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# Assessing livelihood vulnerability induced by climatic hazards: a case study on fishermen communities of Shyamnagar, Shatkhira

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## Abstract

**Purpose** – Bangladesh is highly exposed to climatic hazards, placing communities closely connected to the natural environment, such as fishermen, at significant risk. This study aims to understand the effect of climate change on the livelihood of the fisherman community.

**Design/methodology/approach** – This study assessed the vulnerability of fishermen communities in three unions of Shyamnagar Upazila: Munshiganj, Burigoalini and Gabura, using the livelihood vulnerability index (LVI) IPCC framework. A total of 219 household-level interviews were conducted.

**Findings** – The LVI was found to be 0.5, indicating a high level of vulnerability across all three unions. Key contributing factors included water insecurity, poor health access, natural disasters and climate variability. The climate vulnerability index (CVI) score was minus 0.19, showing high climate vulnerability, as adaptive capacity (0.342) was notably lower than sensitivity (0.477) and exposure (0.748). Among the unions, Gabura exhibited the highest climate vulnerability. Despite these challenges, alternative livelihood practices and local adaptation strategies were observed as important mechanisms helping communities cope with ongoing



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climatic stressors. Findings highlight the urgent need for targeted adaptation support and sustainable livelihood options in coastal disaster-prone areas.

**Originality/value** – The coastal fisherman communities are among the first to be affected by climate change. While studies were done on coastal communities, their livelihood vulnerability to climate change and adaptive capacity has not been assessed thoroughly. This study will explore the interactive relationship between livelihood and climate vulnerability, and it will portray the adaptive dynamics of coastal fishermen.

**Keywords** Vulnerability, Livelihood, Vulnerability assessment, LVI-IPCC, Adaptive strategies

**Paper type** Research paper

## Background

The effects of climate change are felt across different settlements, such as rural, suburban and urban areas, which are interdependent. The consequences of climate change can disrupt these divisions and impact their varying levels of economic stability and resource availability (Saini, 2023). Human-induced climate change has already caused widespread adverse impacts like loss of ecosystems and biodiversity, adverse effect on the ecosystem services related to the livelihood, health, etc. of the inhabitants, extreme climate events that are beyond limits of what the inhabitants can endure, an intensification of hydrological cycle exacerbating water-related crises, cost of damage and reconstruction due to cyclones, flood and many more (Ministry of Environment Forest and Climate Change, 2022a, 2022b).

Over the past few decades, the temperature of Bangladesh has risen by 0.5°C (Mahmud *et al.*, 2021). The increasing climate impacts on coastal areas are concerning, and the fishing communities living there face threats to their livelihoods and the fisheries sector. Climate variability has caused 20% of fishermen in the coastal area of Bangladesh to change their profession over the last ten years (Barua *et al.*, 2020). Climate change can have cascading adversities on vulnerable people and pose threats to food, health, alternative livelihood options and adaptive capacity, among other areas (IPCC, 2022). As the fishing profession is highly dependent on seasonality, a lack of work further pushes them into poverty and chains them to a vicious cycle of vulnerability (Hossain *et al.*, 2024). To cope and adapt to these impacts, there can be short- and long-term social and technical adaptation practices (Islam *et al.*, 2021).

The frequency and intensity of climatic hazards in the coastal region of Bangladesh (cyclones, coastal floods, salinity intrusion, lightning, ocean acidification, etc.) have risen significantly (Ministry of Environment Forest and Climate Change, 2022a, 2022b). One such area of Bangladesh is Shyamnagar Upazila in Satkhira District. It is in Khulna Division and lies on the southwestern coast. Fisherman communities of Satkhira face climatic hazards such as cyclones, salinity intrusion, river erosion and high rainfall. They live alongside the Mangroves, being primarily dependent on their resources (Hassan *et al.*, 2021). As these areas are directly connected to the rivers surrounding them and have mangroves just beside them, the people living there are susceptible to climate extremes. The aftermath of cyclone Bulbul resulted in estimated economic and non-economic losses in the fishing community in Gabura alone, around 4,633 USD (Islam *et al.*, 2022).

Recent studies emphasize that these coastal ecosystems are experiencing intensified climatic stressors, which especially affect marginalized occupational groups like small-scale fishers (Ahmed *et al.*, 2024; Shehab, 2024; Kamal, 2025). New empirical analyses also show that climatic variability has exacerbated salinity intrusion, water insecurity and livelihood instability in these areas (Fahim and Arefin, 2024; Haque *et al.*, 2025). Globally, similar livelihood disruptions have been observed among deltaic and estuarine fishing communities, underscoring the transboundary nature of climate-induced livelihood threats (Alberto, 2024;

Banu and Fazal, 2025; Malhotra, 2025). These recent contributions reaffirm the need for further study on several indicators when assessing coastal livelihoods.

In the last several decades, Bangladesh's efforts in the political and technical dimensions of climate change have been visible through its national-level engagements (Ministry of Environment Forest and Climate Change, 2022a, 2022b). Several relevant ministries, such as the Ministry of Water Resources, Ministry of Fisheries, Ministry of Environment, Forest and Climate Change, Ministry of Food and the Ministry of Disaster Management and Resilience have been working together to achieve climate resilience. Some of these include the National Adaptation Program of Action (NAPA), Bangladesh Climate Change Strategy and Action Plan (BCCSAP) and Bangladesh Delta Plan 2100, etc. (Ministry of Environment Forest and Climate Change, 2022a, 2022b). Still, these policies often fail to consider the ground realities of climate change. Studies argue that policy-level adaptation measures in Bangladesh remain insufficiently localized, failing to capture the lived vulnerabilities of coastal fishers (Rahman *et al.*, 2024; Hossain *et al.*, 2025).

The purpose of this study is to assess the impact of climate change on the livelihoods of fishermen in the Shyamnagar Upazila, Shatkhira district of Bangladesh. This study also aims to find the adaptive strategies practiced by the fishermen's community that help tackle these challenges. Through the use of the LVI-IPCC framework, the study aims to understand the vulnerability of fishermen communities based on socio-demographic factors, livelihood strategies and climate parameters. Overall, the study seeks to contribute valuable knowledge to the understanding of climate-induced livelihood vulnerability in the Shyamnagar region.

## Conceptual framework

To fulfill the objective of this study, a composite livelihood vulnerability model has been chosen. LVI-IPCC Conceptual Framework comprises the livelihood vulnerability index (LVI) and climate vulnerability index (CVI) (Figure 1). To link livelihood vulnerability

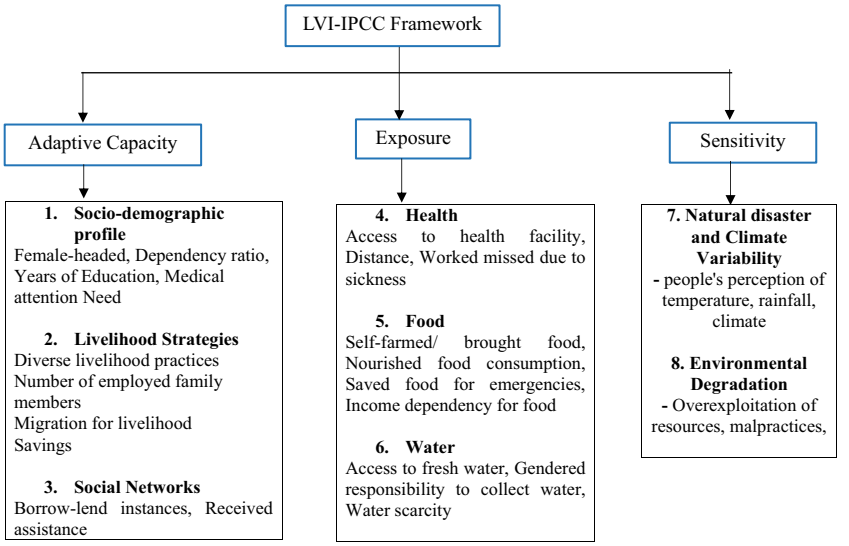


**Figure 1.** LVI-IPCC Framework for fishermen livelihood assessment in Coastal Bangladesh
**Source:** Created by authors

with climatic parameters and exposures, LVI-IPCC is the appropriate one (Hahn *et al.*, 2009; Shah *et al.*, 2013). LVI is measured through eight major components: characteristics of community socio-demographics, livelihood strategies, social networks, health, food and water-related issues, natural disasters/climate variability and environmental degradation (Shahzad, 2021).

