Climate Change-Induced Damages and Loss Assessment: Adaptation Strategies to Achieve Resilience in Coastal Communities of Bangladesh

Submitted by

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Abstract

Climate change is the long-term change of weather patterns that influences the increase of intensity and frequency of natural hazards and the coastal people of Bangladesh suffer as much as other coastal people of the world. The objective of this study is to explore the economic and noneconomic losses and damages experienced by hazard-prone communities in severe climate events and the challenges they face to overcome. The study followed both quantitative and qualitative methods for analysis. The purposive survey was conducted among 110 riverine communities. Besides, Key Informant Interviews (KII), and Focus Group Discussion (FGD) were also conducted on the coastal Island of Bhola. This study first explored people's perceptions of climate change. Around 99.01% of respondents said they knew what that meant and thought it was happening right now. Based on climate events, this study identified economic losses and damages, which are land loss, crop damages, loss of infrastructure, fish reduction, loss of trees, etc. The majority of them (91.82%) agreed that riverbank erosion is the main reason for economic losses. This study also examined noneconomic losses and damages. Migration, loss of social cohesion, loss of biodiversity, health impact, food insecurity, impact on cultural activities, etc. are noneconomic losses and damages. The study found some adaptive techniques that were followed by the riverine coastal community. The majority are migrated (>84%) internally but permanently, considered an adaptive measure. Approximately 92.73% of participants concurred that the celebration of various festivals may be impacted by climate change as a result of financial losses. They also used fertilizer to increase productivity. Changing land use patterns (>90%) and cultivating high-yield varieties (HYV) crops are also their adaptation technique. Again, they take support from NGOs, relatives, family members, and neighbors by borrowing money. This study also tried to document adaptation challenges. Lack of money is the main barrier to adapting to climate change. Proper training and workshops may help them to adapt to climate change issues. Our findings will help in the field of climate change to understand the loss damages and adaptation challenges in the coastal community.

Keywords: Cyclone, salinity, economic, noneconomic, losses and damages, resilience, adaptation, Bangladesh

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List of Abbreviations

KII	Key Informant Interview
FGD	Focus Group Discussion
HYV	High Yield Varieties
EEZ	Exclusive Economic Zone
GDP	Gross Domestic Product
CSA	Climate Smart Agriculture
EbA	Ecosystem-based Adaptation
BWDB	Bangladesh Water Development Board
HWL	High Water Level
LWL	Low Water Level

Chapter One

Introduction

Climate change, as well as the frequency and severity of climatic risks, varies greatly by region (Ahmed & Tan, 2021). It is affecting numerous countries around the world, but Bangladesh has been particularly hard-struck, where a large proportion of the people live in poverty (M. M. Rahman, 2023). Natural hazards and calamities disproportionately affect the poor (Hallegatte et al., 2020). Climate change can cause catastrophic damage and loss to human settlements and the environment as a whole (Ahmed & Tan, 2021). The major threats are land erosion, floods, high levels of salinity, cyclones, drought, heat waves, storm surges, sea-level rise, cold waves, sedimentation, and waterlogging (Sesana et al., 2021) (M. M. Rahman, 2023) (Ahmed & Tan, 2021) (Haque et al., 2019) (Mustafa Saroar et al., 2019). Not all climate change consequences develop in the same way or at the same time: some emerge abruptly, others gradually and over time, and many impacts might occur concurrently and in diverse combinations (Lawrence et al., 2020). The world witnessed over 12,000 climatic and related disasters from 1999 to 2018, resulting in over 495,000 deaths and economic damages exceeding USD 3.54 trillion (Eckstein, D., Kunzel, V., Schafer, L., & Winges, 2019) (Ahmed & Tan, 2021). Myanmar, Pakistan, Haiti, the Philippines, Vietnam, Puerto Rico, the Dominican Republic, Bangladesh, Nepal, and Thailand, were the 10 worst-affected countries (Ahmed & Tan, 2021). According to current estimates, developing nations will require between US$ 290 billion and US$ 580 billion in climate finance by 2030 to cover residual loss and damage (Eckstein et al., 2021).

Oceans encompass approximately 72% of the Earth's surface and have 620,000 kilometers of shoreline (Gopalakrishnan et al., 2019). The Bay of Bengal and the Ganges Brahmaputra Meghna (GBM) river system dominate the geomorphology and hydrology of Bangladesh's coastal zone (GBM) river system and the Bay of Bengal (Haque et al., 2019). Bangladesh's CZ is approximately 47,203 km2, with a 710 km-long coastline and an Exclusive Economic Zone (EEZ) of 200 nautical miles (Shampa et al., 2023) (M. R. Rahman et al., 2021). It is home to about 700 rivers and tributaries (Mustafa et al., 2023) (Rumana et al., 2023). Satkhira, Khulna, Jessore, Shariatpur, Chandpur, Narail, Bagerhat, Pirozpur, Jhalakati, Barguna, Barisal, Patuakhali, Bhola, Gopalganj, Noakhali, Feni, Lakshmipur, Chittagong, and Cox's Bazar are among its 19 districts (Mustafa Saroar et al., 2019). Bangladesh has focused a great deal of attention on five indicators of climate change: precipitation, annual mean temperatures, cyclone frequency and severity, extreme flooding events, and salinization of rivers, groundwater, and soils ((Bernzen et al., 2019). Bangladesh is considered to be the fifth most vulnerable country in the world to natural disasters due to its geographical location (M. A. A. Hoque, Pradhan, et al., 2019). Like other coastal regions, the largest Bhola island is not different. It is situated in Bangladesh's center south and is part of the coastal region. It is one of the most sensitive areas to climate change (Shaibur et al., 2023). It is also a part of the Barishal division and is directly connected with the Bay of Bengal in the south. Shahbazpur Channel and the (lower) Meghna River are located to the east as well as the Tentulia River to the west of this island.

Due to erosion, people who live along the coast or on the banks of large rivers are particularly vulnerable in many developing and less developed nations, including Bangladesh, India, the Philippines, and Indonesia. Natural disasters are expected to drive 9.6 million individuals from 29 country districts to relocate domestically and internationally by 2050. Among these, riverbank erosion will result in the displacement of 1.9 million people (Malak et al., 2021). Over the last century, erosion has severely reduced the size of numerous Bangladeshi islands (Mallick & Mallick, 2021). Asia is home to the greatest concentration of people who live in low-elevation coastal zones and are most vulnerable to coastal flooding. This situation is expected to persist in the future for China, India, Bangladesh, Indonesia, and Vietnam. About 50 million people reside below 5 meters above mean sea level in Bangladesh, and 46% of the country's population lives below 10 meters above sea level (Roy et al., 2022). Since the mid-nineteenth century, the worldwide mean sea level has risen by about 20 cm(M. A. A. Hoque, Ahmed, et al., 2019). Floods are the most destructive natural calamity, having claimed 6.8 million deaths worldwide in the 20th century, according to a recent study that claimed 2.3 billion lives between 1995 and 2015 (Singha et al., 2020). Floods are the primary cause of damage to the environmental ecology, transportation system, agriculture, farming, sociocultural heritage, and human life (Sarkar & Mondal, 2020). Floods have an estimated 350 million effects on people worldwide (Chan et al., 2022). Cyclones strike Bangladesh's shores regularly. A major cyclone affects the country every three years on average. These disasters result in significant loss of life, property, biodiversity, animals, and, most critically, agriculture, resulting in significant social and economic costs for the impacted populations (Rahaman & Esraz-Ul-Zannat, 2021). A projected estimate indicates that approximately 35 million people and 97% of Bangladesh's coastal areas are exposed to several extreme weather occurrences (Hossen et al., 2022). It is also anticipated that salinity affects around 53% of the country's coastal areas (R. Islam et al., 2023).

A rising body of research indicates that alterations in the climate system are causing a variety of biophysical and economic effects that are already influencing the economy. Future consequences are predicted to be severe (Dellink et al., 2019). Bangladesh, the world's fifth largest aquaculture producer, accounts for 56.8% of total national fishing production. This sector accounts for around 60% of animal protein intake, and more than 11% of its 160 million citizens are directly or indirectly employed in this sector (M. M. Islam et al., 2019). According to the Intergovernmental Panel on Climate Change's fifth report (IPCC-AR5), by the middle of the twenty-first century and beyond, marine species will be forced to relocate to new areas because of forecasted climate change. It is anticipated that both direct and indirect effects of climate change will be felt by freshwater and marine fisheries, with implications for ecosystems, populations of coastal fishermen, and economies reliant on fisheries (M. M. Islam, Islam, et al., 2020).

Bangladesh is the world's fourth-largest rice producer (Singha et al., 2020). Climate change and variability may have an impact on crop cultivation in both good and negative ways around the globe (Shakhawat Hossain et al., 2019). Agriculture provided 14.10 percent of the Gross Domestic Product (GDP) in 2017-18, with crops accounting for around 9.28 percent of the GDP. Its geographical location, poor socioeconomic development, inadequate institutional arrangements, and limited local capability are predicted to result in a 7.4% annual drop in rice output from 2005 to 2050, with an accumulative total of 80 million tons from 2005 to 50. Climate change has the

potential to reduce agricultural GDP by 3.1 percent per year, amounting to $36 billion in lost value-added between 2005 and 2050 (Debnath et al., 2019). Bangladesh has had a 1% annual decline in the amount of agricultural land available over the previous 30 to 40 years (M. M. Islam, Jannat, et al., 2020). Water availability is expected to decline due to climate change, while agricultural water consumption is predicted to increase by 19% in 2050. In South Asia (SA), it is predicted that the annual average maximum temperature may increase by 1.4–1.8 ℃ in 2030 and 2.1–2.6 ℃ in 2050, and thus, heat-stressed areas in the region could increase by 12% in 2030 and 21% in 2050. Therefore, in the absence of adaptation measures to climate change, South Asia could lose an equivalent of 1.8% of its annual gross domestic product (GDP) by 2050 and 8.8% by 2100 (Aryal et al., 2020). The average temperature in Bangladesh has been rising at a rate of 0.20 °C each decade. A rise of 153 mm in annual rainfall was expected for 2011-2020, and later studies have indicated a growing tendency for three seasons, except winter, which is becoming cooler and drier while the rest of the year is becoming warmer and wetter (Chowdhury et al., 2022). Cultural heritage places are already being impacted by climate change (Sesana et al., 2021). It was anticipated that a one-meter rise in sea level would submerge over 20% of Bangladesh's land area and force 20-30 million people to be relocated from the coastal zone (M. Z. Hoque et al., 2019). Climate change is also expected to displace one out of every seven people in Bangladesh by 2050 (Khan, 2019). Climate change is hurting people's mental health. Climate change is likely to influence mental health through a variety of direct and indirect channels (Charlson et al., 2021).

According to the FAO, climate change poses a challenge to our ability to accomplish sustainable development, end poverty, and guarantee global food security (Reid et al., 2019). Adaptation includes lowering the susceptibility of coastal areas to climate change and natural disasters (Sultana & Luetz, 2022). Adaptation measures are essential to maintain agricultural productivity, minimize susceptibility, and improve the agricultural system's resilience to climate change (Aryal et al., 2020). Indigenous and diversified scientific knowledge is being used to address the effects of climate change. Nonetheless, a variety of difficulties are impeding long-term adaptation (Chowdhury et al., 2022). Historically, people in Bangladesh have developed coping mechanisms such as using traditional practices to make their homes and homesteads resilient to floods, tornadoes, erosion, and other natural disasters; climatic-season-based cropping, fish-farming, and developing major transportation by boat (Ataur Rahman & Rahman, 2015). Coastal and riverine communities in Bangladesh, on the other hand, are extremely susceptible due to their low adaptation capacity and direct exposure to natural disasters (Chowdhury et al., 2022).

The communities in the study areas faced several challenges to cope with climate change and overcome their economic (decrease of income, land loss, reduced fish, etc.) and non-economic (mental stress, loss of cultural practices, indigenous knowledge, decrease local flora and fauna, etc.) losses. Though they have faced many constraints for it to adapt, they also followed some steps to adapt to it.

We, therefore, wish to look into the climate change-related economic and non-economic losses and damages, the challenges faced by the communities to adapt to it, and lastly the adaptation techniques of the riverine communities in the study area.

1.1 Rationale of the study: This study will help to investigate the perceptions of riverine communities on climate change. It will help to analyze the losses and damages to their livelihoods and the adaptation constraints to address them. From here, we can also observe their adaptation steps to the threat of climate change. It can be used to make national and international policies.

1.2 Objective of the study:

- To observe the losses and damages that emerge because of the climate change impact on the livelihood of riverine communities.
- To investigate which adaptation initiatives have farm households undertaken in response to climatic risks
- To explore what barriers constrain more efficient adaptation initiatives to ameliorate climatic threats.

1.3 Research question:

- What are the climate-related hazards/disasters experienced by the respondents?
- Which hazard will get higher priority?
- What are the climate change-related losses and damage (economic and non-economic)?
- Which constraints they have faced adapting to climate change-related hazards and disasters?
- Which adaptation techniques they have undertaken in response to climate change?

1.4 Significance of the study:

- Can carry out the same investigation in other coastal regions and around the world.
- Can observe the climate change effects in Bangladesh's south-central region
- Can find out local adaptation techniques and the challenges to adapt.

1.5 Expected outcome: After completing this research we'll able to explore the following outcomes:

- The climate-related risks in the study area
- The scenario of loss and damage in the coastal belt of Bangladesh
- Adaptation techniques that followed by coastal belt riverine community
- The obstacle faced by the community to adapt to climate change impact

1.6 Organizations of the research paper: There are five chapters in this research report. The introduction including the objectives and significance of the study is discussed in Chapter 1. The literature review on climate change-related risks losses and damages is covered in Chapter 2. The study area, the data collection, and the data analysis were all broadly covered in Chapter 3. Chapter 4 goes into detail about the general information of the respondents, their perception of climate change, losses, and damages including economic and non-economic, adaptation constraints, and adaptation strategies. Detailed discussion is provided in Chapter 5. The concluding section of Chapter 6 also includes applications and other information.

Chapter Two

Literature review

Reviewing the literature is an important part of research work. It helps to know about the knowledge gap of previous studies by reviewing the books, journals, reports, etc. Some studies related to our work are discussed below:

Bhowmik et al., (Bhowmik et al., 2021) conducted a case study to examine the losses and damages suffered by rural people in Bangladesh as a result of extreme weather occurrences and other climatic stresses. Both economic and noneconomic losses and damages were noted by the researchers. The findings indicated that in Bangladesh, the range of economic loss and damage per household per extreme climatic event was US 568 to US 1,054. The southwest coast saw the greatest losses and damages due to a combination of longer-lasting consequences from several risks. The study also looks at how adaptive capacity can be used to mitigate the effects of extreme weather events, emphasizing the benefits of ICTs and community-based development initiatives for coping and adaptation techniques. Changes in farming methods, diversification of livelihood possibilities, and the development of leadership and entrepreneurial skills were all part of this.

Ahmed et al., (Ahmmed et al., 2020) explored Bhola District's adaption strategies in response to shifting climate circumstances. The strategies included building embankments, altering cropping patterns, introducing mixed cropping systems, raising crabs, enhancing household structures, increasing tree plantations, raising buffalo, enhancing transportation and educational systems, encouraging women to enter the business world, shifting career paths, and establishing new educational facilities. It highlighted the advantages of the adaptation measures used in the Bhola District, such as the improvement of socioeconomic conditions, the protection of the environment, and modifications to agricultural and food production methods.

Sultana & Luetz., (Sultana & Luetz, 2022) wrote a paper titled 'Adopting the Local Knowledge of Coastal Communities for Climate Change Adaptation: A Case Study From Bangladesh' in which they investigated the value of coastal community engagement in Bangladesh's Bhola and Satkhira districts and highlighted priority programs that may increase adaptive capacity in the face of climate change. The findings indicated a few critical problems that require attention related to water management, socioeconomic circumstances, and migration out of coastal areas. According to the study, the best results are obtained from the implementation of coastal adaptation techniques within larger, integrated frameworks for coastal zone management that take into account both short- and long-term sectoral conditions.

Gopalakrishnan et al., (Gopalakrishnan et al., 2019) discussed the challenges to coastal agricultural sustainability, including both climatic and non-climatic stressors in their paper entitled ‘Sustainability of Coastal Agriculture under Climate Change’. Climate stressors pose threats to food security and have a substantial impact on coastal agriculture. These stressors include rising temperatures, shifting rainfall patterns, tropical cyclones, sea level rise, floods, and coastal inundation.

Roy et al., (Roy et al., 2022) researched to investigate the effects of sea level rise (SLR) on coastal communities in Bangladesh and their adaption strategies. Coastal communities have highlighted five primary impacts of sea level rise (SLR): an increase in salt, rising water levels, land erosion, waterlogging, and the appearance of char land. The greatest detrimental effects were determined to be an increase in salinity and land erosion, which caused agriculture to suffer large financial losses. The authors attempted to highlight coastal populations' opinions of SLR consequences and the benefits of various adaptation techniques.

Cianconi et al., (Cianconi et al., 2020) wrote a paper that depicted the impacts of climate change on mental health. A significant percentage of the population is significantly impacted by climate change, especially vulnerable people who have limited access to resources and protection. The impacts of climate change on mental health might be direct or indirect, short-term or long-term, and similar to severe stress. The authors proposed the use of new terminology to express the relationship between climatic events and mental diseases, such as anxiety and ecological bereavement.

Mechler et al., (Mechler et al., 2020) assessed the effects of disasters induced by climate change on the production of fish and crops in Bangladesh's Bhola district. In contrast to rainfall, which varied seasonally, the study found that temperature and humidity rose. Cyclones and floods had varying effects on crop production depending on the season. In ponds, fish productivity decreased as a result of rare natural disasters, but grew owing to non-climatic reasons. To improve agricultural and fish output in the area, the study recommends putting into practice strategies including growing salt- and flood-tolerant cultivars, growing vegetables on floating beds, and using mixed cropping methods.

