; and n

denotes the number of major components in each contributing factor. Finally, the overall MLVI index was calculated using equation (5), as derived by Hahn et al. (2009). The MLVI value ranged from 0 (low vulnerability) to 1 (extreme vulnerability).

$$MLVI_B = \frac{\sum_{k=1}^{16} W_{Mi} M_{Bi}}{\sum_{k=1}^{16} W_{Mi}} \dots \dots \dots (4)$$

2.2.4. Estimating the MLVI-IPCC: Vulnerability Framework

To develop the MLVI-IPCC based on SES groupings and gender (male-headed households and female-headed households), equations (1) to (3) were used for the calculation of exposure, sensitivity, and adaptive capacity using the weighted average method. To calculate the MLVI-IPCC after estimating the value of three contributing factors, they were combined by employing the following equation (5) to obtain the overall result of the MLVI-IPCC:

$$MLVI - IPCC_B = (e_B - a_B) * s_B \dots \dots \dots (5)$$

Here, MLVI-IPCC_B denotes the MLVI for each socio-economic group, gender, and region (i.e., Union); e_B denotes exposure, a_B denotes adaptive capacity, and s_B denotes the sensitivity score calculated for each socio-economic group, gender, and Union. For the MLVI-IPCC_B, the value was estimated on a scale from -1 (least vulnerable) to +1 (extremely vulnerable).

Qualitative data were synthesized to identify and present themes that emerged from the responses. Transcripts were coded to identify key themes, which were then grouped into categories reflecting perceptions of vulnerability and socio-economic disparities. The findings were triangulated with the survey results to substantiate the contextual understanding and interpret certain factors of vulnerability.

2.3.4 Ethics Statement

The research and data collection protocol was approved by the Joint-Faculty Research Ethics Board (JFREB) of the University of Manitoba, Canada [Protocol number: HE2023-0314]. Field data were collected with the written consent of all participants, in accordance with the University of Manitoba, Canada's ethics protocol. The procedures used in this study adhere to

the principles outlined in the Declaration of Helsinki. Information on the study's scope and objectives was provided prior to data collection. Written consent was obtained, respondents were informed of their right to withdraw at any time, and a debriefing session was conducted with them regarding the preliminary research results.

2.4 Results and Analysis

2.4.1 Vulnerability Dynamics and Modified Livelihood Vulnerability Index (MLVI): Gender and Socio-economic Perspectives

The demographic and socio-economic characteristics of the sampled households underpin the vulnerability analysis. Of the sampled 100 households, 90% were male-headed, and only 10% were female-headed households. In terms of occupational distribution, the majority of the sampled households (73%) derived their livelihood solely from fishing, followed by a combination of fishing, cultivation, and business (20%), farming (4%), and daily wage labour (3%). An overwhelming majority of household heads (82%) had a primary education background (up to grade 5), whereas 10% had no formal education. Only 8% of household heads attained secondary or higher secondary education (grades 6–12). According to socio-economic status (SES), the sampled households consisted of 34% “low” socio-economic status (SES), 34% “medium” socio-economic status (SES), and 33% “high” socio-economic status (SES) households (See Supplementary Table 1 in Appendix F).

Data on the dynamics of vulnerability across gender and socio-economic groups in the studied communities are presented in Table 3, which highlights their multifaceted nature and variation by gender and social position. The results reveal that the overall MLVI score for genders combined was 0.467; for female-headed households, 0.537; and for male-headed households, 0.460. A t-test also showed a significant difference between the gender vulnerability of female-headed and male-headed households ($t=-2.91$ (98), $p\text{-value}=0.002$). This finding indicates that female-headed households are more vulnerable to climatic uncertainty than their counterparts.

A significant difference in gender-based intersectional vulnerability was observed (Table 3). Although all households experienced climatic stress (such as cyclones, salinity erosion, and coastal erosion) over the past five years, the exposure index to climatic stress was found to be higher for females than males (0.845 vs 0.755). Results showed that female-headed households were more vulnerable than male-headed households with respect to exposure to cyclones, unemployment, health, food, water, and sanitation. The scores of these vulnerability

indices ranged from 0.845 to 0.648, whereas those for male-headed families ranged from 0.755 to 0.555 (see Table 3).

These results indicate the extreme sensitivity of women to climatic variability. For example, the health index (0.603 vs. 0.364) and the water and sanitation index (0.648 vs. 0.555) were significantly higher for women than for others. In this context, our empirical data showed that 80% of women had health complications, compared to only 14% of men. The findings from KIIs and FGDs also revealed that female-headed households faced greater difficulties relating to pregnancy, reproductive health problems, and other health-related diseases—particularly due to the lack of safe water and sanitation and their continuous contact with saline water. In addressing reproductive health problems, one of the FGD participants from Burigoalini explained:

“Pregnant mothers undergo severe challenges to give birth to babies. Though we immediately call our community midwives, sometimes, a pregnant mother dies on the way due to extremely bumpy roads and a lack of medical support. Further, their pregnancy-related problems increase due to the use of saline water; in particular, some women suffer from ovarian cancer from using acute saline water.”

Socio-political and institutional dimensions of vulnerability were regarded as a key source for increasing intersectional vulnerability between male-headed and female-headed households. The calculated socio-political and institutional index indicated that female-headed households had less access to socio-political and institutional relations than their counterparts (0.752 vs 0.642). The statistical test confirms that vulnerability between women and men differs significantly in terms of political relations and institutional supports ($t=-2.03(98)$, $p\text{-value}=0.022$). However, female-headed fishing households demonstrated greater social network capability (0.530 vs 0.411). Notably, over 70% of female-headed households had the capability to borrow food and money from neighbours and local traders during and after the disaster periods, whereas male-headed households exhibited higher access to institutional support (0.628 vs 0.400) (see Table 3).

Our gender-based intersectional vulnerability analysis also found that women show high adaptive capacity scores despite experiencing heightened vulnerabilities. Female-headed households—in terms of recovery and coping measures, the adoption of sustainable livelihood and risk-reduction strategies, and the human agency index—demonstrated greater adaptive capacity to cyclones than their counterparts. For example, women were observed to assume a

more proactive leadership role in recovery and coping measures than men (0.574 vs 0.348). Seventy-seven percent of female-headed households stored dry food and prepared for evacuation. Eighty percent of respondents reported that women were the primary initiators of risk-reduction and adaptive measures (e.g., storing water in containers, seeking financial assistance) in their households.

We also examined differential vulnerability across socio-economic classes in the sampled households, and the findings revealed that low- and middle-income households experienced greater vulnerability than those in higher socio-economic classes. Specifically, low-SES households witnessed the greatest vulnerability (0.560), followed by medium-SES households (0.421) and high-SES households (0.417). The variation in vulnerability across socio-economic classes was statistically significant ($F(99) = 101.93$, $P < 0.001$).

Our index-wise analysis of socio-economic vulnerability showed that the values of the major components ranged from 0.140 to 0.862, indicating variation in relative levels of household socio-economic position. For instance, the socio-economic vulnerability indices for exposure to cyclones, unemployment, health, food, and water and sanitation in the study area revealed that low- and medium-SES households were more vulnerable than high-SES households. Although exposure was similar across most SES households, economic loss and damage were higher for low-SES households (0.708 vs. 0.208 for high-SES households).

Table 3. *Distribution of Modified Livelihood Vulnerability Index (MLVI) by Gender and Socio-economic Class*

Index of major components	Overall	Gender Dimensions				Socio-economic class				
		Male-headed households	Female-headed households	<i>t(df)</i>	<i>p-value</i>	Low SES	Medium SES	High SES	<i>F(df)</i>	<i>p-value</i>
Exposure to cyclone	0.764	0.755	0.845	-2.32(98)	0.011	0.862	0.755	0.671	38.66(99)	0.000*
Unemployment	0.486	0.462	0.709	-3.57(98)	0.001*	0.624	0.479	0.353	16.67(99)	0.000*
Health	0.388	0.364	0.603	-2.72(98)	0.003)	0.643	0.333	0.180	51.39(99)	0.000*
Food	0.603	0.596	0.667	-1.84(98)	0.035*	0.688	0.585	0.533	21.64(99)	0.000*
Water and sanitation	0.565	0.555	0.648	-2.30(98)	0.011*	0.668	0.557	0.466	39.49(99)	0.000*
Effects on socio-political and institutional relations	0.653	0.642	0.752	-2.03(98)	0.022*	0.730	0.681	0.547	13.97(99)	0.000*
Economic loss and damage	0.456	0.436	0.635	-2.47(98)	0.007*	0.708	0.444	0.208	108.30(98)	0.000*
Access to disaster-related information	0.540	0.551	0.440	2.04(908)	0.022*	0.465	0.510	0.647	13.76(99)	0.000*
Access to community-resources	0.426	0.425	0.432	0.128(98)	0.550	0.462	0.367	0.444	3.25(99)	0.043*
Human capital	0.569	0.579	0.477	1.74(98)	0.042*	0.636	0.515	0.554	4.30(99)	0.016*
Social network	0.424	0.411	0.530	-1.67(98)	0.049*	0.402	0.386	0.484	2.01(99)	0.139
Recovery and coping measures	0.371	0.348	0.574	-3.29(98)	0.001*	0.584	0.267	0.256	49.73(99)	0.000*
Access to institutional supports	0.605	0.628	0.400	1.66(98)	0.050*	0.471	0.621	0.727	3.38(99)	0.038*
Sustainable livelihood and risk reduction strategy	0.271	0.253	0.438	-2.49(98)	0.001*	0.512	0.152	0.140	68.81(99)	0.000*
Reconstruction and rehabilitation capacity	0.500	0.509	0.420	1.79(98)	0.038*	0.382	0.482	0.639	48.74(99)	0.000*
Human agency	0.244	0.231	0.353	-1.71(98)	0.046*	0.415	0.167	0.143	24.39(99)	0.000*
Modified Livelihood Vulnerability Index (MLVI)	0.467	0.460	0.537	-2.91(98)	0.002*	0.560	0.421	0.417	101.93(99)	0.000*

* Significance at 5% level.

The field data consistently showed that high-SES households exhibited higher index values for several variables, including access to information, social networks, institutional support services, and participation in reconstruction and rehabilitation activities. In contrast, low- and medium-SES households demonstrated greater strengths in undertaking recovery and coping measures, diversifying their livelihoods, and leveraging their human capital. In these indices, the variation among the SES groups was also statistically significant (see Table 3).

Overall, the above findings suggest that differences in vulnerability indices primarily stem from the utilization of existing resources. High-SES households tended to rely on their preexisting assets and entitlements, whereas low- and medium-SES groups often innovated by developing new skills, ideas, and strategies to confront climate-related challenges.

The KIIs and FGD session outcomes also substantiated that socio-economically poor families were more proactive in adopting innovative actions, such as entrepreneurship and collective action, to mitigate the adverse effects of cyclones and related storm surges. Low socio-economic groups are heavily dependent on natural resources for their survival. The absence of formal safety nets and stable income sources compels them to continuously diversify their livelihoods and adopt locally grounded coping measures. Based on the indicator scores, repeated exposure to losses has strengthened their capacity for proactive risk reduction and for leveraging existing resources through experiential learning, whereas higher-income households rely more on financial reserves than on innovation-driven adaptation. In this respect, one NGO official from the Burigoalini Union stated:

“People proactively participate in disseminating early warnings among people. When water drains or at low tide, both voluntary groups and villagers attempt to repair the embankments. College-going students in the locality also form groups to help us in evacuation processes during emergencies”.

2.4.2 A Gender and Socio-economic Status-based Comparison of the MLVI-IPCC: The IPCC Framework

The distribution of MLVI-IPCC indices by gender dimensions and socio-economic class is presented in Table 4. The results suggest that female-headed households were more vulnerable than male-headed households with respect to exposure (0.845 vs. 0.755), sensitivity (0.666 vs. 0.504), and adaptive capacity (0.445 vs. 0.403). The scores for exposure, sensitivity, and adaptive

capacity differed significantly between male-headed and female-headed households ($p < 0.05$). However, there was no statistically significant difference in the MLVI-IPCC scores between the two groups (see Table 4).

Table 4. *Distribution of MLVI-IPCC Indices by Gender and Socio-economic Class*

Index	Gender dimensions				Socio-economic class				
	Male households	Female households	<i>t(df)</i>	<i>p-value</i>	Low SES	Medium SES	High SES	<i>F(df)</i>	<i>p-value</i>
Exposure	0.755	0.845	-2.32(98)	0.011*	0.862	0.755	0.671	38.66(99)	0.000*
Sensitivity	0.504	0.666	-3.75(98)	0.001*	0.671	0.504	0.381	151.39(99)	0.000*
Adaptive capacity	0.403	0.445	-1.66(98)	0.050*	0.477	0.345	0.397	49.40(99)	0.000*
MLVI-IPCC	0.101	0.080	1.64(98)	0.947	0.091	0.087	0.115	5.30(99)	0.006*

* Significance at 5% level.

We also estimated MLVI-IPCC by socio-economic group and found that it differed significantly across the three socio-economic classes. Households with low socio-economic status (SES) (MLVI=0.091) were the most vulnerable class, followed by those with medium SES (MLVI=0.087) and high SES (MLVI=0.115). This implies that, by comparing overall MLVI scores with MLVI-IPCC scores, low-SES households are deemed the most vulnerable in both cases. Our qualitative results further confirm that the intersection of various socio-economic and institutional factors has a considerable influence on the vulnerability of low-SES households. In this regard, one FGD participant explained:

“We live under constant hardship in this locality. Although we occasionally obtain credit from both government and non-governmental organizations, repaying these loans throughout the year at high interest rates places an additional burden on our already strained household finances. This financial pressure, combined with everyday family responsibilities, often prevents us from supporting our children’s education.”

2.4.3 Distribution of Livelihood Vulnerability to Cyclones in Coastal Bangladesh

The comparative aggregated values of vulnerability indices are presented in Table 5. The results indicate that both study communities (i.e., Munshiganj and Burigoalini) were equally vulnerable to many cases, although the overall vulnerability of Munshiganj Union was higher than that of Burigoalini Union (0.488 vs 0.451). The comparative analysis between indices reveals that Munshiganj Union was more vulnerable than Burigoalini Union in terms of health (0.48, p-value = 0.001), water and sanitation (0.621, p-value = 0.001), recovery and coping measures (0.447, p-value = 0.001), and sustainable livelihood and risk reduction strategies (0.352, p-value = 0.001). However, Burigoalini Union had higher scores in access to institutional support (0.732, p-value = 0.001) and reconstruction and rehabilitation capacity (0.534, p-value = 0.005).

We found that health, along with water and sanitation, emerged as a critical determinant of overall vulnerability in both regions. The health indices for the Munshiganj and Burigoalini Unions were 0.48 and 0.316, respectively. Likewise, the index values for water and sanitation were estimated to be 0.621 and 0.52, respectively. The KII and FGD results revealed that most households in Munshiganj Union faced dire waterborne diseases and heightened health risks associated with cyclones. The scarcity of safe drinking water compelled families to invest significant amounts of time and financial resources to secure clean water for daily use.

Public service-related activities in Munshiganj Union are hindered by poor accessibility, with *kacha* (unpaved) roads impeding access. This deters NGOs from providing support, reflecting institutional neglect that compounds the existing water crisis. In this context, one woman participant elaborated:

“We walk several kilometres to fetch water from community ponds, often waiting for hours to get water, as everyone depends on the same source. After cyclones, managing safe drinking water becomes even more challenging, and bathing and washing are particularly difficult for women. We need to purchase water drums, which consume a significant portion of our monthly income. However, not all households receive drums or containers from NGOs, depriving others. Due to bad roads, not all NGOs come here for help.”

Effective recovery and coping mechanisms are essential for understanding overall vulnerability and adaptive capacity. The findings indicate that the Munshiganj fishing community had greater adaptability, with a higher score on the recovery and coping measure index (0.447)

compared to Burigoalini Union (0.311). In both communities, households employed a range of coping strategies, including using portable stoves, reducing fish consumption, and temporary migration during periods of food insecurity or forest fishing bans. For instance, adult male members from 12% of Munshiganj Union households and over 7% from Burigoalini Union households were engaged in brick fields outside their respective districts (e.g., Satkhira). Such temporary migration was primarily driven by regulatory restrictions on access to mangrove forest resources imposed by the Government of Bangladesh's Department of Forestry. A Key Informant from an NGO explained:

“Many migrate to cities like Dhaka after cyclones or during seasonal bans in the Sundarbans. While this temporarily offsets expenses, it provides no stable income. Livelihoods remain uncertain; one day, fish harvest may bring 50,000 BDT, the next only 10,000 BDT. Without alternative employment, people’s dependence solely on the Sundarbans keeps them vulnerable. They go and get exploited due to the lack of skills, away from families, which makes them mentally depressed.”

Access to institutions and their support were found to be major predictors for the state of household vulnerability. The Burigoalini Union fishing community demonstrated greater access to institutional support, with a higher proportion of households receiving disaster relief items from regional government departments (62.5%) and NGOs (83.9%). This contrasts with the Munshiganj Union community, where only 50% of households received food relief from the government, and only 38.6% received it from NGOs.

Findings on adaptive capacity suggest that institutional support, reconstruction, and rehabilitation contribute more to reducing household vulnerability in the Burigoalini Union than in the Munshiganj Union. The index value for reconstruction and rehabilitation in Burigoalini was higher than that of Munshiganj; for instance, nearly 45% of households repaired their damaged housing, and many reinforced structures with deep-rooted wooden pillars, reflecting a relatively higher degree of adaptive capacity than in Munshiganj.

Table 5. *Differentiated Modified Livelihood Vulnerability Index (MLVI) Between Two Study Communities (Unions)*

Index of major components	Overall	Burigoalini Union (n=56)	Munshiganj Union (n=44)	Difference	t(df)	p-value
Exposure to cyclone	0.764	0.743	0.791	-0.048	-2.09(98)	0.981
Unemployment	0.486	0.509	0.461	0.048	1.08(98)	0.142
Health	0.388	0.316	0.480	-0.164	-3.11(98)	0.001*
Food	0.603	0.588	0.623	-0.035	-1.47(98)	0.928
Water and sanitation	0.565	0.520	0.621	-0.101	-4.41(98)	0.001*
Effects on socio-political, religious, and institutional relations	0.653	0.663	0.640	0.023	0.676(98)	0.250
Economic loss and damage	0.456	0.421	0.501	-0.080	-1.63(98)	0.054
Access to disaster-related information	0.540	0.544	0.534	0.010	0.315(98)	0.376
Access to community-resources	0.426	0.424	0.427	-0.003	-0.105(98)	0.542
Human capital	0.569	0.553	0.588	-0.035	-0.986(98)	0.163
Social network	0.424	0.409	0.441	-0.032	-0.729(98)	0.766
Recovery and coping measures	0.371	0.311	0.447	-0.136	-3.26(98)	0.001*
Access to institutional supports	0.605	0.732	0.443	0.289	3.66(98)	0.001*
Sustainable livelihood and risk reduction strategy	0.271	0.207	0.352	-0.145	-3.30(98)	0.001*
Reconstruction and rehabilitation capacity	0.500	0.534	0.457	0.077	2.62(98)	0.005*
Human agency	0.244	0.225	0.267	-0.042	-0.98(98)	0.164
Modified Livelihood Vulnerability Index (MLVI)	0.467	0.451	0.488	-0.037	-2.35(98)	0.010*

* Significance at 5% level

2.4.4 Vulnerability Assessment of Satkhira Communities Using LVI-IPCC Index

According to the IPCC (2014), vulnerability is shaped by the interaction of three components: exposure, sensitivity, and adaptive capacity. The comparative analysis using the MLVI-IPCC framework revealed elevated levels of vulnerability in both Burigoalini and Munshiganj fishing communities (see Table 6). The overall vulnerability index for the Burigoalini Union (mean MLVI-IPCC = 0.099, $SD = 0.035$) was slightly higher than that of the Munshiganj Union (mean MLVI-IPCC = 0.097, $SD = 0.049$), but there was no significant variation in overall vulnerability between the two study communities.

An analysis of key contributing factors highlights differential exposure to cyclones between the two Unions. The vulnerability index indicates that the fishing community in Munshiganj experienced greater exposure to cyclonic events than Burigoalini, with average exposure index values of 0.791 ($SD = 0.118$) and 0.743 ($SD = 0.114$), respectively. Results from a two-sample t-test confirmed a statistically significant difference in exposure levels between these communities. Similarly, the two study Unions exhibited varying degrees of sensitivity to cyclones, with Munshiganj exhibiting a higher sensitivity index (mean = 0.556, $SD = 0.138$) than Burigoalini (mean = 0.492, $SD = 0.138$). The t-test results further confirmed this significant difference in sensitivity [$t(98) = -2.345, p = 0.010$].

As reflected in the capacity index, despite experiencing higher exposure and sensitivity, households in Munshiganj Union demonstrated greater adaptive capacity than in Burigoalini Union. This disparity is primarily attributable to greater access to disaster-related information among Munshiganj households, their use of community resources and institutional services, stronger social networks, and a more pronounced demonstration of human agency. This result was further elaborated upon in the KII and FGD results. Community members in Munshiganj Union were deeply engaged in utilizing their social learning from disaster experiences and in building social and institutional networks. One Key Informant explains:

“Both damage to properties and the adaptive capacity of locals have increased simultaneously. Given the extent of resource damage, community members draw on experiential learning from past disasters to adapt to climate-related hazards. Additionally, local community members are more aware of cyclone forecast information. Earlier, they

had no idea of early warning information. Currently, when they perceive any anticipated climatic hazards, they contact local government offices and seek forecast information.”

Table 6. *Distribution of MLVI-IPCC Indices by Union*

Index	Burigoalini Union	Munshiganj Union	<i>t</i> (df)	<i>P</i> -value
	Mean (SD)	Mean (SD)		
Exposure	0.743 (0.114)	0.791 (0.118)	-2.092 (98)	0.019*
Sensitivity	0.492 (0.138)	0.556 (0.130)	-2.345 (98)	0.010*
Adaptive Capacity	0.395 (0.797)	0.422 (0.072)	-1.706 (98)	0.045*
MLVI-IPCC	0.099 (0.035)	0.097 (0.049)	0.267 (98)	0.396

* Significance at 5% level.