These 8 components are further divided into 3 dimensions – adaptive capacity, exposure and sensitivity in the CVI or climate vulnerability approach. CVI or LVI-IPCC allows us to relate climatic parameters with the livelihood vulnerability of communities (Shahzad, 2021). LVI-IPCC uses multiple indicators for each of these major components to assess their adaptive capacity, sensitivity and exposure, which leads to measuring livelihood vulnerability induced by climatic parameters and hazards (Shah *et al.*, 2013). This framework aims to determine the strength of livelihood practices, which vary from community to community and with the geographic area, allowing researchers to add or remove indicators based on their research objectives and area. In addition, this framework allows us to compare these different communities and their current livelihood practices in the context of our study area and population.

## Methodology

### *Study area*

Shatkhira is a coastal district of Bangladesh situated in the southwestern part of the country. This region is susceptible to cyclones, storm surges and salinity intrusion. (Kumar Chakraborty, 2016). For the study, 3 unions of Shyamnagar Upazilla: Gabura, Munshiganj and Burigoalini were chosen for the research (Figure 2). Shaymnagar was selected due to its susceptibility to climate variability. And these three unions are closer to the Sundarbans and Open water sources; the majority of the fishing

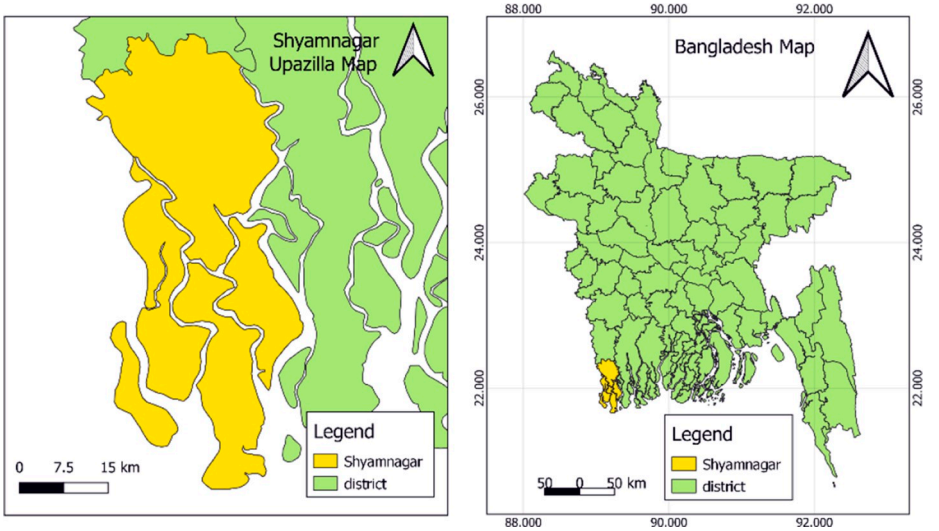


**Figure 2.** Study area map
**Source:** Created by authors

communities live by it. For better accessibility of the targeted population, these 3 unions have been chosen.

A map of our study area, showing where the responses were collected, is shown in Figure 3.

*Study design*

From the three unions, a total of 219 responses were collected. For the study, systematic sampling techniques, cluster random sampling and purposive expert nonrandom sampling were followed. The sampling was done following the flow (Figure 4).

Our study design comprises mixed methods, quantitative and qualitative. For the primary data collection, semi-structured questionnaire surveys and in-depth interviews were conducted. A door survey was conducted for primary data collection. Household heads were

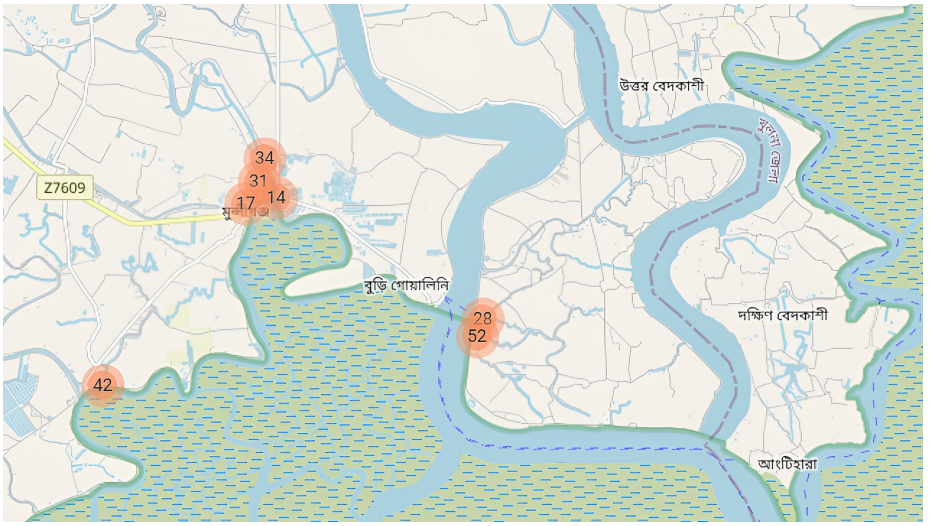


**Figure 3.** Responses collected from the following red-marked areas
**Source:** Created by authors

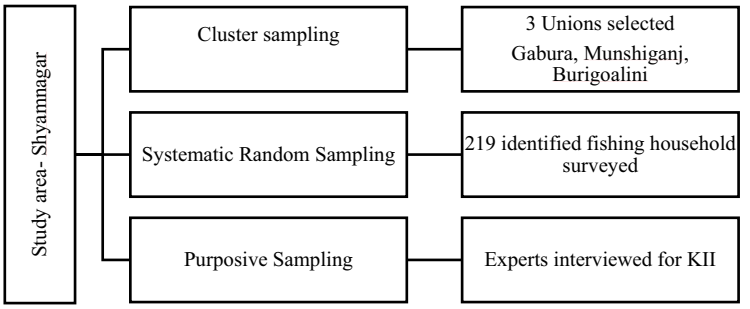


**Figure 4.** Sampling techniques
**Source:** Created by authors

approached for a questionnaire survey. Participants were required to (a) be permanent residents of one of the three selected unions; (b) identify fishing as their source of livelihood; (c) be aged 18 years or older and (d) be willing to provide informed consent during the data collection period. A questionnaire was developed following the LVI-IPCC conceptual framework to determine the LVI induced by climatic parameters (Hahn *et al.*, 2009; Shahzad *et al.*, 2021). Key informant interviews (KII) were done to validate the responses we got from the respondents. Experts involved with the subject matter, such as UNO, Agriculture officers and Fisheries officers, were approached for the KIIs along with the local NGO workers. Consent from all the respondents was obtained before we recorded their responses. No incentives were provided in exchange for their participation in the survey.