Mazumder & Kabir, (Mazumder & Kabir, 2022) explored what challenges farmers experienced when using sustainable adaptation techniques and technologies, with particular attention focused on the issue of soil salinity effects in Bangladeshi agriculture. They discovered that variables including age, education, family size, and farm size had a major impact on the adaptations that farmers employed to control soil salinity in agriculture. Farmers in a variety of categories implemented mulching practice technology. The researchers recommended implementing climate-smart agriculture (CSA) initiatives in impacted areas, offering farmers self-help resources and in-person demonstrations.

Ahmed & Tan, (Ahmed & Tan, 2021) examined spatial differences in climate change and climatic hazards in Bangladesh, revealing the uneven distribution of temperature and rainfall changes, as well as sensitivity to various climatic hazards, across administrative districts. Sixty-four districts in Bangladesh were examined for their susceptibility to hydrological events and climate hazards using data from the Emergency Events Database.

Rahaman & Esraz-Ul-Zannat, (Rahaman & Esraz-Ul-Zannat, 2021) investigated how Bangladeshi coastal villages were affected by cyclones. Every year, cyclones threaten Bangladesh's coast, killing a great number of people and seriously harming the ecosystem. The findings showed that a disaster's effects might not be fixed to a specific area or period; rather, they might vary across time.

Mustafa Saroar et al., (Mustafa Saroar et al., 2019) discussed their study on the current status and challenges of Ecosystem-based adaptation (EbA) adoption in coastal Bangladesh. To improve ecosystem health and lessen vulnerability, EbAs incorporate a variety of ecosystem management practices. According to the authors, farming patterns, soil and nutrient management, water management, erosion control, and the security of food and livelihood are the main causes of EbA in coastal Bangladesh. Additionally, they said that to enhance ecosystem health and community resilience, current EbA initiatives should be in line with scientific understanding.

Shakhawat Hossain et al., (Shakhawat Hossain et al., 2019) attempted to use the Ricardian technique to estimate the effects of climate change on net income from crop cultivation in Bangladesh (Shakhawat Hossain et al., 2019). It recognized that future climate change might have a positive effect on farming revenue in Bangladesh and other parts of Southeast Asia. It was discovered that the climate, especially the seasonal temperature, had an impact on net agricultural income. It is predicted that rising temperatures and more rainfall will boost Bangladesh's crop farming industry's net profits.

Bernzen et al., (Bernzen et al., 2019) highlighted the primary reasons for climate change migration. The main reasons people moved were for better job prospects, education, and marriage/family reunification. The loss of farmland and flooding are two major factors causing migration. Workers who are male, younger, and do not work in agriculture as well as those with more social capital are more likely to migrate. Migration is also influenced by areas used for saltwater shrimp aquaculture, access to large waterways, and severe river erosion. Economic factors are the main drivers of climate migration, with environmental stress playing a secondary role.

Abedin et al., (Abedin et al., 2019) revealed a research titled 'Climate Change, Water Scarcity, and Health Adaptation in Southwestern Coastal Bangladesh' in which they explored the effects of climate change on water resources and human health in a coastal area of Southwestern Bangladesh. The main waterborne health hazards include diarrhea, dysentery, and skin disorders, but it also has complicated effects on overall health and well-being. The local population, according to the authors, believes that freshwater sources and human health are being significantly impacted by climate change. About 70% of the respondents in Gopalpur village rely mostly on pond sand filters for their year-round drinking water supply.

M. M. Islam et al., (M. M. Islam, Islam, et al., 2020) disclosed the present hazards and expected consequences of climate change on the Hilsa shad fishery and related fishing communities in Bangladesh. They emphasized how susceptible the fishery is to changes in breeding and growth performance, as well as movement patterns pushed on by climate change. The study addressed the argument for the Small-Scale Fisheries Guidelines (SSF Guidelines) to be put into practice to strengthen the hilsa fishermen's resilience, particularly during the initial phases of relief, rehabilitation, reconstruction, and recovery, and to lessen their susceptibility to anthropogenic and climatic hazards.

Reid et al., (Reid et al., 2019) discussed the possible consequences of climate change stressors on aquaculture biology and resources, as well as the importance of vulnerability assessment, adaptation, and research development. In shrimp ponds with little water exchange, the study

discovered that higher temperatures are likely to induce stratification, which could increase hypoxia, decrease output, and raise the risk of disease.

M. A. A. Hoque et al., (M. A. A. Hoque, Ahmed, et al., 2019) illustrated how extremely vulnerable the 377 km long eastern coastal region of Bangladesh is to multi-hazardous occurrences, and how this vulnerability is expected to worsen with future climate change. In the study region, 32% of the coastline is in zones of high to very high susceptibility, and 32% is in zones of moderate vulnerability. There are low to very low vulnerability zones along around 21% and 16% of the shoreline, respectively. strong susceptibility zones are influenced by several factors, including low heights, gentle slopes, strong storm surge impacts, sandy beaches, high rates of coastal erosion, and significant sea level rise.

M. Z. Hoque et al., (M. Z. Hoque et al., 2019) formulated an agricultural livelihood vulnerability index (ALVI) and an integrated method for assessing agricultural livelihood vulnerability to climate change in coastal Bangladesh. The index is formed from a collection of 64 indicators that include socioeconomic, agroecological, and biophysical characteristics. The districts of Bhola, Patuakhali, and Lakshmipur have been recognized as the hotspots of vulnerability distribution. The following factors increase the susceptibility in these areas: land degradation, soil phosphorus, crop production, infant mortality, emergency shelter use, cyclones, droughts, rain-fed agriculture, infant mortality, and adoption of agrotechnology.

Chapter Three

Methodology

3.1 Study area: Bangladesh is subject to climate-related disasters such as floods, cyclones, storm surges, river bank erosion, etc. because of the country's geography and geographic locations. Compared to other villages located far from the river, the riverine community has significantly greater suffering. The Bhola research region has been chosen in this regard. Bhola is a coastal district in Bangladesh's middle southern region. It is included in the division of Barishal. It is situated between latitudes 21^0 51′38″ and 22^0 51′40″ N and longitudes 90^0 32′07″ and 90^0 55′44″ E, including an area of 3,737.21 km^2. It spans about 20 km in width and 90 km in length. This island district comprises the following seven upazilas: Tazumuddin, Burhanuddin, Bhola Sadar, Manpura, Charfasson, Lalmohan, and Daulatkhan. About 67 groups comprise these unions (Elahi et al., 2022). The island is bordered to the north by the Laxmipur and Barisal districts, to the south by the Bay of Bengal, to the east by the Patuakhali district and the Tentulia River, and to the west by Laxmipur and Noakhali districts, the lower Meghna River, and the Shahbazpur channel. The Ilisha and Rajapur Union, a portion of Bhola Sadar Upazila, is the research area.

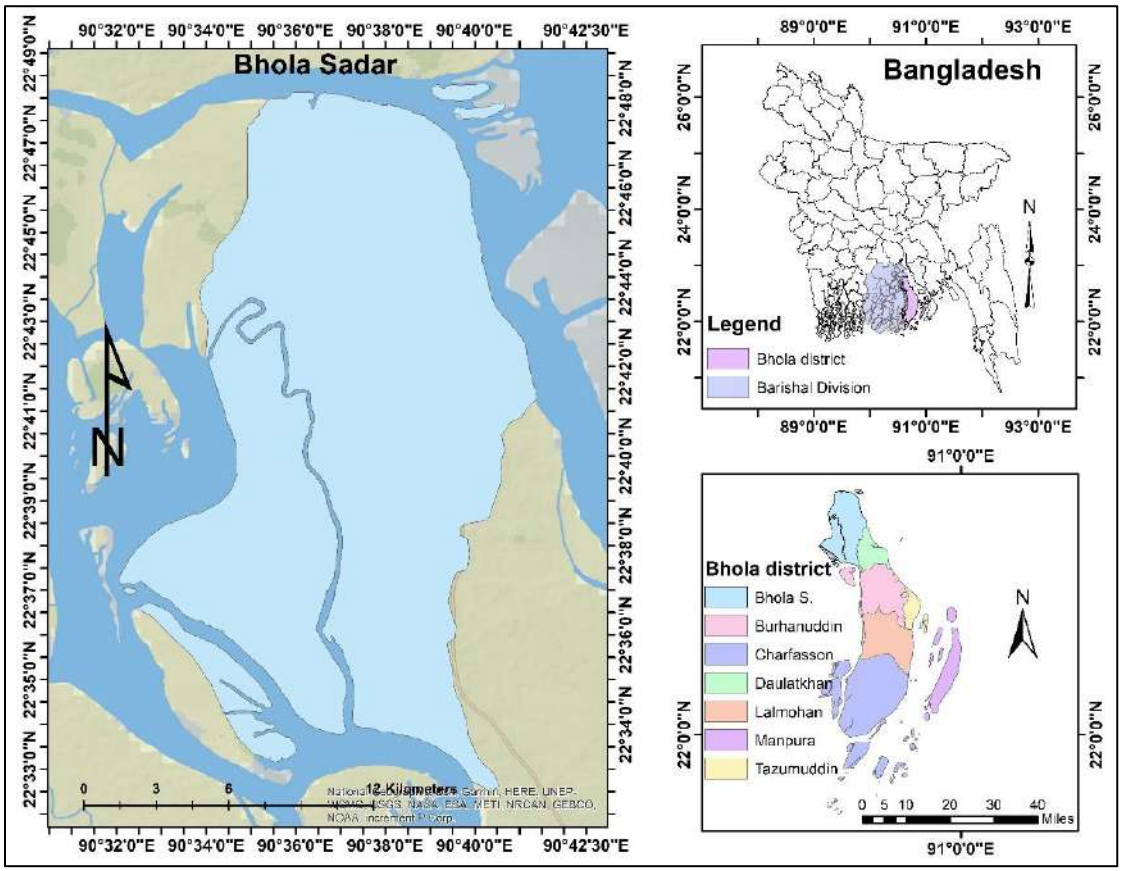

Figure 1: Study area

3.2 Data collection: The study's main set of data was gathered in 2023. The purposive survey approach was used. In the research region, 110 people have responded to our survey. They're all from the riverine area. The maximum of their profession was either farming or fishing. Very few respondents were doing business near the riverside of the study area but had either agricultural land or pond or both. We give them priority because they have experienced losses and damages due to climate change, either directly or indirectly. Three focus group discussions (FGD) were held with members of the community. Three separate focus groups were convened: one was for the housewife women in the research region, while the other two were for the local fishermen and farmers. We asked them various questions during the FGD to learn more about how they experienced losses and damages associated with climate change. Inquiries concerning adaption techniques and limits were also made of them. The FGD was documented by the authors through the use of voice recorders and written notes. The authors outlined the goals of the study at the start of the FGD and interview. A variety of age groups participated in the FGD and survey.

To confirm the data on losses and damages, the authors also performed three key informant interviews (KII) with a primary school teacher, a district fisheries officer, and the deputy director of the Department of Agricultural Extension. The Department of Agricultural Extension's deputy director presented a ranking list of the many climate hazards in the research region. The Kobo Toolbox was used to create the survey questions and gather data. The Department of Agricultural Extension provided on agricultural losses. Satellite images collected from open-access Landsat imagery services at https://earthexplorer.usgs.gov/ to analyze the riverbank erosion. Salinity information was obtained from the Bangladesh Water Development Board (BWDB) to examine the salinity incursion trend. In addition, data on crops gathered from the Department of Agricultural Extension have been affected by heatwaves and cyclones.

3.3 Data analysis: Firstly, the author transcribed all KII and FGD into text. Then the response of FGDs and KIIs is represented according to the theme of the report. Kobo Tool collected the survey questions from one hundred and ten participants. It gave an overview of the survey. We used Sigma Plot to depict our data in a variety of graph formats. We gathered information on damages and losses, classifying them as either non-economic or economic. An analysis of riverbank erosion patterns from 1990 to 2020 is conducted using ArcGIS 10.8. Data on salinity from 2016 to 2020 were examined. For both High Water Level (HWL) and Low Water Level (LWL), BWDB provided eight months of data annually. A month's worth of data was gathered three to four times. We started by averaging the monthly data separately for HWL and LWL. Then set them up monthly. Again, averaged the data month-by-month from 2015 to 2020, averaging each of January, February, March, April, May, June, November, and December separately. Then it is graphically represented by using Sigma Plot.

Chapter Four
Results

4.1 Socio-economic characteristics of the respondents:

4.1.1 Age: The age range of the 110 respondents we questioned for this poll was 18 to 70 years old. Every responder works in agriculture or fishing and is a resident of the riverine village. The age range of the greatest respondents, which is approximately 29.9% of the total, is from 31 to 40. Approximately 19.09% of those surveyed are in the age range of 21 to 30. However, just 1.82% of the respondents are over 70 years old and still depend on farming for their livelihood (fig. 1).

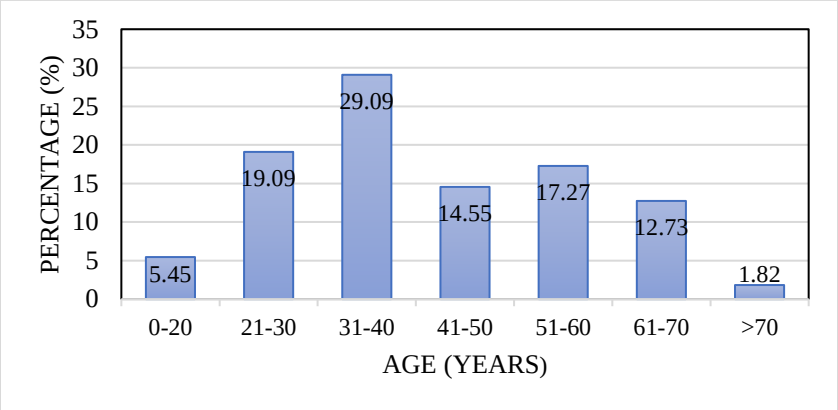

Figure 2: Age ranges of the respondents

4.1.2 River distance: Every respondent resides two kilometers or less from the river. About 32.27% of respondents are located within 200 meters of the river (fig. 2). The habitat distances of about 24.45%, 13.64%, 10%, and 13.73% of the respondents are, respectively, 201-400 m, 401-600 m, 601-800 m, and 801-1000 m from the river. The habitat distance of just one respondent is between one and two kilometers from the river.

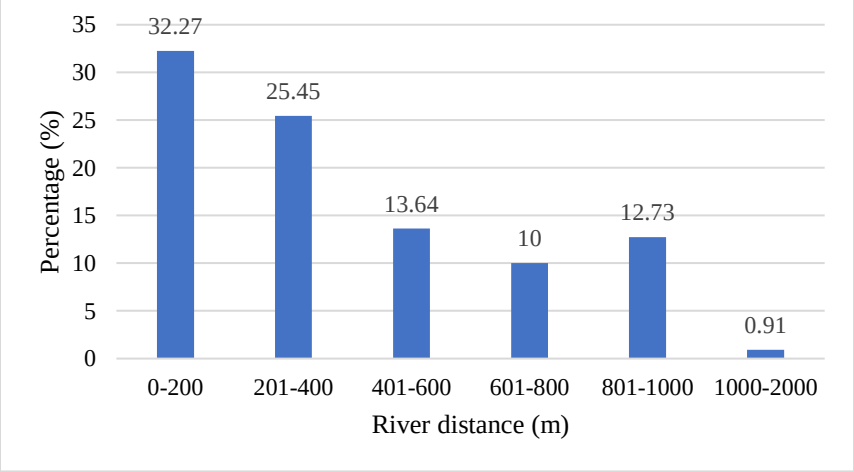

Figure 3: River distance from the property

4.1.3 Living period: Living time and experience are inextricably linked. Individuals who have been in a location since birth or for more than ten years have a deeper understanding of it. In the

research region, 36.36% of respondents have lived for more than 31 years (fig. 3), while 38.18% of respondents have lived there for between 21 and 30 years. There is just one responder who has been there for under two years. The remaining responders range in age from two to thirty.

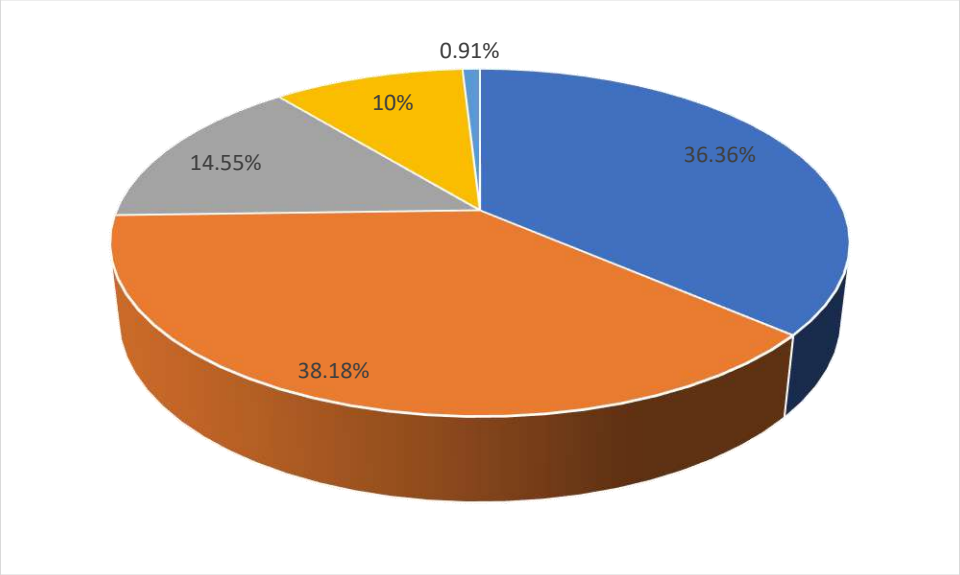

Figure 4: Living period of the respondents in the study area

4.1.4 Monthly income: The community's monthly income status is shown in the following graph. The responders who work in fishing-related businesses make more money than those who work in agriculture. About 18.18% of respondents' monthly income is less than or equal to 10,000 BDT, whereas 31.82% of respondents' monthly income is between 11,000 and 15,000 BDT. Merely 9.09% of interviewees earn more than 25,000 BDT every month.