2.5 Discussion

2.5.1 Intersecting Social Inequalities Shape Differential Vulnerability

Asymmetrical vulnerability within a community is shaped by socio-economic position, including asset ownership, gender roles, access to opportunities, control over community resources, and decision-making capacity, in relation to recovery from disaster-related loss and damage (Cutter et al., 2008; Sen, 2003; Wisner et al., 2004). Our socio-economic status (SES) and gender-based assessment reveals that fishing households face disproportionate vulnerabilities to cyclones, particularly with respect to health, food security, and access to resources. The results indicate that the complex interplay of subsistence-based livelihoods, socio-political relationships, social support systems, and institutional networks is a major determinant of household vulnerability; these factors mutually reproduce and reinforce vulnerability.

A mutual intersection between climate vulnerabilities and intersectional dynamics exacerbates both economic and non-economic losses, such as food insecurity, health risks, and unemployment, intensifying the asymmetrical vulnerability of marginalized fishing groups to disasters. Our findings suggest that low- and medium-income households leverage their existing resources, diversify their income, and take part in collective disaster recovery initiatives—all of which enhance their adaptive capacities—but fell short because of lack of assets and reconstruction

and rehabilitation abilities, compounded by structural barriers like high market price of housing materials, lack of livestock sheds, employment precarities and forest bans, as well as lack of institutional proactiveness in protecting shared resources that protects assets. This reflects how structural barriers and ignorance of governance can undermine high adaptive capacity, resulting in increased intersectional vulnerability for marginalized groups and draining their existing resources. These findings align with those of Ngu et al. (2023), who found that poor households in Vietnam experienced heightened vulnerability due to the compounded effects of extreme climate events, limited decision-making power, and restricted access to socio-political networks and relationships. However, these findings contrast with those of Tannor et al. (2022), who reported that large-scale farming households in rural Ghana faced dual exposure arising from the intersection of climate change and forest extractivism, highlighting a distinct vulnerability pathway.

Gendered vulnerability was particularly evident in the ways women's exposure, sensitivity, and adaptive capacity were shaped by entrenched social values, institutional structures, and economic systems. Women faced heightened burdens related to health risks, employment precarity, and water-related crises due to intersecting power differentials and gendered entitlements to resources. Our findings further show that water insecurity in Shyamnagar is reinforced by structural and procedural factors, including weak institutional capacity to ensure safe and affordable drinking water (e.g., limited access to safe sources, disrupted supply, and high market prices) and unequal distribution of water treatment supplies and storage materials. Even where interventions such as pond sand filters (PSF) are available, access remains constrained by informal gatekeeping and location-based exclusions, disproportionately affecting low-income households. These structural constraints intersect with patriarchal norms that overburden women with unpaid domestic responsibilities, intensifying the physical and mental burden of water collection, filtration, and storage, and limiting women's collective capacity to mobilize for water-related claims in local institutions.

Similar patterns of compounded gendered vulnerability are widely documented in developing-country contexts (Alhassan et al., 2019; Balikoowa et al., 2019). Despite being exposed to multiple forms of vulnerability, our empirical evidence indicates that fishing households exhibit unique adaptations to disaster impacts by leveraging their resources. Low-SES

and female-headed households often demonstrated stronger coping and recovery practices than medium- and high-SES households, reflecting resilience and strategic allocation of limited resources. Low- and middle-income households actively diversified their livelihoods and engaged in collective recovery initiatives, while women were particularly proactive in household-level coping measures (e.g., preserving dried food) and in livelihood activities such as small-scale entrepreneurship and crab fattening, through NGO-supported loans.

Women in female-headed households also exhibited robust social networks despite limited asset entitlements, suggesting that experiential and social learning shape adaptive action. These observations align with those of Uddin et al. (2020), who similarly found that learning from cyclones can create opportunities for livelihood transformation and resilience building. However, limited ownership rights, restricted asset control, and male dominance within households constrained women's adaptive capacities and undermined health and well-being, reinforcing gendered vulnerability at both household and societal scales (Eastin, 2018). These findings also resonate with evidence from Trinidad and Tobago, where female-headed households faced heightened vulnerability due to unequal access to resources and intersecting social disadvantages (Shah et al., 2013), as well as with broader patterns reported by Ngu et al. (2023).

Across intersectional lines, whether by gender or socio-economic position, we found that the degree of vulnerability is closely tied to one's adaptive capacity. Thus, we emphasize the importance of including human agency indicators within the adaptive capacity component of vulnerability analysis to recognize households' inner strength to adapt within external structural contexts, rather than viewing them as passive responders to disasters.

2.5.2 Spatial Distribution of Livelihood Vulnerability Analysis, Without Considering Social Dimensions, Limits the Depiction of a Comprehensive Perspective of Vulnerability

Livelihood vulnerability is influenced by variations in exposure, sensitivity, and adaptive capacity across regional and social settings (Dasgupta et al., 2020; Islam & Ghosh, 2023). Our comparative spatial analysis of two coastal Unions reveals that both communities exhibit similar levels of exposure to climate-induced extreme events. However, the socio-economic facets are major departure points that produce differential vulnerability across communities. The results of our empirical investigation indicate that vulnerability is not shaped solely by geographical settings;

rather, a coupled social-ecological system interacts with and reorients vulnerabilities across geographical entities (Turner et al., 2003). Consistent with our findings, Mamun (2022) asserted that differential flood vulnerability among char (mid-channel island)-dwelling communities in Lalmonirhat, Bangladesh, is shaped by the interaction between community physical characteristics and socio-economic factors, despite their exposure to similar natural hazards.

Spatial features, such as proximity to the Bay of Bengal, are major determinants of unequal vulnerability across Bangladesh's coastal fishing communities. Nonetheless, there is a disparity in exposure between the two study Union communities, not only in the frequency and severity of cyclones but also in the number of fishing households living on Khas (public) land with flimsy housing structures, limited employment options, and limited access to health and social services. Similar findings were reported by Shah et al. (2013), who found in Trinidad and Tobago that, during droughts and floods, geographical isolation and restricted access to amenities and government services in Caroni and Nariva increased their economic and social vulnerability.

Community members have varying degrees of access to institutions and social networks, depending on their socio-economic characteristics (Desai, 2002). Our findings indicate that the magnitude of financial assistance is not distributed uniformly, as limited access stemming from poor infrastructure and potential institutional biases hinders its distribution. As remote coastal fishing communities rely heavily on natural resource endowments, leading to resource-dependent livelihoods, socio-political marginalization and exclusionary processes heighten their sensitivity to physical exposure. Consequently, these processes increase the vulnerability of already marginalized communities. Several recent studies on char-dwellers have also found that exclusions stemming from deficits in social networking, poor communication, limited education, and unsafe relocation exacerbated vulnerability (Alam et al., 2017; Sarker et al., 2019).

The results of our study indicate that, while the geographical distribution of livelihood vulnerability provides a necessary comparative overview, it falls short of offering an in-depth analysis of the critical social dimensions that shape vulnerability. Household heterogeneity in asset endowment, socio-economic status, and gender plays a profound role in generating community vulnerability. These are reflected in the significant variation in vulnerability across socio-economic groups located in comparable spatial units (e.g., Unions).

The present research has a few limitations. First, the usage of indicators and indices is likely to oversimplify the complex reality (Vincent, 2007). Second, although the sample is insightful, it is not fully representative of coastal fishing communities; a larger sample in future research could yield a more comprehensive assessment. Third, the use of cross-sectional rather than longitudinal data limits the ability to capture long-term trends. With respect to hazard inclusion, only cyclones, as an example of climate extremes, were considered. This limits the scope of our study. Future research should develop a framework that integrates household-specific characteristics, incorporates other extremes, and accounts for slow-onset climatic hazards to provide a nuanced understanding of household heterogeneity and vulnerability, thereby informing more effective policy formulation.

2.6 Conclusions

This study examined the dynamics of intersectional livelihood vulnerability and spatial disparities in two small-scale fishing communities in Satkhira District, Bangladesh's coastal region. Using a Modified Livelihood Vulnerability Index (MLVI), we found that livelihood vulnerability arises from several intersectional factors—such as socio-economic status, gender, geographic location, and access to socio-economic opportunities—making it a more complex, nonlinear phenomenon in which socio-economic characteristics lead to cascading effects. The interactions between and within socio-economic and gender divisions mutually intersect and reinforce multifaceted and disproportionate vulnerabilities between socio-economic classes and genders. Additionally, we registered that socio-economic, institutional, and political processes influence the spatial distribution of livelihood vulnerability. Although fishing communities often experience a similar level of exposure to climatic hazards, socially and politically embedded factors determine uneven vulnerability across these communities. We infer that focusing on a single component for assessing vulnerability does not provide a comprehensive picture of livelihood vulnerability. Rather, the interaction between spatial features and socio-economic processes largely shapes the vulnerability of coastal fishing communities to climate-related extreme events.

Our findings suggest that differential vulnerability can be mitigated through adaptive capacity, particularly when households employ proactive coping and recovery practices within broader institutional, social, and political contexts. Incorporating agency-informed dimensions

within adaptive capacity can therefore strengthen vulnerability assessments by capturing how households convert resources into adaptive action.

The results of this study have several policy implications. As noted, vulnerability is nonlinear and intersectional. Future policy interventions need to recognize and incorporate intersectional dynamics, such as gendered power relations and socio-economic position, to achieve sustainable livelihood outcomes among impoverished and marginalized groups. Based on our findings, we argue that strengthening monitoring and accountability of institutions in relation to avoiding political favouritism and unequal institutional reach, and ensuring women's needs (not just participation) in securing leadership in local platforms, is crucial to strengthening livelihood resilience among the marginalized groups. Local-level implementation policy actors (e.g., disaster management committees and agencies, local and national NGOs) can incorporate household-level assessments and prioritize households with limited institutional access or participation in DRR activities (e.g., low-income fishers).

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Chapter 3

Agency, Collective Action, and Adaptation to Climate-related Disasters: Evidence from the Sundarbans Coastal Communities of Bangladesh

Abstract

Human agency, which refers to people's capacity to engage in intentional actions in response to change, is an underexplored area in the climate change impacts and adaptation literature. Despite growing recognition of agency as a significant component of enhancing adaptive capacity and community resilience to climate-related disasters, little attention has thus far been paid to how agency is exercised to shape adaptive pathways and its dynamics with local responses. In the context of recurring climatic, environmental, and socio-political stressors, this study examines how forms of human agency emerge from multifaceted vulnerabilities and how they enact and shape local adaptive responses in small-scale fishing communities along Bangladesh's coast. Our study also explores the barriers and opportunities that either hinder or enable the application of agency in building resilience. We adopted a case study approach using qualitative methods. Primary data were collected through nine key informant interviews, six focus group discussions, and participant observation. Our findings reveal that, alongside deeply embedded social–institutional settings, the human agency of fishing households profoundly influences the adaptive capacity of these households in response to disasters. Adaptation strategies were characterized by both proactive and reactive responses, often grounded in cumulative lived experience and learning from past shocks. Notably, various structural barriers constrain the application of agency attributes in resilience building for households and communities alike. A mechanism to scale up agency-driven adaptation measures, strengthen accountability in adaptation governance, and improve institutional coordination through inclusive disaster policy frameworks is highly recommended. More policy attention should also be paid to supporting other social, institutional, and political enablers and to addressing structural barriers to attaining successful adaptation outcomes.

Keywords: adaptive capacity; adaptation; agency; climate change; fishing community

3.1 Introduction

Climate change shocks and stresses increasingly disrupt livelihoods worldwide, producing uneven risks and losses across various socio-economic classes. In the coastal regions, the consequences are often acute and catastrophic (Adger et al., 2007). Climate-driven hazards, including excessive rainfall, extreme temperatures, sea-level rise, flash floods, and cyclones, generate cumulative asset losses, amplify livelihood volatility, and deepen pre-existing inequalities (Berrang-Ford et al., 2021). In response, community members develop unique adaptation measures in their own unique ways (Agrawal & Perrin, 2008; Santha et al., 2014). Many of such responses are culturally embedded; some examples cited are storing surplus fish during high season and selling them during the off-season period (Santha, 2015), food rationing (Campbell, 2006), borrowing investment funds (Parvin et al., 2008), livelihood diversification (Macchi et al., 2015), and modifying the built environment (Agrawal & Perrin, 2008).

In contrast to formal interventions, which are often monetized and follow a top-down approach (Adger, 2000), locally grounded strategies directly address the everyday struggles and priorities of small-scale fishers. A classic illustration can be drawn from Bangladesh's coastal fishing communities, where decades of recurring disasters, including cyclones, storm surges, and coastal floods, have threatened people's livelihoods. The current high frequency and the broad regional scale of climatic extremes in Bangladesh provide a critical context for examining the dynamics of agency in adaptation. Globally, an estimated 70–80 tropical cyclones occur each year, of which 7% originate in the North Indian Ocean—and the most devastating cyclones strike the coastline of Bangladesh (Singh & Roxy, 2022). Around 44.8 million people live in the coastal zones of the country, where GDP per capita remains below US \$1,700 (Ahsan et al., 2024; Sarwar & Wallman, 2005). Here, vulnerability is compounded by patriarchal norms, inequitable access to resources, and weak institutional structures. Chronic poverty intersects with entrenched patriarchal norms, inequitable resource access, and institutional weaknesses, producing a layered landscape of risk (Zaman and Akhter, 2025).

Experiencing chronic exposure to climatic extremes, these coastal communities have demonstrated remarkable progress in formulating adaptive strategies that drive resilience (Uddin et al., 2020). Mozumder et al. (2018), for example, observed that while authorities' seasonal fishing bans generated severe socio-economic stress among hilsa (*Tenualosa ilisha*)–dependent coastal

communities, these conditions prompted the communities to develop adaptive responses through co-management, community networking, and the pursuit of alternative income sources. Fishing households in coastal Bangladesh continue to engage in diverse individual and collective adaptation strategies, including seasonal migration, informal credit networks, and group-based disaster preparedness, often supported by informal and quasi-formal institutions (Farhana & Naser, 2016; Islam et al., 2014). However, in Bangladesh, adaptation research has largely emphasized assets and institutional barriers, with limited attention to how *agency* drives, shapes, or constrains adaptive decision-making (Anik & Khan, 2012; Choudhury & Haque, 2016; Rahman et al., 2018).

In this study, agency is conceptualized as an evolving, socially embedded capacity through which individuals and communities exercise their free will to mobilize resources and act under constraints (Adger, 2003). Agency is further understood as shaped by cumulative learning from past disruptions, including livelihood loss, economic stress, and disaster impacts, which may foster proactivity in adaptive responses. As Lin (2019) defines, agency is the capacity of individuals or communities to act intentionally and make independent choices in response to change, thereby converting available resources into effective adaptation. In recognizing the interplay between formal interventions and small-scale adaptation efforts (local) as integral in shaping local adaptation contexts and practices, growing literature closely links agency as a form of collective action and political expression within these small-scale practices (Funder et al., 2018; Lindegaard & Sen, 2022; Nightingale, 2017).

While the environmental change literature on conceptual questions clearly recognizes that agency is an integral component of adaptive capacity (Adger, 2003; Coulthard, 2012; McLaughlin & Dietz, 2008), empirical research that unpacks the role of agency at the local level within the social, political, and institutional contexts remains scant. Specifically, little is known about how agency emerges, evolves, and interacts with other contextual factors regarding resource control and inequity in adaptation outcomes (Brown & Westaway, 2011). There is still little systematic evidence on the pathways through which agency is enacted and on who the actors are who sustain it in everyday adaptation practice. While supporting the growing understanding that small-scale, everyday adaptation issues require attention, some scholars argue that there is limited research on the aggregate resistance that accompanies collective action and political expression, which is crucial to understanding whether agency is being interrupted or driving transformational change.

This lack of evidence also obscures the role of agency in grassroots adaptation, particularly in marginalized coastal settings where the everyday struggles to exercise agency are pronounced and where targeted adaptation support remains insufficient (Lindegaard & Sen, 2022). As adaptation cannot operate in a vacuum and involves a highly relational co-production process between formal, externally driven initiatives and small-scale local efforts, it is necessary to examine the interplay among local actors (Eriksen et al., 2021). This study fills a research gap by analyzing the dynamics of agency and calls for evidence of the factors that enable or constrain its application in everyday adaptation practices.

Drawing on evidence from two cyclone-affected fishing communities in the Sundarbans mangrove coastal region of Bangladesh, we empirically trace the linkages among the factors that drive agency; examine the forms of agency (individual and collective; reactive and anticipatory) that trigger adaptive responses; and explore how agency interacts with socio-political structures to shape adaptive capacity and strengthen resilience. In doing so, the study highlights how local adaptation practices are simultaneously shaped by structural constraints and emergent opportunities, influencing the extent to which these agency-triggered responses contribute to resilient outcomes. Accordingly, the sub-objectives under the second objective of this study are threefold: i) to examine how small-scale fishing communities exercise agency in adaptation strategies, ii) to identify the drivers of agency and its role in shaping adaptation actions, and iii) to explore and discuss the implications of the results for formulating adaptation strategies in the country.

3.2 Conceptual Considerations

3.2.1 Adaptive Capacity in Disaster and Resilience Discourse

Responding to the adverse effects of climate change entirely relies on *adaptive capacity*—a principal determinant of success. Adaptive capacity is chiefly associated with social-ecological systems (SES) and social contexts. As Folke et al. (2010) asserted, in the SES resilience stream, adaptive capacity refers to the potential of social and ecological systems to absorb disturbances, reorganize, and facilitate transformation. In a social system, adaptive capacity is the latent ability of individuals, communities, or systems to adjust to and recover from losses and damage resulting from climatic shocks and stressors (Engle, 2011; Intergovernmental Panel on Climate Change [IPCC], 2007).

From a vulnerability perspective, Lei et al. (2014) use the term “vulnerability preference,” in which adaptive capacity is seen as a system’s ability to shape both exposure and sensitivity. Likewise, the “resilience preference” perspective views adaptive capacity as an essential component of a system’s ability to reduce vulnerability and succeed in adaptation, fostering community resilience. However, the societal goals are to reduce vulnerability and enhance resilience to climatic shocks. In the present study, adaptive capacity is regarded not as a path to an inevitable transformed end state but as the ability to adapt to existing stressors without necessarily crossing a transformational threshold. In doing so, we place adaptive capacity at the intersection of disaster risk reduction (DRR) and resilience research to improve our understanding of how adaptation unfolds in climate-vulnerable contexts.

In examining the contextual determinants of adaptive capacity, the early emphasis on coping mechanisms has shifted to broader understandings of how institutions and social actors interact in response to change (Calvin et al., 2023). For example, Gupta et al. (2010) examined how institutional characteristics—such as leadership, resources, learning capacity, fair governance, and autonomous change—can influence social practices, ultimately shaping adaptive capacity. A notable contribution to understanding the roles of socio-economic and political structures in shaping individual and household adaptive capacity was made by Sen (2000)’s research on entitlement and food security, highlighting the importance of examining contextual drivers across multiple scales (Brown & Westaway, 2011)

In shaping locals’ coping and adaptation strategies, Cutter et al. (2008) emphasized the role of antecedent conditions, such as existing asymmetric power structures and financial capacity. These conditions create space for innovative adaptation strategies that unlock greater potential (individual or collective) to ensure livelihood security. Some recent studies have argued that combining local and external innovation–adaptation strategies can encourage self-organization (Haque et al., 2022). Factors such as social bonds, self-organizational ability, collective action, market dynamics, institutions, family norms, and gender are documented in the literature in relation to building collective resilience in small-scale fisheries (Coulthard, 2008). Other studies emphasize the role of social networks, social learning, and social capital as a necessary condition in enabling adaptive capacity in building community resilience (Azad et al., 2022; Vincent, 2007).

Adaptive capacity is manifested through concrete adaptation actions across multiple dimensions, including economic, social, institutional, structural, and behavioural. Economic actions include occupational diversification, shifts in the harvesting of fish species to reduce resource scarcity, entrepreneurship, and migration—all of which help households buffer shocks and seize opportunities amid climatic disturbances (Badjeck et al., 2010; Rahman et al., 2024). Social actions—such as informal knowledge sharing, and collective efforts to repair damaged structures—foster mutual support and coordination; they are key attributes of adaptive capacity. In this respect, Azad et al. (2022) observed that shared practices and social networks enabled small-scale fishers in the *haor* (wetland) region to jointly purchase nets and boats, mitigating livelihood stress after devastating flood events. Behavioural actions stemming from risk perception to change disaster preparedness practices and occupational practices reflect the cognitive and cultural dimensions of adaptation (Grothmann & Patt, 2005; Kuruppu & Liverman, 2011)

Adaptation responses often emerge in the form of both local and external innovations. Local innovations are usually rooted in local knowledge and context-specific adaptation responses within everyday adaptation practices, while external innovations are supported by institutional programs, technologies, and policy interventions (Azad et al., 2022; Gupta et al., 2016). Both local and external innovative strategies effectively enhance adaptive capacity into resilient outcomes. For instance, external innovations, such as NGO-led training on saline-tolerant crops in southwestern Bangladesh, enhanced local practices by introducing new technical or financial inputs (Alam et al., 2017; Islam, 2023). Several studies have offered evidence that, through external interventions applied in the local context, communities can often overcome structural and power-related constraints and engage in social learning that fosters collective resilience (Biesbroek et al., 2014; Cutter et al., 2008). Such overlapping adaptation strategies strengthen livelihoods and enable community resilience within disaster-prone, resource-dependent systems (Blaikie et al., 2014).

3.2.2 Linking Human Agency, Adaptive Capacity, and Resilience in a Disaster Context

Human *agency* has deep philosophical and social-scientific roots, traditionally defined as an internal psychological mechanism and capacity to act independently, reflect upon choices, and exercise independent decision-making (see Bandura, 2006). At its core, *agency* refers to the capacity of individuals or communities to act intentionally and make free choices independently in response to change, thereby converting available resources into effective adaptation (Lin, 2019).

Early scholarship in philosophy and psychology emphasized the moral and cognitive dimensions of agency, viewing it as the internal capacity for self-reflection and self-efficacy that motivates purposeful behaviour (Bandura, 2001; Yamamoto, 2006). While earlier studies explored cognitive aspects of agency, such as motivation and self-efficacy (Grothmann & Patt, 2005; Kuruppu & Liverman, 2011), the concept later evolved within social science discourses to include its relational and structural dimensions. Drawing on Sen's capability approach, Alkire (2005) views agency as the ability of individuals to pursue goals that they value, and to influence desired change. Notable contributions to conceptualizing agency include the well-being approach, social cognitive theory (Bandura, 2001), the theory of structuration (Giddens, 1984), and development sociology (van der Ploeg & Long, 1994). These conceptual expansions informed environmental social science and climate adaptation research, where agency has been analyzed as both a determinant and an expression of adaptive capacity (Adger, 2003; Cinner et al., 2018; Lister, 2004; McLaughlin & Dietz, 2008).