*Study tool*

A pilot study was conducted to justify the questionnaire, which was later finalized. Both closed-ended and open-ended questions were included in the questionnaire. The questionnaire was prepared and collected using Kobo Toolbox (KoboToolbox, 2023).

The final questionnaire consisted of 8 parts, which included socio-demographics of the community, livelihood strategies, social networks, health, food, water, natural hazards and climate variability. These components were further subdivided into 45 indicators or sub-components. After the data were aggregated, they were scored. The detailed questionnaire and the components that were considered to calculate the LVI and CVI have been added in Appendix of this study.

*Data analysis*

For analyzing the data, IBM SPSS Statistics 27 and Microsoft Excel were used. But for the portion where analyses were required, the data were first replaced with numerical values assigned to each closed-ended question. "Yes" = 1, "Maybe" = 0.5, "No" = 0, with these values, the answer was replaced.

*Livelihood vulnerability analysis*

For the measurement of the vulnerability index of the targeted community, the seven components were further divided into 40 sub-components. The details of the sub-components and the measurement are detailed in the tables attached.

First, the sub-components were scored and transformed into numbers between 0 and 1. Unit standardization of all the data was done, based on the following formulas,

Sub-components of a particular component were calculated into an average, which is denoted by Cn, and the formula that was followed:

$$\text{index for each Sub} - \text{component}\left(\text{standardized, } \text{Index}_{sc} = \frac{Observed\ value - Minimum}{Maximum - Minimum}\right) \quad (1)$$

Here, the observed value refers to the actual value that was derived from each sub-component, Maximum refers to the maximum possible value, and Minimum refers to the minimum value possible for that particular sub-component:

$$\text{Index of Major components } M_n = \sum_{i=1}^{n} \frac{Index_{sc}}{n} \quad (2)$$

Here, after determining the value of each sub-component under the major components, the value for the major components was calculated, where n refers to the number of sub-components under that particular major component.

To measure the LVI, we used:

$$\text{Index of the components LVI} = \frac{\sum_{i=1}^{7} M_n * n}{\sum_{i=1}^{7} n} \quad (3)$$

Here, the summation of the number of each sub-component for all seven major components ensures the equal contribution of these factors in the calculation of the LVI score.

The value of LVI will be in the range of 0–0.5, where 0 will denote the least vulnerable and 0.5 the most vulnerable (Shahzad, 2021).

*Climate vulnerability analysis*

Following the LVI-IPCC framework, the eight major components were grouped into three segments: adaptive capacity, sensitivity and exposure. Adaptive capacity was composed of socio-demography, livelihood strategies and social networks. Sensitivity measures people's standing on health, food and water facilities. Finally, exposure was composed of natural disasters and the region's climate variability. The formula that was followed while computing the CVI was:

$$CVI = (Adaptive\ capacity\text{-}Exposure) * Sensitivity$$

The CVI scale had values between −1 and 1.

CVI would be determined as:

Adaptive Capacity > (exposure + sensitivity) is Less Vulnerable.

Adaptive Capacity = (exposure + sensitivity) is Moderately Vulnerable.

Adaptive Capacity < (exposure + sensitivity) is Highly Vulnerable.

*Ethical issue*

This research complies with the ethical standards outlined in the Declaration of Helsinki and its subsequent amendments (WMA – The World Medical Association-WMA Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects, 2025). The ethics clearance committee granted ethical approval. Informed consent was obtained from all participants before each survey. No incentives were offered for participation.

*Limitations*

The limitations of this study are several. First, the research is geographically confined to three unions of Shyamnagar Upazila, which may not fully represent the larger variability in livelihood vulnerability. Another limitation is reliance on self-reported data from the fishermen communities, which can be subject to biases. In addition, the study uses a composite framework for vulnerability measurement, which, although comprehensive, may overlook some nuanced local vulnerabilities specific to individual households or sub-groups.

The study's methodology also faces constraints related to seasonal fishing. The reliance on household-level data, particularly for certain livelihood strategies and social networks, might not capture the full dynamics of community-wide vulnerabilities. Furthermore, the study does not address the long-term impact of adaptation strategies on community resilience, as it focuses on immediate vulnerability. It also faces limitations due to the availability of certain resources, such as government incentives, which were not uniformly distributed across the community. This lack of access to support can further skew the results and affect the robustness of the findings related to governmental support.

Moreover, there is a limited exploration of the potential interplay between climate-induced vulnerabilities and other socio-economic factors such as migration patterns and educational attainment. The absence of longitudinal data means that the study is unable to assess how vulnerabilities and adaptive strategies evolve. Finally, external factors, such as ongoing policy changes and broader environmental changes beyond the scope of this research, could impact the community's vulnerability in ways not captured during the study period.

## Results

### *Socio-demographic frequency distribution*

To determine the implications of their livelihood patterns on these aspects of their social life, a total of 219 households from three unions were interviewed. Detailed frequency distribution can be found in Appendix. Among all the fishermen that we interviewed, a total of 207 respondents were professional. And 12 respondents were seasonal fishermen, meaning they would adopt this profession only when necessary. Among the 207 professional respondents, 204 fishermen ventured into open waters, such as rivers, creeks and the Bay of Bengal, for fishing, accounting for 98% of the professional fishermen. Meanwhile, only four of those professional fishermen worked in enclosed gear.

Then again, among these professional fishermen who venture out to the open water, they reported that the forest and open waters are accessible to them for 5–7 months a year. For the other 5–6 months, the forest and open waters are off-limits to them. This ban comes in two to three segments over the year.

Even the Upazila Nirbahi Officer (UNO) of that area confirmed the livelihood practices adopted by the community to sustain themselves, given that their access to open water bodies is restricted for several months each year. But the restriction arises to protect natural resources from overexploitation and to provide a safe breeding space for the mother fish.

Now, with the forest and open water entry ban, fishermen opt for various alternative livelihood sources to sustain themselves (Figure 5). For instance, one works both as a day

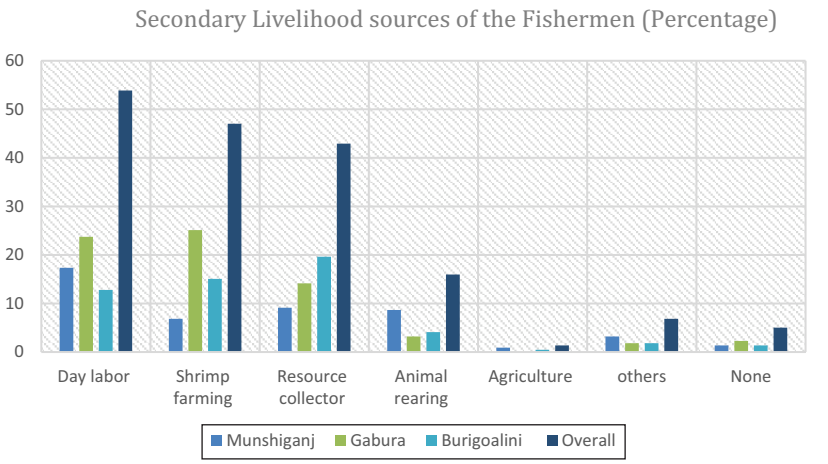


**Figure 5.** Alternative livelihood sources adopted by the fishermen community
**Source:** Created by authors

laborer and a resource collector in the Sundarbans. It allows some extra earnings for the professional fishermen during the bans imposed.

