

Assessment of Indigenous Knowledge and Technology Used for Climate Adaptation and Resilience in Bangladesh



**Centre for Environment and Climate
Change Research (CECCR) Project**
Ministry of Environment, Forest and Climate Change

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Sanjay Kumar Bhowmik

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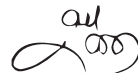
MESSAGE

We, as a nation, are one of the most climate vulnerable countries and we have to constantly face the challenges of climate change. As we are a developing country, we have to take adaptation measures to confront the adverse impacts of climate change.

MoEFCC is working for a sustainable environment, optimum forest coverage and to build a climate resilient community in Bangladesh. CECCR is a government initiative to establish a research centre under MoEFCC and it will be a national knowledge hub for climate change research in Bangladesh. CECCR works on a research project titled “Assessment of indigenous knowledge and technology used for climate adaptation and resilience in Bangladesh” to appreciate the adaptive measures taken by the climate vulnerable people of our country.

The research has assessed the indigenous knowledge and technology used for climate adaptation and resilience in Bangladesh. It will help in policy making for the best indigenous techniques and adaptive measures taken by the vulnerable people. It will also specify the most vulnerable area and the community and government will take steps by selecting the area, community and profession-based support system. The main purpose of the study is to know the sufferings from genuine victims of climate change and provide recommendations on how the government can make a sustainable way to reach victims through the channel of proper authority.

Finally, I wish this report will reveal the real struggle of the affected people that can be used as an important landmark for the institution and bring a holistic change for this country.



Sanjay Kumar Bhowmik

Acknowledgment

The completion of this research paper, entitled 'Assessment of Indigenous Knowledge and Technology Used for Climate Adaptation and Resilience in Bangladesh,' stands as a testament to the collective effort and dedication of numerous individuals.

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List of Acronyms and Variables

BCCT	-	Bangladesh Climate Change Trust
BCCSAP	-	Bangladesh Climate Change Strategy and Action Plan
CECCR	-	Centre for Environment and Climate Change Research
COP	-	Conference of Parties
CPP	-	Cyclone Preparedness Programme
FGD	-	Focus Group Discussion
GCA	-	Global Center on Adaptation
GoB	-	Government of Bangladesh
IPCC	-	Intergovernmental Panel on Climate Change
KII	-	Key Informants Interview
LLA	-	Locally Led Adaptation
MoEFCC	-	Ministry of Environment, Forest and Climate Change
NAP	-	National Adaptation Plan
NAPA	-	National Adaptation Programme of Action
NDC	-	Nationally Determined Contribution
NGO	-	Non-Governmental Organization
SLR	-	Sea-Level Rise
UNFCCC	-	United Nations Framework Convention on Climate Change

Glossary

Climate change: Climate change refers to long-term (30 years or more) shifts in temperatures, rainfall and weather patterns.

Global warming: Global warming is the long-term heating of Earth's surface observed since the pre-industrial period (between 1850 and 1900) due to human activities, primarily fossil fuel burning, which increases heat-trapping greenhouse gas levels in Earth's atmosphere.

Coastal area: Coastal areas are Local Administrative Units (LAUs) that are bordering or close to a coastline. A coastline is defined as the line where land and water surfaces meet.

Char area: Char is a tract of land surrounded by the waters of an ocean, sea, lake, or stream; it usually means, any accretion in a river course or estuary.

Adaptation: Adaptation refers to adjustments in ecological, social or economic systems in response to actual or expected climatic stimuli and their effects. It refers to changes in processes, practices and structures to moderate potential damages or to benefit from opportunities associated with climate change (UNFCCC).

Locally led adaptation: Adaptation process that led by the local community in the climate victim areas.

Executive summary

Bangladesh is seventh among the most climate vulnerable countries according to the Global Climate Risk Index 2021 and every year it faces heat waves, sea level rise, salinity intrusion, drought, flood, cyclones and storm surges as consequences of climate change. People of coastal areas and char areas have been struggling constantly to cope up with their lives and livelihoods with the adverse impacts of climate change through practicing different adaptation techniques. This research addresses how people are using indigenous pieces of knowledge and technology to become climate resilient in coastal and char areas. Given the limited time and resources available for this project, three case study sites from each of the coastal and char areas were selected to conduct a detailed and in-depth analysis. Field data was collected to analyze the existing challenges of the local communities due to the adverse climatic conditions using Focus Group Discussion (FGD) and Key Informant's Interview (KII). The sample size was calculated as 380 for each of the coastal and char areas based on the population size of the area, which was distributed to union level using a stratified sampling method. The respondents for the survey were selected based on who are living in the area for at least 30 years and facing in terms of livelihood change, frequency of displacement, health vulnerability, and safe water scarcity. Respondents for FGDs were selected from the local people based on their experiences with the effects of climate change and their responses to overcome the challenges posed by these effects. The size group was limited to 10-15 ensuring participation of women, community leaders, local government representatives and government officials. The aim of conducting KII was to gain a comprehensive understanding of specialized responses to climate change from experienced professionals working in the area. DC, UNO, relevant other government officials, union council chairman and NGO officials were the selected participants for KII. The survey, FGD and KII revealed that sufferings of coastal and char area people knows no bounds. The farmers and fishermen are the most vulnerable communities due to climate change effects like cyclone, flood, tidal surge,

SLR, salinity intrusion and drought. Those locally led adaptation techniques need to be recognised and the local community require support from authority to make them climate resilient. The vulnerable people need financial help immediately after a climate change event occurs to recover their houses, availability of safe drinking water, and health care services. Access to climate adaptive agriculture, building sustainable infrastructures, promoting industrialization for creating employment are crucial needs both for coastal and char areas to confront and sustain with the inimical situation of nature. More advanced research is essential to figure out changing patterns of climate change events in coastal and char areas of Bangladesh.