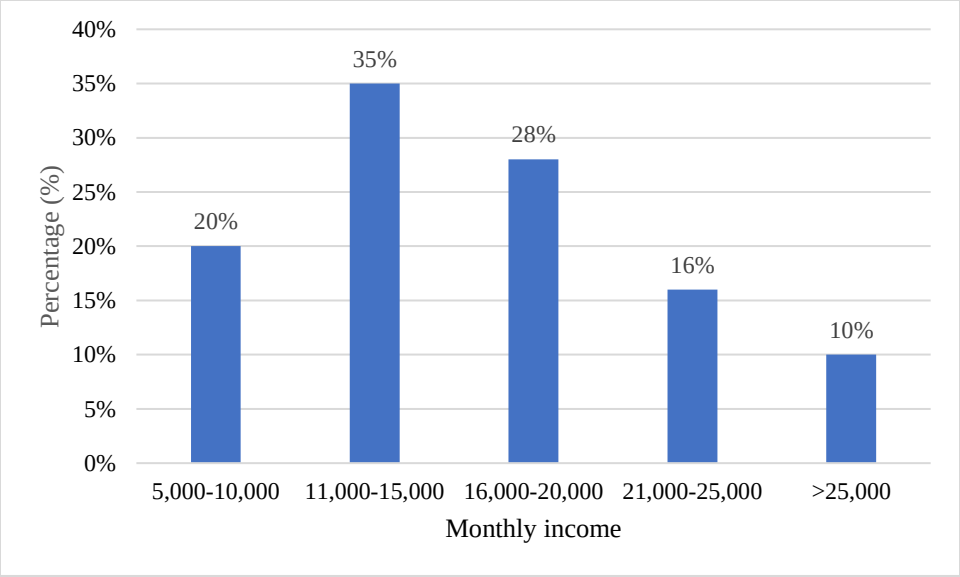

Figure 5: Monthly income of the respondents

4.1.5 Crop types and harvesting time: The majority of responders cultivate their property many times. Nonetheless, 16.36% of those surveyed said they had only ever planted their property once. Conversely, around 33.64% and 35.45% of those surveyed farm their land twice, and three times, respectively. During the winter, they grow a variety of veggies. Among them are mustard seeds, potatoes, chili, wheat, snake gourds, and capsicum. Three varieties of rice are grown by the community in the research area: Aus, Amon, and Iri rice.

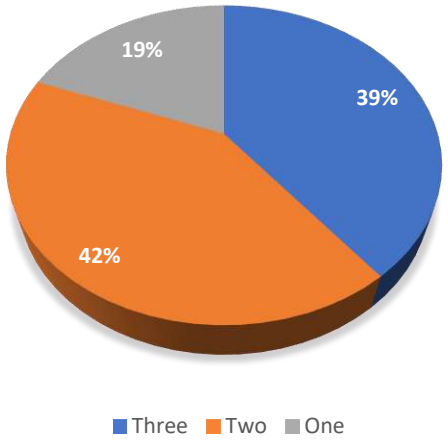

Figure 6: Cultivation times in a single land

4.2 Climatic risk perception:

4.2.1 Climate change perception: Long-term changes in weather patterns are a result of climate change. It is crucial to understand how they see climate change before beginning the survey on risks associated with climate change. Just one person didn't know what climate change was, while 99.01% of respondents said they knew what that meant and thought it was happening right now.

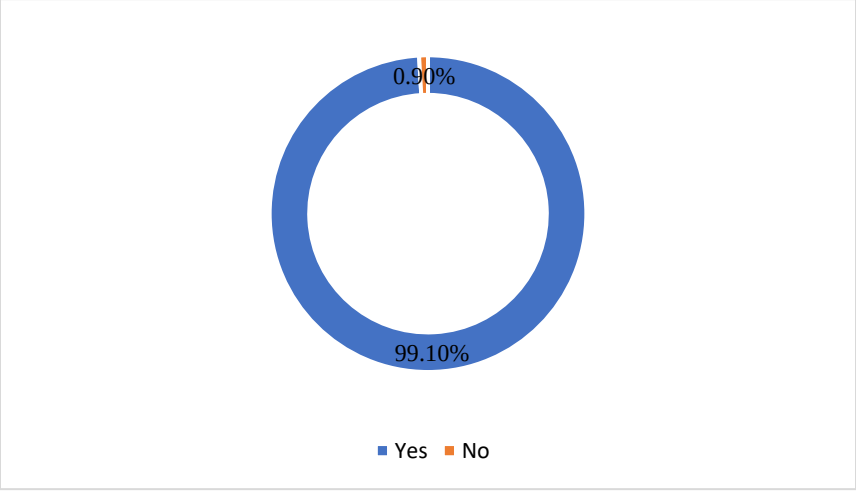

Figure 7: Perception of climate change among the respondents.

"Climate change is happening here and frequency is higher than previously. Heatwaves can be seen in the Bangla month Ashar and Shrabon which indicates that climate change is happening."- **Siraj,** fishermen, Elisha, Bhola

4.2.2 Major disaster: Knowing that climate change is occurring on a global scale, Bangladesh is undoubtedly experiencing some detrimental effects. The goal of this study is to identify the potential hazards associated with climate change in the study region, such as heat waves, cyclones, riverbank erosion, tidal floods, unpredictable high rains, etc. When asked about the main risks or catastrophes in their area during their living time, the majority of them (91.82%) agreed that riverbank erosion was a concern. They have experienced riverbank erosion several times throughout their lives. There are those individuals who have experienced riverbank erosion seven times in their lifetime. For those who live near the shore, salinity poses a problem as well; around 40.91% of respondents agreed. The study area's population is well-versed in the names of cyclones based on their geological locations. Day by day, respondents (73.64%) reported an increase in the frequency of heat waves.

Without a doubt, this climate risk has caused the communities in the studied regions to suffer both non-economic and economic losses. Because of the erosion of riverbanks, they have lost both their habitat and agricultural land. The respondent's financial situation has gotten worse over time. Climate-related risks also have an annual impact on their harvests.

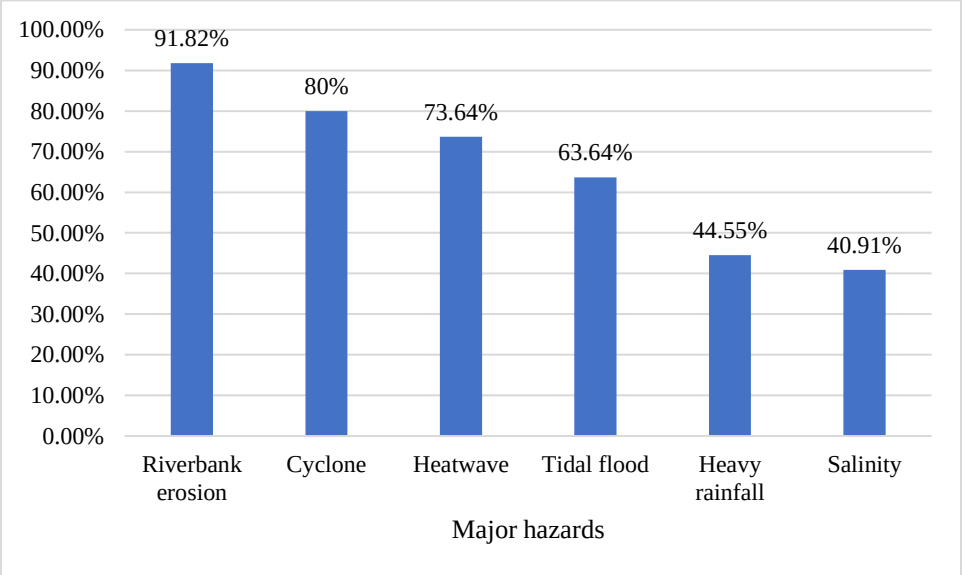

Figure 8: Major climatic hazards/disasters in the study area

'River bank erosion was stopped for the previous two years for the use of blocks. However, this year some portion again eroded. We have been here for more than 20 years. River was so far from here (his house) but now it's so close.'- **Mokammel Hosain**, School teacher, Elisha, Bhola

'The impact of climate change on agricultural sector are loss of agricultural land, riverbank erosion, increasing soil salinity, season change, changing length of photoperiod, drought, heavy rainfall, increasing supplementary irrigation for successful Amon cultivation, change of tide. Other impacts are crops damaged by uncertain heavy rainfall or tidal flood, existing crop varieties couldn't give higher value return, uncommon diseases (Blast of Wheat, let blight, early blight), thunderstorm and lightening, waterlogging period increase, fog weather, increased temperature between day and night etc.'- **Md. Hasan Warisul Kabir**, Deputy Director, Department of Agricultural Extention, Bhola.

'Climate change is happening for global warming. It means that the world temperature is rising. Therefore, it creates a great impact on the fish sector. In addition, this impact is categorized into two parts, which are open water impact and cultural pond impact.

Due to climate change, the water level of water bodies has decreased. Therefore, fish are reduced. Due to the shortage of water in the pond, shot circle fish cultivation increased. Drought is another climatic risk. Water level decreased for drought. Siltation on the riverbed, hamper the breeding of fish.'- **Md. Abul Kalam Azad** is the District Fisheries Officer at the District Fisheries Department, Bhola.

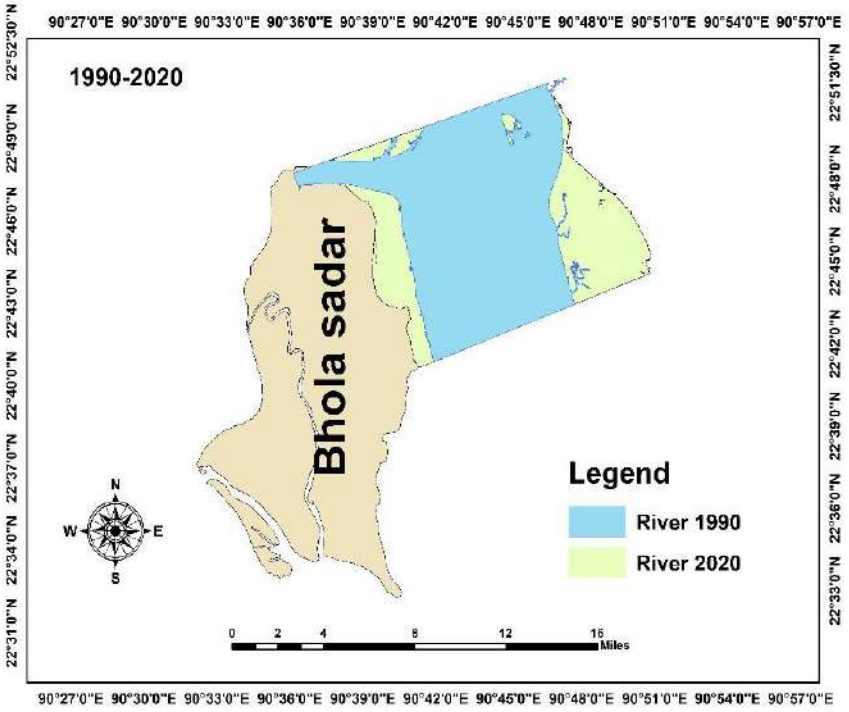

Figure 9: River bank erosion of Bhola Sadar 1990-2020

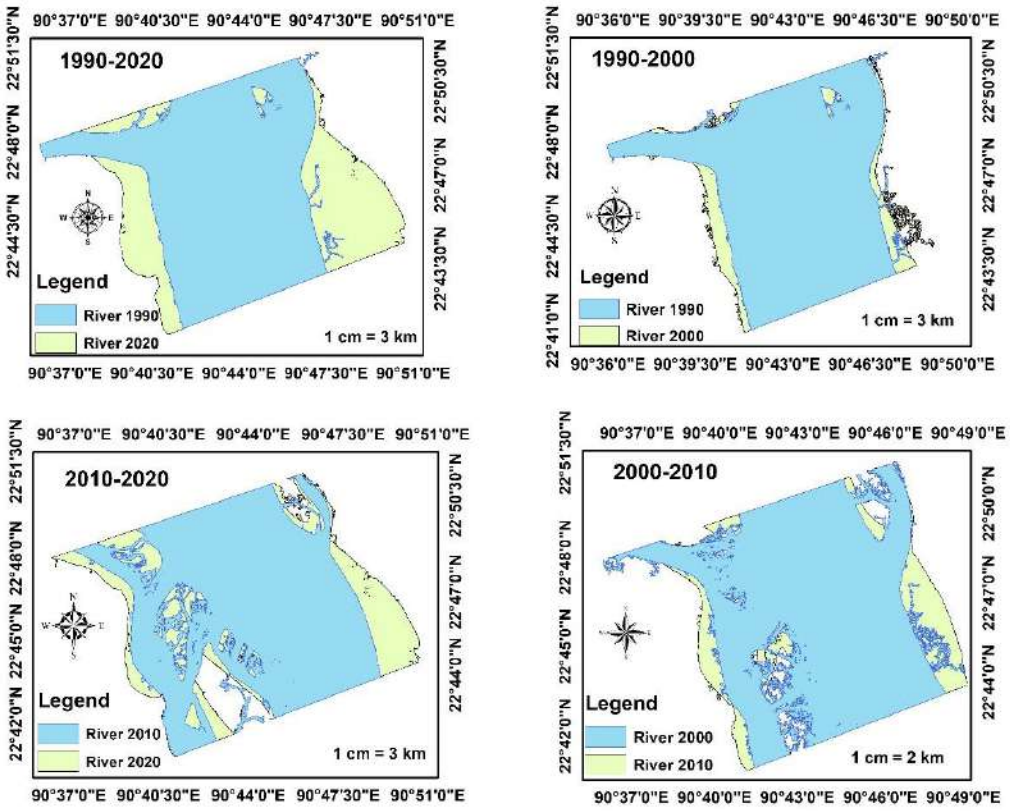

Figure 10: Riverbank erosion 1990-2020

The Meghna River at Bhola Sadar's undisturbed area, accretion, and riverbank erosion are depicted in Figure 8 during the years 1190–2020. About 11431.426 hectares remain unaltered after 30 years, of which 5967.846 hectares and 7994.282 hectares were regions subject to erosion and accretion, respectively. Bhola Sadar Upazila was impacted by riverbank erosion, according to a GIS study. The research area's various regions saw varying levels of erosion and deposition. Between 1990 and 2000, the areas along both banks of the river that experienced erosion and accretion were around 11805.774 ha, 5593.498 ha, and 3418.840 ha, respectively. For the years 2000–2010, the comparable unchanging areas subject to erosion and accretion were 11969.698 ha, 6298.486 ha, and 3254.916 ha; for the years 2010–2020, the corresponding areas were 13457.353 ha, 4810.83 ha, and 5968.355 ha. Between 2010 and 2020, there appeared to be less erosion on both riverbanks. Despite this, erosion happened close to Bhola Sadar, and the rate of accretion is greater than the rate of erosion.

The monthly change in salinity in Bhola is shown in Figure 18. Approximately 940.01, 1183.05, 1492.48, 1633.728, 1044.524,469.73, 682.69, and 805.45 ppm for HWL and 909.383, 1152.94, 1445.194, 1575.94, 1125.91, 408.20, 638.31, and 778.53 ppm for LWL were the salinity values for January, February, March, April, May, June, November and December. Both HWL (1633.728 ppm) and LWL (1575.94 ppm) salinity peaked in April. The salinity was found to be increased significantly between November and April. At the end of April, a sharp fall occurred.

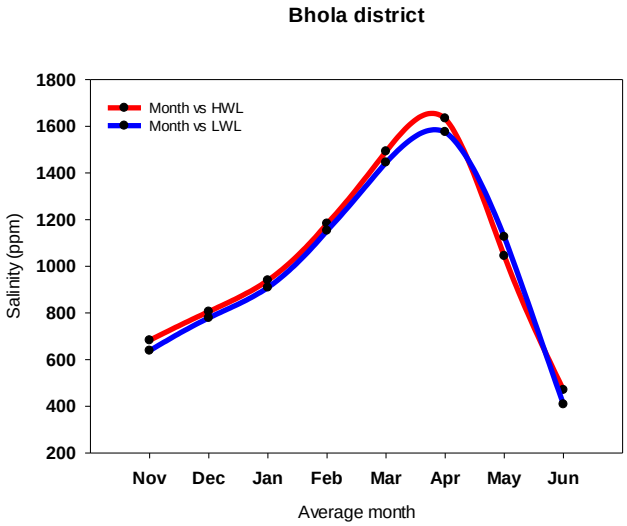

Figure 11: Monthly salinity intrusion in Bhola district

The salinity difference between HWL and LWL was incredibly small. Perhaps a few years from now, the salinity of HWL and LWL will be found a similar gap, or the difference will be much smaller than it is right now.

The development of salt intrusion in the Bhola area between 2016 and 2020 is seen in Figure 10. Here, we discovered that salinity had risen above prior HWL and LWL levels. For 2016, 2017, 2018, 2019, and 2020, respectively, salinity at HWL is around 459.26, 663.29, 963.45, 1530.09, and 1921.77 ppm while at LWL is approximately 419.03, 625.54, 979.33, 1505.19, and 1873.71 ppm.