From the fishermen's responses, it was seen that only 26 households own fishing trawlers and boats. So, in the case of deep-sea fishing, they must borrow from the boat owners at high interest, which puts them into debt and decreases the value of their original income. 45% of the families interviewed reported being in debt. 80% replied that they needed and accepted assistance from government agencies in the last 6 months. Debt traps are a major barrier to financial independence.

The health segment highlights the disparities in access to healthcare facilities, the impact of illnesses on work and the prevalence of specific health issues in the surveyed areas. There seems to be a significant portion of the population (54.34%) in the surveyed areas without access to health facilities near their homes. This lack of access might contribute to the fact that a majority (61.19%) have to travel more than 2 kilometers (KM) to reach a nearby health center. The distance might be a barrier to timely healthcare.

A considerable number of respondents (93.61%) reported having to miss work due to illness. It suggests that health issues are affecting the economic productivity of the community.

Particularly in the surveyed area, cold and fever (204) and diarrhea (190) are widespread. These ailments, along with stomach aches (96) and rash and skin diseases (192), contribute to the health challenges faced by the community (Figure 6).

Most households are uncertain about the quality of their food, with almost 43% saying yes, 39% saying no and 18% expressing doubt. While the majority sources their food from the local market (98%), there's a negligible percentage that relies on self-farming, the forest or fisheries.

While 27.85% claimed to have abundant drinking water, a staggering 71.69% denied such availability, with only 0.46% uncertain. Tubewells were the primary source for 28.77%, ponds for 52.97% and rainwater-harvested plants for 40.18%. Surprisingly, 43.84% bought water, highlighting a dependency on external sources. In total, 12.33% reported arsenic contamination in their drinking water. The responsibility for water collection rested mainly on males (209), with only 72 females involved. Only 68.04% could collect water in under an hour, but 25.57% spent more than an hour. Regarding sanitation, 74.89% had kancha latrines, and 71.69% of women faced challenges during menstruation due to saline water.

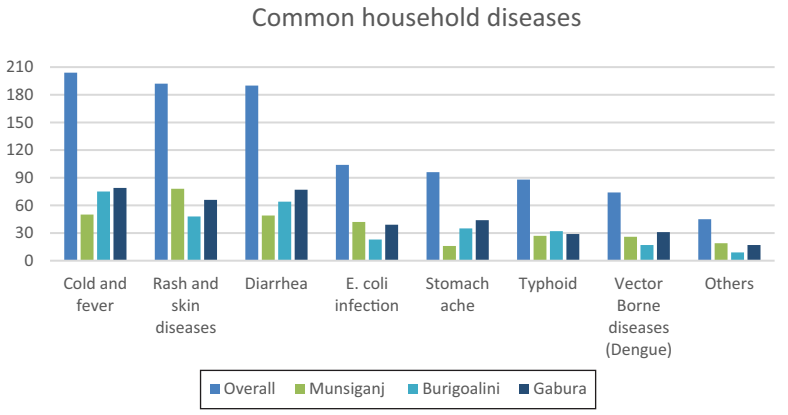


**Figure 6.** Common diseases in fishermen's households
**Source:** Created by authors

Surprisingly, 83.56% of fishermen's communities stored water, with containers (203) being the most common storage means. Containers are not sustainable for long-term water storage, and harsh weather makes the availability of fresh drinking water scarce. Water tanks, however, are most preferred by the community because they can store water for up to 3 months for a single household's use.

However, only 49 households responded that they have water tanks, often self-funded (27) or provided by NGOs (17). Only 10% of these tanks were provided by government organizations.

On the other hand, 95.43% believed that water scarcity had intensified in recent years, contrasting with only 2.74% who disagreed. Water scarcity peaked in summer at 97.72%, whereas only 0.46% faced it in the rainy season and 1.83% in winter. These results underscore the urgent need for improved water infrastructure and management.

Most people in the surveyed areas are aware of and have experienced various climate-induced hazards. Cyclones, floods and river erosion are among the prevalent hazards.

A majority of respondents (83.11%) perceived a high risk of their living places being threatened by climatic hazards (Figure 7), whereas 16.44% considered it moderate, and only 0.46% considered it low. During emergencies, 63.93% of the population could practice their regular livelihood activities, whereas 36.07% faced limitations. Most people (83.11%) agreed that climatic hazards affect their income because of the hazards' duration. Also, housing loss due to climate change or variability was considered high by 74.34%, moderate by 24.66% and none reported a low impact.

The majority of people (98.3%) have access to early warning systems, and a similar percentage (98.17%) reported understanding these systems. Access to cyclone shelters was high, with 92.69% confirming availability. The proximity of the nearest cyclone shelter

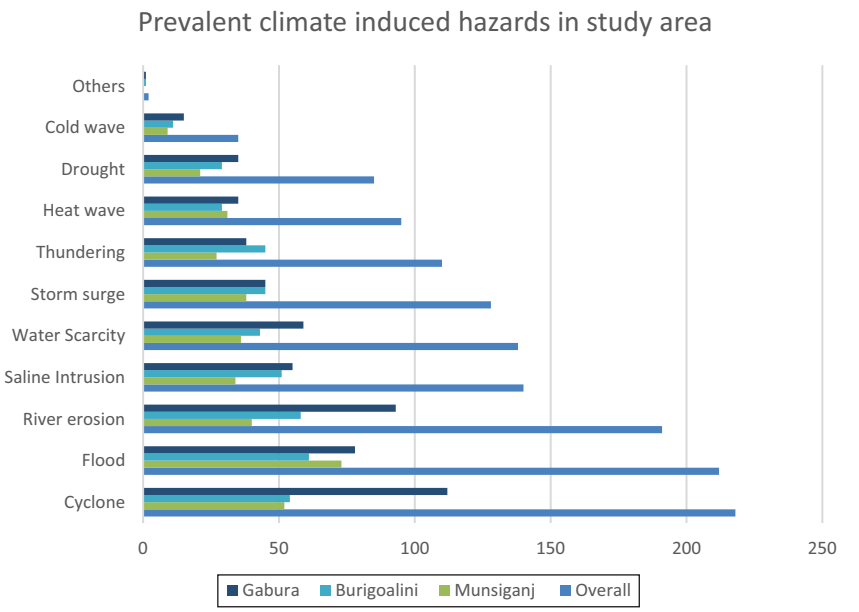


**Figure 7.** Prevalent climatic hazards
**Source:** Created by authors

varied, with 35.16% within less than 1 KM, 26.48% at 1 KM, 16.44% more than 1 KM but less than 2 KM, 2.74% at 2 KM, and 19.18% more than 2 KM. In response to early warnings, 79.45% of respondents evacuated, whereas 20.55% did not.

Tragically, 76.71% reported the loss of family members due to climate-induced disasters, and 64.38% reported family members sustaining serious injuries. Furthermore, 50.68% of the population had shifted or migrated to housing to protect their families from these natural hazards, whereas 49.32% had not taken such measures.

A significant majority in the surveyed area, around 94%, noticed changes in rainfall patterns, such as a decrease in rainfall, over the past two decades. A substantial 96.35% of respondents acknowledged changes, with the majority indicating an increase in temperature.

Moreover, a notable 90.87% of participants observed variations in the frequency of cyclones, floods, droughts and saline water intrusion. In the context of the increase in the intensity of these hazards, most responders agreed with that.