Within climate change adaptation research, human agency has increasingly been recognized as central to understanding and outlining the determinants of adaptive capacity in response to climatic disturbances. Incorporating agency into adaptation studies contrasts with the conventional framing of people as merely victims rather than active agents, which cannot fully account for the variety of individual responses to disaster risks. Recent scholarly work has begun to advocate for an agent-centric understanding of adaptation, in which individuals are viewed as “autonomous, purposive, and creative actors” (Lister, 2004, p. 125) who actively build resilience (Bohle, 2009; Coulthard, 2012). As Cinner et al. (2018) and Bandura (2001) argue, other relevant domains of adaptive capacity, such as learning or access to assets, remain insufficient when individuals lack the motivation, decision-making power, or freedom to use them. Consequently, the concept of agency evolved in relation to its structural and institutional embeddedness (Bartelet et al., 2023).

Several studies have linked agency with broader societal dimensions of power, legitimacy, and inequality (Giddens, 1984; McLaughlin & Dietz, 2008). This is because people do not always have control over other conditions that affect their well-being, such as dependence on common-pool resources; climatic shocks; governance policies, structures, and functions; the presence of formal and informal institutions; and socio-political factors (Badjeck et al., 2010). The

Structuration theory, in the context of the interplay between agents and social structures, asserts that humans cannot exercise their abilities in a vacuum; instead, they are embedded in external structures that shape agency. However, it can be argued that the theory overlooks the ecological dimensions of adaptation (Giddens, 1984).

Centering on the influence of governance systems, social networks, and institutional arrangements in enabling or constraining adaptation, Adger, (2003) conceptualizes agency as socially situated and intentional capacity of individuals and groups through which they actively act, make decisions, and mobilize resources in response to climate-induced challenges. Extending this understanding, Cinner et al. (2018) developed a framework that explicitly identifies agency as a distinct domain of adaptive capacity alongside assets, flexibility, organization, and learning, and thereby credits human action as the driving force that activates other adaptive domains.

Key expressions of agency include leveraging social position to access physical and financial properties, institutional support, fostering social capital, and exercising decision-making power to advocate for change (Adger, 2003; Barnes et al., 2017; Cinner & Barnes, 2019; Ling & Dale, 2014). For example, land ownership, access to credit, extension services, and diversified income sources have been identified as major pathways for enhancing adaptive capacity in disaster-prone areas in South Asian countries such as Bangladesh (Datta et al., 2022; Lamichhane et al., 2022; Pandey et al., 2018). Despite a critical role of agency in adaptation, most adaptation research in Bangladesh has centered on vulnerability assessments and adaptation barriers (Anik & Khan, 2012; Habiba et al., 2012; Hasan et al., 2018; Kabir et al., 2021; Sarker et al., 2013), and little attention has been paid to how agency manifests within or drives adaptation choices. Empirical studies have shown that local innovative adaptation strategies are grounded in local knowledge and are often mediated by external innovations or interventions (e.g., through markets or institutions) to enhance or constrain adaptive capacity (Choudhury et al., 2021; Khan, 2024). However, the explicit linkage of these strategies to the driving forces and expression of agency remains underexplored. Evidence is also limited regarding how social-ecological factors intersect to determine the effectiveness of adaptation (Haque, 2020; Kulsum et al., 2021; Pouliotte et al., 2009). Moreover, adaptation scholarship continues to prioritize material assets (e.g., income, infrastructure, technology) over non-material dimensions such as decision-making, power, and self-organization (Amin et al., 2018; Islam et al., 2014). These critical gaps prompt us to explore

how agency facilitates adaptation decisions in small-scale fisheries in coastal Bangladesh (e.g., (Collins, 2014; Hoque et al., 2018). However, agency facilitating adaptation decisions does not necessarily imply a successful outcome or a threshold of transformational change. Moreover, locally driven strategies may alleviate immediate stress while failing to shift deeper structural constraints, thereby sustaining patterns of risk and exposure over time (Adger et al., 2009). Therefore, it is essential to understand how agency is meaningfully exercised or constrained toward outcomes of resilience. It has been argued that agency extends beyond access to resources, encompassing the capacity to innovate, mobilize, and act under conditions of vulnerability (Hoque et al., 2018) while collective expressions of agency through collaboration, social networks, and institutional linkages have been recognized as crucial factors in enhancing resilience in disaster-prone contexts (Sejersen, 2009).

Notably, agency is often constrained or enabled by structural, social, and institutional factors. Weak governance, fragmented institutional coordination, and unequal power relations can limit resilient outcomes, even with a high level of adaptive capacity in the system (Alam et al., 2018; Cutter et al., 2008; Uddin et al., 2020). For example, Choudhury and Haque (2016) found that political favouritism and elite capture in northeastern Bangladesh constrain local collective adaptive capacity despite their active participation in disaster preparedness. Similarly, fishers' locally grounded adaptive innovations in coastal Sri Lanka, such as gear modification, were left unrecognized in policy, which was a significant barrier to scaling up their local strategies into national policy frameworks (Galappaththi et al., 2021). These examples underscore that, in many cases, formal interventions can disrupt local adaptive responses and agency of local actors, potentially leading to increased vulnerability (Eriksen et al., 2021; Funder et al., 2018). Under political and institutional dominance, communities often respond through avoidance, circumvention, selective compliance, or contestation; these practices are increasingly conceptualized as *resistance* within adaptation scholarship. This lens helps capture the political expression of agency under power differentials and clarifies the interplay between formal and everyday adaptation processes (Eriksen et al., 2015; Lukes, 2004; Scott, 1989).

For analytical clarity, this study distinguishes between reactive and proactive expressions of agency. This distinction is analytically important because both individual and collective agency may generate adaptive responses, yet may also differ in intentionality and timing, which may either

strengthen resilience or unintentionally reproduce vulnerability (Eriksen et al., 2021). *Reactive* agency reflects expressions of adaptive responses that emerge primarily as coping and recovery measures following experienced shocks, often under severe constraints, and may remain limited in their ability to reduce vulnerability (Adger, 2003; IPCC, 2022). In contrast, *proactive* agency refers to expressions of forward-looking actions taken to reduce future risk through preparedness, livelihood adjustments, or collective planning, and is more closely aligned with sustained vulnerability reduction (IPCC, 2022).

Disaster *resilience* refers to the capacity of a system (community, individual, or environment) to anticipate, resist, absorb, adapt, transform, and recover from the effects of disasters, through its inherent strengths—ideally to bounce back better to improve future preparedness, not just return to the original state (see UNDRR, 2017). It involves managing risks through preparedness, reducing vulnerabilities, and maintaining essential functions during and after a disaster. In the present study, resilience is not regarded as a transformation into a new socio-ecological state, but as a negotiated and adaptive process through which communities maintain viable livelihoods amid recurring hazards (see Walker et al., 2004). Here, agency serves as the bridge between adaptation and resilience, grounding both lived experiences and localized responses. Accordingly, it positions agency as a socially and institutionally embedded capacity to act under constraint, which is central to adaptive capacity but also generative of it, rather than just a feature of an adaptive system (Adger, 2003).

Drawing on Cinner’s adaptive capacity framework (Cinner et al., 2018) and Adger’s (2003) socially embedded conception of agency, this study employs an integrated conceptual lens to address three key questions that guide the analysis: (i) How do agency-triggered adaptation practices contribute to strengthening resilience? (ii) How does agency emerge and evolve under recurrent climatic and socio-political stressors? (iii) What kind of constraints shape the expression of agency in resource-dependent settings? To investigate these questions, agency is viewed in this study as a socially embedded capacity of individuals, households, or communities to exercise their independent choices and proactive abilities (e.g., use skills, knowledge, aspirations, motivation, or decision-making ability) to act, shaped by institutional arrangements, power relations, social norms, and governance structures. It also embodies the ability of individuals and collectives to make choices and negotiate risk, not necessarily bringing a transformative change in the system,

while positioning agency as a central domain of adaptive capacity that activates other key domains, including assets, learning, flexibility, and social organization. Together, these perspectives enable the analysis to move beyond examining cognitive capacities (potential) or structural conditions in isolation, and instead capture how agency is dynamically produced and enacted through the interaction among lived experience, institutional contexts, and adaptive practice.

3.3 Methods and Materials

3.3.1 Study Area

Shyamnagar *Upazila*⁶ was purposively selected for the present study, with focus on the two unions, Munshiganj and Burigoalini, in our empirical investigations. Detailed descriptions of the study area, including its socio-ecological and climatic context and relevance to the research objectives, are provided in Chapter 1 and Appendix H to avoid duplication.

3.3.2 Data Collection and Data Analysis

Primary data were collected through key informant interviews (KIIs), focus group discussions (FGDs), and participant observation. Using a participatory approach allowed participants to actively share their lived experiences and interpretations grounded in local realities. The participants were considered as social actors who produced knowledge to inform an in-depth understanding of adaptation in the region (Creswell & Poth, 2016).

A total of 12 in-depth, face-to-face KIIs were conducted with a range of relevant stakeholders, including six NGO representatives, a Project Implementation Officer (PIO), a *Union Parishad*⁷ member from each Union, Union Parishad Chairman(s) from each union, and a community member with a proven track record of leadership. These interviews offered insights into underlying factors influencing local-level adaptation practices.

A total of six focus group discussions (FGDs) were conducted: three in Munshiganj Union and three in Burigoalini Union. The inclusion criterion for participant recruitment was direct engagement in fishing-related livelihoods or reliance on Sundarbans mangrove forest resources for subsistence. Priority was given to individuals involved in small-scale fishing, fish processing, and related market activities, as well as those who regularly accessed forest resources to generate

⁶ *Upazila* is the second lowest administrative unit of Bangladesh, with the *Union Parishad* (UP) being the lowest. Upazilas are sub-districts within a district, further divided into unions.

⁷ *Union Parishad* is the primary and lowest administrative government structure to govern rural areas of Bangladesh.

income or meet household needs. Each session involved 6 to 8 participants and lasted 35 to 45 minutes. We conducted two FGDs with male fishers from each union, two with female household heads, and two mixed-gender FGDs, thereby capturing diverse experiences and perspectives.

Participant observation complemented interviews and FGDs by deepening insights into informal practices, local knowledge, and community dynamics shaping adaptive responses. Observations in public spaces, such as tea stalls and local shops, which are key social hubs in rural Bangladesh, revealed everyday livelihood concerns and fostered the researcher's trust and acceptance. Informal conversations with stakeholders further illuminated the values and philosophies guiding disaster risk reduction. Field notes from these interactions enriched and triangulated the primary data, adding depth and nuance to participants' accounts.

All interviews and discussions were audio-recorded with consent and transcribed manually. Transcripts were analyzed using thematic content analysis, a widely used qualitative research approach that facilitates the systematic identification, organization, and interpretation of recurring patterns and meanings within the data (Braun & Clarke, 2006). Special attention was given to how expressions of agency emerged in participants' narratives and were shaped by broader socio-ecological, institutional, and political contexts that influence adaptive practices. Throughout the analysis, reflexive and inductive reasoning were maintained to ensure that interpretations remained grounded in participants' lived experiences rather than being imposed by predefined assumptions (Nowell et al., 2017).

3.3.3 Ethics Statement

The research and data collection protocol were approved by the Joint Faculty Research Ethics Board at the University of Manitoba, Canada (Protocol Numbers: HE2023-0314). Data for the study were collected with the written consent of all participants and in accordance with the University of Manitoba, Canada's ethics protocol. Information about the study's scope and objectives was provided prior to data collection; written consent was obtained; respondents were informed of their right to withdraw at any time; and a debriefing was conducted with respondents regarding the preliminary research results.

3.4 Results

The results of our empirical investigation are presented under three sections: (1) characteristics of the agency-triggered adaptation responses; (2) the contextual drivers that trigger the application of

agency and its role in shaping adaptation, and 3) constraints against and opportunities for applying agency in strengthening resilience.

3.4.1 Agency-Triggered Adaptive Responses and Implications for Resilience Building

Empirical findings from in-depth discussions with fishers and key informants indicate that, in the study area, both locally grounded and externally supported adaptation strategies adopted by small-scale fishers—at household and community levels—are triggered by expressions of agency (see Table 7). These agency-triggered adaptive responses span economic, social, institutional, behavioural, and technological dimensions, reflecting fishers' adaptive capacity to mobilize available resources toward resilience building. The processes through which the agency triggers adaptive responses by shaping adaptive capacity are elaborated in the following section (4.2). This section presents empirical evidence on the range of agency-triggered adaptive responses identified locally and discusses their implications for resilience outcomes.

In Shyamnagar, we found that families engage in multiple income-generating activities year-round to cope with prolonged economic hardship stemming from frequent disasters and seasonal bans on forest access, which constrain their livelihoods. In response, fishers strongly emphasized livelihood diversification as a key local adaptation strategy. Familiar alternative income sources include retail shopkeeping, rickshaw pulling, wage labour, and tailoring, which are physically demanding but vital for income stability during livelihood disruptions. Seasonal migration to urban areas also emerged as a widely practised strategy to offset cyclone-related losses. A fisherman from the Burigoalini Union explained:

“Many people cannot survive the damage of the storm and cannot adapt. We move to towns and cities in search of work and support our livelihoods; we work in brick fields. There are too many dangers in the forest and too many constraints to access them, so it’s better to do any other work than go into the forest.”

An initiative in small-business entrepreneurship in crab fattening and shrimp cultivation was observed. These are usually supported by local NGOs or community projects, creating new opportunities to enhance local job creation. Some fishers generated additional income by supplying shrimp larvae to hatcheries. Women contribute through micro-enterprises, such as processing honey wax into candies and making pickles, thereby providing modest yet meaningful support to household income during a crisis.

Fishing households prepare to reduce disaster losses by protecting their assets with their own resources. Participants consistently mentioned various household-level strategies, such as storing dry food, medicine, and essential documents in polythene bags and/or burying them safely near homes before a cyclone. Women participants in FGDs reported storing fuelwood in elevated platforms (locally known as *mancha*) to prevent post-disaster scarcity. They form small action groups to conduct basic maintenance and cleaning in the cyclone shelter. This evidently shows proactive engagement in community readiness. A female FGD participant stated that:

“Due to cyclones, the woods usually get wet, so when we find a few dry ones, we put them over the wet woods so they can get dry over time, and we can reuse them. We also keep some on shelves, but if everything gets washed away, we will have nothing at hand. We do these and go to shelter centres. But the situation is unhygienic, and sometimes septic bulbs do not work, so we do basic cleaning and fix bulbs ourselves.”

Given the absence of formal livestock shelters, women devised their own protective measures, including building separate or elevated rooms for animals or leaving them untethered to enhance survival during storm surges. Damage to housing structures from cyclone wind forces and storm surge-related water forces prompted reconstruction efforts tailored to households’ financial capacities, including tying roofs with bamboo, raising foundations, and replacing thatched roofs with more durable materials such as brick, concrete, and cement. As one of the FGD participants shared:

“We tie up the base (Khuti) with the roof so that the wind cannot blow away our houses. Another option is to increase the base height so that the house is less submerged or not washed away by storm surge. We cannot even consider anything beyond this to secure our future because we don’t have money. One additional measure we implement is to provide an additional room for cattle during cyclone disasters. During storm surges, if I tie them in the room, they can drown and die. We cannot take them to the shelter centre, so I keep them open in the hope they make their way and survive.”

Table 7. *Types of Adaptation Actions and Their Implications for Building Resilience to Climatic Hazards*

Dimensions	Examples of agency-triggered adaptation actions		Implications for building resilience to climate change
	Local innovation	External innovation	
Economic	-Seasonal and economic migration -Alternative and non-farming activities (e.g., rickshaw pulling, retail business) -Collecting fish fry from the rivers	-Introducing entrepreneurship for crab fattening cultivation -Farm shrimp by large holders in the form of aquaculture	-Ensuring food security, health, and well-being -Increasing household income and addressing the unemployment crisis
Structural/physical	-Storing necessary dry foods, valuable items, and documents in a polyethene bag and burying them underground -Raising the basement of houses and tying up the base with the roof -Collection and preservation of fuelwoods from Sundarbans	-Constructing a brick-built housing structure -Arranging material for separate rooms for cattle and purchasing fodder -Preparing the shelter centre before a cyclone by fixing septic bulbs; cleaning the shelter upon receiving warning information	-Reducing food costs and sustaining health and well-being during cyclones -Reducing fuel cost and fostering cooking ability -Protecting houses from strong winds and cattle from frequent cyclones -Locating and repairing shelter centres, fostering a quick decision to move from inundated houses
Behavioural	-Reducing and adjusting daily meals -Adopting water storage practices during the disaster period	-Reliance on personal resources, along with better engagement with local institutions	-Strengthens proactive attitudes toward risk management; fosters reliance on local resources,

	-Using cultural forecasting signs (e.g., humidity or sky colour) to predict cyclones -Changing the fishing period and fishing less than the estimated amount		-Improves institutional relationships and adaptive behaviour
Institutional	-Developing locally-led cyclone-related decision-making groups for evacuation (e.g., community-led volunteers)	-Using local platforms for negotiations with government and non-government institutions -Obtaining credit from organizations to overcome economic loss -Becoming a member of different NGOs and organizations (e.g., a person can be a member of an NGO, along with MFI, to take money/credit support as per their own need) -Volunteering under organizations to help the community during disasters (through organizations)	-Establishing a linkage with organizations that help to secure resources from local organizations and markets -Identifying multiple sources of funds to relieve mental pressures -Local voices receive priority in making cyclone risk management decisions
Educational	-Peer learning among <i>gher</i> (shrimp farm) owners on disease management and disaster recovery	-Participating in NGO-led awareness programs and disaster preparedness workshops -Partaking in local institution-led awareness programs and observing Disaster Preparedness Day	-Increasing climate risk understanding capacity and adaptability -Locally-led knowledge supporting the adoption of more appropriate disaster reduction actions

Social/collective	-Informal lending process between community members and making personal timelines for payments -Placing sandbags on breached areas of embankments -Collectively elevating roadsides to prevent overflow of river water in the village during high tide -Forming small local groups (including women) to informally start fixing embankments during low tide -Forming small groups to enter the forest and collect forest resources, by sharing a boat	-Active participation in organizational campaigns/programs and better networking with them to resolve confusion about tackling community issues	-Informal lending enhances the ability to recover quickly from the aftermath of a cyclone - Collective actions fostering social solidarity to withstand the cyclone jointly
Technological	-Taking out all fishing materials from shrimp farms (<i>ghers</i>) or rivers before cyclones -Tie up fishing points firmly in case of storms -Using black fertilizers in <i>ghers</i> during high tide for increased cultivation of fish - Using flags (1 to 3) to understand the intensity of cyclones -Listening to megaphone announcements from organizations;	-Purchasing necessary materials—for example, purchasing nets (as they get damaged by cyclones); a sewing kit or a repairing kit for fixing damaged nets and boats; bamboo sticks to firmly hold fishing points; and a hand tool to pile mud for immediate use after cyclones -Dialing 1090 using IVR to get an early warning	-Helping to make a quick evacuation decision -Improved mechanism for receiving early warning -Utilizing local knowledge to predict disasters if they cannot receive early warnings, and increase fish growth in <i>ghers</i>

	receiving SMS from the government about early warnings		
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Local collective actions to repair shared structures were found embedded within fishing communities, reflecting collective agency in building resilience. Households frequently relied on building kinship networks and local community cooperation to address shared challenges, including economic hardship, food insecurity, and water insecurity. Community members also relied on informal lending systems, such as *hawlat* (kin-based borrowing), to share food and small loans, and to reduce dependence on formal financial institutions. These create a local safety net based on trust and reciprocity. Collective actions to disseminate early warnings in remote areas also reflect external innovations, such as youth and women's participation in the Cyclone Preparedness Programme (CPP), in which volunteers use flags, megaphones, and motorbikes. These socially embedded participatory initiatives not only facilitate timely evacuation but also encourage individuals to share information and assist others, demonstrating the strength of both local and external innovative strategies in creating solidarity among communities.

Institutional participation provided another avenue to resilient outcomes, as participants identified involvement in early warning dissemination, access to credit, relief distribution, and participation in local decision-making as key institutional engagement points. Fishers strategically joined multiple organizations to obtain loans during fishing ban periods or post-disaster recovery, selecting those that offered flexible repayment terms and technical support. Local NGOs, through their projects, not only provided financial assistance but also served as platforms for community members to engage in dialogue and learning. Communities gain greater access to secure credits and financial support by sharing community issues on local platforms, thereby enhancing adaptive capacity.

Behavioural changes were also evident in reshaping perceptions and practices over time. Participants reported traditional forecasting skills, such as interpreting unusual humidity as early warning signs. They also showed greater willingness and openness to participate in training and entrepreneurship programs, particularly among women who had previously faced social restrictions. As one NGO key informant shared:

“In Datinakhali (Burigoalini) in 2008, there was a woman who used to talk to us from behind the walls. We convinced the male counterpart that she can participate in local campaigns and businesses to contribute to the household, which will be helpful overall. We began including men and women working together, which facilitated the transition to empowering

women. Now that the woman who talked behind the walls speaks with confidence at the local government platform.”

Some key informant respondents reported that households currently show increased interest in receiving early warnings, climate education, and exposure to basic technologies for water storage and filtration. Such behavioural shifts indicate a gradual transformation from dependence to self-organization and inclusion, as communities increasingly align their fishing schedules with seasonal bans, embrace conservation awareness, and participate in collective decision-making processes.

Technological practices reflect the adoption of external innovations among fishing households. Fishing households tend to integrate both modern and low-cost local technologies to enhance disaster preparedness. Mobile phones, SMS alerts, and IVR systems (e.g., 1090), along with Cyclone Preparedness Program⁸ (CPP) miking (announcements via local megaphones) play critical roles in disseminating information and ensuring timely evacuation. A female respondent explained:

“We receive early warning information in multiple ways. Youth volunteers wave flags and announce information via megaphone. We also receive SMS messages from telecommunications providers and the government. Radio is no longer used; people do not have television either. CPP people announce everything, and they also help with the evacuation.”

Simultaneously, low-cost local innovations, such as bamboo-anchored nets, black fertilizer for *gher* productivity, and post-disaster net repairs, demonstrate context-specific adaptation to minimize economic losses. In this regard, mutual support and social learning play a crucial role, as fishers often share knowledge about these low-cost innovations to develop more effective strategies for healthy fishing cultivation and to secure fishing materials before disasters. These hybrid strategies (a combination of local and external innovation strategies) bridge local and institutional knowledge systems to build resilience.