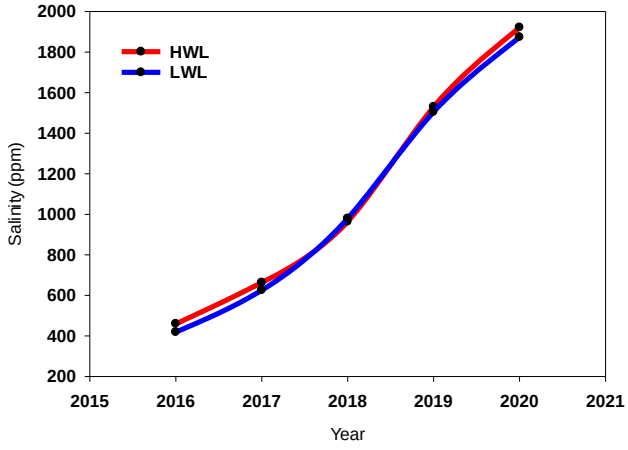

Figure 12: Yearly salinity intrusion trend in Bhola district

4.2.3 Frequency of hazard/ disaster: The frequency of dangers or disasters as compared to the last 20 years is shown in Figure 8. There are several divisions for this frequency: low, low to medium, medium, medium to high, and high. A little over 29% of respondents claimed that there were fewer climate-related risks or catastrophes this year than there were the year before, while a

little over 26.36% claimed that the frequency of these events had increased over time. Hazards are occurring at a rate higher than in the preceding 20 years, as shown by the 4.55% of respondents who felt that they are medium to high frequency.

We made an effort to get replies from the respondents in the research region even if the frequency of dangers is higher now than it was earlier. Here, some of the respondents view some threats as normal, while others view them as dangerous. It also depends on how well they can adjust and what obstacles they encounter. Because we never consider anything dangerous if we can effectively adjust to dangers or tragedies. The community that believes that dangers are occurring less frequently than in the past might experience similar outcomes.

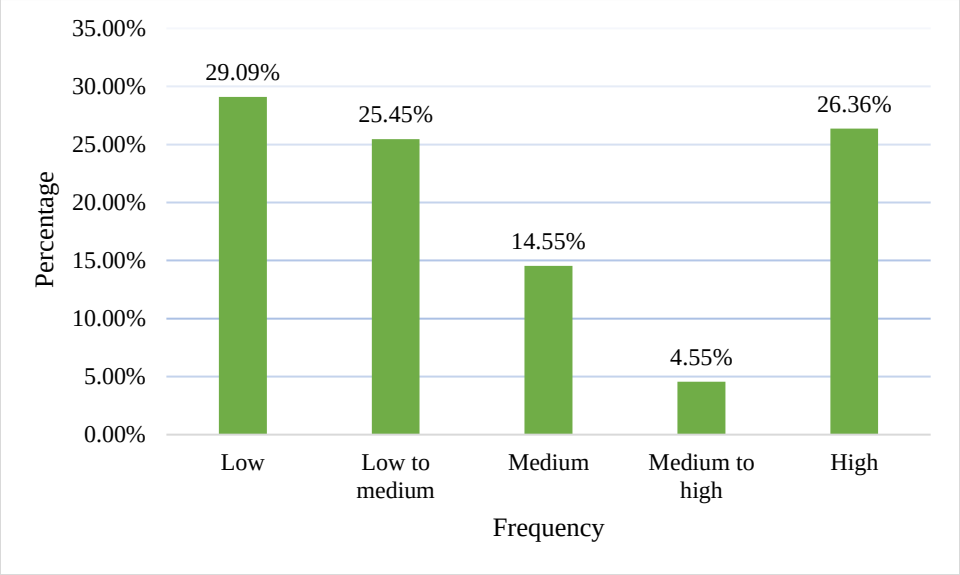

Figure 13: Frequency of damage from climatic risk

4.3 Losses and damages:

4.3.1 Economic losses: The economic and non-economic sectors of a community must be threatened by any hazard or disaster. The economic losses resulting from riverbank erosion are depicted in Figure 9 and include land, cattle, businesses, infrastructure, fisheries, and agricultural production. The respondents ranked the loss of agricultural productivity (78.18%) and land (79.09%) nearly equally. As per the responses of 41.82% of the participants, the business sector was impacted by risks mostly after riverbank erosion. A little over 71.82% of participants concurred that climate dangers also have an impact on the fishing industry. Additionally, the water source's salinity rose throughout the preceding year. Unbearably high salinity caused the extinction of several fish species and other organisms. Thus, the fishing industry was impacted by these three reasons.

> "If the development work is done immediately after the erosion, then the damage never so worse. From here river was 5 km away, but it is close to the main road." – **Mijan**, Shopkeeper, Elisha launch ghat, Bhola

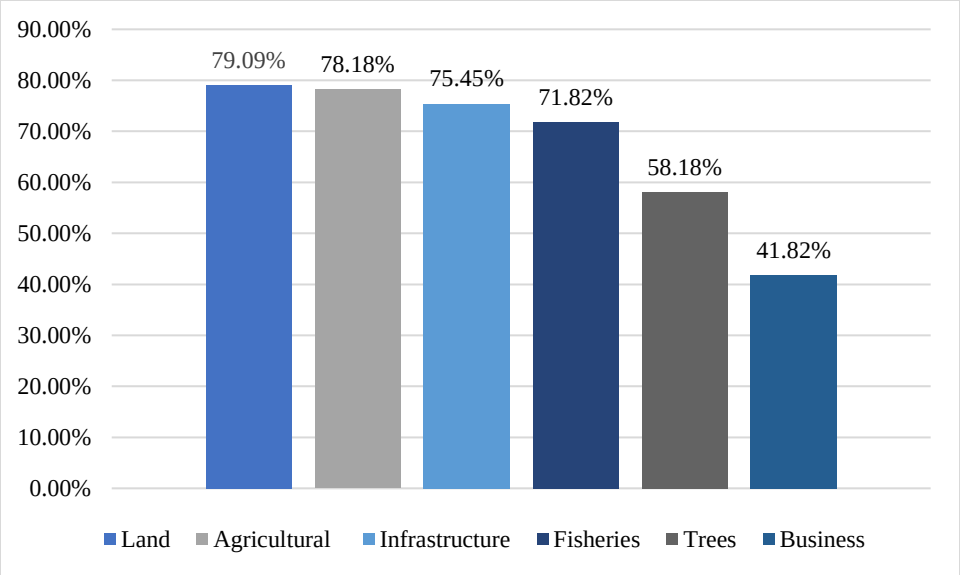

Figure 14: Economic losses from climatic hazards/ disaster

The Bhola Sadar people's economic losses in the agriculture industry are shown in Table 1. In addition to riverbank erosion, other natural disasters like windstorms and cyclones can also cause agricultural losses. In addition, cyclones and riverbank erosion also caused infrastructural damage. However, riverbank erosion caused the greatest loss and damage to infrastructure. Tree damage and loss may be caused by cyclones, windstorms, and riverbank erosion. Climate risks also have an impact on the business economy since they lower revenue during certain periods. Consequently, it may be concluded that climate hazards harmed the riverine community in the Bhola coastal zone.

Table 1: Economic losses from climatic hazards at Bhola Sadar, Bhola

Type of hazards	**Year**	**Affected crops name**	**Disaster-prone land (Hectors)**	**Affected land in total (Hectors)**	**Probable loss of crops (Metric ton)**	**Probable loss in taka (Lakh)**	**Affected farmer**
Windstorm and heatwave	4/4/2021	Boro	125		26.25	6.89063	125
Cyclone Jawad	5/12/2021 - 6/12/2021	Amon	10948	0	0	0	0
		Seedbed of Boro	37	0	0	0	0
		Grass Pea	2050	360	432	216	775
		Lentil	20	3.75	4.5	3.105	60
		Mustard	825	120	144	72	1800
		Wheat	100	15	37.5	11.25	225
		Potato	100	25	550	55	375

		Winter vegetables	500	75	1350	202.5	1125
Cyclone Sitrang	27/10/2022	Amon	3160	31.6	115.19	31.10	237
		Vegetables	150	96	1167	175.05	115
		Betel Leaf	3	0.3	12	36.00	90
		Banana	60	9	108	43.200	50
		Papaya	70	12.25	245	36.750	60

Source: Department of Agricultural Extension, Bhola

4.3.2 Non-economic losses: This section illustrates the non-economic losses and damages resulting from hazards and catastrophes. Non-economic losses are those that are not directly related to monetary losses. Impact on health, migration, disintegration of society, extinction of species, scarcity of food, etc. The vast majority of participants (68.18%) ranked migration higher. They stated that throughout their early years, societal cohesiveness had declined. Any danger or calamity can influence one's health, and around 39.09% of respondents agreed. Due to financial constraints, some 26.36% of participants had food insecurity issues either during or following risks or disasters.

The majority of responders moved internally but permanently. Their movement is caused by erosion of riverbanks. Every single biotic component is dependent on its surroundings. Biodiversity is also altered by climate change. A few also have health issues. There might be a climatic explanation for it. Crops suffer harm during hazardous periods, as we discussed in the economic part. Consequently, there are issues with food insecurity in the impoverished neighborhood.

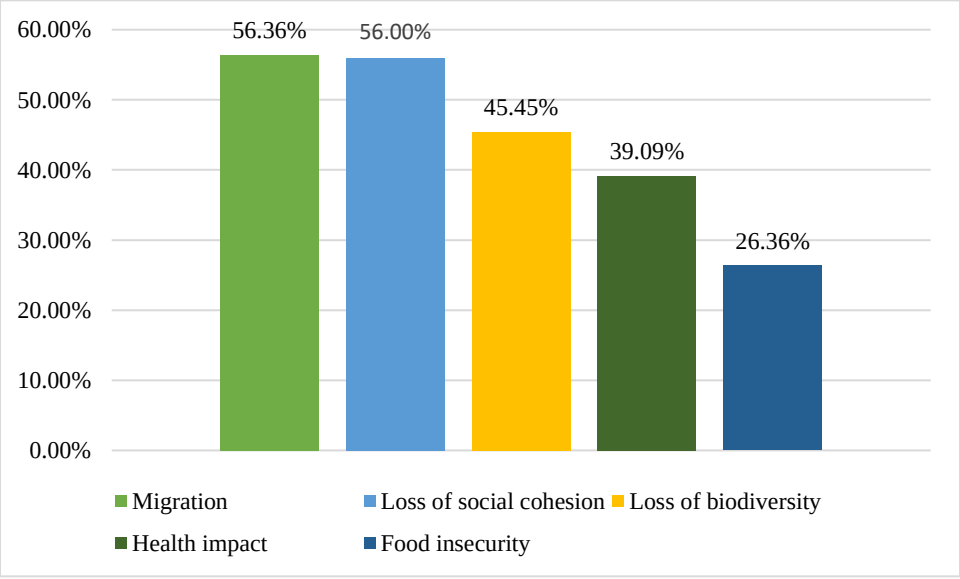

Figure 15: Non-economic losses from climatic hazards/ disaster

4.3.3 Impact on income source: Following or during any risks and calamities, the source of income is also impacted. It is mostly visible following riverbank erosion. About 32.73 percent of

respondents agreed that riverbank erosion had a significant impact on their livelihood activities, compared to about 40.36 percent who believed it had a medium impact. However, 26.36% of respondents said that the erosion of riverbanks had little effect on their source of income.

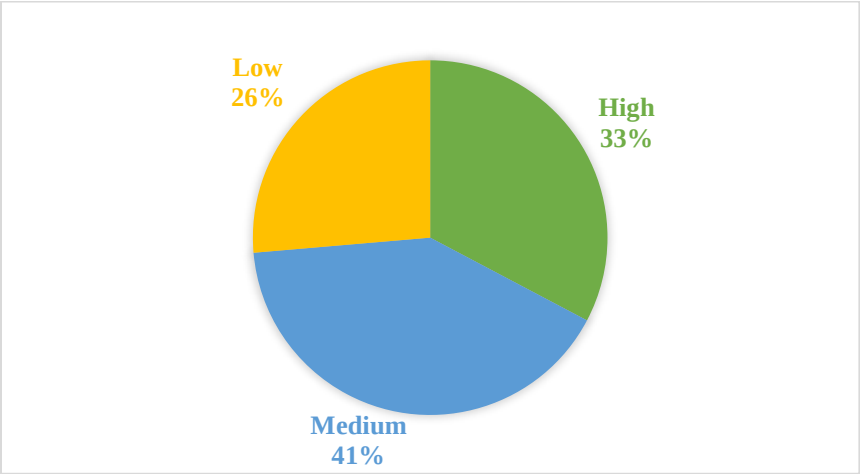

Figure 16: Impact on income source

The effect on revenue streams might be contingent upon both economic stability and adaptability. The community that could adapt to climate change-induced hazards, this kind of people face the low or medium impact of changing climate. However, those who were unable to adjust to it suffered significant financial consequences both during and after any risks.

4.3.4 Land loss: A loss of land can be considered an economic loss. The land loss amount of about 35.46% of the respondents is between 501 and 1000 decimals, and its approximate market worth is between 11 and 50 lacks BDT. Roughly 15.45% of participants lost 1100–15,00 decimals. It should be noted that around 6.36 percent of respondents had not yet experienced a difficulty related to land loss. However, because of the high danger of climate change and the proximity of their property to the river, they run a significant financial risk.

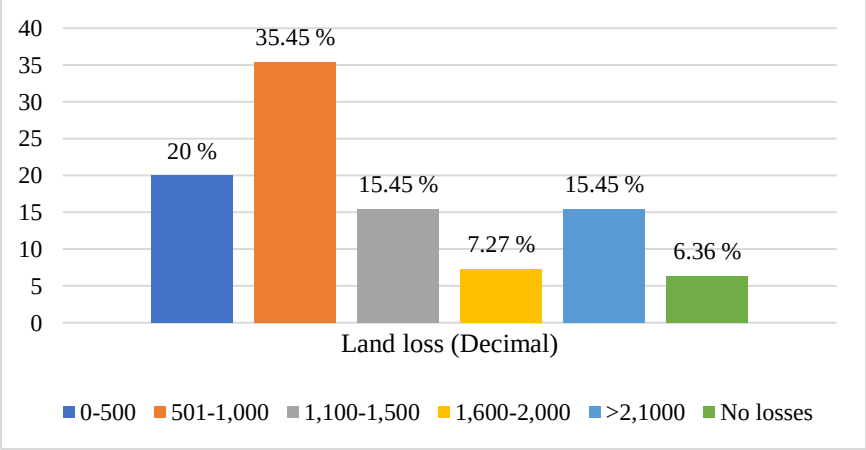

Figure 17: Approximate amount of land loss.

Land loss was caused by riverbank erosion, as we previously discussed. Maximum losses they will ever have on their land, at least once. The respondent's home is situated close to the river overall. The loss of land resulted in the loss of trees, agricultural goods, infrastructure, etc. The majority has moved elsewhere and some are changing professions as a result of losing their land.

Table 2: Approximate land loss and its market value

Amount (Decimal)	BDT	Frequency	Percentage
0-500	0-10 Lack	22	20
501-1,000	11-50 Lack	39	35.45
1,100-1,500	51 Lack-<1 Crore	17	15.45
1,600-2,000	>1 Crore – 5 Crore	08	7.27
>2,1000	>5 Crore	17	15.45
No losses	0	7	6.36

4.3.5 Mental stress during or after disaster/ hazards: It is common for people to experience mental tension before, during, or after any risky event. Regarding mental stress during or after significant catastrophes such as riverbank erosion, cyclones, storm surges, etc., about 61.82% of respondents agreed. It is also important to note that 1.82 percent of people reported feeling stress-free. Because they were adapted to it very well. Furthermore, those who did not experience mental stress can have a stable enough financial situation to survive any kind of environmental disaster.

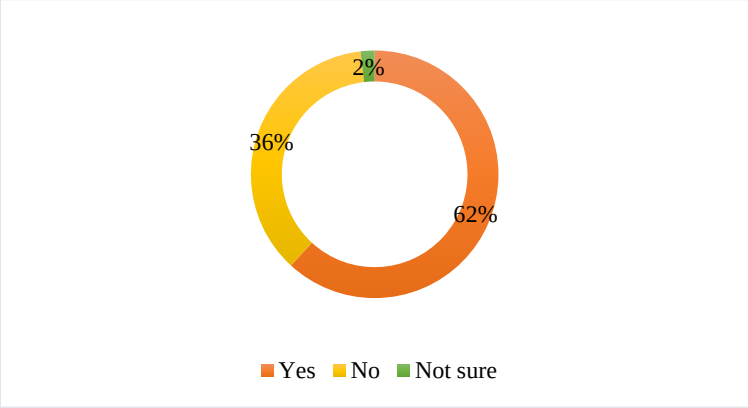

Figure 18: Mental stress during or after disaster/ hazards

4.3.6 Changing of flora and fauna: Fish, birds, and other animal species can all be observed in one location. as the weather is shifting daily. From this point on, the number of plants and animals began to decline because they were unable to adjust to the changing environment. Around 95.45% of respondents affirm it, whereas 1.82% of respondents are unsure about how the flora and fauna are changing. Because of climate change, the environment may become unsuitable for the survival of flora and wildlife, leading to their extinction or alteration in niche.

'Many types of fish species are extinct and some are starting to extinct. Changing the breeding system due to climate change. Climbing Fish (Koi), Barbel (Shing and catfish (Magur) decreased in a natural system. Now these are cultivating in pond system.' - **Md. Abul Kalam Azad** is the District Fisheries Officer, at the District Fisheries Department, Bhola.

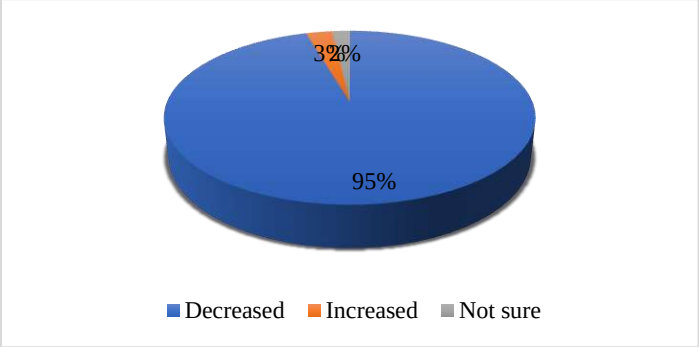

Figure 19: Changing of flora and fauna

4.3.7 The impact on cultural activities: In the past, the people of the study area celebrated different festivals such as the loss of cultures, loss of religious monuments, loss of local practices, loss of indigenous knowledge, and others. In the past like the whole country people in the community of the study area celebrated 1st day of Bangla month (Baishak), making a cake (pitha) with new rice and date juice.