*Livelihood vulnerability index*

From the data on all components contributing to livelihood vulnerability, natural disasters and climatic parameters were identified as the most significant factors affecting the fishermen community. Sensitivity-inducing factors: health, food and water were the components that contributed to their vulnerability. However, people seemed fine with alternative livelihood strategies and social networks that reflect their relationships with relatives, neighbors and friends.

The LVI calculated for this study was 0.5, which would be termed as "Highly Vulnerable".

Among the 40 sub-components of the 8 major components, the fishermen community showed high susceptibility due to natural hazards (0.685) and climatic variability (0.937), which seemed to impact the livelihood loss of this population (Table 1). However, strategies that they follow to cope have led them to score better in this segment of livelihood strategies (0.225). Water (0.64) is yet another major component that makes them suffer living in their community.

Following the LVI-IPCC framework, the value for LVI (0.5) and CVI (−0.19) was calculated (Table 2), where LVI scored the highest possible number, indicating the high livelihood vulnerability of these fishermen's communities. As CVI scores are also dependent on LVI scores, CVI also showed a high vulnerability of people due to the induced climatic parameters.

Socio-demography in areas of Munshigaj (0.407) and Gabura (0.363) was just above the low threshold determined for this component (Table 3 and Figure 8). Burigoalini's people had better aspects regarding that. Repeated implications due to the natural hazards have brought them a good inflow of support from NGOs. People in all three areas scored low when asked about the components of their livelihood strategies and social networks, indicating a lack of resilience in these areas.

From there, there was a visible change in their sensitivity to the components of water and health. The availability of fresh drinking water was reported to have been scarce by 71.69% of the population. In total, 116 households reported using pond water for community use, and 96 households reported buying water regularly. Buying necessities can take a toll on income. On top of that, water scarcity has only got worse over the last few years. In total, 68% population agreed upon that. It also has implications for the WASH facilities in those areas. Women are the most affected by the water scarcity issue in that area.

In total, 64% of the population reported that they lose all sources of income during any emergency. In total, 83% of people's income is affected by various climatic hazards. Almost

**Table 1.** Calculating the major components and sub-components for composite LVI score

| Major component | Factors | Units | Minimum value | Maximum value | Score | Standardized value |
|---|---|---|---|---|---|---|
| Socio-demographic | Gender (female headed household) | % | 0 | 100 | 22 | 0.22 |
| | Age | Ratio | 0 | 1 | 49 | 0.49 |
| | Family type (joint) | % | 0 | 100 | 29 | 0.29 |
| | Households head that have not gone to school | % | 0 | 100 | 36 | 0.36 |
| | People with a constant need for medical attention | % | 0 | 1 | 0.47 | 0.47 |
| | | | *0.366* | | | |
| Livelihood strategies | How many people are currently employed in your household? | Average | 0 | 1 | 0.282 | 0.282 |
| | Households choosing to migrate somewhere else for livelihood generation? | % | 0 | 100 | 41 | 0.41 |
| | Savings | % | 0 | 100 | 17 | 0.17 |
| | Average livelihood diversity | Average | 0 | 5 | 0.2 | 0.04 |
| | | | *0.225* | | | |
| Social networks | HH does not have relatives and friends who can help financially during a disaster strikes or during low income | % | 0 | 100 | 51.4 | 0.514 |
| | HH that during any hazardous situation not send children to safety to your relatives' | % | 0 | 100 | 61 | 0.61 |
| | HH that had to borrow money from friends and relatives in the past 6 months? | % | 0 | 100 | 43 | 0.43 |
| | HH has not received any help or assistance from the local government | % | 0 | 100 | 19 | 0.19 |
| | HH has not received any financial or other aspect of assistance from NGOs | % | 0 | 100 | 33 | 0.33 |
| | | | *0.414* | | | |
| Health | HH not having access to health facilities near home? | % | 0 | 100 | 54.34 | 0.543 |
| | HH is a long distance from a nearby health center | % | 0 | 100 | 61.19 | 0.611 |
| | Average of family members falling sick(ratio) | Average | 0.25 | 1 | 0.555 | 0.41 |
| | HH members missing work due to illness | % | 0 | 100 | 93.61 | 0.93 |
| | | | *0.623* | | | |
| Food | HH consumes a proper amount of nourished food | % | 0 | 100 | 42.92 | 0.42 |
| | HH gets food from fishing | % | 0 | 100 | 0.91 | 0.0091 |
| | HH gets self-farmed food | % | 0 | 100 | 0.46 | 0.0046 |
| | HH not having saved food for emergencies like-cyclones, or flooding? | % | 0 | 100 | 49.77 | 0.497 |
| | HH goes starving when there is low income in the family? | % | 0 | 100 | 6.85 | 0.068 |
| | | | *0.199* | | | |
| Water | HH not having fresh drinking water available in abundance? | % | 0 | 100 | 71.69 | 0.716 |
| | HH where females are responsible for collecting drinking water | % | 0 | 100 | 32.87 | 0.328 |
| | HH spent more than 1-hour collecting drinking water | % | 0 | 100 | 68.04 | 0.68 |

(*continued*)

**Table 1.** Continued

| Major component | Factors | Units | Minimum value | Maximum value | Score | Standardized value |
|---|---|---|---|---|---|---|
| | HH thinks water scarcity has become more crucial | % | 0 | 100 | 68.04 | 0.680 |
| | Households that store water? | % | 0 | 100 | 83.56 | 0.835 |
| | | | *0.64* | | | |
| Natural disasters | HH rating the risk of current living place to be in threat of hazards induced by climatic parameters? | % | 0 | 100 | 83.11 | 0.831 |
| | Is HH losing their livelihood practices during this emergency situation? | % | 0 | 100 | 63.93 | 0.633 |
| | Do HH rating climatic hazards affect their income? | % | 0 | 100 | 83.11 | 0.831 |
| | HH rating climate change or climate variability affect housing loss high? | % | 0 | 100 | 75.34 | 0.753 |
| | HH has access to early warning systems regarding impending hazards | % | 0 | 100 | 98.63 | 0.986 |
| | HHs not able to access cyclone shelters during any emergency? | % | 0 | 100 | 7.31 | 0.731 |
| | HHs losing family members died due to these climate-induced disasters | % | 0 | 100 | 23.29 | 0.2329 |
| | HHs family member sustaining any serious injury due to the hazards? | % | 0 | 100 | 64.38 | 0.643 |
| | HHs shifted their housing or migrated your housing to protect your family from these natural hazards? | % | 0 | 100 | 49.32 | 0.493 |
| | | | *0.685* | | | |
| Climate variability | Are HHs noticing any change in the Rainfall pattern of this area over the past 20 years? | % | 0 | 100 | 94.06 | 0.940 |
| | HHs noticed a change in the Temperature pattern of this area over the past 20 years? | % | 0 | 100 | 96.35 | 0.963 |
| | HHs noticing changes in the frequency of cyclones/flood/drought/ saline water intrusion in the past 20 years? | % | 0 | 10 | 90.87 | 0.908 |
| | | | *0.937* | | | |

**Source(s):** Created by authors

half of the population had to relocate their homes due to the risk of hazards imposed upon them. For the fishing community, this risk is much more prevalent due to their proximity to the rivers. Besides that, over 90% of the population perceives that temperature and rainfall patterns have shifted rapidly over the past years.