⁸ The Cyclone Preparedness Program (CPP) is a unique institutional arrangement for community preparedness initiated by Government of Bangladesh and Bangladesh Red Crescent Society to mitigate the challenges of catastrophic cyclones through community disaster preparedness.

3.4.2 The Role of Agency in Shaping Adaptation

Drawing on in-depth interviews and key informant discussions, the results illustrate how expressions of agency unfold adaptation actions within social and institutional settings. The identified adaptation strategies are organized according to the form of agency reflected (individual or collective) and the orientation of adaptation (reactive or anticipatory), capturing whether responses emerge primarily as post-shock coping and passive responses (reactive) or as forward-looking preparedness (anticipatory) and risk reduction. Our findings also explore how triggers of agency contribute to the adoption of responses in fishing communities. The results are organized across economic, social, institutional, political, natural, and physical dimensions, illustrating how agency emerges through lived experiences and crises across these dimensions (Table 8).

Economic uncertainty is a major driver of triggering agency among fishing households. Recurrent cyclone-induced losses, restrictions on forest access, and seasonal fishing bans create profound livelihood instability, driving the need to seek new sources of income. Conversations with fishers revealed a shift toward alternative, labour-intensive income sources, reflecting deliberate decisions to sustain household expenses during prolonged hardship when traditional fishing becomes uncertain. An NGO key informant noted:

“Unemployment opportunities lead to seasonal migration in this area. Salinity intrusion and frequent disasters are the main reasons. Usually, they go to brick fields seasonally. During low tides and the dry season (which lasts almost six months), people who depend on fishing and forest resources cannot earn money here. So, they leave this region. The forest permit is also off for almost six cumulative months. During the rainy season, many people come back. Almost 40% come back.”

Due to a lack of diverse employment opportunities in the region and, at times, fear of entering the forest alone, many male fishers migrate and pursue other income-generating activities. They typically assess migration options by relying on social connections outside the region, mentally prepare for being away from family, and entrust household responsibilities to their wives during their absence. Such a decision-making mechanism requires a proactive role in addressing an ongoing crisis and hence reflects an anticipatory expression of agency. Similar sentiments were echoed in the community-based FGD conversations. An FGD member stated:

“Many people cannot survive the damage of the storm and can't adapt. We move to towns and cities in search of work and livelihood. There are too many dangers in the forest, so it's better to do any other work than go into the forest.”

Similarly, the decision to seek credit from both formal and informal sources indicates the emergence of strategic agency that assesses rigid institutional terms and identifies flexible systems suited to their capacity. As we heard from fishers in Burigoalini: *“We prefer loans for an entire year all at once; small loans limit us from investing in long-term measures or purchasing housing materials.”*

We found that physical losses due to cyclone impacts further activated individual agency in fishing households. Repeated damage to houses and livestock sheds from cyclones underscores the need for long-term adaptation measures. Participants frequently described aspirations to reinforce roofs or elevate housing bases when savings or credit allow. However, low-SES households can barely invest in long-term adaptation efforts to strengthen housing structures due to high market prices and lack of affordability; hence, the effectiveness of these adaptation efforts is, in most cases, limited to selective households. Similar intentionality underpins actions for water insecurity, as women highlighted the need to adopt basic filtration methods, store water in advance, and seek safer sources. These challenges have fostered a collective intent to adopt basic water-filtration practices and seek safer water sources as an anticipatory expression of agency in implementing household-level disaster preparedness. Many women mentioned their intent to repair septic systems and clean shelter centres, reflecting local innovations informed by lessons learned from past experiences.

Institutional engagement also plays a key role in shaping collective agency, reflecting an anticipatory expression of agency, as community members informally plan and decide to show solidarity on local government platforms to reduce institutional lag and prompt a response to disasters. Experiences of exclusion and delayed support from formal organizations, particularly the Bangladesh Water Development Board (BWDB), have fostered a sense of collective urgency and leadership among community members to respond promptly and coordinate evacuation efforts, as well as to protect shared structures. As one of the FGD participants recounted,

“These days, we repair the damaged embankments ourselves using our own resources and with some support from the Union Parishad. Government agencies typically require at

least 15 days to respond, but we cannot wait that long, given the extent of the submerged assets. So, we fix them on our own.”

Knowledge sharing and maintaining strong social linkages have become an intentional practice for enhancing readiness and shaping adaptive decision-making. Communities feel the need to find an alternative to formal financial mechanisms due to stringent payment conditions. In this situation, they rely heavily on kinship and neighbourly networks to mobilize funds informally. This reflects strong social linkages that are used to temporarily offset financial hardship, thereby enhancing adaptive capacity.

We found that political aspects also generate collective agency among local inhabitants by mobilizing a sense of injustice and motivating political participation. Fishers reported instances of exclusion from government relief packages and other formal processes, which have spurred empowerment and led communities to engage more assertively in Union Parishad meetings and local campaigns, demanding fair resource distribution. This collective agency allows a transition from passive dependence to civic assertion. An FGD participant among the fishers explained:

“Those with good political connections receive government aid, while those living below the poverty line, who could truly benefit even from 5,000 to 10,000 Taka, are excluded. The government provides monthly rations of 5 kg of rice, 2 kg of lentils, and oil, but not everyone receives them. People are required to pay 70 Taka to access these rations.”

We also found passive responses among fishing households to political and structural constraints. For example, landless fishers living on embankments or in char areas are sometimes evicted due to land regulations, infrastructure management, or when char lands are leased to local elites, often without prior notice or relocation arrangements. As a result, some households are forced to move and temporarily live along roads or search for other char areas for settlement. In Munshiganj, several households have lived in char areas for decades despite repeated exposure to disasters, as no long-term relocation options are available. Similarly, households in Burigoalini reported reducing food consumption for extended periods due to chronic poverty and selling livestock before disasters to anticipate losses. These responses illustrate reactive forms of agency shaped by immediate survival needs.

The natural and ecological dimensions of agency formation are deeply tied to fishers' exposure to natural threats, such as wildlife attacks. Many participants emphasized the need for group-based resource collection and coordination with youth and community networks for both safety and mutual support. A FGD participant stated, *"Forest is a scary place, poses a threat to our security, so sometimes we enter in groups for moral support too"*.

Table 8. *The Role of Adaptive Capacity Dimensions in Triggering Agency for Adaptation Actions*

Adaptive capacity dimensions	Processes that trigger agency	Role of agency in adopting adaptation actions	Form of agency	Agency-orientation
Economic	-Cyclone-led economic hardship triggers innovation for overcoming economic loss -Climatic events and prolonged hardship stimulate the aspiration to pursue labour-intensive, non-farming work -Seasonal forest bans motivate the adoption of seasonal migration as a strategy to manage income insecurity	-Ability to decide, identify, and pursue non-fishing livelihood options enhances income stability -Assessing ways for seasonal migration to tackle the economic crisis	Individual, and collective	Anticipatory
Physical	-Repeated destruction of homes and assets during cyclones triggers prioritization of asset protection and preparedness. -Severe water insecurity motivates exploration of alternative sources and storage methods -Scarcity of dry fuelwood drives innovation in storage and usage practices.	-The ability to understand the implications of property damage enables one to decide on actions to safeguard assets before cyclones -Navigating collective efforts to secure drinking water through storage, filtration, and timed collection - Collecting information related to fuelwood markets and collecting money	Individual, and collective	Reactive and Anticipatory
Political	-Inequitable distribution of relief by the government organizations makes disaster victims more ardent to bargain	-Recognizing the need to participate in government	Collective	Anticipatory

	with local politicians and communicate with local organizations -Political control of embankments during coastal floods drives marginalized groups to raise their voices	campaigns to attract more funds or resources -Rising voices and engagement with local politicians are increasing leadership capacity and leading to the decision to repair the embankment utilizing local resources		
Social capital	-Debt cycles motivate stronger social ties and cooperation -Debt traps due to high interest rates and strict payment conditions from organizations, encouraging informal transactions	-Seeking financial help informally through using social networks to manage funds	Individual	Reactive
Social learning	-Peer learning and iterative knowledge exchange among fishers foster adaptive ideas during fishing bans -Queries regarding resource collection, information related to ban-period, common fishing barriers in the forest, and the need among fishers to develop a network with local organizations to share or interact during workshops and meetings	-Learning that building institutional linkage and social linkage can support managing funds -Building a network with local organizations can help to support adaptive decisions -Creation of informal learning networks improves information flow on fishing, resource access, and early warning systems	Individual, and Collective	Anticipatory
Institutional	-Limited access to formal credit highlights the need for flexible loan conditions	-Identifying economic organizations that prioritize marginals for credits	Collective	Anticipatory

	-Employment insecurity during the ban period of fishing instigates new ideas to be a member of multiple organizations -Realization of limited technical skills and education spurs participation in training and workshops	-Finding suitable organizations for membership to receive credits and have a backup source of funds -Deciding to get enrolled in higher schools, engage in training and workshops, and develop skills		
Natural	-Loss of lives and livelihoods from extreme events fosters motivation to access early warning information -High risk and fear of losing lives, being subject to tiger and crocodile attacks during resource collection in the forest, generating a need for collective safety measures -Excessive loss of fishing materials and less fish cultivation after disaster, producing a need to protect the materials before disaster, and use local knowledge to increase fish cultivation in <i>ghers</i>	-Finding appropriate sources for early warning information from technological sources (e.g., cellphones, social media) and community-based communication sources (e.g., radio youth groups, local announcements) -Collective coordination for forest entry and resource collection to ensure safety -Looking for the pricing of necessary fishing materials; learn about usage from other fishers to increase fishing cultivation	Individual, and Collective	Reactive and Anticipatory

Human agency (proactiveness)	-Cyclic and chronic poverty throughout the year due to frequent and extreme disaster losses, generating a strong desire to get out of poverty -Gendered barriers motivate women to pursue entrepreneurship and collective engagement -Inadequate cyclone shelter conditions raise awareness of gender-sensitive disaster preparedness	-Assessing ways to engage in a new business or start your own business (e.g., crab business, pickle business, working in shrimp farms) -Contacting women-based organizations in the locality to access more opportunities and leadership roles -Feeling an urge to improve hygiene and safety, especially for women and children	Individual, and collective	Anticipatory
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Note: Natural systems and geographical landscapes here are considered capitals that empower locals to develop new ideas to adapt to changing situations

3.4.3 Constraints Against, and Opportunities for, Applying Agency in Strengthening Resilience

Our research suggests that agency-driven adaptation actions tend to foster resilience; however, not all do, as fishing communities' ability to act on adaptive intentions is frequently constrained by structural, social, and ecological barriers. These constraints influence how adaptive capacity is exercised and whether opportunities for transformation can emerge. Despite these limitations, communities continue to negotiate change and identify alternative pathways for adaptation (Table 9).

Persistent economic constraints significantly limit the adaptive capacity of fishing communities. A lack of diversified skills and local employment confines many to physically demanding, low-paying jobs, such as brickfield labour or rickshaw peddling. Despite these barriers, some participants expressed aspirations to pursue small-scale entrepreneurship, such as crab cultivation or shrimp farming, and to take on leadership roles in community-based economic initiatives. A key adaptation strategy is to consider seasonal migration, which often results in wage deprivation, harassment, and unsafe working conditions. Return migration is rarely an option due to the lack of employment locally and the prolonged forest ban in the Sundarbans. An NGO key informant explained:

“People here have depended on the Sundarbans since their childhood. When they go to brickfields, they often become sick because they’re not used to such an environment or workload. They take dadon [a high-interest, local moneylending system] and are forced to remain—even when chained—when they want to return. One boy couldn’t come back until we sent money from our house.”

A major barrier to physical adaptation is the limited financial capacity to repair or strengthen housing structures after disasters. Many fishing households remain in partially damaged structures for extended periods, heightening exposure to future hazards and delaying recovery. The absence of dedicated livestock shelters, both on household premises and in cyclone centres, increases livestock's physical vulnerability to cyclones. Families often leave cattle unattended during storms, leading to losses through drowning or displacement. Some fishers find an alternative option by selling livestock early at low prices, while a few build makeshift sheds or allocate rooms for animals; these measures are generally unaffordable for poorer households.

Political barriers significantly shape who benefits and exclude marginalized members from adaptation interventions, thereby limiting equitable governance. For example, relief distribution favours households with political connections and excludes marginalized ones. During repairs to a damaged embankment, local power dynamics come into play, leading to repairs in only selective areas. As a result, trust in formal safety nets erodes, and communities are often forced to undertake collective embankment repairs with their own resources before government aid arrives. An FGD member explained political favouritism in the following words:

“The government relief and rations do not reach us properly; those are distributed among the favoured people by the local government. Government relief is first handed over to the Chairman or a Union council member. He/she then distributes these relief goods or cash to the people closest to him/her, and then the leftovers are given to other local people.”

A woman respondent from Munshiganj added:

“We are required to buy water drums by taking loans from organizations for regular use. Even if we bring 20 drums, our roads are damaged, so we cannot always bring them home. Due to favouritism and damaged roads, this area is deprived of this help.”

In the face of challenges in inclusive decision-making, community members exhibited a growing collective awareness of governance accountability. Women in general expressed greater interest in participating in local platforms to raise their issues. One woman, a member of the disaster management committee, highlighted the gender imbalance in local governance and the need for more female representation:

“More women's involvement is needed because men tend to discuss social problems in tea stalls during leisure, whereas women raise issues all the time, while doing household chores near rivers and ponds. We could raise more and different issues if we were in the Union Parishad, but it doesn't happen due to the exclusion of women members.”

Institutional barriers, particularly in accessing credit, constitute a significant impediment to households' financial sustainability during lean fishing periods. Women who manage daily household expenses emphasized that the cumulative burden of water costs, children's needs, and other essentials often exceeds the capacity of institutional loans to cover. It was noted that community solidarity in voluntary disaster response (e.g., elevating roadways to protect land from

high tides, or collective actions to repair embankments) and the incentives to engage in such actions can enhance agency and lead to resilient outcomes. In this regard, fishers reported financial struggles with credit loans. An FGD respondent explained:

“The loan we take is usually used in our household expenses, children’s miscellaneous expenses like educational expenses, especially when the permit is off, and we must drain our loans and savings. We have difficulty allocating the loan. One water jar (30L) costs 40 Taka and lasts a day or two. We buy 30 jars a month. Then there’s transport cost, and these all add up.”

Corruption in forest governance further constrains adaptation. Fishers reported demands for bribes from government officials, threats of fabricated legal charges, and misleading navigation signs that foster fear and restrict local inhabitants’ access to forest resources. Group entry into the forest is a locally developed mechanism to tackle corruption in the forest and to address wildlife threats together. Many fishers discussed corruption in the forest as another form of institutional vulnerability they face: An FGD participant from Burigoalini said:

“In the forest, there are specific areas for collecting honey; these locations can’t be accessed without bribing the officers in charge. People who go to the forest aren’t scared of tigers. They fear Bonodoshyu (armed robbers), foresters, and coast guards. Foresters must be bribed to enter the forest during the off-season and to bail them out of jail if they are arrested for attempting to enter prohibited areas. There are confusing signs indicating regions of the forest that are safe and the regions that are not (protected areas), which creates an opportunity for the forest officials to develop fabricated legal cases.”

Another structural limitation stems from seasonal conservation bans that impede the translation of agency-led economic actions into resilience. While participants supported conservation, they criticized blanket bans as misaligned with local realities. For example, the hilsa fishing ban during October and November affects fishing communities in Shyamnagar, where the species is rarely found. Similarly, the January–February ban on crab collection restricts access for other resource users. With multiple overlapping bans and inadequate compensation, these regulatory measures undermine livelihood security and, at times, drive illegal fishing.

Social constraints, particularly gendered norms, continue to limit women's participation in adaptation. Women bear the brunt of domestic responsibilities, such as water collection, childcare, and disaster preparedness. In turn, such overburdened responsibilities lead to emotional strains and, in some cases, to domestic violence. An FGD participant elaborated:

“There are some matters we cannot say in public. We have a responsibility to manage everything. When my child asks for school supplies, how do I cover that? When my husband returns home, and I reveal my frustration, that leads to violence.”

A female respondent from Burigoalini stated that, *“Previously, women stayed totally silent by tolerating violence, but now we also talk back because this cannot go on.”*

NGO interventions are gradually shifting to deal with these gender-related issues. Gender sensitization efforts involving men have supported women's growing roles as Union Parishad members, NGO staff, and leaders in women-focused campaigns.

Overall, while systemic inequalities such as persistent economic hardship, governance failures, and gendered social norms continue to constrain adaptive capacity, fishing communities consistently mobilize both individual and collective agency to address these barriers, using their own limited resources and abilities.

In contrast, external interventions also lead to escalating individual agency into collective agency even amidst strong patriarchal norms, which stresses how structural management can extract opportunities out of constraints. As one of the KII participants reflected on a gender sensitization initiative for women in Burigoalini:

“We wanted to engage women in entrepreneurship but patriarchy is very strong in the area. Some women used to talk from other side of the wall with us, and were not allowed to work outside. We counselled with men of the household about positive sides of women working in entrepreneurship and small businesses that can bring financial stability. With time, these women are now engaged in pickle, candle, wax making, receiving training from outside the country and more independent than before.”

Collective agency can also enhance individual agency when community norms, values, and shared learning environments generate knowledge and aspirations among individuals. For instance, newly engaged fishers often interact with experienced fishers to learn practices such as improving fish cultivation in gher, protecting gher from cyclones, storing fishing materials, processing and marketing fish, and treating fish diseases, particularly when formal training programs and organizational workshops are not available year-round. In this context, the informal practice of gathering with experienced fishers, along with social networking and kinship ties, enables individuals to strengthen their skills and manage available resources more effectively.

Table 9. *Barriers Against Adaptive Capacity Building and Adaptation Actions, and Opportunities*

Types of Barriers	Example of barriers	Implications of barriers	Opportunities
Economic	-Lack of skillset for different alternative income generation activities, leading to just looking for labour-intensive options -Lack of employment options increases dependency on loans or credits -Difficulty in paying off interest and credits to multiple institutions on time	-Economic migration limits the scope for investing in other jobs or opportunities -Working for other labour-intensive jobs limits diversification -Falling into a vicious loan trap	-Engagement in entrepreneurship and leadership positions
Physical	-Lack of a cyclone shelter for livestock -Lack of funds to strengthen the housing structure	-Draining savings to re-purchase cattle/livestock, with fear of losing them during the next cyclone -Inability to adopt long-term adaptation measures for housing	-Purchasing housing materials at a lower price -Constructing the livestock and cattle sheds collectively
Political	-Political favouritism is affecting equal relief distribution, creating conflicts -Failure to regularly manage and respond to repairing embankments on time -Political support for corrupt forest officials for abusing forest resources	-Unequal access to resources due to political favouritism (like water drums, forest pass cards, ration cards) -Excessive loss of assets due to overflow of water and organizational lag (government) in responding to the damage -Longer recovery from disasters due to a small amount of credits for expenditures, which leads to zero savings and no investment for long-term adaptation measures	-Invest in fair distribution of relief and prompt institutional response -Invest in long-term adaptation measures like rehabilitation and reconstruction of houses, boats for fishing, etc.

Gender	-Social norms create a hindrance to women's participation in campaigns -Fewer women participate in Union-level programs, and no remuneration is provided to them -People who raise their voice against discrimination are not called in the meetings anymore -During the collective work of sandbagging during the fixing of embankment locally, there is a lack of trained personnel to do the fixing. Some people use pipes through the embankments for water usage in the <i>gher</i>, which weakens the embankments	-Affecting learning from institutions and the smooth execution of campaigns -Disregarding the role of women in disaster management -Weakened embankment due to mud-only repairs, and installing pipes weakens the embankment's strength	-Seek opportunities related to women entrepreneurship and businesses to foster employment in the region -Invest in training workshops related to collectively fixing structures
Institutional	-Administrative lag and corruption in disaster response -A small number of credits are given at a time, making it difficult to fix damaged houses and allocate funds for recovery expenses fully	-Communities feel an urge to take up the function of administrative bodies in disaster response due to administrative lag and corruption, which makes administrations more laid back	-Community collective actions can influence institutions to provide a fast-paced institutional response -Incentives for local people to participate in voluntary actions in disaster response
Natural	-Illegal catching by fishers using harmful fishing nets and poisoning of water bodies to collect fish, causing depletion of fish stock -Seasonal forest closures to protect Hilsa (<i>Tenualosa Ilisha</i>) breeding	-Deterioration of water bodies, affecting conservation and fish catch -Less recovery time from disaster losses due to frequent disasters	-Seek proper shelter inside the forest to save lives from tiger attacks or cyclones -Seek a scheduled ban period for resource collection, suitable for each

	grounds in the Sundarbans have consequences, as they restrict access for other resource-dependent groups, such as honey collectors and fuelwood gatherers -Increased intensity and frequency of disasters due to climate variability, including salinity intrusion -No protection for fishers being trapped inside the forest during cyclones due to not receiving early warnings while working inside the forest	-Lack of drinking water; excessive shrimp farms leading to the shrinkage of cultivable lands due to salinity intrusion	resource collector group -Getting more recovery time with fewer disaster events leads to a more stable financial situation to invest in long-term measures -Participatory governance that balances ecological goals with social needs
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3.5 Discussion

Our findings illustrate that small-scale fishing communities in the Sundarbans are not passive recipients of adversity but active agents who mobilize intentional, contextually grounded adaptation responses. Fishers exercise their agency here. Agency emerges as a dynamic, evolving process shaped by cumulative disaster experiences and recurring hardship across economic, physical, institutional, social, political, and ecological dimensions, as reflected in adaptation strategies and contributing to resilient outcomes (see Tables 7 and 8). The decisions and aspirations shared by fishing communities in the Sundarbans region reflect deliberate, experience-based learning and an evolving capacity to plan and act. While constrained, agency catalyzes innovative practices that vary by context and dimension, revealing how people improvise amid uncertainty (see Table 9).

In our study, we categorized forms and orientation of agency across adaptive capacity dimensions as either collective or individual to clarify their roles in resilience building. Individual agency emerged through personal decision-making and planning, such as seasonal migration during fishing bans or in emergency preparedness. Collective agency involved coordinated efforts supported by markets or institutions, including embankment repairs, forest access management, mutual aid networks, and credit-based memberships. With respect to orientation or expression of agency, we identified both reactive and anticipatory/proactive agency, reflecting whether responses emerge primarily as post-shock coping or as forward-looking preparedness and risk reduction. Some practices bridged both forms: post-cyclone depleted fish stocks led individuals to adopt aquaculture, which later evolved into collective learning. Similarly, women's entrepreneurial aspirations, initially constrained by social norms, gained momentum through NGO support, resulting in ventures such as honey-wax candle and pickle production. These examples show how repeated exposure to hazards can cultivate overlapping capacities that enable pathways out of vulnerability. However, their contribution to resilience depends on how the agency interacts with structural barriers.