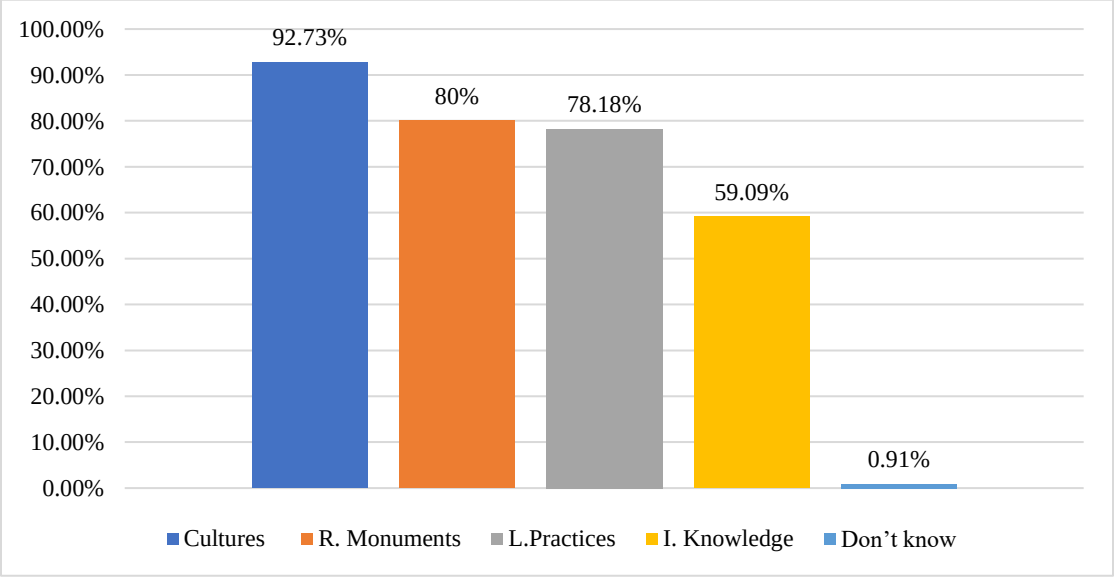

Figure 20: Impact on cultural activities

Approximately 92.73% of participants concurred that the celebration of various festivals may be impacted by climate change as a result of financial losses. The community's customs are no longer

the same on a local level. Merely 0.91% were unable to figure out a connection between historical and contemporary cultural practices. People used to be able to notice their surroundings, but these days it's harder to read them. As a result, they were unable to utilize native methods in the previously farmed area.

Table 3: Impact on cultural activities

Type	Frequency	Percentage
Loss of cultures (making pitha, celebrating festivals)	102	92.73
Loss of religious monuments	88	80
Loss of local practices	86	78.18
Loss of indigenous knowledge	65	59.09
Others	4	3.64
Don't know	1	0.91

"We cannot celebrate festivals due to lack of money. If sufficient, you can two taka instead of one taka. If income becomes low, you cannot do work and need to stay home."- **Mijan**, shopkeeper, Launchghat, Elisha, Bhola

4.4 Adaptation:

4.4.1 Fertilizer use: The research area's population reported using more fertilizer than in prior years to boost soil nutrients, boost production, and protect against insects—roughly 70%, 60%, and 41.82%, respectively.

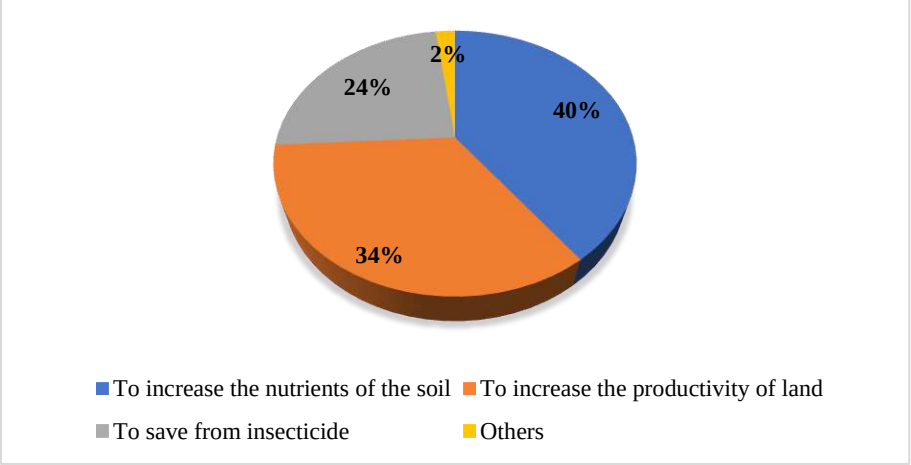

Figure 21: Causes of fertilizer use

Crop growth is increased when fertilizer is applied properly. Crops are protected from insects and pests by insecticides and pesticides. As a result, appropriate utilization needs to benefit them. As previously said, they had no training for learning and lacked appropriate information about it. Proper use of fertilizer yields benefits; improper application causes losses in agricultural output for those who cannot use it appropriately.

4.4.2 Productivity increase or not: As a means of adaptation, the study area's community utilizes fertilizer more than in prior years to boost agricultural yield. Here, 58.18% of respondents claimed that applying fertilizer to their farmland has improved crop yield. Merely 3.64% expressed uncertainty over the growth or decline in crop productivity. A little over 25.45% reported that production has not gone up. Their lack of understanding about the appropriate dosage is the root reason for this.

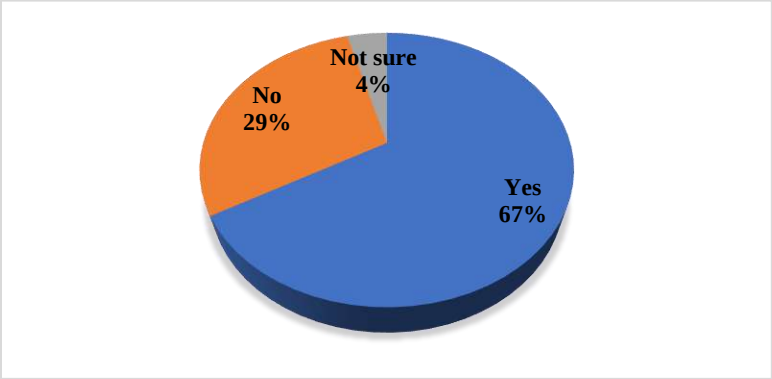

Figure 22: Productivity increase or not in the agricultural field of the study area

4.4.3 Fish cultivation: They claim that there are fewer freshwater fish in rivers. Since the respondents noted that their need for food or business objectives is now less than in the past, they also raise freshwater fish. The respondents raised around 78.18%, 67.27%, 63.64%, 59.09%, 24.55 %, and 7.27 % of Tilapia, Rui, Katla, Pangas, and Catfish, respectively. In addition, they raise Chitol and Chaina Puti in their freshwater source.

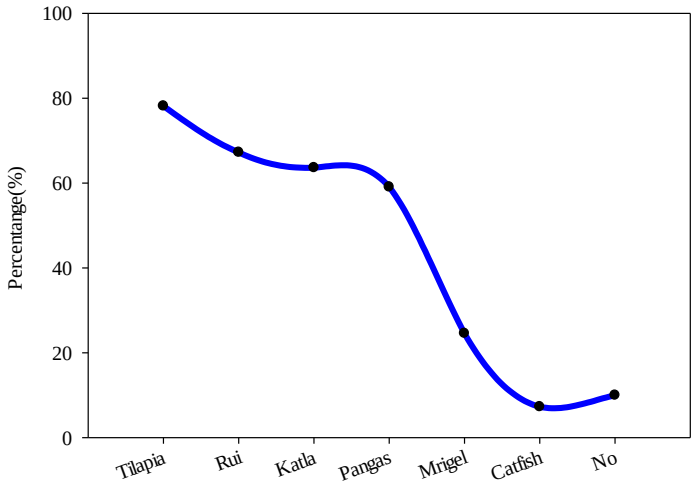

Figure 23: Fish cultivation as an adaptation measure in the study area

4.4.4 Earning from fishing: As previously said, they view Graph 23—which shows the annual revenue from the fishing industry—as a response to climate change, with 55.45% of respondents earning less than 10,000 BDT annually.

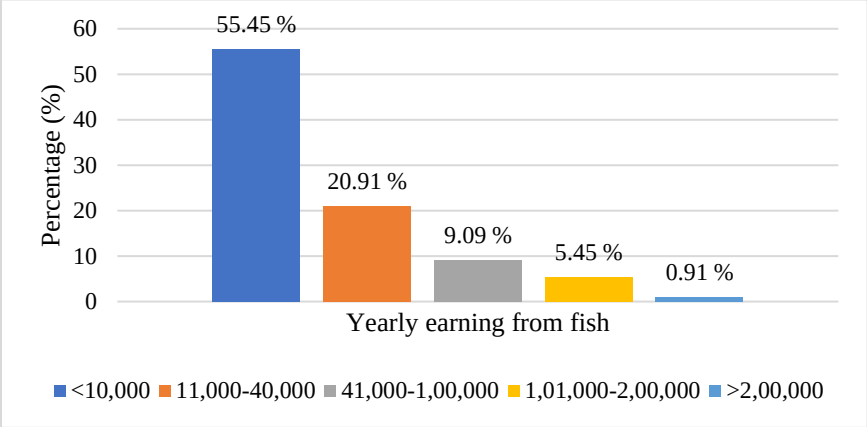

Figure 24: Yearly earnings from the fishing sector

Many people make their living by catching fish in the river. People who work directly in the fishing industry make more money than farmers who grow crops in ponds. Because they obtained valuable fish from the river, such as pangas and hilsha. Over 20 percent of people make between 11,000 and 40,000 BDT per year from fishing. In this sector, just 0.91% of workers make more than two crore.

4.4.5 Livestock: The study's community overcomes obstacles by farming animals as a source of additional income. Around 57.27% of rear ducks. 51.82 percent of rear chickens, 52.73 percent of rear cows, and over 30 percent of rear goats with another occupation. These animals can meet their protein needs. The remaining ones can be sold on the market once their demands have been met. These animals can provide them with financial advantages.

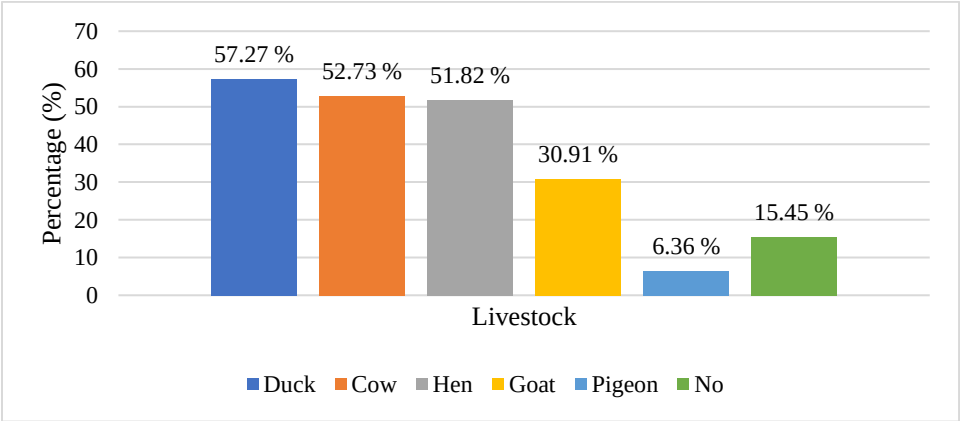

Figure 25: Rear livestock from the responders

4.4.6 Migration: One of the crucial stages in being resilient to natural disasters is migration. A person is said to be permanently relocated when they leave one location and move to another. However, it is referred to as internal migration if it takes place in the same community in which

he previously resided. Over 84% of respondents relocate permanently while staying in the same area, as seen in Figure 25. They must relocate because of their vulnerability to climate change. According to the respondents, migration is caused by riverbank erosion. Furthermore, because their house hasn't deteriorated yet, around 0.91% of people haven't moved yet.

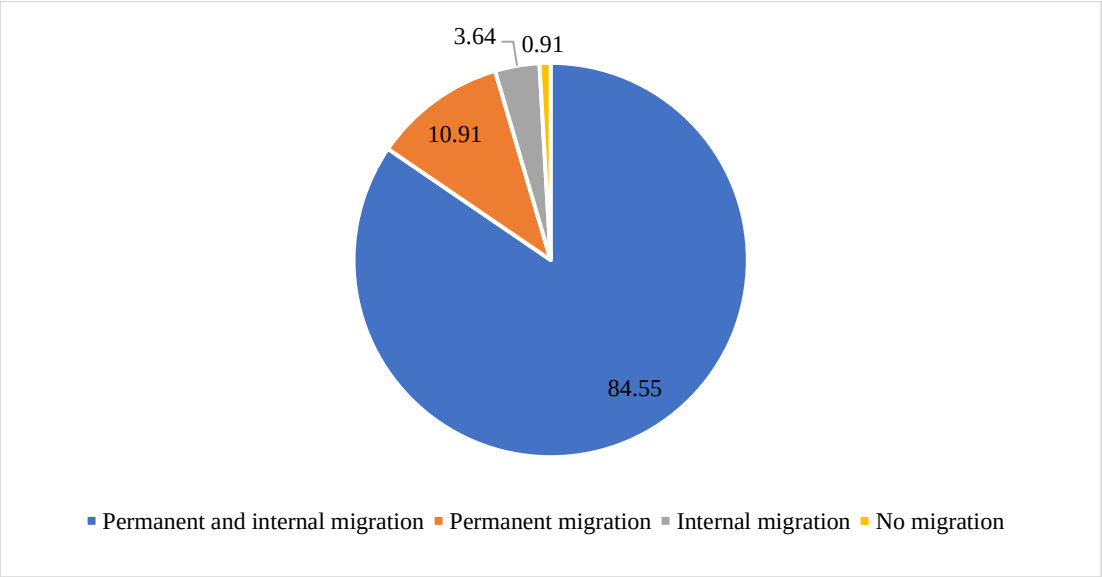

Figure 26: Migration status in the study area

4.4.7 Reasons for migration: There are a variety of factors that contribute to migration. 83.64% of those surveyed stated that they had to relocate because riverbank erosion had caused them to lose their land. They also mentioned that they migrated not only for land loss but also for better facilities, as their livelihood was destroyed by riverbank erosion and they felt food insecurity in their living place. Because of the possibility of erosion, several respondents moved.

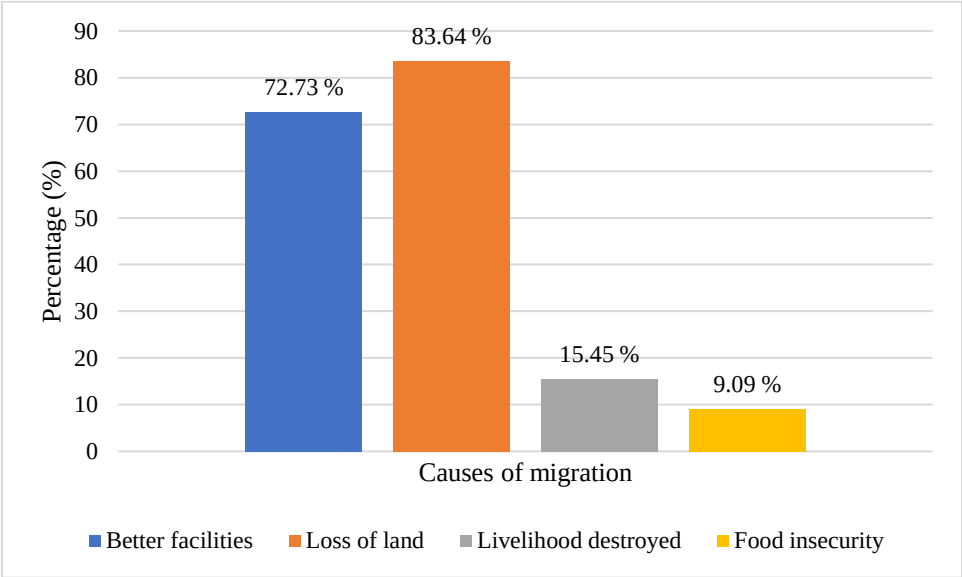

Figure 27: Reasons for migration

5.4.8 Land use pattern change: Over 90% of those surveyed altered their land use pattern, while 75.45% made changes to create infrastructure. They altered the migratory land to construct homes and other structures as their habitat land began to erode. Some people make shops as a side business while they transition professions. As the salt rises, the ground loses its fertility and people attempt to grow new species that can withstand the salinity. About 21% of landowners have altered their land use pattern in response to the risk of riverbank erosion, while roughly 7.27% have not done so yet.