Answering the open-ended questions, respondents reported that increased Temperatures were due to the prolonged summer and shortened winter. On top of that, the rainfall season has shifted from its usual time to later in September and October.

The extremity of these climatic aspects has significantly impacted the fishermen's lives and livelihoods in these areas.

For the overall score of the LVI, people scored the highest level of vulnerability due to scarce water resources and climate variability factors. Health and frequent natural hazards

**Table 2.** Calculating LVI and CVI score

| Factors | Major components | Major component values | No. of Sub-components | LVI | Contributing factor values | CVI value |
|---|---|---|---|---|---|---|
| Adaptive capacity | Socio-demographic profile | 0.366 | 5 | *0.5* | 0.342 | *−0.19* |
| | Livelihood strategies | 0.225 | 4 | | | |
| | Social networks | 0.414 | 5 | | | |
| Sensitivity | Food | 0.623 | 4 | | 0.477 | |
| | Health | 0.199 | 5 | | | |
| | Water | 0.64 | 5 | | | |
| Exposure | Natural disasters | 0.685 | 9 | | 0.748 | |
| | Climate variability | 0.937 | 3 | | | |

**Source(s):** Created by authors

**Table 3.** Area-wise segregation of LVI scores

| Components | Munshiganj | Burigoalini | Gabura |
|---|---|---|---|
| Socio-demographic | 0.407 | 0.338 | 0.363 |
| Livelihood strategies | 0.197 | 0.23 | 0.242 |
| Social network | 0.42 | 0.395 | 0.48 |
| Health | 0.52 | 0.625 | 0.78 |
| Food | 0.43 | 0.33 | 0.33 |
| Water | 0.74 | 0.74 | 0.85 |
| Natural disasters | 0.51 | 0.56 | 0.624 |
| Climate variability | 0.91 | 0.94 | 0.94 |
| *LVI* | *0.5* | *0.5* | *0.5* |
| *CVI* | *−0.15* | *−0.19* | *−0.22* |

**Source(s):** Created by authors

were other contributing factors to this result. Considering all the facts mentioned above, the overall LVI score of 0.5 would be regarded as Highly Vulnerable.

*Climate vulnerability analysis*

Taking all aspects of CVI, all components of it were calculated. After this, the scores for adaptive capacity, exposure and sensitivity were determined, resulting in a final CVI score of −0.19 (Table 4).

The score for the fishermen's community's adaptive capacity is lower than that of the other two factors (Figure 9). It indicates that people in those communities were less vulnerable in terms of their socio-economic conditions, livelihood strategies and social bonds with others.

On the other hand, people scored higher in the exposure segment, which comprised the components of natural disasters and climate variability. Their exposure to frequent natural disasters, changing climate patterns and unpredictable climatic parameters is the main reason behind the increased vulnerability in this particular section.

The same goes for the sensitivity section. The three interrelated aspects, with one compromised or missing component, directly impact the community's people, their monetary standing, and ultimately their earnings. It is a vicious cycle of food insecurity,

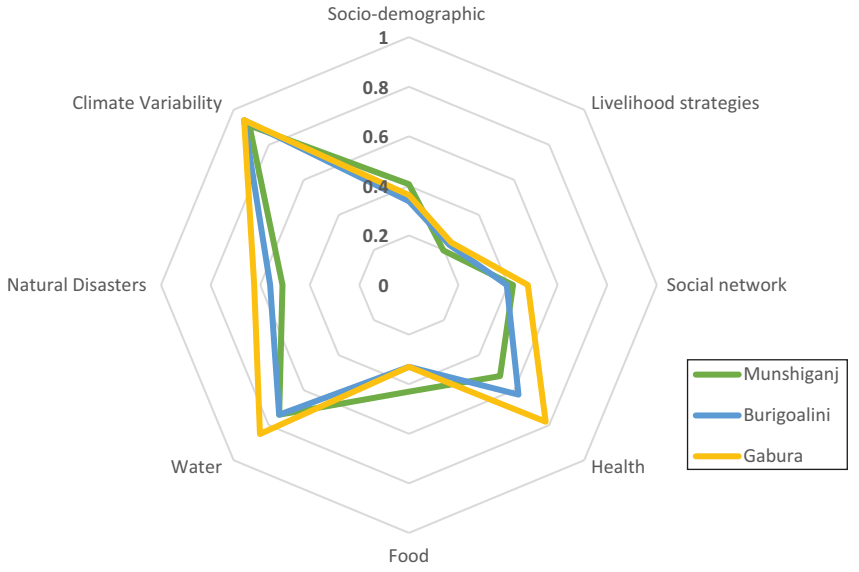


**Figure 8.** Union-based depiction of LVI components
**Source:** Created by authors

**Table 4.** Climate vulnerability index table

| | | |
|---|---|---|
| Adaptive capacity | 0.342 | Here, adaptive capacity<(exposure +sensitivity) |
| Sensitivity | 0.447 | |
| Exposure | 0.748 | Hence, Highly Vulnerable |
| *CVI* | *−0.19* | |

**Source(s):** Created by authors

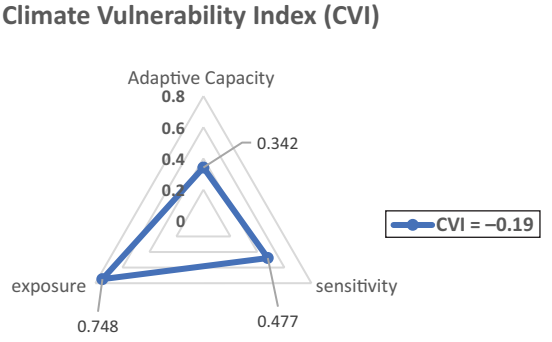


**Figure 9.** CVI score for each component
**Source:** Created by authors

malnutrition, ill health, loss of livelihood, low flow of income and hence, susceptibility to poverty.

**Discussion**

Through this study, the vulnerability of the fishermen's community and the underlying causes of their susceptibility were identified. Here, the CVI is designed to assess the vulnerability of communities to climate change, particularly in mountainous regions (Pandey and Jha, 2012). According to the index, the community will be termed "Highly vulnerable" and will show high susceptibility to extreme climate.

The study revealed that the fishermen's household had moderate adaptive capacity, which comprised diverse socio-demographic aspects, alternate livelihood strategies and strong social bonding. They save whenever they can, have alternative sources of income, maintain strong bonds with their relatives and neighbors and help each other during difficult times. Understanding adaptive capacity is crucial for assessing vulnerability to climate change, and it helps this community identify how well they can cope with and respond to climate-related challenges (Edmonds *et al.*, 2020). Studies discussed in their respective studies that knitted community structure, small savings and having an extra source of income help fishermen to survive the fishing ban in countries like Bangladesh and Indonesia (Siddique *et al.*, 2023; Riantini *et al.*, 2024).

Firstly, to maintain sustainable fish stocks, which is vital for the long-term health of ecosystems, a fishing ban is imposed on fishermen approximately three times each year (Shamsuzzaman *et al.*, 2017). During the ban, they cannot enter the open water, and the forest is also restricted. This ban is in June-August, November-December and March-April (Hoq *et al.*, 2021). Bans are provided to protect the natural breeding of shrimps, Crabs and local white fish. The fishing ban imposed for 5–7 months each year forces the fishermen to stay at home for half of the year. These alternative livelihoods are essential for fishermen, especially during periods when fishing is restricted or less productive (Shamsuzzaman *et al.*, 2017). To maintain the inflow of money into the family, they work as day laborers in brick kilns, shrimp farms and agricultural fields. Sometimes, they migrate to other parts of the country for months to work as day laborers. There were instances of gender disparity in the community of Shyamnagar. Women are paid less than men who perform similar work as day laborers. The study found that women working as day laborers in shrimp farms earn 320 taka per day, whereas men earn 400 taka per day.