3.5.1 Role of Agency in Undertaking Adaptive Initiatives

Economic insecurity remains a central driver of agency. Cycles of asset loss, food scarcity, and repeated storm damage have led households to recalibrate their livelihoods to ensure survival while diversifying risk. Strategies such as seasonal migration, tailoring, small-scale shopkeeping, and homestead livestock rearing demonstrate what Pelling (2010) describes as incremental adaptation: forward-looking, experience-based adjustments aimed at sustaining household stability. These proactive shifts indicate a shift from coping to anticipatory

adaptation, consistent with Deb & Haque (2016) in coastal Bangladesh and Below et al. (2012) in sub-Saharan Africa, where economic stress has similarly fostered livelihood diversification as an adaptive strategy. In this context, agency becomes visible as both necessity and innovation, a deliberate response to structural precarity that enables continuity within constraint.

Economic stress also prompted strategic engagement with formal and informal institutions. Fishers increasingly display *strategic agency* by selectively engaging with organizations that offer flexible repayment terms or longer credit cycles aligned with their uncertain income patterns. As observed in this study, the *hawlat*—a kinship-based, trust-driven borrowing system—serves as a vital informal safety net, buffering shocks when institutional loans fall short. This dual engagement constitutes what Cinner et al. (2018) and Below et al. (2012) describe as hybrid resilience systems, in which formal mechanisms (institutional credit, NGO programs) intersect with local social capital to enhance adaptive capacity. Our findings conform to those of Islam & Walkerden (2014), who highlight the pivotal roles of social trust and reciprocity in recovery among marginalized groups. Thus, financial adaptation in the Sundarbans reflects not only economic pragmatism but also relational agency—anchored in cooperation, interdependence, and collective learning.

Social learning and collective agency also underpin community-level adaptation. Through shared labour and coordination, fishers collaboratively engage in embankment repair, cyclone preparedness, and forest access management, illustrating the transition from individual to collective action. Women's participation in cyclone shelter management, livestock protection, and early warning dissemination further demonstrates how localized agency manifests through cooperation. These practices resonate with Cutter et al.'s (2008) argument that resilience emerges from shared responsibility and social capital, and with Pelling's (2010) claim that adaptive learning is embedded in collective experiences. Comparative studies from Nepal (Gentle et al., 2014) and Odisha, India, (Banerjee & Mohapatra, 2023) similarly show that community cooperation, distributed leadership, and gender-inclusive participation strengthen social resilience by fostering mutual trust and reinforcing institutional memory. In the Sundarbans of Bangladesh, such collaboration transforms disaster response from reactive relief into organized community-led preparedness.

To secure assets and minimize damage, the agency is evident in the adoption of low-cost, experience-based innovations that mitigate disaster damage. Practices such as tying roofs

with bamboo, raising house foundations, or burying valuables in polythene illustrate what Pelling (2003) and Ebi et al. (2006) termed *appropriate technologies*: locally adapted, accessible innovations developed through trial and error rather than external intervention. These actions represent cumulative learning processes that transform everyday experience into practical knowledge, fostering a culture of preparedness. Similar adaptive behaviours have been documented across hazard-prone regions of Bangladesh (Alam et al., 2018; Deb et al., 2011), demonstrating that lived experience, rather than financial capital, often drives innovation in disaster contexts. Even among the poorest households, aspirations to invest in durable housing or prepare emergency kits reflect adaptive intention, even when material realization is delayed.

Ecological challenges, such as recurrent cyclones, salinity intrusion, and wildlife threats, further shape both individual and collective agency. Rather than disengaging from risk-prone livelihoods, fishers have developed coordinated approaches to manage risk collectively, such as entering forests in groups, maintaining communication networks, and cooperating with youth volunteers to receive early warnings. These practices embody what Eriksen & Kelly (2007) and Azad et al. (2022) described as *collective risk memory*, in which repeated exposure to hazards fosters awareness, solidarity, and anticipatory capacity. Through cumulative learning, communities internalize preparedness behaviours that evolve into adaptive norms. Thus, ecological adversity, rather than merely constraining action, becomes a crucible through which adaptive agency matures.

The integration of external and local innovations further demonstrates how agency develops adaptive capacity. The widespread use of mobile phones, SMS alerts, IVR systems, and the Cyclone Preparedness Programme (CPP) miking network illustrates the localization of external technologies into community practice. These tools enhance anticipatory decision-making, allowing households to prepare more effectively for disasters. Simultaneously, local innovations, such as bamboo-anchored fishing nets, gear repair, and the use of black fertilizer for *gher* cultivation, reflect grassroots experimentation that sustains livelihoods with minimal resources. Together, these practices exemplify the interplay of *external* and *internal* innovation streams (Cinner et al., 2018), reinforcing that adaptive learning is co-produced through the interaction of institutional support and local knowledge.

Taken together, these findings affirm that agency operates as more than a domain within adaptive capacity; rather, it serves as a catalyst that enables small-scale fishers to mobilize their

adaptive capacity through innovation and learning. This echoes van der Ploeg & Long's (1994) conception of agency as the capacity to maneuver within and against structure, continually negotiating constraints. By situating agency within its social and institutional context, our findings extend the theoretical understanding that adaptive capacity is not static but dynamically produced through lived experiences.

3.5.2 Major Constraints and Opportunities Shaping Agency-Triggered Adaptation Actions

While agency is essential for enabling adaptation, our findings indicate that it does not always translate into resilience. In the Sundarbans, fishers exhibit strong intentions and capacities to act, yet intertwined structural, institutional, and social forces constrain their ability to convert these into adaptive outcomes. This aligns with Sen's (1996) and Adger's (2003) assertion that access to resources, institutional responsiveness, and prevailing power structures shape agency. Its realization is mediated by structural, institutional, social, and ecological constraints that shape how adaptive capacity is mobilized, constrained, or redirected. The following discussion highlights how these interconnected barriers reinforce cycles of vulnerability, while also revealing opportunities that emerge within these constraints.

Our findings suggest that the most significant barriers to translating agency into resilience stem from institutional fragmentation, political favouritism, and economic precarity. As Giddens (1984) posits, agents operate within structures that both enable and constrain their capacity to act. In the Sundarbans, this duality is evident: fishers deliberately choose to repair embankments, diversify livelihoods, and negotiate institutional credit, yet these actions remain constrained by systemic governance failures. Relief distribution and credit allocation are often mediated through elite networks, privileging those with political connections and excluding poorer households, echoing Choudhury and Haque's (2016) findings on elite capture in disaster governance. Similar dynamics have been documented elsewhere, such as in Ethiopia, where local leaders' control over water access reinforced inequality (Yohannes et al., 2017). These structural asymmetries erode trust in formal systems and compel communities to rely on informal networks, reinforcing a pattern of "reactive adaptation" (Cutter et al., 2008) rather than sustained resilience.

Economic constraints further limit the agency's transformative potential. The absence of affordable, disaster-resilient infrastructure traps households in cyclical rebuilding after each storm. As Alam et al. (2018) note, this creates "adaptation fatigue," where repeated coping depletes resources and motivation for long-term investment. Institutional loans, while vital, are

often insufficient for major reconstruction, leading households to depend on informal credit systems such as *hawlat*, trust, and reciprocity. These forms of social capital, while strengthening short-term recovery, highlight the relational rather than structural basis of resilience (Brown & Westaway, 2011). They enable survival under constraint but cannot substitute systemic investment and equitable governance. In this sense, agency is visible but bounded, a pragmatic response to constraint rather than a pathway to transformation (van der Ploeg & Long, 1994).

Gendered norms compound these challenges by shaping who exercises agency and how. Women's growing engagement in micro-enterprise and NGO activities illustrates adaptive initiative, yet caregiving burdens, mobility restrictions, and limited decision-making power constrain their autonomy. These findings echo the feminist political ecology perspective (Arora-Jonsson, 2011; Rocheleau et al., 2013), which emphasizes that resilience is not gender-neutral but mediated through patriarchy and everyday inequities. As women in our study expressed, their participation in adaptation often leads to increased emotional strain, further causing domestic conflict, revealing the hidden costs of adaptation within patriarchal systems. As NGOs focus on women's inclusion and participation campaigns, it is necessary to broaden men's perspectives simultaneously. Nonetheless, our findings also support that NGO-led gender sensitization and inclusion in Union Parishad activities are fostering incremental shifts; these reflect signs of what Lister, (2004) terms "transformative agency", in which individuals collaborate to renegotiate social norms and political spaces. This reflects how agency evolves when external interventions consider cultural aspects of a community and, therefore, escalates individual agency to collective agency with time.

Environmental governance policies, such as extended forest and fishing bans, illustrate another domain where institutional decisions constrain local agency. These top-down conservation measures, while ecologically motivated, often disregard local livelihood contexts, pushing fishers into exploitative labour markets or illegal forest entry. This echoes Ribot's (2014) critique of "green governance," where adaptation and conservation frameworks inadvertently reproduce marginalization. Yet these same experiences of exclusion can, in some cases, catalyze new forms of collective action. According to our findings, fishers' emerging advocacy for fair compensation and participation in policy decisions indicates a shift from passive compliance to political engagement. This aligns with Adger et al.'s (2009) argument that adaptation becomes sustainable only when communities have voice and agency within governance systems.

Despite these constraints, our findings also highlight communities' creative capacity to turn adversity into opportunities. When institutional aid is delayed, fishers organize collective embankment repairs; when formal loans fall short, they pool savings through social networks; when gender norms restrict women's public roles, they create informal spaces for dialogue and cooperation. These actions reflect what Pelling (2010) calls *incremental transformation*—that is, small but significant actions that help build everyday resilience and maintain social cohesion in contexts of uncertainty. Similarly, Berkes and Ross (2013) emphasize that resilience is rooted not solely in assets or infrastructure, but in trust, cooperation, and local leadership. We find all these attributes evident in the adaptive behaviour of Sundarbans fishers.

The agency operates here as both *resistance* and *resilience*: resistance against structural inequities and resilience through collective adaptation. This dual function is well explained through Scott's (1989) concept of everyday resistance and Lukes' (2004) multidimensional view of power, showing how aggregate the micro-practices (subtle, and may be non-political) in response to the externally driven formal interventions that interrupt existing adaptation strategies—and agency—of local actors, considered as resistance, may be overlooked under domination of powerful actors. As our findings on local adaptation practices in water storage and filtration recognize both individual and collective agency as anticipatory responses to increased water insecurity, this is also a classic example of everyday resistance amid structural neglect. Despite extreme salinity intrusion, government interventions remain limited and often ineffective—tubewells extract saline water, PSF installations are scarce, and NGO water support is selective—leaving households dependent on rainwater harvesting, purchased water, and saline water for daily chores. In response, fishers and their families adopt locally improvised strategies to secure water and sustain livelihoods, reflecting what Scott (1989) conceptualizes as “everyday resistance,” in which marginalized groups protect their survival through practical, non-confrontational actions in the absence of formal support. When embankments break, and roads are damaged by storm surges and cyclones, communities often mobilize rapidly, drawing on their own labour and resources to prevent further loss, reflecting strong collective agency.

However, this self-organization is not simply a sign of local capacity, but also a desperate response to administrative delays and inadequate state action. Despite repeatedly voicing concerns on local platforms, repairs remain delayed and poorly implemented, and state action is widely perceived as shaped by corruption and elite capture, with public funds diverted and relief distributed through favouritism. Interpreted through Scott's (1989) lens, this

represents a form of everyday resistance: communities act to secure their survival and protect their assets in ways that compensate for neglect by governance, while open protest remains constrained because it is socially and politically risky. At the same time, Lukes' (2004) framework helps reveal how visible power (control over resources) and agenda-setting power (limiting accountability) suppress community demands, keeping collective agency bounded within structures of domination. From an intersectionality lens on power and vulnerability (Johansson and Vinthagen, 2016), our findings recognize a high agency element in women of Burigoalini in raising voice for more inclusion of women (securing seats in local government) in governance and against local discrimination of women in relation to ownership of assets; however, the findings reveal how institutional gatekeeping can limit women's participation, reflecting Lukes' (2004) second dimension of power. These patterns align with evidence of elite capture and institutional discontinuity shaping adaptation outcomes (Choudhury & Haque, 2016; Gentle et al., 2007).

Our findings also indicate that not all adaptive responses are primarily driven by proactive initiatives. In many cases, responses emerged from structural pressures that left households with limited alternatives. For example, landless fishers residing on embankments or char lands reported sudden evictions due to land regulations, infrastructure management, or the leasing of char areas to local elites, often without relocation arrangements; this led to their subsequent movement to roadsides or to search for alternative char settlements. This represents adjustments compelled by immediate survival needs rather than planned adaptation, and, therefore, these are non-agency-triggered responses. Similarly, households in Burigoalini described reducing food consumption during prolonged periods of poverty and selling livestock in anticipation of disaster losses, reflecting distress responses shaped by economic constraints. These examples suggest that some adaptation responses arise from structurally imposed conditions rather than from proactive decision-making. In this context, agency becomes constrained and reactive, illustrating how structural inequalities and governance limitations shape the scope and direction of adaptive actions.

In summary, while human agency in the Sundarbans catalyzes adaptive practices, translating them into resilience depends on enabling conditions, such as equitable governance, sustained institutional support, and social inclusivity. The findings contribute to theoretical debates by emphasizing that agency is not merely a domain within adaptive capacity (Cinner et al., 2018) but a mediating mechanism whose effectiveness depends on the structural and institutional environments in which it operates. Hence, agency needs to be considered an

explicit dimension of adaptive capacity. When constrained, agency generates coping; when supported, it cultivates resilient outcomes. Recognizing and strengthening this dynamic interplay is thus crucial for advancing more equitable and durable resilience in disaster-prone, resource-dependent settings.

3.6 Conclusion

This research clearly showed that exploring the link between human agency and adaptation actions yields a more nuanced understanding of communities' adaptive capacity in the context of disasters. Empirically, we examined how small-scale fishing communities in Bangladesh's mangrove coastal regions develop and implement adaptive responses by exercising human agency amid chronic climatic and non-climatic stressors. Drawing on primary data analysis, we infer that adaptation strategies are not merely reactive but deliberate, strategic actions shaped by accumulated lived experiences and structural constraints. Agency in these communities emerges as a dynamic process, constantly negotiated and recalibrated in the face of recurring shocks and uncertainties that play a crucial role in building resilience.

By examining both locally driven and externally supported adaptation strategies across multiple dimensions, our research underscores that individual and collective agency are central to building resilience. In relation to intentionality, adaptive responses also reflected reactive and anticipatory expressions of agency. These responses—such as alternative income generation, informal lending practices to offset financial hardship, household-level adaptations to disaster impacts, and collective actions to protect shared resources—reflect purposeful efforts to reduce vulnerability, sustain livelihoods amid chronic precarity, and contribute to bringing resilient outcomes.

Yet application of agency remains persistently constrained by systematic and social limitations, such as political favouritism, corruption in forest governance, entrenched gender norms, and repeated seasonal bans that undermine recovery. In response to the political dominance in adaptation processes, our findings reveal increased civic engagement and participation, particularly among women leaders and youth volunteers. This shift indicates that communities have moved beyond passive dependence on aid to more strategic, organized advocacy, reflecting resistance as a strategic expression of agency amid constraints. Ultimately, the resilience of these communities is underpinned not only by material resources and asset mobilization but also by the capacity to exercise agency through context-specific adaptive responses amid uncertainty.

Several policy priorities arise from this study. Strengthening accountability and reducing political bias in the distribution of relief and adaptation resources are essential to ensure equitable support for marginalized households. Investments in context-specific livelihood programs can help transition coping strategies, such as exploitative migration, into pathways that build skills and long-term economic security. Fostering inclusive decision-making platforms and recognizing women's roles in adaptation, alongside measures to increase women's asset ownership, are critical to unlocking the full potential of collective agency. Finally, improving transparency in institutional collaboration and strengthening the monitoring of disaster risk reduction and livelihood initiatives will be critical for restoring community trust and sustaining participation in resilience-building efforts. Future research should explore how hybrid institutional arrangements and locally embedded innovations can be supported and scaled across other hazard-prone coastal regions. As this study underscores the central role of human agency in shaping adaptive capacity under persistent stressors, we further emphasize the need to develop context-sensitive tools and approaches that enable more integrative assessments of adaptation processes in disaster-prone settings.

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Chapter 4

Discussion and Conclusion

4.1 Introduction

This study examined the multidimensional nature of livelihood vulnerability and the dynamics of adaptation among small-scale fishing communities in the Sundarbans mangrove coastal region of Bangladesh. The overarching aim was to understand how varying degrees of vulnerability are produced or amplified by intersecting socio-economic realities and social dynamics within fishing communities, and how they develop and implement adaptation actions in the context of disasters. In examining fishing community members' adaptive capacity, this study keeps agency formation as a focal point to clarify their role in resilience building, thereby contributing to a more nuanced understanding of the vulnerability and adaptation of small-scale fishing communities in a disaster-prone context.

The research was guided by two specific objectives:

- i) to examine the patterns and dynamics of livelihood vulnerability of small-scale fishing communities in the Sundarbans region of Bangladesh; and
- ii) to explore how agency is exercised in adaptation strategies and to identify the drivers and role of agency in shaping adaptation actions.

The results were presented in Chapters 2 and 3. Chapter 2 (Manuscript 1) addressed the first objective by quantifying livelihood vulnerability using a composite index based on socio-economic class and gender, and by highlighting significant disparities between the two study Unions. The analysis revealed that lower-income households and women-headed households exhibited higher adaptive capacity despite greater exposure and sensitivity. These characteristics underscore the roles of structural inequalities, intersectionality, and social norms in amplifying vulnerability and shaping the constraints and opportunities of adaptation.

Chapter 3 (Manuscript 2) examined the second objective through a qualitative lens, offering insights into the dynamics of agency amid structural constraints. The analysis revealed that fishers engage in hybrid economic practices, rely on local knowledge, and maintain strong social networks, all of which support locally grounded resilience-building strategies. These practices reflect elements of agency that evolve through cumulative learning experiences. However, the application of agency in driving resilience was often limited by institutional barriers and environmental stressors. Importantly, the study found that many of these adaptive

strategies reflect intentional and strategic decision-making, challenging narratives that frame local responses as purely reactive. By foregrounding agency, the research identifies critical adaptive pathways through which fishers negotiate risk, restructure their livelihoods, and pursue greater security amid uncertainty.

This chapter synthesizes the key findings and discussions from both manuscripts, elaborates on their contributions to the literature on climate change adaptation and vulnerability, and offers policy and practice recommendations. It also outlines the study's limitations and proposes directions for future research. The chapter concludes with the researcher's final reflections on the significance and implications of this work.

4.2 Discussion

The objectives have been achieved, and the associated results and findings have been presented in Chapters 2 and 3. A synthesis of the key findings is given below:

4.2.1 Socio-economic Dimensions and Gender Dynamics Interact to Produce Asymmetric Vulnerability

The vulnerability assessment in this study confirmed that fishers face multiple forms of vulnerability (e.g., health, food security, access to resources) due to the complex interplay between socio-economic position and gender roles in the mangrove coastal region. Lower-income households experienced significantly higher levels of exposure and sensitivity to climatic risks such as cyclones, storm surges, and salinity intrusion, primarily due to limited asset endowments, insecure housing conditions, and unequal access to institutional support. Women-headed households were found to be more vulnerable due to the compounded effects of unequal gender roles, responsibility for household care, constrained decision-making power, and chronic health burdens arising from food and water insecurity.

Even when these groups demonstrated relatively strong adaptive practices, such as maintaining social networks, diversifying income options, or engaging in small-scale businesses, these efforts did not fully offset their heightened vulnerability. Medium- and higher-income households, by contrast, were generally better positioned to protect assets and to access rehabilitation measures, which kept them comparatively less vulnerable—yet they still faced socio-economic class-specific problems, such as exclusion from the beneficiary list despite greater asset loss. These findings conform with Djoudi et al. (2016), who demonstrated that intersecting gendered and economic inequalities amplify the burdens of climate change, frequently resulting in poorer health outcomes, food insecurity, and reduced capacity to

recover. Similarly, Denton (2002) and Eastin (2018) have shown that entrenched patriarchal norms and exclusionary institutional arrangements systematically undermine women's adaptive capacities, despite their essential contributions to household survival and resilience.

In this context, vulnerability remains a persistent and unevenly distributed burden that cannot be fully understood without attention to social hierarchies and gendered power relations. This study highlights the need to incorporate community heterogeneity and an intersectional perspective into vulnerability assessments, rather than assuming uniform experiences across all households. This study further emphasized the importance of measuring actual and relative vulnerability before applying a comparative lens to capture the full picture of a particular region.

At the same time, our study found that the same factors that drive vulnerability also create opportunities for innovation as households attempt to mitigate risk and rebuild livelihoods. For example, women-headed households, despite facing disproportionate burdens of food and water insecurity and limited decision-making power, engaged in proactive livelihood diversification, micro-enterprise, and collective action to secure resources. These actions demonstrated greater proactivity in developing new ideas for entrepreneurial activities and leadership positions. Similar observations have been reported by Tschakert (2007), who found that chronic poverty and environmental stress in rural Senegal spurred farmers to develop innovative livelihood strategies, and by Coulthard (2012), who showed that fishers in India's Chilika Lagoon transformed repeated crises into opportunities for agency-led adaptation. Rather than viewing vulnerability solely as a deficit, these findings suggest that it can also be a generative space in which agency catalyzes innovation. This underscores the importance of including agency as a core element within vulnerability assessments to more accurately capture how adaptive capacity evolves in contexts of chronic adversity.

4.2.2 Assessment Beyond Spatial Features: Adding Depth in Viewing Place-based Vulnerability

The results of the present study underscore that the interaction between spatial features and socio-economic processes largely constructs the vulnerability of coastal fishing communities. Findings from this study demonstrated that the Munshiganj and Burigoalini Union communities are similar in their exposure to cyclonic hazards but exhibit significant disparities in livelihood vulnerability, driven primarily by variations in social, economic, and institutional conditions. Households in Munshiganj Union reported higher vulnerability due to a combination of factors: greater geographic isolation, more frequent exposure to cyclones and

tidal surges because of proximity to major water bodies, insecure tenure arrangements on government *Khas* land, and limited livelihood options outside of fishing and day labour, as well as multiple forest bans. These challenges were compounded here by limited access to disaster-related information, weaker institutional support networks, and lower rates of financial assistance than in the Burigoalini Union. In contrast, households in Burigoalini Union benefited from stronger ties to local government offices and NGOs, as well as better access to early warning systems and credit, which contributed to relatively lower vulnerability despite high exposure to hazards.