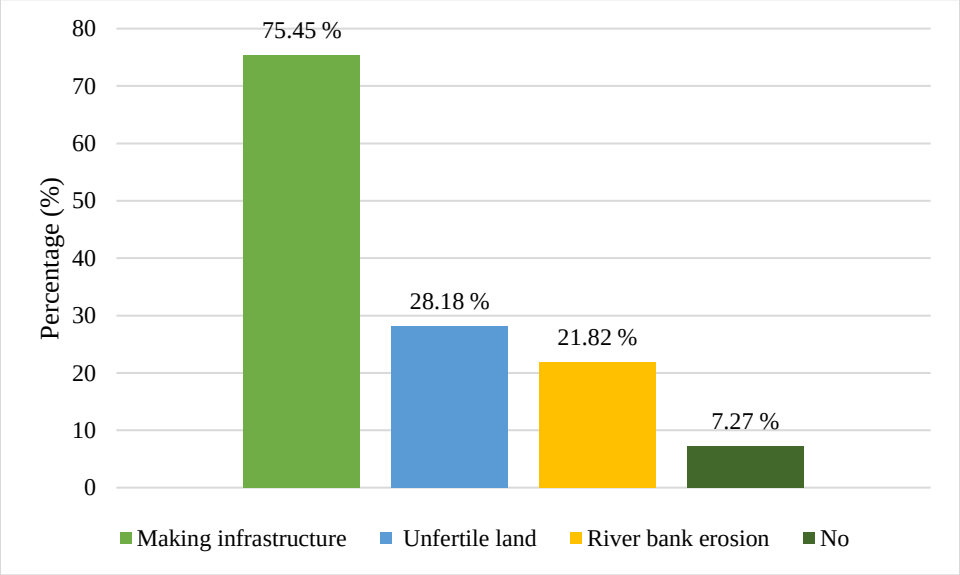

Figure 28: Land use pattern change

5.4.9 Strategies to overcome the challenges: Despite the numerous obstacles they face, people are managing to get by by adopting different coping mechanisms. They receive roughly 40% of their financing from NGOs. NGOs lend money to people. Those who take out loans must repay the entire amount plus interest within the predetermined period. A portion of them take out loans to purchase agricultural supplies including seeds, insecticides, and pesticides. A few individuals stated that they receive instruction from governmental entities like the Department of Agriculture's extension service. Knowing this, the forecasters decided to cut certain crops sooner because of the possibility of harm. The Agricultural Extension Department offers these forecasting services. Some respondents don't take any proactive measures to manage climate risk, which is about 21.82 %.

> 'The first one is research. Crop varieties should improve by doing research that can survive with climate change impact. The second one is need enough cold storage to store the crops he added.'- **Md. Hasan Warisul Kabir**, Deputy Director, Department of Agricultural Extention,

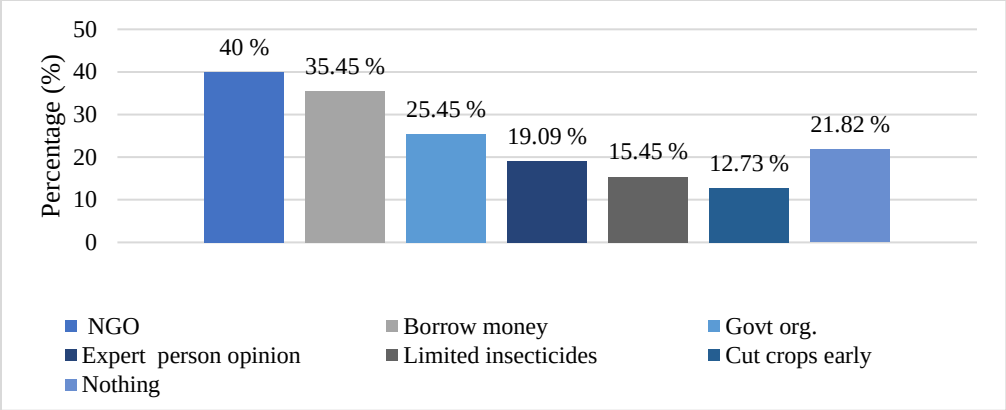

Figure 29: Strategies to overcome the challenges

5.4.10 Support from the institution: The community in the study area takes support from an institution as a part of adaptation. They accept loans from government and non-governmental organizations and take part in their training. They occasionally borrow money from someone they know well. They receive assistance from volunteer and local groups both during and after any significant calamities. Nonetheless, the majority of respondents—roughly 30.91%—did not locate or get any assistance from the mentioned organization.

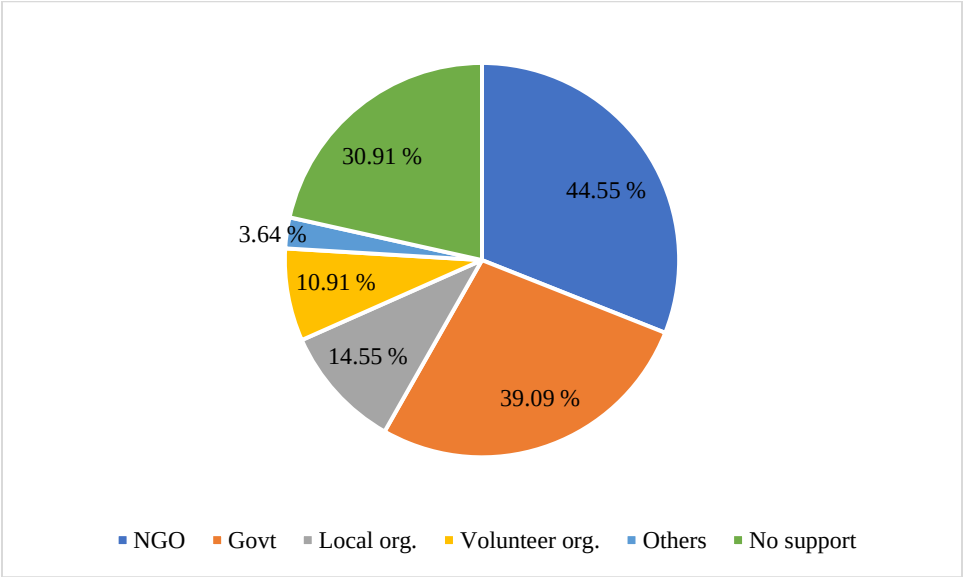

Figure 30: Support from the institution

‘The Climate Smart Technology project which is implemented in Khulna as an adaptation measure. We have an agriculture weather project. By this, we forecast the weather change 7 days earlier. We use the SMS system. Floating bed vegetable cultivation, short-duration varieties, discovering new cultivation methods to adapt to salinity, etc. are the major adaptation strategies of the Department of Agricultural extension, Bhola.’

‘We trained 638 farmers in Lalmohan to make eco-friendly fertilizers like vermicompost. Also about 1736 farmers in the whole Bhola region got this training from where after fulfilling their demand rest of the part was sold to others. This is one kind of adaptation strategy.’- **Md. Humayun Kabir**, Assistant Plant Conservation Officer, Department of Agricultural extension, Bhola.

‘Climate change has a great impact on farmers' livelihoods. As an adaptation measure, the fishermen are not allowed to capture fish from the fish sanctuaries. There are two fish sanctuaries in Bhola. In the breeding, fish capture is declared to stop. It is one kind of adaptation. A meeting is arranged in the banned period to make them aware. Dredging is also the adaptation period. The breeding period of Elisha is the banned period to capture fish. So, we provide 25 kg of rice for each family, cow, goat, sewing machine, etc.’ - **Md. Abul Kalam Azad** is the District Fisheries Officer, of the District Fisheries Department, Bhola.

4.5 Challenges:

4.5.1 Constraints to adapt: Each person has unique challenges in adjusting to climate change. In the research area, the same observation was made. The most important constraint to adapt is lack of money agreed by 81.82 % of respondents. Having money is essential for adjusting to risks. If a person has a reliable source of income, they may be able to get their losses and damages covered. It is possible who do the job. The responders, however, are either fishermen or farmers. Therefore, the previously indicated dangers have an impact on the maximum income source of the respondents. Acquiring knowledge does not equate to academic success. It is achievable with the right counseling, instruction, courses, etc. Maybe they aren't getting it, though. Because over 60% of respondents claimed they lacked the necessary information (agricultural knowledge) to adapt. Other restrictions were not receiving any training, decreasing fish populations, water body overflow, and food shortages during the crisis, which were cited by 54.55%, 40%, 19.09%, and 14.55% of respondents, respectively. Of all communities, 8.18% have enough money and expertise to prepare for disasters. However, 7.27% of respondents claimed that WASH (Water, Sanitation, and Hygiene) is not accessible and that the cyclone shelter is too far away. Once more, 40% of respondents claimed that there is less fish now than there was before.

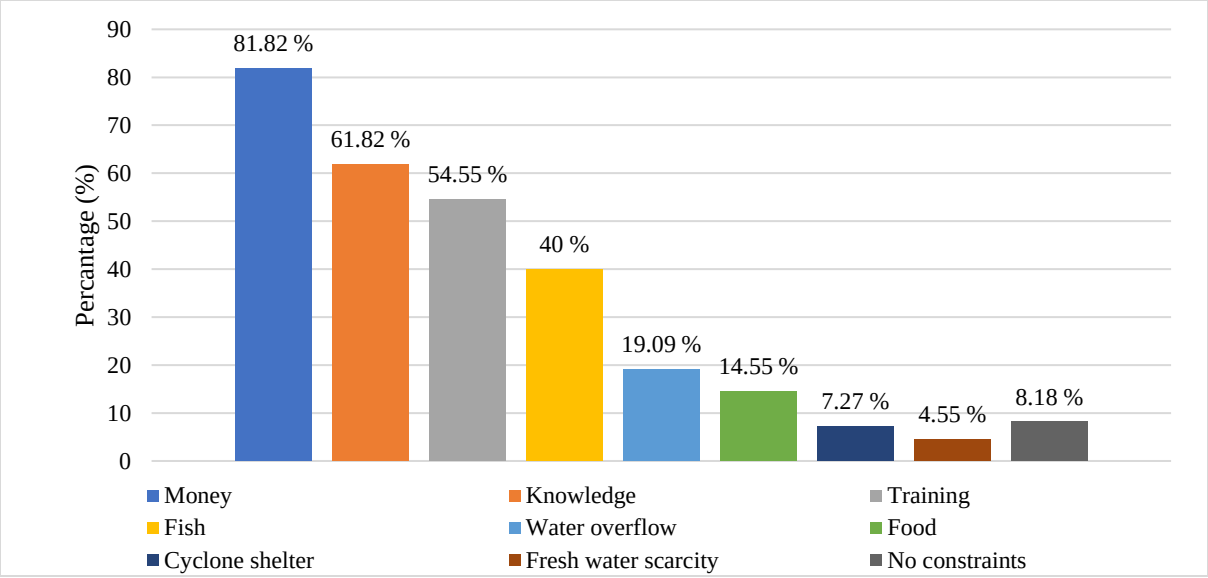

Figure 31: Constraints to adapt in the study area

Table 4: Constraints to adapt in the study area

Type	Frequency	Percentage
Lack of money	90	81.82
Lack of knowledge	68	61.82
Didn't get any training	60	54.55
Reduce fish	44	40
Overflow of the water body	21	19.09
Lack of food during a disaster	16	14.55
Cyclone shelter is so far	8	7.27
Scarcity of fresh water	5	4.55
Others	1	0.91
No constraints	9	8.18

4.5.2 Impact on food cultivation: A rise in natural disasters affects the production of food. Economic loss is the first and most significant element. When crops are destroyed or yield less than their potential, economic loss occurs. Roughly 66.36% of those surveyed experienced financial loss. 46.36% of respondents agreed that the lack of water during the dry season caused the crops to deteriorate, and around 12.73% said that food poverty makes farming difficult. Roughly 10.91% of those surveyed had sufficient wealth to farm. Crops suffer harm when the land submerges. Due to the intense sunshine during the dry season, crops and fields get dry and suffer from climate change when the crops cannot survive with it, farmers face economic losses.

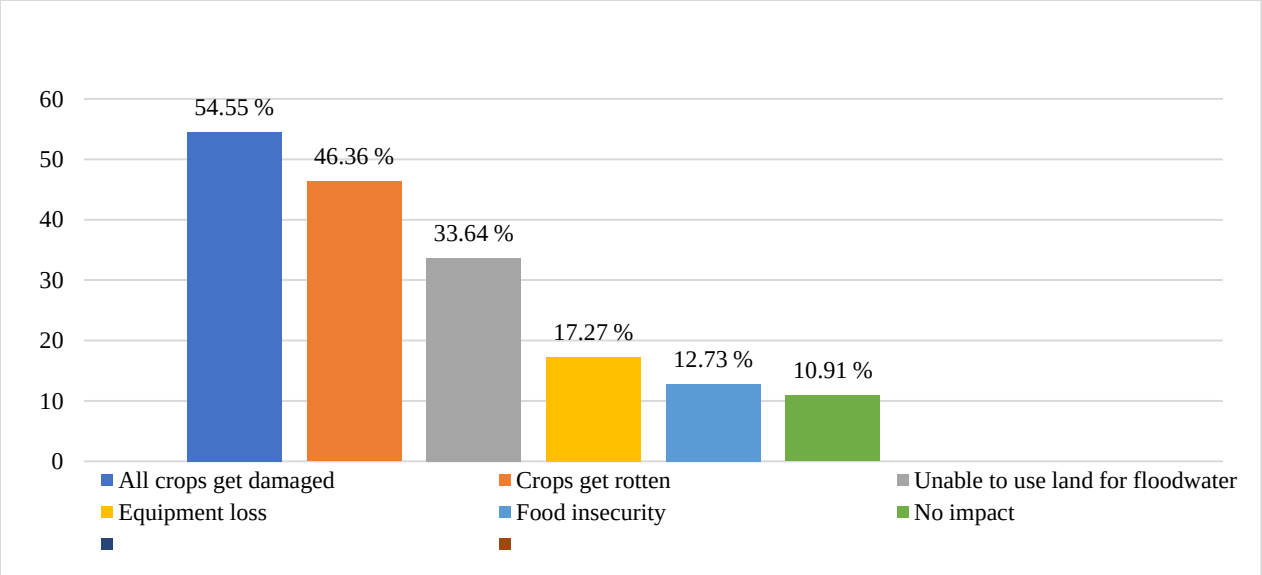

Figure 32: Impact on food cultivation

4.5.3 Challenges for cultivation crops: The difficulties individuals in the research area encounter with agricultural crop production are depicted in the following graph (fig. 18). The habitats in the research region confront several difficulties, including a lack of information, a lack of workshops and training, a lack of equipment, a lack of competence to help, a lack of food storage facilities, health risks, and a shortage of water. A little over 57.27% of respondents said they didn't know enough about food production. They utilize fertilizer or pesticides based only on assumptions since there are inadequate training sessions and professional aid available. Their presumptions are accurate occasionally, but not always. A little over 11.82% of respondents agreed that applying insecticides might pose health risks. They (12.73 %) face a problem, as there is no food storage system where they can store their seed for the next year. Crops got rotten due to a lack of water responded by 12.73 %.

> 'There is a negative impact of salinity intrusion but the farmer didn't understand it. Salinity impact is different in different stages of crops according to their age. Salinity mostly affects the showing period of crops.'- **Md. Hasan Warisul Kabir**, Deputy Director, Department of Agricultural extension, Bhola.

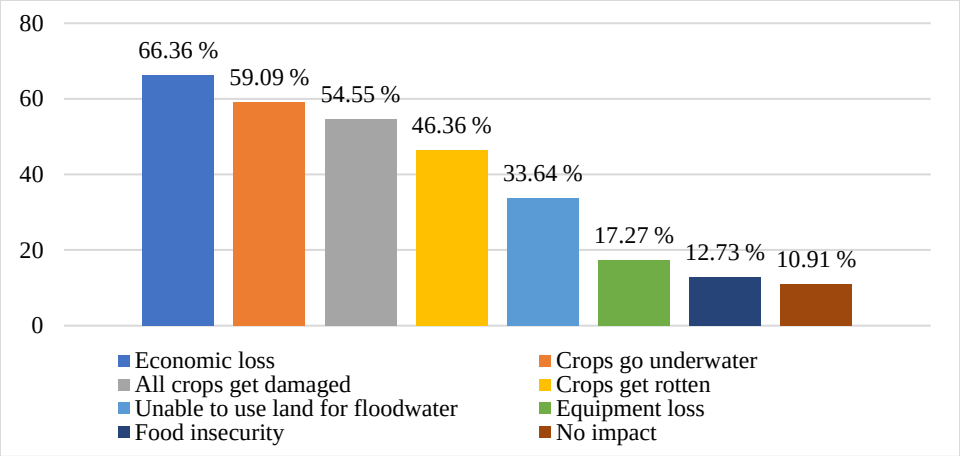

Figure 33: Challenges for cultivation crops

4.5.4 Challenges to rear livestock: Raising cattle is a common way for the respondents to increase their income and mitigate the effects of climate change. Regretfully, they encountered distinct difficulties when raising animals. About 47.27 percent of those surveyed said that gathering grass was difficult during inclement weather, such as storm surges, cyclones, or rainy seasons when everything is submerged and ruined. A few people (32.73%) said that they had difficulties providing food for their cattle both during and after disasters due to a lack of funds. For food, the goat and cow require verdant grass. Nevertheless, a lot of people were unable to gather it throughout the danger. since land is submerged. The cyclone shelter is located distant from the respondents' locality, according to 16.36% of respondents, and around 32.73% of respondents claimed that there are no facilities for animals there. It should be noted, nevertheless, that 16.36% of respondents said they had no difficulties in that scenario as they were able to deal with the inclement weather.