But livelihood generation can also contribute to the degradation of the ecology. Local practices of collecting minnows to sell are reducing fish production at a concerning rate, according to the Forest Department officer, Zillur Rahman. Fishermen themselves also reported not finding as many fish as before. Many fishermen also poison the creeks of Sundarbans to catch fish, which damages the ecology of the region. That is why the fishing ban is compulsory to support the biodiversity of all fish species in Bangladesh (Rahman *et al.*, 2017).

Respondents were found to be highly sensitive when it came to health, food and water components. Poor scores in their health, food and water factors indicated susceptibility to poor health and hygiene. But these sectors are crucial for the well-being of communities, especially in coastal cities (Balica *et al.*, 2012). Respondents with low income cannot afford nutritious food and often report going hungry. These factors make them susceptible to diseases like malnutrition and low immunity, which cause frequent sickness (Sunny *et al.*, 2020). Water scarcity and lack of WASH provision contribute to problems like diarrhea, cholera and skin diseases. Compromised food and health further take a toll on earnings, making them more vulnerable.

People store and collect rain-harvested water to meet their daily needs for fresh water. Women and men both contribute to the collection of water, often traveling miles to do so. In the local markets, water is sold for 5 taka per container. So, sustainable water management practices are necessary to maintain water quality and availability for the community people (Balica *et al.*, 2012). The health sector plays a vital role in ensuring the population's well-being, particularly during and after any hazardous events (Balica *et al.*, 2012). For health services, people can avail themselves of the Upazilla Health Complex and "Friendship Hospital" for their needs. Despite the broad distance, they have no choice. In extreme weather, it becomes tough to commute to the hospital. All of this information has been verified by our Key informant, Medical Officer, Saud Bin Khairul Anam.

Respondents scored the highest in terms of their exposure to natural hazards and climate variability, indicating the high vulnerability of the said community. Frequent and intensified natural hazards necessitate annual house repairs, and constant exposure to climate change at the local scale has normalized this for the people. A study also found similar instances in his study (Nguyen *et al.*, 2017). They cannot work during those times, which force them to lose their home and livelihoods. People need to start over, leading to a vicious cycle.

However, people responded to having a systematic early warning system in place. They received the early warning well in advance and had enough time to evacuate. They understand the warnings and the implications those can have for them. However, the prolonged summer, unpredictable rainfall patterns, shortened winter and consequent income loss make them perceive themselves as highly vulnerable, and the scores in this regard also justify that. However, people have been addressing these issues through adaptation strategies such as coastal afforestation programs and placing geo-bags and dams around the river to protect it from coastal erosion, cyclones and storm surges.

A key finding from the study is the unequal access to government incentives and subsidies. Registered fishermen who have the "Jele Card" can avail themselves of these incentives. However, not everyone is given a card, and its registration process is administratively complex. Hence, there is an unequal distribution of the rations allocated for the fishing ban time period. When asked why they don't have the card, fishermen, whether they have the card or not, responded to the discrepancies and corruptions regarding this. When asked, the Fisheries officer denied the allegations and said:

> It takes only 100 taka to open a card and 70 taka to renew it. There are no discrepancies from our side. But if any middleman is involved during the process, there might be a chance of corruption and extortion.

Regardless of the reason, it is transparent that many fishermen are devoid of the government facility that is dedicated only to them. Without that, they are susceptible to this profession's uncertainties. A study also acknowledged the complexity of subsidies allocated for small-scale fishermen in this region (Zainab and Shah, 2024). By being proactive, governments can significantly enhance the resilience of these communities (Nguyen *et al.*, 2017).

The findings of this study emphasize the urgent need to integrate diversified livelihood mechanisms, implement gender-sensitive labor and sanitation policies and ensure transparency in government policy and intervention. Addressing these challenges and institutional gaps can help alleviate the fishermen community from the vicious cycle of poverty and vulnerability. Similarly, the LVI-IPCC can be further incorporated to evaluate and identify the localized components of livelihood vulnerability, thereby strengthening climate action governance in Bangladesh.

## Conclusion

Fishermen communities of the coasts live at the frontline of climate extremes, and their livelihood depends on the already vulnerable and scarce ecosystems there. Using the LVI-IPCC framework, this study quantified the community's livelihood vulnerability and presented localized aspects contributing to the cause. Even though people have strong social networks and alternative livelihood practices in place, frequent exposure to natural hazards makes it difficult for them to be resilient. Despite having institutional mechanisms like early warning systems and cyclone shelters in place, gaps were identified in policy, ground-level intervention, government and access-related assistance. This study revealed that adaptive capacity remains relatively weak compared to exposure and sensitivity factors, largely due to water scarcity, health challenges and livelihood instability. The findings highlight that climatic stressors such as salinity intrusion, erratic rainfall and recurring cyclones directly undermine household income and food security. Moreover, social and gender disparities further exacerbate vulnerability, especially for women and marginalized fishers.

To enhance resilience, targeted interventions are required, such as strengthening local adaptation funds, expanding equitable access to the "Jele Card" program, promoting nature-based livelihood diversification and integrating gender-sensitive and community-driven adaptation planning. Policy coherence among fisheries, environment and disaster management ministries is essential to translate national adaptation frameworks into tangible local benefits. From a research perspective, future studies should incorporate longitudinal data to assess changes in adaptive capacity over time and explore how ecosystem restoration and digital early warning systems can enhance the adaptive governance of coastal livelihoods. The inclusion of socio-psychological and migration-related variables can also deepen the understanding of household-level adaptation dynamics. Overall, this study contributes empirical evidence to the growing discourse on climate-induced livelihood vulnerability and emphasizes the urgent need for localized, inclusive and sustainable adaptation strategies to safeguard the coastal fishing communities of Bangladesh.

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## Appendix

**Table A1.** Frequency analysis

| Questions | Factors | No. (*n*) | Frequency (%) |
|---|---|---|---|
| *Socio-demographic* | | | |
| Gender | Male | 171 | 78 |
| | Female | 48 | 22 |
| Age | 18–25 years old | 28 | 12.79 |
| | 26–35 years old | 38 | 17.35 |
| | 36–45 years old | 49 | 22.35 |
| | 46–55 years old | 38 | 17.35 |
| | 56–65 years old | 42 | 19.18 |
| | >65 years old | 24 | 10.96 |
| Family type | Nuclear | 154 | 70 |
| | Joint | 65 | 30 |
| Education level | No formal education | 81 | 38 |
| | Can write name | 83 | 37 |
| | Primary education | 49 | 22 |
| | Secondary level | 5 | 2 |
| | Higher secondary level | 1 | 1 |
| Fishermen type | Professional | 207 | 94 |
| | Subsistence | 12 | 6 |
| Type of residential unit | Kancha | 190 | 87 |
| | Semi-pakka | 27 | 12 |
| | Pakka | 2 | 1 |
| Do you own this land? | Yes | 60 | 73 |
| | No | 159 | 27 |
| Monthly income | <5,000 | 110 | 50 |
| | 5,000–10,000 | 91 | 41 |
| | 10,000–15,000 | 13 | 6 |
| | 15,000–25,000 | 4 | 2 |
| | >25,000 | 1 | 1 |
| Do you have anyone in the family who is in constant need of medical attention? | Yes | 104 | 47.49 |
| | No | 115 | 52.51 |
| | Maybe | 0 | 0 |
| *Livelihood strategies* | | | |
| How many people are currently employed into your household? | 1 person | 114 | 53 |
| | 2 people | 87 | 38 |
| | 3 people | 18 | 9 |
| Did you ever migrate to somewhere else for livelihood generation? | Yes | 90 | 41 |
| | No | 128 | 58 |
| | Maybe | 1 | 1 |
| Do you have any savings? | Yes | 181 | 83 |
| | No | 38 | 17 |
| Which of these subsistence do you own? | Fishing gear (nets, traps, etc.) | 198 | 91 |
| | Fishing crafts (trawlers, boats) | 26 | 11 |
| | None of these | 12 | 6 |
| *Social networks* | | | |
| Do you have relatives and friends who can help you financially during a disaster strikes or during low income? | Yes | 101 | 46.6 |
| | No | 113 | 51.4 |
| | Maybe | 5 | 3 |
| During any hazardous situation do you send your children to safety to your relatives? | Yes | 82 | 37 |
| | No | 133 | 61 |
| | Maybe | 4 | 2 |