The evidence in this study underscores that place-based vulnerability cannot be fully explained by spatial proximity to hazards alone. Socio-economic conditions, institutional entitlements, and social networks are equally critical in shaping how households experience and respond to risk. This finding echoes Cutter et al. (2003) and Cannon (2017), who argue that vulnerability frameworks must move beyond static hazard exposure to account for the social fabric that determines who suffers most. Mamun (2022) similarly found that disparities in institutional reach and social capital were key factors explaining why char-dwelling communities in Bangladesh facing the same flood risks experienced markedly different outcomes.

Taken together, these findings reaffirm that socio-economic diversity within communities sharing similar livelihood portfolios is a critical determinant of differential vulnerability. They validate the need to embed human systems, such as household characteristics, access to institutions, and local power relations, at the center of place-based vulnerability assessments.

4.2.3 Adaptation Strategies as Dynamically Evolving Expressions of Agency

Qualitative findings from this study revealed that adaptation strategies adopted by fishing households are not merely reactive (coping) but rather deliberate, forward-looking decisions that build community resilience. Rather than passively absorbing shocks, fishing communities exhibited strong cognitive and strategic capacities, as evidenced by anticipatory decision-making, solidarity-based action, and sustained engagement in risk management at both the individual and collective levels. Adaptation strategies such as seasonal migration, flexible credit arrangements, incremental housing improvements using self-taught skills, and low-cost protective measures were not isolated responses but part of iterative learning processes that evolved over time.

Similarly, collective actions, including embankment repair, coordinated forest entry, shared asset use, and engagement with early warning systems, reflected accumulated experiential knowledge and growing confidence in coordinated risk governance. These patterns indicate that agency is enacted through practice, experimentation, and social learning, and extends beyond the domain of adaptive capacity. This pattern aligns with Cinner et al. (2018), who found that small-scale fishers in the Western Indian Ocean region similarly drew on local knowledge, past learning, and experimentation to adapt in ways that balanced immediate survival with longer-term livelihood security.

The results of the study also reveal that agency among fishing communities evolved in response to various triggers, including economic insecurity; unequal access to resources and water; health risks; biased institutional arrangements; and restrictive social norms—highlighting that adaptive behaviour is rarely driven by a single stressor. Instead, agency emerged from the interaction between cumulative lived experiences and intentional decision-making to address stressors, reinforcing its role as a dynamic process rather than a fixed attribute or an isolated domain of adaptive capacity. The dynamic aspect of agency particularly functions in enabling households and communities to mobilize available resources, negotiate on household decision-making (e.g., livelihood diversification, migration, credits), and use local knowledge to pursue adaptation even in absence of institutional support. This study also extends conceptualizations of agency beyond individual action to include collective, relational, and context-dependent forms that are central to disaster risk reduction in resource-constrained settings.

4.2.4 Major Constraints Limiting the Application of Agency in Strengthening Resilience

It was found that while human agency catalyzes adaptive practices by facilitating innovation among fishing households, the translation of these practices into resilient outcomes depends on enabling conditions, such as equitable governance, sustained institutional support, and social inclusivity. Across the Sundarbans coastal region, fishers' adaptive intentions and innovative practices were frequently constrained by political favouritism, bureaucratic delays, exploitative governance practices, and exclusionary eligibility criteria for formal support programs. These factors systematically limited access to credit, relief, and infrastructure support, particularly for the poorest and most marginalized households. Viewed through a climate justice lens, these constraints reflect both distributive and procedural injustices, where those most exposed to hazards experience unequal access to adaptation resources and limited opportunities to shape decision-making processes.

Such constraints reflect Giddens' (1984) structuration perspective, wherein agency operates within structures that simultaneously enable and constrain action. Although fishers actively negotiated risk through livelihood diversification, informal finance, and collective action, their efforts were often undermined by inequitable governance arrangements and weak institutional accountability. As observed in this study, political bias in aid distribution and delayed embankment repairs not only exacerbated material losses but also eroded trust in formal systems, reinforcing reliance on informal networks. These findings are consistent with Choudhury and Haque's (2016) observations in Bangladesh's wetlands, where structural inequalities constrained the realization of adaptive capacity despite strong local initiatives.

Gender roles further shaped how agency could be exercised. While women increasingly participated in micro-enterprises, disaster preparedness, and NGO-led initiatives, caregiving responsibilities, social stigma, and limited decision-making authority constrained their autonomy. In cases of increased participation in local platforms, women's agency is seen suppressed by political elites as they are not welcomed anymore if they raise their voice against discrimination. This reflects procedural injustice, as women's participation and voice in formal decision-making spaces remain conditional. It also reveals distributive and recognitional injustices within a climate justice lens, where women experience uneven access to adaptation resources and institutional support while their everyday adaptive labour and local knowledge remain undervalued (Paavola & Adger, 2006; Schlosberg, 2004). We underscore that addressing power relations to identify who benefits from adaptation and whose agency is supported or interrupted is crucial for understanding adaptive capacity embedded in social relations and norms.

At the same time, the synthesis highlights that constraints also generate opportunities for emergent forms of agency. In response to institutional inefficiencies, women self-organized to clean and prepare cyclone shelters, addressing sanitation and safety gaps. Fishers collectively entered forests, shared assets, and mobilized solidarity to confront both environmental threats (such as wildlife attacks) and bureaucratic exploitation. These practices reflect what Berkes and Ross (2013) describe as resilience rooted in trust, cooperation, and local leadership rather than material assets alone.

Taken together, these findings reaffirm that, without enabling institutions, equitable governance, proper recognition, and crediting of local knowledge, the exercise of human agency remains incomplete. Addressing these structural inequities is therefore essential to

ensure that the innovative adaptive capacities of small-scale fishers can contribute meaningfully to resilience building.

4.3 Major Contribution of the Research

The findings of this study make substantial contributions to the following areas:

4.3.1 Reconceptualizing Vulnerability Through Agency and Household Heterogeneity in Disaster Contexts

In most existing research, vulnerability is primarily conceptualized as a negative, static condition, emphasizing exposure to hazards while paying less attention to how people act creatively within constraints. This study contributes to a more nuanced understanding by demonstrating that vulnerability can also be a space where agency emerges and is exercised, prompting households to develop new ways to cope and adapt. By connecting vulnerability and agency in a single analytical framework, the research advances an approach that moves beyond deficit-based thinking. In addition, it underscores the importance of recognizing household-level heterogeneity—particularly differences in socio-economic status and gender—as a core dimension of vulnerability analysis. These conceptual insights, grounded in the study’s empirical findings, offer a more comprehensive understanding of resilience-building processes among resource-dependent communities facing recurrent climate risks.

4.3.2 Advancing an Intersectional, Place-based Perspective to Vulnerability Analysis

This study advances vulnerability scholarship by demonstrating that vulnerability is not uniform, even within communities exposed to similar climatic hazards and dependent on comparable livelihood systems. By applying an intersectional lens that captures the interplay of socio-economic status, gender, and spatial positioning, the research strengthens a place-based framework that centers local context in conceptualization. In doing so, it moves beyond aggregate or sector-level analyses and reveals how differentiated household characteristics and socio-ecological settings shape uneven experiences of climate impacts across the region. These empirically grounded insights offer critical guidance for designing more equitable and context-responsive disaster risk-reduction interventions.

4.3.3 Advancing Understanding of how Agency Evolves and Shapes Local Adaptation Practices

The results clearly show that agency is not merely reactive but often deliberate and rooted in experience-based learning, as reflected in the adaptation strategies adopted by fishing households. They illustrate how individual and collective actions can create pathways for reducing vulnerability, even in highly constrained environments. By foregrounding agency in

local adaptive practices, the research challenges portrayals of vulnerable communities as passive recipients of external interventions and instead emphasizes adaptation as a process shaped by intentional decision-making. Furthermore, the findings highlight that agency extends beyond individual cognitive capacity and is embedded within broader structural arrangements, underscoring the need to consider relational, institutional, and contextual factors when analyzing how agency operates in community resilience-building processes.

4.4 Policy Implications

Among existing disaster risk-reduction policies, the Bangladesh National Adaptation Plan 2023–2050 (NAP) outlines a multilevel, inclusive institutional framework that emphasizes horizontal coordination and vertical linkages to strengthen and scale locally led adaptation. This study aligns with the NAP’s direction toward inclusive and accountable adaptation, while highlighting that effective implementation must address power asymmetries and elite capture to ensure that marginalized groups’ agency translates into sustained resilience outcomes. However, supporting NAP’s direction, we further outline some other major policy implications derived from the findings of this study, as follows:

- The findings reveal that vulnerability is not determined solely by geographic exposure but is shaped by household-level heterogeneity in asset endowment, socio-economic position, gender roles, and political access. Vulnerability is therefore non-linear and intersectional. Policy frameworks should consider and incorporate socio-economic, institutional, and political dimensions when assessing vulnerability and designing interventions, particularly for marginalized and resource-dependent groups. This would require disaggregated data and targeted policy instruments that recognize differentiated needs within communities rather than treating them as homogeneous units.
- Drawing from both scholarly literature and my own field observations, it becomes evident that collective actions such as community-led embankment repairs, informal lending networks, coordinated access to forest resources, and household-level disaster preparedness measures were identified as some of the most effective strategies for strengthening adaptive capacity. These practices evolve through experiential learning under constrained conditions and reflect embedded local knowledge. Scaling community-driven adaptation, and implementing Local Adaptation Programme of Action (LAPA) through local government initiatives and community-based actors is crucial in coastal Bangladesh, as mentioned in National Action Plan of Bangladesh (2030-2050).

- The study highlights that fishing communities exercise strong individual and collective agency, demonstrated through planning, strategizing, and adaptive decision-making. However, this capacity is frequently constrained by governance failures, political favouritism, corruption, restricted livelihood options, and inconsistent institutional support. Reducing bias in aid distribution, enhancing accountability, and creating inclusive, participatory spaces, particularly for women and marginalized households, are essential to enabling the meaningful exercise of agency. Policies should explicitly invest in and facilitate women's access to credit, skills training, and productive assets, while addressing unpaid care burdens that limit their participation in adaptation and governance processes, thereby enabling the smooth translation of agency into resilience-building among communities. Government agencies, NGOs, and development partners should prioritize establishing a monitoring system that includes local-level accountability (e.g., tracking the fairness of relief distribution, the quality of embankment repairs, and inclusion indicators). The NAP explicitly emphasizes strengthening transparency and accountability through a national monitoring system. However, it does not clearly outline how local adaptation financing and implementation will be protected from political favouritism, corruption, or informal gatekeeping, which the findings identify as central barriers to resilience.
- Finally, vulnerability and adaptation are not static conditions, but evolve over time in response to environmental, institutional, and social change. National and regional assessments should develop context-sensitive monitoring tools that track these dynamics within local cultural and governance settings. Policymakers should move beyond beneficiary counts and short-term outputs toward evaluating whether interventions effectively reach the most vulnerable households and contribute to sustained resilience outcomes.

4.5 Future Research

Future research should examine the extent of agency among other coastal communities in Bangladesh and analyze the cognitive and social pathways through which people exercise agency in the face of recurrent environmental challenges. This remains an underexplored area in the present study.

While this research focused on vulnerability and adaptation at the union level, applying the same framework at larger scales could help assess how additional intersectional factors—such as ethnicity, age, or disability—shape vulnerability across regions and populations.

Expanding these analyses to the national level would yield a more comprehensive understanding of patterns in risk and adaptive capacity.

Moreover, developing new frameworks for integrating agency into disaster research is essential to move beyond viewing communities as passive victims. A deeper understanding of how vulnerability translates into agency can improve disaster policy, highlight the strengths of local adaptive strategies, and position Bangladesh's experience in disaster risk reduction as an example for international learning.

4.6 Limitations of the Study

In addition to common methodological limitations, this study is constrained by its focus on union-level analysis within two communities. While it offers an initial attempt to link vulnerability and resilience through adaptation mechanisms, a more in-depth examination of intersecting factors that shape vulnerability, such as ethnicity, caste, or disability, would be necessary for a more comprehensive understanding of the region as a whole.

The findings may not be directly generalizable to all coastal communities in Bangladesh or beyond, as the diverse combination of social, economic, and environmental factors, along with differences in occupational settings, produces varied adaptation strategies and outcomes. As such, caution should be exercised in applying these insights to other contexts without careful consideration of local dynamics.

4.7 Final Reflections

The process of conducting this master's research has been both challenging and deeply rewarding. Reflecting on this journey, several important realizations stand out. My academic background in environmental science and management has shaped my motivation to examine how vulnerability, agency, and resilience intersect in the everyday lives of small-scale fishing communities in coastal Bangladesh amid disasters.

At the outset, I spent considerable time reviewing the literature to understand the evolving debates on vulnerability assessment and the role of human agency in disaster contexts. I also found ambiguity, questions in the field, and disagreements that enriched my understanding of the topic. Fieldwork in the Munshiganj and Burigoalini Union communities was particularly illuminating. Engaging with fishers and their families allowed me to witness firsthand the ingenuity, determination, and resilience that are often hidden behind statistical measures of risk. I was deeply moved by how people living with persistent poverty and recurring disasters still found ways to smile and support one another. Their resilience in the

face of corruption, shifting government campaigns, and limited resources was both humbling and inspiring. As a researcher, it is difficult to fully grasp the trade-offs they face when choosing between survival needs and longer-term recovery, but these experiences have deepened my appreciation and respect for them as a community.

I saw how people create small opportunities from whatever resources become available, whether through collective action, informal networks, or simply by refusing to give up. This made me realize that vulnerability and adaptation are much more than frameworks, reports, or indexes. They live in realities that often defy neat categories. The resilience I observed is a testament to the human capacity to endure and adapt in circumstances that are, at times, almost impossible to articulate.

Overall, this research has strengthened my appreciation for the complexity of disaster resilience and the importance of recognizing community diversity. I hope that the insights generated here will inform more nuanced policies and encourage further research that recognizes the dignity, agency, and knowledge of those living on the front lines of climate change.

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APPENDIX A: Research Ethics and Compliance from the University of Manitoba



University
of Manitoba

Research Ethics and Compliance

Human Ethics - Fort Garry
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Winnipeg, MB R3T 2N2
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PROTOCOL APPROVAL

Effective: February 2, 2024

Expiry: February 1, 2025

Principal Investigator: Rukhsar Ahmed
Advisor(s): C Haque
Protocol Number: HE2023-0314
Protocol Title: *Vulnerability, coping and adaptation of small-scale fishers in Bangladesh: A case study of transformation in the Sundarban mangrove coastal region.*

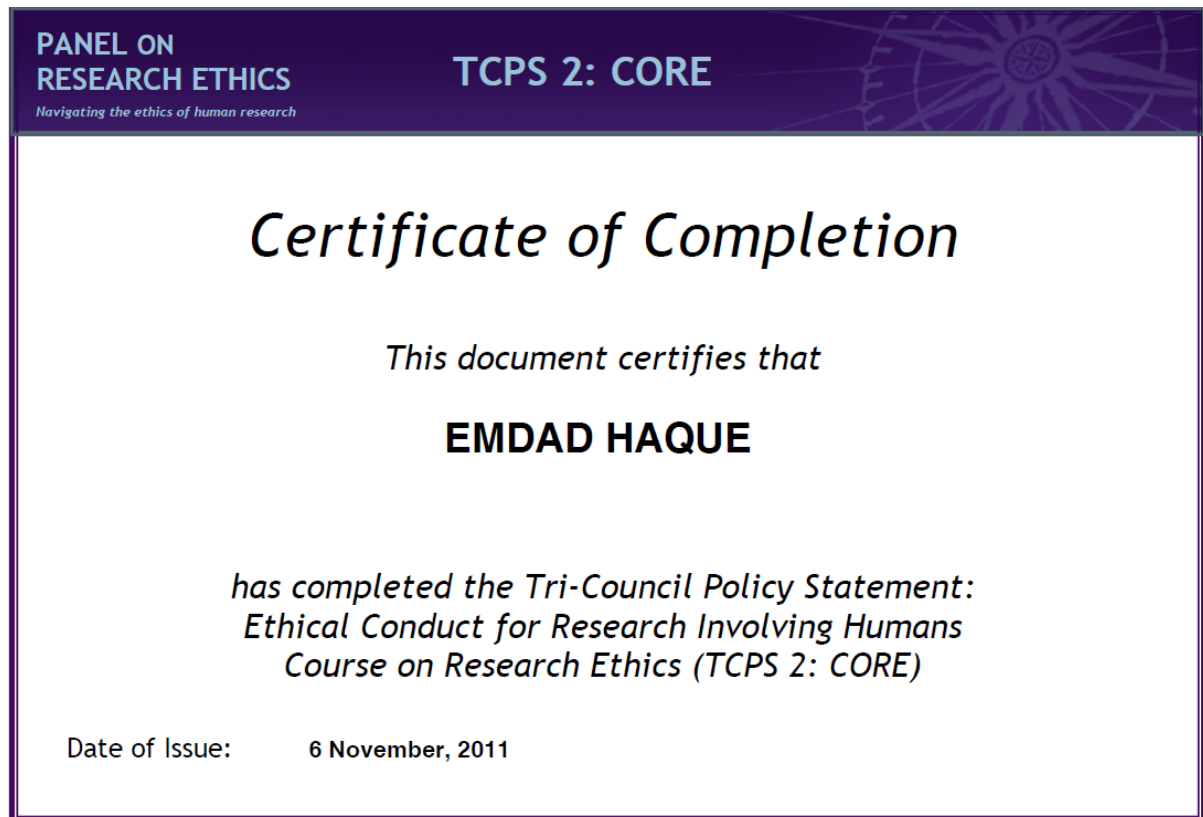
Merissa Daborn, Acting Chair, REB2

Research Ethics Board 2 has reviewed and approved the above research. The Human Ethics Office (HEO) is constituted and operates in accordance with the current *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans*- TCPS 2 (2022).

This approval is subject to the following conditions:

- i. Approval is granted for the research and purposes described in the protocol only.
- ii. Any changes to the protocol or research materials must be approved by the HEO before implementation.
- iii. Any deviations to the research or adverse events must be reported to the HEO immediately through an REB Event.
- iv. This approval is valid for one year only. A Renewal Request must be submitted and approved prior to the above expiry date.
- v. A Protocol Closure must be submitted to the HEO when the research is complete or if the research is terminated.
- vi. The University of Manitoba may request to audit your research documentation to confirm compliance with this approved protocol, and with the UM *Ethics of Research Involving Humans*[Ethics of Research Involving Humans](#) policies and procedures.

APPENDIX B: TCPS 2 CORE Certification



APPENDIX C: Questionnaire for Household Survey

Questionnaire for Household Survey

A. Identification

Date: _____ Day – Month --- Yr	Census ID No. _____	District: Satkhira	Upazila: Shyamnagar
Union: _____	Name of village:		
Name of the respondent:			

C.1 Basic household Information (not asked in baseline census)

Sl. No.	Questions	Answer & Codes	Skip
1.	How long have you and your family members household been living here?	[Insert in yrs] _____	
2.	Who is your head of household [Single entry]	1=Male-headed 2= Female-headed 3=Others (specify).....	
3.	What is the type of family? [Single entry]	1= Nuclear family 2=Joint family 3=Extended family 4=Others (please specify)	
4.	How many members are living in your HH?	_____ [Insert Number]	
5.	How many of the household members are aged from 15–60 years?	_____ [Insert Number]	
6.	How many members are engaged in income earning activities in your family?	_____ [Insert Number]	
a.1.6.1	Monthly income		
a.1.6.2	Yearly income		

C.1 Current Socio-Economic Profile

Possession of assets						
7.	Does your household posses the following items/assets that generate income in your household? [Multiple responses]					
Sl. No.	Items	Quantity (Insert '0' if none exist)	Present market price	Income generated monthly (BDT)	Income generated yearly (BDT)	
1.	Household Utensils					
2.	Radio					
3.	Television					
4.	Bicycle					
5.	Boat					
6.	Net for fishing					
7.	Sewing machine					
8.	Mobile Phone					
9.	Electric fan					
10.	Livestock					
11.	Poultry					
12.	Rickshaw/van					
13.	Cash in hand					
14.	Jewellery					
15.	Crops					

	16	Homestead vegetables				
	17	Cultivable crops				
	18	Trees				
	19	Fishes				
	20	Prawn Gher				
	21	Fishes (Rui Katla, etc.)				
	22	Crab				
	23	Motorcycle				
	24	Solar Panel				
	25	Cash in hand				
Quality Of House						

8.What are the material of your housing wall (main house) ?	1= Clay wall 2= corrugated iron (tin) wall 4= House made of straw and leaves from Sundarbans 3=Pucca Brick 5= Wood or bamboo 6=Asbestor
9. Does your household have electricity?	1= Yes 0= No 99= Not applicable
10.. If Yes, what type of electricity does your household use? [Single entry] CODES: 1=Solar, 2=Connection to generator, 3=Sideline (illegal but paid), 4=REB (Rural electricity Board/Rural electrical society) 5=Other (specify)	

11. Where do you get water for drinking? (Multiple entry)

1	Pipe/Supply
2	Hand Tube Well
3	Deep Tube Well
4	Open Pond/River/Canal
5	Well-maintained well/pond
6	Rainwater
7	Shared water source belonging to government or any other entity
8	Pond Sand Filter (PSF)
9	Other

1=Pipe/Supply, 2=Hand Tube Well, 3=Deep Tube Well, 4=Open Pond/River/Canal, 5=Well-maintained well/pond, 6=Rainwater 7= Shared water source belonging to government or any other entity 8=Pond Filter (PSF) 9=Other

12 What type of sanitary facility do you use? [Single entry]

1= Flush Toilet
 2= Water Sealed/Slab
 3= Pit Latrine/Open Pit
 4= Open defecation
 5= Other (Specify)

C.2 Social capitals: Relations with informal and formal institutions

Sl. No.	Questions	Answer & Codes	Skip
13	In your opinion, to what extent you have relation with your neighbours?	1= Low 2=Medium 3=High	
13.1	In your opinion, to what extent you have relation with your community organizations and their leaders?	1= Low 2=Medium 3=High	
13.2	In your opinion, to what extent you have relation with local political parties or groups and their leaders?	1= Low 2=Medium 3=High	
13.3	Is your household a member of any community-based organization?	1=Yes 2=No	If No, go to
13.4	If yes, how many organizations' membership does your household members have?	_____ [Insert number]	
13.5	If yes, to what extent your household have a relation with the following community-based organizations? [Multiple responses]		
	1= Fishing cooperatives	1= Low 2=Medium 3=High	