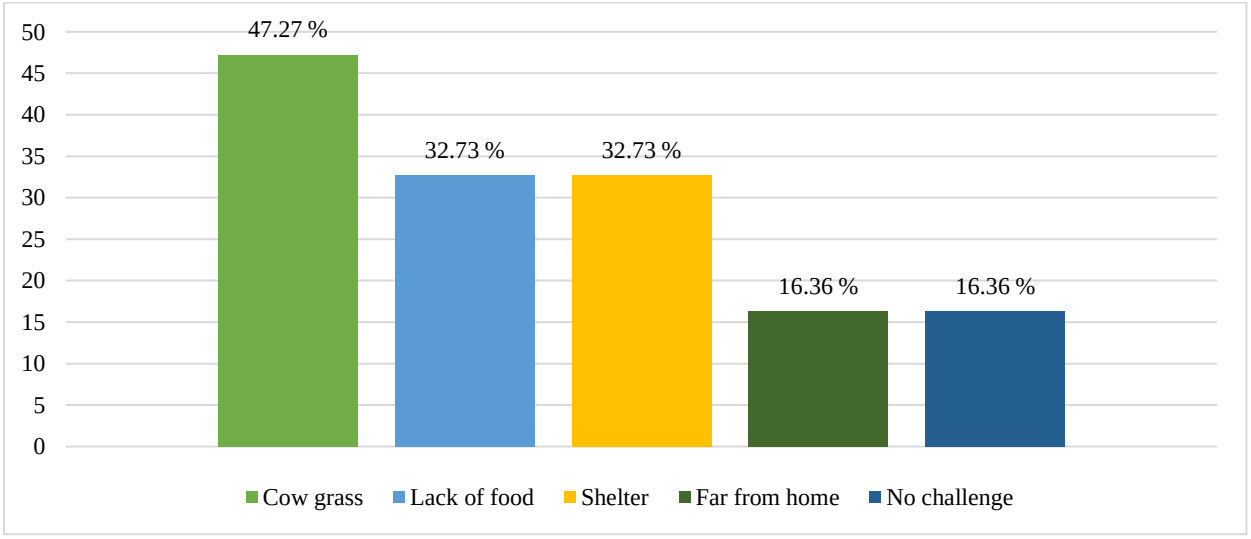

Figure 34: Challenges to rear livestock

Chapter Five

Discussions

After surveying the study region, it can be concluded that the majority of people are aware of climate change and the problems it has caused. Being a village near rivers, they have experienced various losses and damages due to climate change. As we've seen, they noted several losses and damages. There are two categories for losses and damages: non-economic and economic. They made an effort to adjust to the changing climate, but they encountered many obstacles. Their physical settings cause them much suffering, whereas the Bhola area has direct access to the Bay of Bengal. While some said that the frequency is higher than before, others claimed that it is low, medium to low, etc. It depends on their perception of which disaster they consider or not. The responders who gave it more thought believed that it happened more frequently than before. The community in the research region is vulnerable to a variety of hazards, including heat waves, cyclones, tidal floods, riverbank erosion, saline intrusion, unpredictable severe rains, and more. Even though these are all risks associated with climate change, one causes others to intensify. There is a connection between cyclones and hot temperatures. It establishes the conditions for cyclone formation. Flooding and storm surges can happen during a cyclone. Erosion of riverbanks may occur during a flood. Once more, saline intrusion and severe rainfall transpired during cyclones. Soil and pond salinity rises as a result of flooding. There are occasionally visible floods and inundations due to the erratic strong rains.

The responders described all of their damages and losses. Due to riverbank erosion, almost 90% of the respondents lost their land. Other economic losses include decreased fisheries production, trees, businesses, infrastructure, and agricultural output, ranked from highest to lowest. Cyclones, heat waves, floods, saline intrusion, riverbank erosion, and erratic, intense rains all cause crop damage at different phases.

The vulnerable population that lives along the shore and depends on natural resources is the one whose livelihoods are impacted by the effects of climate change on fisheries, livestock, off-farm activities, and even the locations of human settlements (Hasan et al., 2016). According to respondents fish are less abundant due to saline intrusion. The structure and productivity of fish populations and marine and coastal ecosystems are significantly impacted by rising sea levels, changing precipitation patterns, ocean acidity, rising temperatures, and dissolved oxygen concentrations (Hasan et al., 2016). The stages of the hilsa life cycle and migration patterns may be impacted by climate change (M. M. Islam, Islam, et al., 2020). But fish output in Bhola, particularly Hilsha fish, has increased owing to non-climatic factors such as raids during non-fishing times and the restriction of current nets; nevertheless, fish productivity in ponds has decreased as a result of uncommon natural disasters. Riverbank erosion affects businesses, land loss, infrastructure loss, and tree loss. The cyclone, one of the most dangerous threats in the study region, also has an impact on the business sector, trees, and infrastructure. It might be questioned how risks impact business. Poor residents can't work during hazardous periods like cyclones and floods, therefore they only make extremely minimal purchases. The merchant was impacted by it. In addition, some businesses related to the agricultural and fisheries sector. Thus, it had an effect during danger. According to this study, individuals who are farmers experience far greater

suffering than those who are fishers. The impact on respondents' revenue sources was significant for roughly 32% of them and medium for about 48%. The ability of farmers as well as some environmental factors affect agricultural activity. As previously stated, erosion caused more than 90% of respondents to lose their land. The farming community must bear a heavy price for its livelihood. due to a decrease in agricultural fields. Every respondent lost between 0 and 500 decimals at the very least.

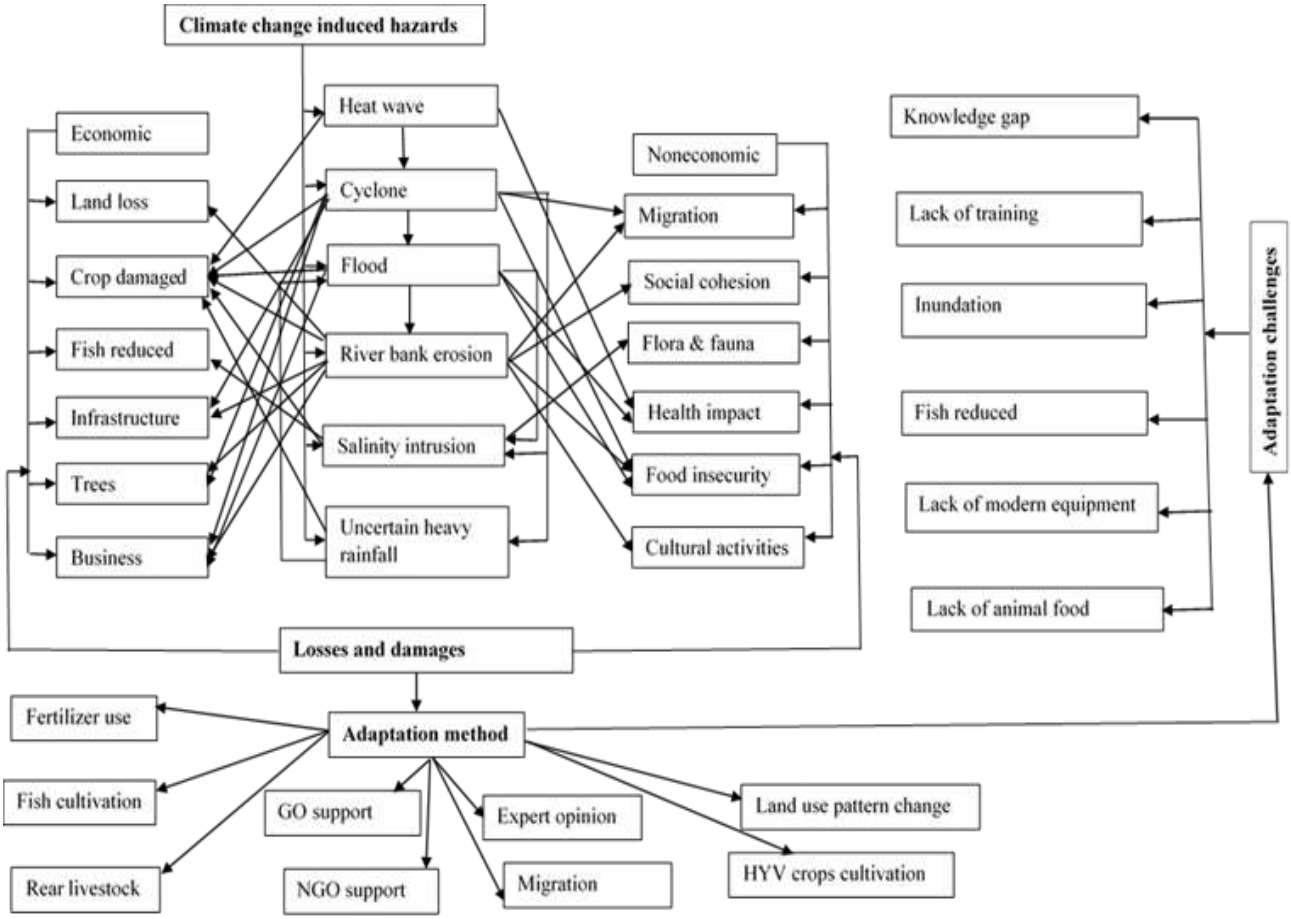

Figure 35: Conceptual framework

The noneconomic damages ranked greatest to lowest are food insecurity, health effects, loss of biodiversity, migration, loss of social cohesion, etc. For them, the most important risk is riverbank erosion. Both riverbank erosion and cyclones cause migration to occur. People are internally and permanently moved in response to the riverbank erosion, but not permanently displaced due to the cyclone. We made an effort to determine how cultural activities are affected by climate change. Their lack of resources prevented them from participating in secular celebrations such as cake festivals (pitha), the first day of Bengali month (pahela Baishakh), and other events. Their opinion was that without money we couldn't do anything according to our will. They do not enjoy holidays the way they did in childhood because of their unpredictable economic situation. Biodiversity is also affected by climate change. The respondents also concurred that a portion of the flora and

fauna they knew as children has diminished, while others have gone extinct or are not found in their native habitat. There might be several causes for the local wildlife and flora to become extinct or to decrease. The first is environmental requirements, which are necessary for biodiversity growth. As a result, neither the fauna nor the flora could adapt. Land loss and rising soil and water salinities might be the main contributing reasons. It had an impact on the extinction of biodiversity.

Once more, soil conditions and weather have an impact on agriculture. Seasons and other weather-related patterns are not as evident as they formerly were. The growing of food was greatly impacted by it. A greater number of insects than previously reported by the respondents and agricultural experts are the result of many problems. Furthermore, the soil's salinity rose more than it did previously. To boost productivity, they applied fertilizer more than they had previously. from the consequences of climate change on the economy.

They have had a difficult time adjusting to climate change. Because of unseasonably massive rainfall and tidal effects, a large number of agricultural areas are submerged. There are instances when the land gets drier during the drought. All of them harm the crops. It is also to blame for the majority of people developing food insecurity after disasters. The responders gave it their hardest in attempting to overcome the obstacles using various techniques. Their most popular adaptation strategy is to allocate their daily expenses in line with their income. A few of them rely on loans from the institution. They have to pay for it, though. They don't have any other means of getting money. They occasionally attempted to borrow supplies and funds from other people. Still, it is insufficient to deal with climate change. To lessen the impact of climate change, they invested this money in the agricultural or fishing industries. In an attempt to prevent harm, a few of the interviewees attempted to harvest their crops sooner. Accept advice as well as professional views on occasion. Although the government agency set up some training, most of them were not able to make use of it. Everyone should be able to access the training.

The agriculture extension department has undertaken adaptation projects such as the climate-smart agriculture and water management project, the improvement of the agricultural methodological information system project, the establishment of a farmer's service center at the union level, a pilot project to increase crop production through the expansion of solar energy and water-saving modern technologies, a research project on floating bed vegetables and spiceberry cultivation, etc. All of these, nevertheless, are absent from Elisha Bhola. It must be easier to deal with climate change if everything applies in Bhola.

Chapter Six

Conclusions and Recommendation

The study findings provide a scenario of economic and noneconomic losses and damages in the largest coastal island Bhola of Bangladesh. According to the response cyclones, riverbank erosion, salinity intrusion, uncertain heavy rainfall, heatwaves, drought, etc. are the climate-induced risk in the study area. The local community suffered for a long time due to these hazards. Due to climate events, they lost their lands, crops, trees, and infrastructures, and their business sector was also affected. When asked about the main risks or catastrophes in their area during their living time, the majority of them (91.82%) agreed that riverbank erosion was a concern. There are those individuals who have experienced riverbank erosion seven times in their lifetime. About 11431.426 hectares remain unaltered after 30 years, of which 5967.846 hectares and 7994.282 hectares were regions subject to erosion and accretion, respectively from 1990-2020. The land loss amount of about 35.46% of the respondents is between 501 and 1000 decimals, and its approximate market worth is between 11 and 50 lacks BDT. Salinity poses a problem as well; around 40.91% of respondents agreed. They also faced food insecurity, economic crisis, and mental stress, and migrated permanently to another place to make new settlements. A little over 71.82% of participants concurred that climate dangers also have an impact on the fishing industry which caused economic loss. Over 20 percent of people earn between 11,000 and 40,000 BDT per year from fishing. Approximately 92.73% of participants concurred that the celebration of various festivals may be impacted by climate change as a result of financial losses.

Around 16.36% of those surveyed said they had only ever planted their property once. Conversely, around 33.64% and 35.45% of those surveyed farm their land twice, and three times, respectively. The research area's population reported using more fertilizer than in prior years to boost soil nutrients, boost production, and protect against insects—roughly 70%, 60%, and 41.82%, respectively. Here, 58.18% of respondents claimed that applying fertilizer to their farmland has improved crop yield. In addition to losing their property, the disadvantaged coastal population also experienced socioeconomic vulnerability as a result of these occurrences. They implemented many efforts as adaptive measures, such as altering agricultural practices, utilizing HYV crops, applying more fertilizer than before, and keeping cattle, to reduce the losses and damages. Accept financial assistance from NGOs, the government, etc. However, it's important to note that they had several difficulties throughout the adaptation period. Among these include financial difficulties, information gaps, a lack of workshops and training, a decline in fish populations, food poverty, and so on. The NGO and government sectors have to pay more attention to this industry and take greater action to reduce damages and losses. Besides, to minimize the loss of climate events, some measures should be taken at different levels:

- Training on disaster preparedness involving local institutions or local government.
- Engaged NGOs, local-level civil society, and the private sector in training and workshop
- People who live in poverty or have the lowest incomes are impacted by numerous river erosion incidents. GO should endeavor to enhance their standard of living. Social/public awareness should be strengthened.

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Annexure A

Key Informant Interview

KII-1

Interviewee Name	Mokammel Hosain
Designation	Primary School Teacher, Elisha, Bhola
Date of Interview	14. October. 2023

Mokammel Hosain is a teacher. He has been living there for more than 20 years. After asking about climate change, he said it is happening there and the impact is more than in previous years. He used the terms heavy rainfall and uncertain rainfall as an example of climate change. He said it was the time of winter and the farmers planted Capsicum, Watermelon, Bitter gourd, etc. seedlings. However, the uncertain heavy rainfall damaged all the crops, as they could not tolerate the rainfall. Also added that in the rainy season to the shortage of rainwater, the crops got dry and damaged.

He mentioned that there is a Cyclone shelter. The harvest is less than before. The fish production cost is increased than previous. Not only he but also the other community had lost their land due to riverbank erosion. The amount land loss of is about 5 crore. He said that cultural heritage was lost due to riverbank erosion. The bank erosion was stopped for the previous two years by using blocks but this year some portion again eroded. Social cohesion among the community is decreased and diseases are increased due to food insecurity he added. Fresh drinking water is available in this locality.

Mainly he cultivated rice, mustard, wheat, etc. on his agricultural land. Other farmers not only cultivated these crops but also cultivated capsicum, watermelon, potato, corn, etc. They cultivate their land two times and sometimes three times. However, using fertilizer more than in the previous few years to increase productivity and to save from insect crops. By using the fertilizer productivity is increased he added. By asking why people use more fertilizer than previously. He said that climate change is responsible for that. He cultivates different types of fish in his pond.

He said that he is highly economically affected by climate change. He gave an example that the potato field was damaged due to uncertain heavy rainfall. He migrated there due to land loss by riverbank erosion and for better facilities. The flora is increased but fauna are decreased than previously he added. Cultural practices, festivals, and indigenous knowledge are decreased.

He felt many constraints in adapting to climate change. The main constraint is crop cultivation. Crops land go under water and crops are damaged due to excessive water. Lack of money is another constraint to adapting. He mentioned that lack of knowledge or training in agriculture is another constraint. He tries to get help from the local expert to gather knowledge about agriculture. Also, take assistance from government organizations.

KII-2

Interviewee Name	Md. Hasan Warisul Kabir
Designation	Deputy Director, Department of Agricultural Extension, Bhola
Interviewee Name	Md. Humayun Kabir
Designation	Assistant Plant Conservation Officer, Department of Agricultural Extension, Bhola
Date of Interview	15. October. 2023

Md. Hasan Warisul Kabir is a deputy director and Md Humayun Kabir is an assistant plant conservation officer at the Department of Agricultural Extension, Bhola.

As they are working in the Department of Agricultural Extension, we asked about the impact of climate change on the agricultural sector. Md. Hasan Warisul Kakir mentioned different points on the impact of climate change. Such as loss of agricultural land due to riverbank erosion, increasing soil salinity due to the entrance of saline water, season change, changing length of photoperiod, drought, heavy rainfall, increasing supplementary irrigation for successful Amon cultivation, change of tide, couldn't harvest the high-value crops as it damaged by uncertain heavy rainfall or tidal flood, existing crop varieties couldn't give higher value return, uncommon diseases (Blast of Wheat, let blight, early blight), thunderstorm and lightening, waterlogging period increase, fog weather, increased temperature between day and night etc.

He said that there is a negative impact of salinity intrusion but the farmer did not understand it. Salinity impact is different in different stages of crops according to their age. Salinity mostly affects the showing period of crops.

He suggested different recovery options. The first one is research. Crop varieties should improve by doing research that can survive with climate change impact. The second one is need enough cold storage to store the crops he added.

Md. Humayun Kabir talked about the Climate Smart Technology project, which is implemented in Khulna as an adaptation measure. He also said that they have an agriculture weather project. By this, they forecast the weather change 7 days earlier. We use the SMS system added by Md. Hasan Warisul Kabir. Floating bed vegetable cultivation, short-duration varieties, discovering new cultivation methods to adapt to salinity, etc. are the major adaptation strategies of the Department of Agricultural Extension, Bhola.

Md. Humayun Kabir added that from their department they trained 638 farmers in Lalmohan to make eco-friendly fertilizer like vermicompost. About 1736 farmers in the whole Bhola region got this training also, from where after fulfilling their demand rest of the part was sold to others. This is one kind of adaptation strategy.

The percentage of Wheat and Soybean production has increased. They claimed climate change for this fact. Also increased the production of foreign fruit added by Md. Hasan Warisul Kabir.