(*continued*)

**Table A1.** Continued

| Questions | Factors | No. (*n*) | Frequency (%) |
|---|---|---|---|
| Did you have to borrow money from friends and relatives in the past 6 months? | Yes | 97 | 43 |
| | No | 118 | 55 |
| | Maybe | 4 | 2 |
| Did you receive any help or assistance coming from the local government? | Yes | 177 | 80 |
| | No | 41 | 19 |
| | Maybe | 1 | 1 |
| Did you receive any financial or other aspect of assistance from NGOs? | Yes | 140 | 64 |
| | No | 74 | 33 |
| | Maybe | 5 | 3 |
| *Health* | | | |
| Do you have access to health facilities near your home? | Yes | 94 | 42.92 |
| | No | 119 | 54.34 |
| | Maybe | 6 | 2.74 |
| Distance from a nearby health center from your home? | Less than 1 KM | 40 | 18.26 |
| | 1 KM | 23 | 10.5 |
| | More than 1 KM | 21 | 9.59 |
| | 2 KM | 1 | 0.46 |
| | More than 2 KM | 134 | 61.19 |
| How often do you and your family members fall sick? | Once a week | 12 | 5.48 |
| | Once in a month | 90 | 41.1 |
| | Once every two months | 52 | 23.74 |
| | Once every six months | 65 | 29.68 |
| Do you ever have to miss your work due to illness? | Yes | 205 | 93.61 |
| | No | 14 | 6.39 |
| | Maybe | 0 | 0 |
| *Food* | | | |
| Does your household consume a proper amount of nourished food? | Yes | 94 | 42.92 |
| | No | 85 | 38.81 |
| | Maybe | 40 | 18.26 |
| Where do you get most of your food from? | Self-farmed | 1 | 0.46 |
| | Forest | 2 | 0.91 |
| | Fisheries | 2 | 0.91 |
| | Local market | 214 | 97.72 |
| Do you have saved food for emergencies like-cyclone, flooding? | Yes | 107 | 48.86 |
| | No | 109 | 49.77 |
| | Maybe | 3 | 1.37 |
| Does your household go starving when there is low income in the family? | Yes | 196 | 89.5 |
| | No | 15 | 6.85 |
| | Maybe | 8 | 3.65 |
| *Water* | | | |
| Do you have fresh drinking water available in abundance? | Yes | 61 | 27.85 |
| | No | 157 | 71.69 |
| | Maybe | 1 | 0.46 |
| Who is responsible for collecting drinking water for the household? | Male | 209 | |
| | Female | 72 | |
| How much time does it take to collect drinking water from these sources? | <1 Hour | 149 | 68.04 |
| | 1 Hour | 14 | 6.39 |
| | <1 Hour | 56 | 25.57 |
| Do you think in recent years, water scarcity has become more crucial in your household and nearby areas? | Yes | 209 | 68.04 |
| | No | 6 | 6.39 |
| | Maybe | 4 | 1.83 |

(*continued*)

**Table A1.** Continued

| Questions | Factors | No. (*n*) | Frequency (%) |
|---|---|---|---|
| Does your household store water? | Yes | 183 | 83.56 |
| | No | 35 | 15.98 |
| | Maybe | 1 | 0.46 |
| In which season does this water scarcity turns into the worst? | Summer | 214 | 97.72 |
| | Rainy | 1 | 0.46 |
| | Winter | 4 | 1.34 |
| *Natural hazards* | | | |
| How do you rate the risk of your current living place being in threat of hazards induced by climatic parameters? | High | 182 | 83.11 |
| | Low | 1 | 0.46 |
| | Moderate | 36 | 16.44 |
| Can you practice your livelihood practices during this emergency situation? | Yes | | 36.0779 |
| | No | 140 | 63.93 |
| To what extent do these climatic hazards affect your income? | High | 182 | 83.11 |
| | Medium | 37 | 16.89 |
| | Low | 0 | 0 |
| To what extent does climate change or climate variability affect housing loss? | High | 165 | 75.34 |
| | Medium | 54 | 24.66 |
| | Low | 0 | 0 |
| Do you have access to early warning systems regarding the impending hazards? | Yes | 216 | 98.63 |
| | No | 3 | 1.37 |
| Do you understand the early warning systems? | Yes | 215 | 98.17 |
| | No | 4 | 1.83 |
| Can you access cyclone shelters during any emergency? | Yes | 203 | 92.69 |
| | No | 16 | 7.31 |
| How close is the nearest cyclone shelter to your home? | Less than 1 KM | 77 | 35.16 |
| | 1 KM | 58 | 26.48 |
| | More than 1 KM | 36 | 16.44 |
| | 2 KM | 6 | 2.74 |
| | More than 2 KM | 42 | 19.18 |
| Do you evacuate after getting early warnings? | Yes | 174 | 79.45 |
| | No | 45 | 20.55 |
| Did any of your family members die due to these climate-induced disasters? | Yes | 51 | 23.29 |
| | No | 168 | 76.71 |
| Did any of your family members sustain any serious injury due to the hazards? | Yes | 78 | 35.62 |
| | No | 141 | 64.38 |
| Have you ever shifted your housing or migrated your housing to protect your family from these natural hazards? | Yes | 108 | 49.32 |
| | No | 111 | 50.68 |
| *Climate variability* | | | |
| Did you notice any change in the Rainfall pattern of this area over the past 20 years? | Yes | 206 | 94.06 |
| | No | 13 | 5.94 |
| What sort of changes did you observe regarding the rainfall pattern changes? | Majority – Rainfall decreased | | |
| Did you notice any change in the Temperature pattern of this area over the past 20 years? | Yes | 211 | 96.35 |
| | No | 8 | 3.65 |

(*continued*)

**Table A1.** Continued

| Questions | Factors | No. (*n*) | Frequency (%) |
|---|---|---|---|
| What sort of changes did you observe regarding the temperature pattern changes? | Majority – temperature increased | | |
| Did you notice any changes in the frequency of cyclones/floods/drought/ saline water intrusion in the past 20 years? | Yes | 199 | 90.87 |
| | No | 20 | 9.13 |
| What sort of changes did you observe regarding the intensity pattern of these hazards? | Majority – hazards increased | | |

**Source(s):** Created by author

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