	2= Farming association (agricultural)	1= Low 2=Medium 3=High																								
	3= Faith-based institutions (mosque committees, temple committees)	1= Low 2=Medium 3=High																								
	4= Local political associations	1= Low 2=Medium 3=High																								
	5= Youth cooperatives	1= Low 2=Medium 3=High																								
	6= Women income earning and generation association.	1= Low 2=Medium 3=High																								
	7=Disaster Management Committees (community-based)	1= Low 2=Medium 3=High																								
	8=Micro-Finance Institution (MFI)	1= Low 2=Medium 3=High																								
	8=Others [specify]	1= Low 2=Medium 3=High																								
13.6	Does your household members have a relation with formal organizations?	1= Yes 2= No																								
13.7	If yes, how many times have you visited the following organizations in the last year? [Multiple responses]																									
	<table border="1"> <thead> <tr> <th>Name of organizations</th> <th>Codes 1=Yes 0=No</th> <th>Number of visits (last year)</th> </tr> </thead> <tbody> <tr> <td>1=Union Parishad/chairperson</td> <td></td> <td></td> </tr> <tr> <td>2=Upazila Parishad/Upazila Nirbahi officer</td> <td></td> <td></td> </tr> <tr> <td>3=Agricultural extension office</td> <td></td> <td></td> </tr> <tr> <td>4=Upazila fisheries office</td> <td></td> <td></td> </tr> <tr> <td>5=Upazila livestock office</td> <td></td> <td></td> </tr> <tr> <td>6=Upazila health office</td> <td></td> <td></td> </tr> <tr> <td>7=Police station</td> <td></td> <td></td> </tr> </tbody> </table>	Name of organizations	Codes 1=Yes 0=No	Number of visits (last year)	1=Union Parishad/chairperson			2=Upazila Parishad/Upazila Nirbahi officer			3=Agricultural extension office			4=Upazila fisheries office			5=Upazila livestock office			6=Upazila health office			7=Police station			
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6=Upazila health office																										
7=Police station																										

		8= Forest Department			
		99=Others [Please specify].....			
13.8	Does your household have a membership with NGOs?	0=No 1=Yes			
13.9	If yes, what types of NGOs?	1= Local NGOs 2= National NGOs 3=International NGOs 4= Micro-finance Institutions (MFI) 4= Others [please specify]			
13.10	Do you have any savings in Bank/NGO/any other institution/shomiti ?	0= No 1= Yes 88= Don't Know			
13.11	If yes, how much do you have?	_____ [total BDT]			

B. Vulnerability and nature of disasters experienced by small-scale fishers in coastal Bangladesh

Sl. No.	Questions	Answers and codes	Skip
Exposure (bio-physical)			
Past number of disaster experienced and asset damage			
14	Did your household experience with any natural disasters in the last five years?	0= No 1= Yes 88= Don't Know	

14.1	If yes, what were the most common types of natural disasters experienced by your household? (multiple responses)	<table border="1"> <thead> <tr> <th data-bbox="689 233 1167 308">Hazards</th> <th data-bbox="1167 233 1480 308">Response (1=Yes 0=No)</th> <th data-bbox="1480 233 1995 308">Frequency in the last 5 years (year)</th> </tr> </thead> <tbody> <tr> <td data-bbox="689 308 1167 363">1. Storm Surge</td> <td data-bbox="1167 308 1480 363">0=No 1=Yes</td> <td data-bbox="1480 308 1995 363"></td> </tr> <tr> <td data-bbox="689 363 1167 419">2. Cyclone</td> <td data-bbox="1167 363 1480 419">0=No 1=Yes</td> <td data-bbox="1480 363 1995 419"></td> </tr> <tr> <td data-bbox="689 419 1167 475">3. Coastal Flooding</td> <td data-bbox="1167 419 1480 475">0=No 1=Yes</td> <td data-bbox="1480 419 1995 475"></td> </tr> <tr> <td data-bbox="689 475 1167 531">4. Coastal Erosion</td> <td data-bbox="1167 475 1480 531">0=No 1=Yes</td> <td data-bbox="1480 475 1995 531"></td> </tr> <tr> <td data-bbox="689 531 1167 587">5. Waterlogging</td> <td data-bbox="1167 531 1480 587">0=No 1=Yes</td> <td data-bbox="1480 531 1995 587"></td> </tr> <tr> <td data-bbox="689 587 1167 643">6. Heavy precipitation/rainfall</td> <td data-bbox="1167 587 1480 643">0=No 1=Yes</td> <td data-bbox="1480 587 1995 643"></td> </tr> <tr> <td data-bbox="689 643 1167 699">7. Thunderstorm</td> <td data-bbox="1167 643 1480 699">0=No 1=Yes</td> <td data-bbox="1480 643 1995 699"></td> </tr> <tr> <td data-bbox="689 699 1167 754">8. Salinity Intrusion</td> <td data-bbox="1167 699 1480 754">0=No 1=Yes</td> <td data-bbox="1480 699 1995 754"></td> </tr> <tr> <td data-bbox="689 754 1167 810">9. Others [specify]</td> <td data-bbox="1167 754 1480 810">0=No 1=Yes</td> <td data-bbox="1480 754 1995 810"></td> </tr> </tbody> </table>	Hazards	Response (1=Yes 0=No)	Frequency in the last 5 years (year)	1. Storm Surge	0=No 1=Yes		2. Cyclone	0=No 1=Yes		3. Coastal Flooding	0=No 1=Yes		4. Coastal Erosion	0=No 1=Yes		5. Waterlogging	0=No 1=Yes		6. Heavy precipitation/rainfall	0=No 1=Yes		7. Thunderstorm	0=No 1=Yes		8. Salinity Intrusion	0=No 1=Yes		9. Others [specify]	0=No 1=Yes	
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9. Others [specify]	0=No 1=Yes																															
14.2	Which disaster affected your household in the last 5 years most? (Only one answer)	1=Storm Surge 2=Cyclone 3=Coastal Flooding 4=Coastal Erosion 5=Waterlogging 6=Heavy precipitation/rainfall 7= High Tide 8= Thunderstorm 9=Salinity Intrusion 10=Others [specify]																														

14.3	Which cyclone have impacted your household most severely in the last five years? [Single entry]	1= Cyclone Fani, 2019 2= Cyclone Bulbul, 2019 3= Cyclone Amphan, 2020 4=Cyclone YAAS, 2021 5=Cyclone Sitrang, 2022 6=Cyclone Mocha, 2023 7= Cyclone Hamoon, 2023 8= Others [Please specify]																													
14.4	Did the last severe cyclone impact your physical assets?	0= No 1= Yes 88= Don't Know																													
	If yes, what types of physical assets were impacted by the last cyclone that you had experienced?																														
14.5	<table border="1"> <thead> <tr> <th rowspan="2">Name of items [put zero (00) if no loss or damage to physical assets]</th> <th colspan="2">Amount of damage/loss</th> </tr> <tr> <th>Quantity</th> <th>Market value (if appropriate)</th> </tr> </thead> <tbody> <tr> <td>Housing structure</td> <td></td> <td></td> </tr> <tr> <td>1= Livestock (cow, buffalo, goat, and others)</td> <td></td> <td></td> </tr> <tr> <td>2=Poultry (duck, hen, and others)</td> <td></td> <td></td> </tr> <tr> <td>3=Fish from a pond</td> <td></td> <td></td> </tr> <tr> <td>4=Crop</td> <td></td> <td></td> </tr> <tr> <td>5=Household utensils</td> <td></td> <td></td> </tr> <tr> <td>6=Furniture</td> <td></td> <td></td> </tr> <tr> <td>7=Transportation and communication</td> <td></td> <td></td> </tr> </tbody> </table>	Name of items [put zero (00) if no loss or damage to physical assets]	Amount of damage/loss		Quantity	Market value (if appropriate)	Housing structure			1= Livestock (cow, buffalo, goat, and others)			2=Poultry (duck, hen, and others)			3=Fish from a pond			4=Crop			5=Household utensils			6=Furniture			7=Transportation and communication			
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	8=Electric and electronics (e.g., cell phone, internet, television, radio, DVD)				
	9=Agricultural equipment				
	10=Fisheries equipment				
	11=Water and sanitation equipment				
	12=Other livelihood sustaining equipment				
	13=Gold and other ornaments				
	14=Tree plantation (total trees)				
	15=Others (specify)				
14.7	If yes, why did the cyclone affect your physical assets? (Multiple responses).	1= The cyclone struck with high storm surges 2=The cyclone lasted for more than a week 2= Household adjacent to the coast/river/ sea 3=Low-elevated farming land 4= The lack of strong embankment 5= Limited water and supply facilities 7=Poor housing structure 9=Others (specify)			

Sensitivity

Sl. No.	Questions	Answer & Codes			Skip
B.1.1	Fishing related unemployment due to cyclone				
15	Did the cyclone impact your fishing activity? (Unemployment related)	0= No 1= Yes 88= Don't Know 99=Not applicable			
	If yes, what are the underlying reasons behind fishing related unemployment? [Please insert options if possible]	1= Could not go fishing due to intense waves 2= During disaster warning periods 3= Taking time for immediate coping after disaster Others (please specify)			
15.1	If yes, how many days did you spend without fishing due to the impact of disaster?	-----[Total number days]			
15.2	How much did you lose from fishing due to the last cyclone?	_____ [Total BDT]			
B.1.2	Health related vulnerability				
16	Did the cyclone impact health of your family members?	0=No 1=Yes			
16.1	If yes, how many days did your family members suffer from physical illness due to the impacts of cyclone?	Members	Total Days of Suffering		
		Adult Male members (15 – 60 yrs)			

		Adult Female members (15 – 60 yrs)			
		Children (0-14 yrs)			
		Elders (above 60 yrs).			
16.2	If yes, what types of health issues did your HH member suffer from?	1= Physical injuries 2= Waterborne disease (diarrhea, cholera, dysentery) 3= Skin diseases 4= Mental health issues (trauma) 5= Others (please specify)			
16.3	How many days of work did your household members miss due to illness?	Members	Missed work/school Days		
		Adult Male members (15 – 60 yrs)			
		Adult Female members (15 – 60 yrs)			
		Children (0-14 yrs)			
		Elders (above 60 yrs).			
16.4	Did any of your household member die last cyclone?	0= No 1= Yes 88= Don't Know			
16.5	If yes, how did the loss of person impact your wellbeing?	1=Income loss			

		2= Lost connection with organization 3= Children dropped out of school 4= Debt trap 5=Other	
B.1.3	Food-related vulnerability [Single entry]		
17	Did your HH (household head) suffer from food insecurity due to the cyclone?	0= No 1= Yes 88= Don't Know	
17.1	How many days did your HH starve due to the last cyclone?	_____ [Total days]	
17.2	How much was the reduced amount fish of consumption due to the last disaster?	_____ % of regular consumption [During and post cyclone period].	
	Water-related vulnerability [Single entry]		
18	Did your family suffer from accessing safe drinking water crisis due to the cyclone?	0= No 1= Yes 88= Don't Know	
18.1	If yes, how many days did your family suffer from not having access to safe drinking water?	_____ [Total Days]	
18.2	Did the cyclone impact your toilet facility?	0= No 1= Yes 88= Don't Know	
18.3	How many days did you use HH open defecation	_____ [Number of days]	
B.1.4	Vulnerability to in relation to social causes		
19	To what extent did the cyclone impact your following activities?		

	1 = Religious actions/festivals	1= Low	2=Medium	3=High													
	2 = Political actions/activities	1= Low	2=Medium	3=High													
	3 = Community-based activities and participation in community-based programs	1= Low	2=Medium	3=High													
20	“The cyclone has changed our HH relationship with the following institutions”.	Scale (1–5), 1 implies least positive and 5 implies most positive Scale –(1–5), -1 implies least negative and -5 implies most negative															
	1= Union Parishad	<table><tr><td>1=Positively changed in relationship</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr><tr><td>2=Negatively changed in relationship</td><td>-1</td><td>-2</td><td>-3</td><td>-4</td><td>-5</td></tr></table>			1=Positively changed in relationship	1	2	3	4	5	2=Negatively changed in relationship	-1	-2	-3	-4	-5	
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	2=Upazila Parishad/Upazila Nirbahi officer	<table><tr><td>1=Positively changed in relationship</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr><tr><td>2=Negatively changed in relationship</td><td>-1</td><td>-2</td><td>-3</td><td>-4</td><td>-5</td></tr></table>			1=Positively changed in relationship	1	2	3	4	5	2=Negatively changed in relationship	-1	-2	-3	-4	-5	
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	3=Agricultural extension office	<table><tr><td>1=Positively changed in relationship</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr></table>			1=Positively changed in relationship	1	2	3	4	5							
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	4=Upazila fisheries office	1=Positively changed in relationship	1	2	3	4	5	
		2=Negatively changed in relationship	- 1	- 2	- 3	- 4	- 5	
	5=Upazila livestock office	1=Positively changed in relationship	1	2	3	4	5	
		2=Negatively changed in relationship	- 1	- 2	- 3	- 4	- 5	
	6=Upazila health office	1=Positively changed in relationship	1	2	3	4	5	
		2=Negatively changed in relationship	- 1	- 2	- 3	- 4	- 5	
	7=Police station	1=Positively changed in relationship	1	2	3	4	5	

		2=Negatively changed in relationship	- 1	- 2	- 3	- 4	- 5		
	8=Local NGOs.	1=Positively changed in relationship	1	2	3	4	5		
		2=Negatively changed in relationship	- 1	- 2	- 3	- 4	- 5		
	9= National NGOs	1=Positively changed in relationship	1	2	3	4	5		
		2=Negatively changed in relationship	- 1	- 2	- 3	- 4	- 5		
	10. INGOs	1=Positively changed in relationship	1	2	3	4	5		
		2=Negatively changed in relationship	- 1	- 2	- 3	- 4	- 5		
	11. Bank	1=Positively changed in relationship	1	2	3	4	5		
		2=Negatively changed in relationship	- 1	- 2	- 3	- 4	- 5		

	12. Others [Please specify]	<table><tr><td>1=Positively changed in relationship</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr><tr><td>2=Negatively changed in relationship</td><td>-1</td><td>-2</td><td>-3</td><td>-4</td><td>-5</td></tr></table>	1=Positively changed in relationship	1	2	3	4	5	2=Negatively changed in relationship	-1	-2	-3	-4	-5	
1=Positively changed in relationship	1	2	3	4	5										
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21	Did your household borrow money from moneylenders?	0= No 1= Yes 88= Don't Know													
22	Does your household member feel pressure for fishing from the money lenders?	0= No 1= Yes 88= Don't Know													
23	If yes, in what situation do the owners create pressure for fishing?	1=Extreme weather condition 2= Physical illness 3= During the period of early warning 4= Ban period 5= Others [please specify]													

Adaptive Capacity: Coping Mechanisms, Adaptation Strategies and Agency

Sl. No.	Questions	Answer & Codes	Skip
	Early Warning Information and Shelter Centre		
24	Did any member of your household seek early warning information about the last cyclone that impacted your family?	1= Yes 0=No	

24.1	If yes, from which sources did your HH member collect early warning information? [Multiple responses]	1= Community Radio 2= Electronic media (Radio/television) 3= Print Media (newspaper) 4= Interactive Voice Response System (IVR)/ Cellphone 5= Community-Based organizations (CPP, Volunteers) 6=Relatives/Neighbours 7=Others [Please specify]	
24.2	Were you proactively able to get early warning information from your intended source?	1= Yes 0=No	
24.3	What factors inspired you to seek early warning information? (agency)	1=Having a proactive desire to reduce loss and damage 2=Anticipatory capacity influencing to obtain early warning information 3= Ability to take decision-making power for cyclone risk mitigation 3=Other (Please specify)	
24.4	Did you go to the cyclone shelter to reduce impact of cyclone?	0= No 1= Yes 88= Don't Know	
24.5	If yes, how far was the cyclone shelter from home?	_____ [Distance in Km]	
C.1.2	Coping and Adapting to Food Crisis		

225	Did your household borrow money to cope with food crisis?	0= No 1= Yes 88= Don't Know	
25.1	Did you take any coping measures with food crisis during post disaster period?	0= No 1= Yes 88= Don't Know	
25.2	If yes, what measure did your household take? [Multiple responses]	1= Using stored dry food 2= Using portable stove to cook food during the cyclone 3= Borrowing food from neighbours 4= Borrowing food from local traders 5= Reduced consumption of food items. 4=Others [please specify]	
25.3	What factors encouraged you to take food coping measures during post-disaster period?	1= Fear of starving during the post-disaster period 2= Prioritizing needs of nutrition 3= Desire to better manage household expenses for food 4=Influenced by food coping strategies by neighbours 5=Other (specify)	
25.4	Did you receive food items as relief from any organization?	0= No 1= Yes 88= Don't Know	
25.5	If yes, from which organization did you receive relief? [Multiple responses]	1= Government organizations 2= non-government organizations 3=Relatives/neighbours	

		4= Others [please specify]	
25.6	Did your HH borrow money from anywhere immediately after the cyclone?	0= No 1= Yes 88= Don't Know	
25.7	If yes, how much did your HH borrow?	_____ [Total BDT]	
25.8	Who borrowed you the money?	1= NGO 2=FNF 3=Dadon/ loan from Mohajon 4= Union Parishad 5=Government 6=Others (Please specify)	
C.1.3	Coping and Adapting to Unemployment Situation		
26	Did your HH member any measure to recover from unemployment?	0= No 1= Yes 88= Don't Know	
26.1	If yes, what measures had your member taken to cope with the loss of employment situation? [Multiple responses]	1= Working as a day labour with low wage in fishing firm 2= Working as a day labour with low wage in non-farming . 3= Doing rickshaw pulling for a short period 4= Collecting honey and selling in the local market	

		5= Collecting wood from the Sundorban and selling in the market. 6= Collecting shrimp fry and selling to overcome unemployment situation. 7= Fixing fishing net jobs 7= Others [specify]	
26.2	If yes, what types of long-term measures had your HH member taken to adapt to loss of employment situation? [Multiple responses]	1= Doing small entrepreneurship (business) 2= Making handicrafts including pottery 3= Involving employment generation training program, like mobile mechanics. 4= Doing timber sawing. 5= Others [Please specify].....	
C.1.4	Coping and Adapting to Livelihood Crisis		
27	Did your household take any long-term cyclone risk reduction and adaptive measures to cope with livelihood crisis?	0= No 1= Yes 88= Don't Know	
27.1	If yes, what types of measure did your HH take for adaptation to livelihood crisis resulted by the cyclone?	1= Receiving training on fishing activities. 2= Seeking financial supports from NGOs and GOs 3= Increasing alternative income by doing poultry 4= Doing homestead gardening and planting trees 5= Taking training on farming activities from GOs and NGOs 6= Using salinity tolerant seed in agricultural field	

		7= Others [Please specify]	
27.2	What kept you motivated to take these adaptation measures to tackle livelihood crisis?	1= Fear of losing savings 2= Encouraged by community members 3=Good connection with community members who work in other occupation 4=Other (Please specify)	
27.3	Did your household member take any measures for recovering from physical illness resulted from the cyclone?	0= No 1= Yes 88= Don't Know	
27.4	If yes, what measures did your HH member taken?	1= Remaining without treatment 2= Taking treatment form local doctor/village doctor 3= Taking treatment from quack doctor/herbal practitioners 4= Taking treatment from religious practitioners 5= Taking treatment from local hospital/clinic 6= Consulting with expert doctor. 7= Other [specify]	
30	Did you repair your housing structure due to the cyclone?	0= No 1= Yes 88= Don't Know	
30.1	If yes, what measure did your household take to repair housing structure?	1= Tying roof to clay walls 2= Protecting house by planting <i>Kalmi</i> tree 3= Preparing platform made of bamboo	

		4= Making platform with cement and wood and building housing on that platform. 5= Increasing the height of the plinth 6=Applying strong and deep-rooted wooden pillars 7= Making plinth with cement and bricks 8= Others [specify].....	
31	Did your household take any measure to overcome post-cyclone water crisis?	0= No 1= Yes 88= Don't Know	
31.1	If yes, what measures did you household undertake to overcome post-cyclone water crisis?	1= Using water purification tablets 2= Preserving water in container 3= Receiving water from GOs and NGOs as relief 4= Harvesting rainwater 5= Using Pond Sand Filter (PSF) 6=Collecting water from Managed aquifer recharge (MAR) 7=Others [please specify]	
D.	Human Agency toward Building Resilience		
31	To recover from capital loss (long-term), did your household take any initiative?	0= No 1= Yes 88= Don't Know	
31.1	If yes, did you take any help or you planned the whole initiative on your own? [multiple responses].	1= Planned on my own 2=Planned consulting with neighbours	

		3=Took support from neighbours/relatives 4=Took support from NGO/CBO 5=Took support from political connection 6= Other (Please specify)	
31.2	Did your HH members take any proactive initiative for preparedness to disasters?	0= No 1= Yes 88= Don't Know	
32	If yes, what steps did you take? (e.g., housing, food, storage of valuables, etc. [Please include responses]).	Detailed responses	
32.1	What have you thought that motivated you to take these steps for preparedness to disasters?	1= Fear of losing savings 2= Encouraged by community members 3=Good connection with community members who supported your decision 4= Anticipation capacity based on previous experience with cyclone 5=Other (Please specify)	
32.2	What barriers have you faced while planning and implementing these steps?	1= Lack of moral support from community members 2= Lack of fund to take preparedness 3= Lack of skills to take preparedness 4=Lack of knowledge about disaster preparedness 5=Other (please specify)	

32.3	Did your household member migrate due to the cyclone?	0= No 1= Yes 88= Don't Know	
32.4	If yes, What was the type of migration was it?	1= Seasonal migration 2= Circular migration 3= Permanent migration	
32.5	What was the source of information for migration?	1= Connection outside the village 2=Political connection 3=Influential contact 4=Took information from any organization 5= Other (Please specify)	
33	Has your household taken any entrepreneurial steps or business related to fishing?	0= No 1= Yes 88= Don't Know	
33.1	If yes, can you share more about the entrepreneurship?	1= Involved with fish business 2= Aquaculture 3= Dry fish business and processing 4= Crab farming 5= Others (Please Specify)	
33.2	Has your household taken any entrepreneurial steps or business related to non-fishing activities. (e.g., farming, garment, poultry, etc.)	0= No 1= Yes 88= Don't Know	

33.3	If yes, can you share more about the entrepreneurship?	1= Livestock 2= Poultry 3= Shopowner 4= Handcraft 5= Tailoring 6= Small Businesses 7= Others (Please Specify)	
33.4	What reasons encouraged you to take these entrepreneurial steps?	1= Generating new source of employment for community members 2=Coming out of the ‘normal’ employment options 3= Showing leadership in the community 4= Bringing financial stability for your household 5=Other (please specify)	
34	Have you or your household members been actively involved in any leadership position in the community activities related to disaster management?	0= No 1= Yes 88= Don’t Know	
34.1	If yes, can you share more about it? (name of the campaign or program, your role in it)	1= Consultation with locals as member of Ward Disaster Management Committee. 2= Member of the Union Disaster Committee.	