The deputy director gave a priority ranking of different climatic hazards in Bhola, which are given below in the table:

Hazard	Tidal Impact	Storm surge	Drought	Heavy rainfall	Salinity	River bank erosion	Heat wave	Cold wave	Water logging	Cyclone	Insurgence of minor insect	Prevailing uncommon diseases	Thunder storms & lightning	Others
Ranking	01	02	03	04	05	06	07	08	09	10	11	12	13	14

Figure 36: Taking interview of Md. Hasan Warisul Kabir

KII-3

Interviewee Name	Md. Abul Kalam Azad
Designation	District Fisheries Officer, District Fisheries Department, Bhola
Date of Interview	15. October. 2023

Md. Abul Kalam Azad is the District Fisheries Officer, District Fisheries Department, Bhola. We took his interview about climate change's impact on the fish sector and its adaptation measures.

Firstly, he said that climate change is happening because of global warming. It means that the world temperature is rising he added. Therefore, it creates a great impact on the fish sector. In addition, this impact is categorized into two parts, which are open water impact and cultural pond impact.

He said that due to climate change, the water level of water bodies has decreased. Therefore, fish are reduced. Due to the shortage of water in the pond, shot circle fish cultivation increased. Drought is another climatic risk. Water level decreased for drought. Siltation on the riverbed hampers the breeding of fish. Many types of fish species are extinct and some have started to extinct. Changing the breeding system due to climate change. Climbing Fish (Koi), Barbel (Shing) and catfish (Magur) decreased in a natural system he added.

Climate change has a great impact on farmers' livelihoods. As an adaptation measure, he talked about fish sanctuaries where the fishermen are not allowed to capture fish from the fish sanctuaries. There are two fish sanctuaries. In the breeding, fish capture is declared to stop. It is one kind of adaptation he said. He also arranged a meeting to make them aware. Dredging is also the adaptation period. The breeding period of Elisha is the banned period to capture fish. So, the authority provides 25 kg of rice for each family, cow, goat, sewing machine, etc.

Annex B

Focus Group Discussion

FGD-1

Location: Elisha, Bhola Date: 14. October. 2023

Sl No	Name	Age	Profession
01	Parvin	45	housewife
02	Shahnaz Begum	60	Housewife
03	Mala	30	Housewife
04	Kulsum	50	Housewife
05	Tasmia	40	Housewife
06	Nasima	40	Housewife
07	Tasnur	60	Housewife
08	Rashida	45	Housewife
09	Sharmin	50	Housewife
10	Jannat	55	Housewife
11	Arfuja	40	Housewife
12	Bokul	70	Housewife
13	Arju	55	Housewife

The Focus Group Discussion (FGD) started with knowing them about the purposes of FGD. The conversation started with a general talking about their occupation, ages, house distance from the river, etc. We asked for the house's distance from the river to ensure that they are a riverine community.

When asked about the perception of climate change, they agreed it is happening right now. Though they are farmer, their other family members are either farmers or fishermen. Everyone has lived their more than 10 years. After asking about major disasters, they said it is happening more than in previous years. The major hazards are salinity, heat waves, heavy rainfall, drought, etc. They witnessed many disasters several times in their life. However, they have cyclone shelters but do not like to go there in the worst situation.

They also mentioned some economic and non-economic losses and damages for climate change impact. Loss of land, agricultural production, fisheries, livestock loss, business loss, loss of trees, and infrastructure are the economic losses due to major disasters they mentioned.

When we explained the terms of non-economic losses and damages, they mentioned some, which are loss of social cohesion, health impact, biodiversity loss, etc.

Most of the farmers of their family cultivate two times in their agricultural fields. Some of them are tomato, potato, rice, cucumber, ridge gourd, etc. However, they said that they used excessive about of fertilizer to increase the productivity and nutrients of the soil. Therefore, the cost of cultivation is increased. They mentioned that without fertilizer the growth of crops is not good.

Some of them suffer from skin problems and kidney problems. They shifted to new places due to riverbank erosion. However, mentioned that profit or facility is not as good as a previous living place.

As some of the respondent's husbands are fishermen. They said it is reduced than previous. Also mentioned is that the flora and fauna reduced than previous. People are not celebrating festivals or not participating in cultural practices, which is a sign of non-economic losses.

They face several challenges to cope with disaster. The first one is lack of money. Others are lack of training, lack of knowledge, lack of expert opinion, etc. Take a loan from an NGO, which is the adaptive measure.

When asked about their health problem, they said that they faced different health issues during disasters. They suffer much in the time of menstruation. As they are poor, suffer much from climate change but try hard to adapt to it.

Figure 37:FGD1

FGD-2

Location: Elisha, Bhola Date: 14. October. 2023

Sl No	Name	Age	Profession
01	Ab. Malek	65	Farmer
02	Saddam	20	Farmer
03	Mannan	20	Fisherman
04	Abdul Rab	32	Farmer & Fishing
05	Md. Shorif	22	Business
06	Imam Hosain	40	Farmer
07	Md. Milon	60	Farmer
08	Ab. Hasim Hawlader	70	Fisherman
09	Md. Tofayel Hawlader	27	Farmer & Fishing
10	Faruk	32	Fisherman

Firstly, we gave them a short description of the purposes to go the study area. The conversation started with Abdul Malek which age is 65 years old and he is a farmer. His house is within 200 m of the river. For other members of FGD, house distances from the river are within 500 m. It was a mixed FGD where most of them were farmers and fishermen.

The respondents said that climate change is happening right now. This FGD was taken in October; they said it was raining that month. They did not see rain in the rainy season. They mentioned some climate-related risks that are heatwaves, salinity, riverbank erosion, thunderstorms lightning, storm, etc. The Malek said that his maximum property has been lost from riverbank erosion. However, he is still a farmer but doesn't earn enough from his profession. He lost approximately 160 decimals to riverbank erosion. Imam Hosain faced moderate impact for climate change-related risk. He lost approximately 320 decimals to erosion.

They explained the economic and noneconomic losses from the calamities. The economic losses are loss of agricultural production, loss of land, reduced fish and livestock. The noneconomic losses are loss of important infrastructure, health impact, loss of social cohesion, etc. The maximum is internally permanent migrated people except for Malek. Maximum migrated 3-5 times due to erosion.

The amount of fertilizer that they used is higher than the previous few years. When asked why to use excessive amounts they mentioned that the performance of fertilizer was not as as good as previously. So, need to use excessive amounts. In addition, they use pesticides and insecticides to save crops from pests and insects. As fertilizer also helps to improve the nutrients of the soil, they mentioned productivity is increased. The Malek mainly harvest Iri, and Amon rice and other vegetables on his land. Other responders also do the same things. They all cultivate their land two times a year. Few are facing food insecurity during disasters. Imam Hosain added that their agricultural land goes underwater due to heavy rainfall or tidal impact. Crops are got damaged for it. The land cannot be used during the rainy season.

They also suffer from high blood pressure, kidney problems, diarrhea, etc. They faced several challenges to overcome their situation, which were created by climate change. The first one is lack of money. They said that did not get an opportunity to participate in government training and workshops. They do not have proper knowledge about agriculture. Also faced to rear livestock. They did not like to go to cyclone shelters. Some also take loans as institutional support from NGOs and borrow money from others to cope with climate change-related risks.

Figure 38:FGD 2

FGD-3

Location: Elisha, Bhola Date: 14. October. 2023

Sl No	Name	Age	Profession
01	Siraj	30	Fisherman
02	Nur Nobi	40	Fisherman
03	Farid	45	Fisherman
04	Jasim Uddin	35	Fisherman
05	Maksud	55	Fisherman
06	Salahuddin	48	Fisherman
07	Md. Hossein	50	Fisherman
08	Mijan	28	Shopkeeper

The FGD started with knowing about the perception of climate change-related natural calamities. Siraj a fisherman said that climate change is happening here and frequency is higher than previously. Mijan who has a tea stall near the river said that climate change is happening. Here he first talked about the worst situation of riverbank erosion, which is common in the study area. "If the development work is done immediately after the erosion, then the damage never so worse," Mijan said. "From here river was 5 km away, but it is close to the main road." He added.

Heatwaves can be seen in the Bangla month Ashar and Shrabon which indicates that climate change is happening, said Mijan. In addition, heavy rainfall, strong wind flow, drought, storms, and salinity are common in the study area. When asking about the economic losses they mentioned some, which are land loss, infrastructure loss, reduced fish, agricultural production loss, etc. In heavy rainfall or storm times, the fishermen couldn't go to the river for fishing fish. Therefore, the fishing business fell a great loss added by Siraj. Loss of social cohesion, reduced flora and fauna, especially trees, breaking of families, etc. are noneconomic losses. Siraj said that the production of vegetables is reducing than previous years.

They said that people are not celebrating festivals like previous. Here they think that riverbank erosion is responsible for that. Because it financially influences their life. Due to a lack of money, they could not continue their relationship with their kin.

When asking them about institutional support for adapting to climate change-related risk they said that they did not participate in any governmental training and workshop. Because they never find the opportunity to participate, they added. Nevertheless, they always take financial support from NGOs as a loan which helps them to cope with climate change. However, some people face barriers to taking loans. Because if they take a loan they have to pay it.

Mijan again said, "They buy the daily necessary products according to their income." It is one kind of adaptation measure that they take.

Figure 39: FGD 3

Annex C

Survey Questionary

Name: **Sex:** **Age:** **Occupation:**

Basics information of the respondents:

Survey Questionnaire:

1. River distance from house or property.
    a) 0-200 m
    b) 201-400 m
    c) 401-600 m
    d) 601-800 m
    e) > 801 m
2. How long have you been living here?
    a) Less than one year
    b) 2-10 years
    c) 11-20 years
    d) >20 Years
3. Monthly income?
    a) 5,000-10,000
    b) 11,000-15,000
    c) 16,000-20,000
    d) 21,000-25,0000
    e) > 25,000
4. Do you think climate change is happening right now?
    a) Yes
    b) No
    c) Don't know
5. Do you think climate change is the main reason behind the hazards?
    a) Yes
    b) No
    c) Not sure
6. Do you experience hazards/disasters in your area in the last 20 years?
    a) Yes
    b) No
    c) Not sure
7. What are the major disasters in your locality?
    a) Flood
    b) Drought
    c) Thunderstorms and lightning
    d) Storm surge
    e) Cyclone
    f) River bank erosion
    g) Heatwave
    h) Salinity
    i) Heavy rainfall
    j) Cold wave
    k) Other
8. How many times you have faced in the last 20 years?
    a) 0-5
    b) 6-10
    c) 11-15
    d) 16-20
    e) >21
9. How frequently hazards are occurring compared to previous years?
    a) Low
    b) Low to medium
    c) Medium
    d) Medium to high
    e) High
    f) Don't know
10. Do you have any multipurpose cyclone shelters in your village?
    a) Yes
    b) No
    c) Not sure

Loss and damage:

11. Which economic losses you have experienced due to climate change?
    a) Agricultural production
    b) Fisheries
    c) Livestock
    d) Business
    e) Property/land
    f) Infrastructure
    g) Trees
    h) Others

12. Which non-economic losses you have experienced due to climate change?
    a) Loss of cultural heritage
    b) Health impacts
    c) Displacement or migration
    d) Loss of biodiversity and ecosystems
    e) Loss of social cohesion
    f) Increase sickness
    g) Food insecurity
    h) Water insecurity
    i) Education hampered
    j) Other
13. How does flood/ cyclone/ water logging impact your water collection and consumption?
    a) The water source gets underwater
    b) Contaminated and unusable
    c) Polluted
    d) Road damage
    e) Water source damage
    f) Long distance from house
    g) Others
14. If you have agricultural land then which crops do you produce in your agricultural land and at which time?
    a) …
    b) …
    c) …
    d) …
15. How many crops do you cultivate in one year on the same land?
    a) One
    b) Two
    c) Three
    d) Four
    e) More than four/ Multi cropping
16. Do you use less or more fertilizer from the previous 20 years?
    a) Less
    b) More
    c) Not sure
17. Why do you use more?
    a) To increase the productivity of land
    b) To increase the nutrients of the soil
    c) To save from insecticide
    d) Others
18. Is the productivity less than the previous?
    a) Yes
    b) No
    c) Not sure
19. If yes, do you think climate change is responsible for it?
    a) Yes
    b) No
    c) Not sure
20. Which kind of fish do you cultivate in your pond?
    a) Catfish
    b) Tilapia
    c) Katla
    d) Pangas
    e) Rui
    f) Pabda
    g) Chitol
    h) Prawn
    i) Others
    j) No
21. How much do you earn from the fishing business in a year?
    a) <10,000 Taka
    b) 11-40 Thousands
    c) 41-100 Thousands
    d) 11-2 lack
    e) > 2 lack
22. Which kind of animals do you have and how many?
    a) Cow
    b) Duck
    c) Hen
    d) Pigeon
    e) Goat
    f) Others
    g) No
23. What kind of illness do you or your family suffer from climate-related hazards or risks?
    a) High pressure
    b) Diarrheal disease

c) Reproductive health-related problems
d) Kidney problem
e) Malnutrition
f) Skin disease
g) Asthma
h) Heart disease/chest pain
i) Obesity
j) Others
k) No

24. How long have you/they suffering from this illness?
    a) Less than one year
    b) 1-5 years
    c) 6- 10 years
    d) > 10 years
25. How does your income source get affected due to climatic hazards?
    a) Low
    b) Medium
    c) High
    d) Don't know
26. Have you ever migrated due to any hazard and what kind of migration do you take?
    a) Internal migration
    b) External migration
    c) Emigration migration
    d) Immigration migration
    e) Seasonal migration
    f) Permanent migration
    g) No migration
27. What is the main reason for migrating?
    a) Livelihood destroyed
    b) Better income
    c) Food insecurity
    d) Loss of land
    e) Better facility
    f) Others
    g) Don't know
28. How much land you have lost to river bank erosion?
    a) 0-5 decimal
    b) 6-10 decimal
    c) 11-15 decimal
    d) 16-20 decimal
    e) >21 decimal
    f) No losses
29. How much did you lose for your infrastructure or house from hazards/disasters?
    a) 0-10,000 Taka
    b) 11-50 Thousands
    c) 51-100 Thousand
    d) 101-500 Thousand
    e) >5 lack
30. Why did you change the land use pattern in your land?
    a) Land becomes unfertile
    b) To make infrastructure
    c) Chace of river bank erosion
    d) Others
    e) No
31. How much time did you change your profession?
    a) One-time
    b) 2- 3 times
    c) 4- 5 times
    d) Not yet
32. If a change, then why change your profession?
    a) Climate change
    b) Better income
    c) Others
33. What are the reasons behind the productivity change of your land?
    a) Climate change
    b) Human
    c) Others
    d) No change
    e) Not sure
34. Do you feel anxious/ mental stress before and during natural disasters such as floods/cyclones/ storms/others?
    a) Yes
    b) No
    c) Not sure
35. Have you noticed any changes in the number of animals and birds (Not the domesticated ones) due to climate change/ natural disasters?
    a) Increased
    b) Decreased
    c) No change

d) Not sure

36. Do you notice any change in the flora and fauna (Flowers, fruits, trees)
    a) Increased
    b) Decreased
    c) No change
    d) Not sure
37. Have these disasters caused harm to any religious and cultural sites and practices?
    a) Loss of cultures (making pithy, celebrating festivals)
    b) Loss of religious monuments
    c) Loss of local practices
    d) Loss of indigenous knowledge
    e) Others
    f) Don't know

Barriers/constraints:

38. What are the constraints you face to adapt to climate change?
    a) Lack of money
    b) Lack of knowledge
    c) Didn't get any training
    d) Cyclone shelter is so far
    e) The transportation system is not a good
    f) Lack of food during a disaster
    g) Overflow of water body
    h) Reduce fish
    i) Scarcity of fresh water
    j) No constraints
    k) Others
39. How hazards are impacting food cultivation?
    a) Crops go underwater
    b) All crops get damaged
    c) Unable to use land for floodwater
    d) Crops get rotten
    e) Poor communication system
    f) Economic loss
    g) Food insecurity
    h) Equipment loss
    i) No impact
    j) Others
40. What are the challenges you face while cultivating crops?
    a) Lack of proper knowledge
    b) Lack of training and workshop
    c) Lack of equipment
    d) Lack of expertise assistance
    e) Health hazards while using insecticides
    f) Scarcity of water
    g) No food storage system
    h) No challenge
    i) Others
41. Which challenges do you face during disasters to rear livestock?
    a) To collect grass
    b) Lack of livestock food
    c) Lack of place for shelter
    d) Shelter is far from home
    e) No challenge
    f) Others
42. What challenges do your children face while getting an education during natural calamities?
    a) Poor communication
    b) Water remains on the road and they cannot go to school
    c) Teachers remain absent
    d) School remains closed
    e) Books get damaged
    f) Illness
    g) Get traumatized
    h) Other
    i) No challenge
43. Why you or your family don't take shelter in a cyclone shelter?
    a) No separate toilets for women and men
    b) Sexual harassment
    c) No separate facilities for women and men
    d) No facilities for a newborn child
    e) No facilities for livestock
    f) Bad transportation system
    g) Lack of medicine and food
    h) Lack of menstrual facilities
    i) Lack of facilities for disabilities and old
    j) Others
    k) Take shelter

Adaptation technique:

44. What strategies do you take to overcome the challenges?
    a) Watch agriculture-related programs to learn
    b) Take assistance from an experienced person
    c) Try to use limited insecticides
    d) Use improved seeds and fertilizer
    e) Take assistance from govt org.
    f) Take assistance from an NGO
    g) Try to cut crops early
    h) Borrow money to buy equipment
    i) Others
    j) Nothing

45. Do you get any support from any institution?
    a) Govt
    b) NGO
    c) INGO
    d) Local organizations
    e) Volunteer organization
    f) No support
    g) Others

Annex D

KII and FGD Question

Knowledge and perception about climate change and disaster.

a) Perception of climate-related risk/ hazards/ disasters
b) Major Disasters in your locality
c) Experience with disaster: losses and damages
d) Constraints to adapt to climate change/ hazard/ disaster
e) Adaptation strategies