		3= Member of the Cyclone Preparedness Program (CPP). 4= Others (Please Specify)	
34.2	Can you point out an innovative adaptation strategy that the community adopted, which helped your household to overcome your household losses?	1= Raise base of land (Bhita) 2= Strengthen fence around the house 3= Raise the height of garden area 4= Raise the bank of the pond. 5= Raise the boundary of fishing farm 6= Others (Please Specify)	
34.3	Do you face any constraints to adopt these strategies?	1= No ownership of land 2= House located on the embankment 3= Lack of employment opportunities 4= Lack of financial resources	
34.4	Please suggest how the government and non-government agencies can take action to overcome these challenges?	1= Households should be brought under safety net 2= Loan interest should be reduced. 3= Fair distribution of relief packages 4= Others (Please Specify)	

APPENDIX D: Guidelines for Key Informant Interviews (KII)

Guidelines for Key Informant Interviews (KII)

- **Interview guide for Community Based Organizations**

Code:

Location of interview:

Participant ID:

Date:

1. I already mentioned some of your organizational work on reducing vulnerabilities of fishing communities in Shyamnagar. Did I miss out on any work you would like to highlight?
2. In your experience, what are the main physical vulnerabilities that fisher communities in Shyamnagar face in relation to climate change-related disasters?
3. In your experience, what do you think are the social vulnerabilities that fisher communities in Shyamnagar face in relation to climate change-related disasters?
4. What have been the observed impacts of the last cyclones or other climate change-related disasters on the assets of households and the community in Shyamnagar? Can you quantify the extent of loss and damage?
5. How does your organization collaborate with fisher communities to support their coping strategies during and after climate change-related disasters? Are there any specific initiatives or programs you have implemented?
6. What coping and adaptation practices have you observed in the affected communities to recover from shocks and stresses caused by climate change-related disasters? Are there any specific practices that have proven to be successful or innovative?
7. Based on your experience, which coping and adaptation strategies are considered to initiate a positive transformation of the fishing communities? Can you share any success stories or case studies?

8. In your organization's interactions with fisher communities, what lessons have been learned collectively and individually from past experiences of surviving and recovering from climatic extremes?
9. Which community practice supports or hinder the vulnerability reduction and adaptation efforts in the fishing communities?
10. Based on your organization's work and experience, what recommendations would you propose to improve the vulnerability reduction and adaptation strategies in the Shyamnagar coastal fishing community, considering the multiple stressors they face?

- **Interview guide for Non-Governmental Organizations (NGOs)**

Code:

Location of interview:

Participant ID:

Date:

1. In your experience, what are the main vulnerabilities that fisher communities in Shyamnagar community face in relation to climate change-related disasters? How does your organization address these vulnerabilities?
2. What have been the observed impacts of the last cyclones or other climate change-related disasters on the assets of households in Shyamnagar? Can you quantify the extent of loss and damage?
3. How does your organization collaborate with fisher communities to support their coping strategies during and after climate change-related disasters? Are there any specific initiatives or programs you have implemented?
4. What coping and adaptation practices have you observed in the affected communities to recover from shocks and stresses caused by climate change-related disasters? Are there any specific practices that have proven to be successful or innovative to reduce the vulnerability of the community?
5. Based on your experience, which coping, and adaptation strategies are considered to initiate a positive transformation of the communities for a resilient fisheries sector? Can you share any success stories or case studies?

6. In your organization's interactions with fisher communities, what lessons have been learned collectively and individually from past experiences of surviving and recovering from climatic extremes? How have these lessons influenced your organization's approach to future interventions?
7. How does your organization engage with other stakeholders, such as government agencies, NGOs, or research institutions, to address the vulnerability and adaptation needs of fisher communities in Shyamnagar? Can you describe any collaborative efforts or partnerships?
8. Which community practice supports or hinders the vulnerability reduction and adaptation efforts in the fishing communities?
9. What are some of the main challenges or constraints your organization faces in implementing interventions to address climate change-related vulnerabilities and promote adaptation in the fishing communities?
10. Based on your organization's work and experience, what recommendations would you propose to improve the vulnerability reduction and adaptation strategies in the Shyamnagar coastal fishing community, considering the multiple stressors they face?

- **Interview guide of Local Government Representatives**

Code:

Location of interview:

Participant ID:

Date:

1. How does your office collect and assess information about the impacts of climate change-related disasters on the fishing community and their assets at both household and community levels?
2. What initiatives or programs does the local government have in place to support coping strategies in the fishing community during and after climate change-related disasters? How are these efforts coordinated with other stakeholders?
3. Are there any specific coping and adaptation practices prevalent in the affected communities that have been successful in helping them recover from shocks and stresses caused by climate change-related disasters?

4. From your experience, which coping and adaptation strategies are considered to be effective in initiating a positive transformation of the fishing communities for a resilient fisheries sector?
5. In your role, what have you learned collectively and individually from the past experiences of the fishing community in surviving and recovering from climatic extremes? How have these lessons informed your future plans and actions?
6. How does the local government collaborate with other stakeholders, such as community-based organizations, NGOs, or research institutions, to address the vulnerability and adaptation needs of fisher communities in Shyamnagar community?
7. What are some of the main challenges or barriers you face in implementing interventions to address climate change-related vulnerabilities and promote adaptation in the fishing community?
8. Based on your experience and role, what recommendations would you propose to improve the vulnerability reduction and adaptation strategies in the Shyamnagar coastal fishing community, considering the multiple stressors they face?
9. Based on your experience, which coping, and adaptation strategies are considered to initiate a positive transformation of the communities for a viable fisheries sector? Would you please share any success stories?

APPENDIX E: Interview Guide for Focus Group Discussions

Interview guide for Focus Group Discussions

Code:

Location of interview:

Date

1. Have you experienced any climate change-related disasters, such as cyclones or other extreme weather events, in the recent past (i.e., 10 years)? If yes, would you please describe your experiences?
2. In your opinion, what are the most significant vulnerabilities faced by the fisher communities in Shyamnagar due to climate change-related disasters? What are the underlying causes behind vulnerabilities in fisher communities?
3. What types of coping and adaptation techniques do you pursue in order to adapt to climate-driven hazards, like cyclone and storm surges?
4. What are the main challenges you encounter in coping and adaptation with and recovering from climate change-related disasters at the community level?
5. Are there any ongoing initiatives or projects focused on climate change adaptation in the fishing community? If yes, what are they, and how have they impacted on the community's resilience?
6. What are some successful examples of coping and adaptation strategies that have helped the community recover from past climate change-related disasters?
7. What kinds of support or assistance do you think would be most helpful in building the community's capacity to cope with climate change-related disasters effectively?
8. Based on your experiences and insights, what recommendations would you like to propose to reduce the loss and damage of resources and assets from future climate change-related disasters?

APPENDIX F: Supplementary Table 1—Distribution of sampled households

Variables	N	Proportion (Mean/Standard Deviation)
Age of Household Head (household)	100	53.41 (8.89)
Categories of Households		
Female-Headed Households	10	10.00
Male-Headed Households	90	90.00
Occupational status		
Fishing-dependent livelihood	73	73.00
Fishing cultivation and business	20	20.00
Farming	4	4.00
Non-farming and fishing daily wage labourer	3	3.00
Education status of households		
No schooling	10	10.00
Primary (grades 1–5)	82	82.00
Secondary and Higher secondary (Grade 6–12)	8	8.00
Socio-economic status (SES) of households		
Low SES	34	34.00
Medium SES	33	33.00
High SES	33	33.00

Source: Fieldwork, 2024.

APPENDIX G: Codebook of PCA Variables

SL. No.	Variable Name	Description	Responses	Var types	Var. name	Source (Informed/Adapted)
	<u>Index id</u>					
Household characteristics						
1.	Household head	Gender of HH	1=Male-headed 2= Female-headed	Categorical	head_hh	(Islam & Sallu, 2014; Hahn et al., 2009)
2.	Age of the HH	Age of the HH		Count	age_hh	(Islam & Sallu, 2014)
3.	Education level of household head	Education level of household head	1=Class 1–5 Primary, 2=Secondary education complete or higher, 0=No schooling	Categorical	edu_hh	(Islam & Sallu, 2014; Hahn et al., 2009)
4.	Occupation	Primary occupation of HH	1= Fishing-dependent livelihood (collection) 2=Fishing cultivation and business 3= Farming 4= non-farming and fishing daily wage labourer	Categorical	occupri_hh	(Bronfman et al., 2024)
5.	Earning members	Total members of HH engaged in employment		Count	earn_mem	(Hahn et al., 2009)
6.	Income	Annual income of households		Count	an_income	Adapted from (Bronfman et al., 2024)
Asset and land ownership						

7.	Total price of assets	Total price of assets per HH		Count	asstvalue	(Islam & Sallu, 2014)
8.	Value of land owned	Market value of total land owned		Count	val_land	(Sarker et al., 2019)
Housing infrastructure						
9.	Wall of house	What are the material of your housing wall (main house) ?	1= Wood or bamboo made house 2= Wall made of clay wall, corrugated iron, straw and leaves 3=Asbestor and pucca brick	Categorical	wall_house	(Islam & Sallu, 2014)
10	Roof	Material of the roof of the house	1=Asbestor 2=tin and leaves 3=brick	Categorical	roof_house	Adapted from (Islam & Sallu, 2014)
11	Floor	Material of the floor of the house	1=Clay 2=Brick	Categorical	floor_house	Adapted from (Islam & Sallu, 20134)
12	Number of rooms	Number of rooms		Count	rooms_house	Adapted from (Islam & Sallu, 2014)
Access to facilities						
13	Type of electricity	Types of electricity used by HH	1= REB (Rural electricity Board/Rural electrical society) 0=Solar or sideline (illegal but paid)	Categorical	type_elect	(Islam & Sallu, 2014)

14	Total number of water sources	Total number of water sources used by HH		Count	total_watso urce	(Islam & Sallu, 2014)
15	Types of sanitary facility in HH	Types of sanitary facility in HH	1= Ring slab toilet 2= Pucca pan toilet	Categorical	san_facility	(Islam & Sallu, 2014)
Networking and access to institutions						
16	Extent of relation with neighbours	Extent of relationship with neighbours	1=Low 2=Medium 3=High	Count	rel_neighbr	(Namara, Clissold, & Westoby, 2021)
17	Extent of relation with community organizations	Extent of relationship with community-based organizations	1=Low 2=Medium 3=High	Count	rel_comorg	(Bronfman et al., 2024)
18	Extent of relation with political parties or leaders	Extent of relation with political parties or leaders	1=Low 2=Medium 3=High	Count	rel_pol	(Adger,2006)
19	Number of memberships with community-based organization	Number of memberships with community-based organization		count	num_como rg	(Bronfman et al., 2024;.Turner,2020)

20	Extent of relation with total number of community-based organizations	Extent of relation with community-based organizations (having membership)		Count	extnd_cbor el	(Developed by this study, informed by Turner, 2003)
21	Relation with formal organizations	Relation with formal organizations	1=Yes 2=No	Categorical	rel_formalorg	Developed by this study, informed by Turner, 2003
22	Total number of government organizations	Total number of government organizations a household is connected with		Count	num_govorg	Developed by this study, informed by Turner, 2003
23	Total number of visits to formal organizations	Total number of visits to formal organizations a household is connected with		Count	visit_fororg	Developed by this study, informed by (Turner, 2003; Ensor & Harvey, 2017)
24	Total number of types of NGO membership	Total number of types of NGOs a household has membership with		Count	total_ngo	(Developed by this study and adapted from Adger, 2006; Islam and Nursey-Bray (2017))

25	Local NGOs	Membership with local NGOs	1=Yes 2=No	Categorical	local_ngo	(Developed by this study and adapted from Adger, 2006; Islam and Nursey-Bray (2017))
26	National NGOs	Membership with national NGOs	1=Yes 2=No	Categorical	nat_ngo	
27	International NGOs	Membership with international NGOs	1=Yes 2=No	Categorical	int_ngo	Developed by this study and adapted from Adger, 2006; Islam and Nursey-Bray (2017)
28	Microfinance Institution	Membership with Microfinance Institution	1=Yes 2=No	Categorical	mfi_hh	Developed by this study and informed from Santha, 2015)
29	Savings in Bank/NGO/ any other institution/s homiti	Savings in Bank/NGO or other institution or shomiti, if any	1=Yes 2=No	Categorical	sav_hh	Developed by this study, adapted from (Su et al., 2021)
30	Total savings in Bank/NGO/ any other	Total amount of savings in Bank/NGO/any other institution/shomiti		Count	total_sav	Developed by this study, adapted from (Su et al., 2021)

	institution/s homiti					
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APPENDIX H: Study Area

This research was carried out in the coastal *Upazila* of Shyamnagar, located within the Satkhira District of southwestern Bangladesh (21.55° N, 89.11° E). The area lies adjacent to the Bay of Bengal and the *Sundarbans* mangrove forest, forming a complex ecological system. The local economy sustains primarily through small-scale fishing and subsistence agriculture.

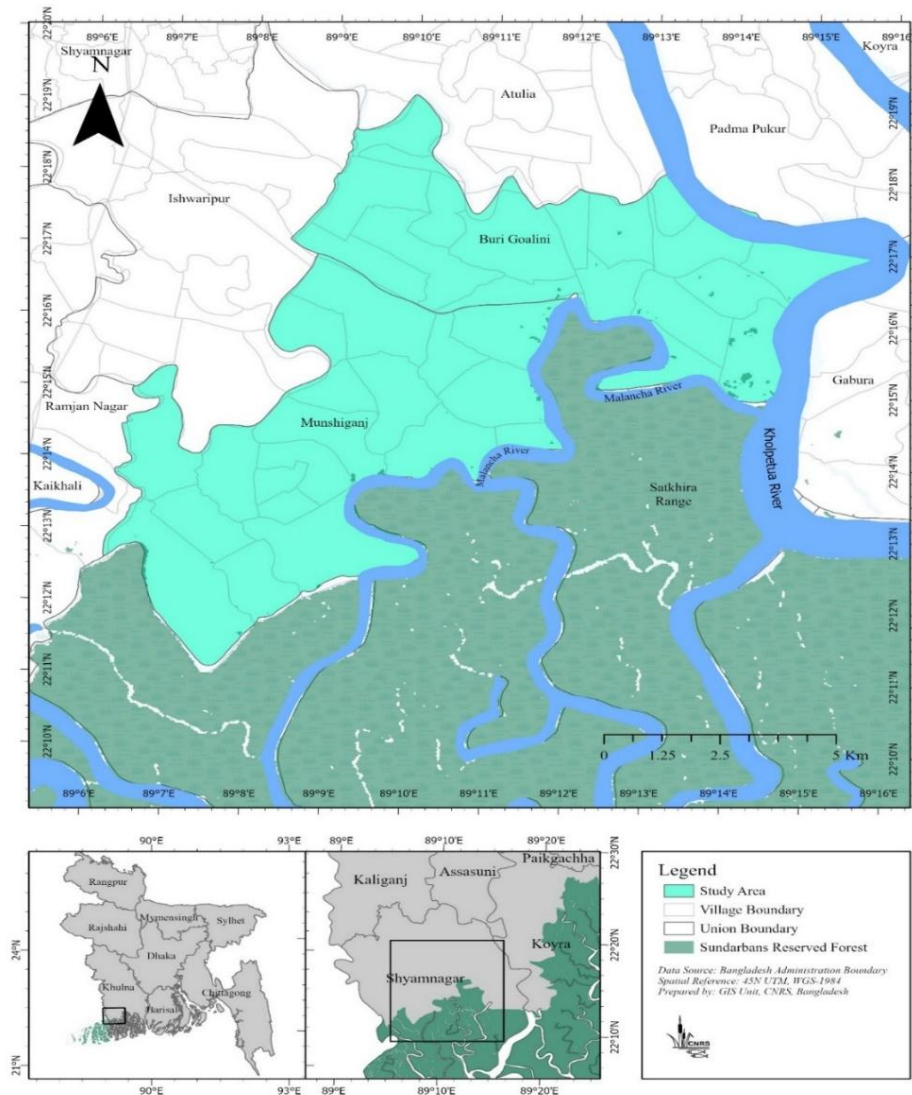


Figure H1. Location of the study area: Two study Unions of Burigoalini and Munshiganj in Shyamnagar Upazila. Source: Bangladesh Administration Boundary, 2022" and Field Assessment, 2025

Shyamnagar's low elevation and proximity to the coast make it particularly susceptible to tidal flooding, saline water intrusion, and climate extremes, including storm surges, cyclones, and sea-level rise. These environmental threats are compounded by poor infrastructure, limited

access to healthcare, education, and disaster-related services, reinforcing structural vulnerabilities across the region.

The study area is in a region prone to periodic cyclones driven by climate change (Figure 1). The tracks of major cyclones over the historical period (1905–2020) are depicted in Figure 3, highlighting the study area's acute vulnerability to climatic shocks. Consecutive events, such as Cyclone Sidr in 2007 and Cyclone Aila in 2009, devastated coastal communities, causing widespread damage to infrastructure and livelihoods. Cyclone Sidr alone affected 2.3 million households and resulted in an estimated loss of US\$1.1 billion, while Cyclone Aila displaced or disrupted the lives of 3.9 million people, generating financial losses of approximately US\$240 million (M. M. Islam, 2011; Tajrin & Hossain, 2017). In the years that followed, Cyclone Bulbul struck the Sundarbans directly, bringing tidal surges, inundation, and torrential rainfall that inundated more than 11,223 hectares of ponds and *ghers*, with fisheries losses valued at about US\$5.5 million (Iqbal, 2020). More recently, Cyclone Amphan in 2020 impacted Bangladesh, along with coastal Odisha and West Bengal in India, causing damage of nearly US\$130 million in Bangladesh alone. The cyclone destroyed over 176,000 hectares of productive land, including shrimp and fish farms. Although the Sundarbans acted as a natural buffer, reducing wind speeds and tidal surges, heavy rainfall still triggered extensive flooding (Rashid et al., 2023)

Shyamnagar Upazila was selected as the study area for the present study based on four specific criteria: (i) frequent exposure to climatic hazards including cyclones, tidal surges, high winds, and salinity intrusion; (ii) reliant characteristics of natural resource-based livelihoods, particularly through fishing and forest resource collection from the Sundarbans; (iii) high level of poverty among fishing households; and (iv) socio-political and economic inequalities that constrain adaptive opportunities (see Alam et al., 2018).

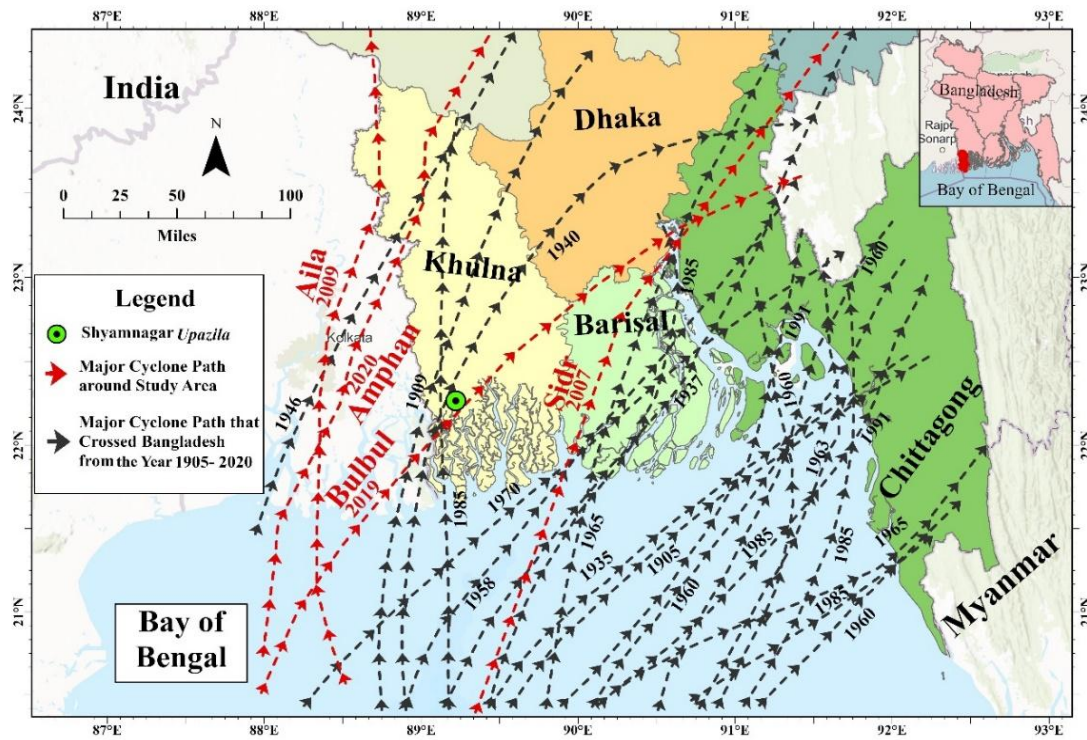


Figure H2. Major cyclone tracks that made landfall in Bangladesh from 1905 to 2020.

Source: Compiled from Ahmed et al. 2022; Badarinath et al. 2012; IFRC, 2020; Tamim & Islam (2025), (Md. M. Islam et al., 2014)

For our empirical investigation, we purposefully selected two unions in Shyamnagar Upazila: Munshiganj and Burigoalini Union (the lowest-level administrative unit), where the majority of the inhabitants depend on fishing as their primary occupation. Communities of these unions face extreme livelihood challenges stemming from periodical climate-induced shocks, such as cyclones and storm surges (Ashrafuzzaman, 2023; Bernard et al., 2022). The varied adaptive strategies of small-scale fishers, shaped by place, social, and environmental factors, were compelling reasons for selecting these spatial units as ideal study sites.

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