1. Informing Insights of This Report

Climate change due to global warming is one of the most discussed topics in the last four decades. It is estimated that the global temperature has already increased to 1.18°C (NASA, 2021) since the pre-industrial period. Some of the major consequences of temperature rise are heat waves, sea-level rise (SLR), salinity intrusion, drought, flood and extreme events such as cyclones, and storm surges (Hathaway and Maibach, 2018). People living in climate-vulnerable countries face the deadliest impacts of climate variability in their lives and livelihoods. Bangladesh is one of the highly climate-vulnerable countries (World Bank, 2022) and a major victim of climate-induced extreme events (IPCC, 2014). Although the country shares only 0.47% in global warming activities (NDC, 2021), it bears the most shares in terms of sufferings. Almost every year Bangladesh has been attacked by different climate change induced events. This report will discuss the utmost sufferings that people of Bangladesh are facing and how they adapt with the situations.

1.1. Why LLA is Needed and What We Aspired to Do?

The report of this study will be a baseline study to produce future research directions in this regard. The study would capture the best indigenous knowledge and technology that are used to combat climate to bring forward exemplary good practice model for domestic and international use by taking live example, this project might produce evidence-based study that help better policy design, implementation and governance for effective and positive outcomes create an inventory of the practiced adaptation techniques by local marginal peoples and reflect their expectation. Thereby make possible the needed support for climate victims as they require and in process ensure their engagement and empowerment for future sustainability.

1.2. Introducing the Study Region and Its Climate Change Issue

Climate change induced extreme events have the most detrimental impacts on the coastal regions (ICCAD, 2019) and the char areas (Mamun et al., 2022) in Bangladesh. Though these two types of areas have dissimilarities in their topographical,

geomorphological, physical, social, and ecological patterns, the impact of climate change is most prominent in these regions in different forms. It has been reported that the country's loss and damages caused 56.41% by flood, 14.99 % by river/coastal erosion, 14.25 % by cyclone, 5.4% by waterlogging and 1.16 % by salinity intrusion (BBS 2021). The major shares of these events are concentrated in coastal and char areas of Bangladesh (BBS 2021). Therefore, it is necessary to address coastal and char areas about how people are adapting themselves with their indigenous pieces of knowledge and technology to become climate resilient.

The coastal areas of Bangladesh are located nearest to the Bay of Bengal between 21-23° N and 89-93° E. Around 50 million people live below the mean sea level and 46% of the country's population lives within 10 meters of it (Luet et al., 2018). This huge number of populations are potentially at high risk of slow onset impacts of climate change such as salinity intrusion, sea level rise (SLR) as well as rapid onset disasters like cyclones, tornadoes and storm surges (Adnan, Haque et al. 2019). SLR-induced physiographic impacts have numerous perceived consequences on livelihoods across coastal areas (Roy, Penha-Lopes et al., 2022). The climate change effects have changed livelihood patterns and resource degradation of coastal people over the last couple of decades (Minar et al., 2013). Agricultural operations in Bangladesh's coastal regions have been experiencing economic losses as crop productivity declined due to the salinity intrusion (Brammer, 2014; Islam and Paul, 2018).

Contrary to coastal areas, char areas are low-lying areas located near the river basin. More than 6.5 million people live in the char areas of Bangladesh (Alam et al., 2018). The area is critically vulnerable to riverbank erosion and floods including other climatic hazards like cyclones, tornadoes, heat and cold waves and drought (Al Mamun et al., 2022; Sarker et al., 2020; Alam et al., 2017). This study addressed the vulnerability of coastal and char areas and tried to notice the adaptation practices adopted by the local people to overcome climate change effects.

1.3. Overarching Research Goals and Techniques

The aim of the study is to investigate LLA to climate change of the selected coastal and char area people. The specific research questions are:

- ♦ What are the climate-induced challenges faced by the studied population?
- ♦ How are their existing practices and knowledge creating climate resilience?
- ♦ What strategies and planning governments might induce to support their existing practices and increase resilience?

1.4. Report Structure

In the first chapter of this report the aim of the study was mentioned. General climate change effects in Bangladesh have been described in the second chapter. The methodology used in this study has been described in detail in the third chapter. The study findings have been narrated in the fourth chapter. Finally, the fifth chapter was the conclusion.

2. Rewinding the Climate Action and Needs of Bangladesh: A Brief Literature Review

Bangladesh is one of the highly climate-vulnerable countries (World Bank, 2022) and a major victim of climate-induced extreme events (IPCC, 2014). The people of Bangladesh suffer the worst impacts of climate change induced events. Almost every year the country faces troubles with cyclone, flood, drought and other events which causes loss of life and damages properties. Study says that since 1960 the country has been exposed to cyclones frequently almost every year. The table 1 below shows cyclone events that occurred in Bangladesh from 1960 to 2010 (Haque 2012). All of the events caused the death of hundreds of people as well as damaged properties of high value. People have been adapting themselves using their indigenous knowledge and indigenous practices to minimize loss and damages.

Table 1. Severe cyclones occurred in Bangladesh from 1960 to 2010 and caused deaths.

Year	Number of deaths	Wind speed	Severity index
1960	8119	210	5
1961	11466	146	5
1963	11520	203	5
1964	196	NA	NA
1965	20152	210	5
1966	850	146	5
1969	75	NA	NA
1970	500300	223	6
1973	183	122	5
1974	50	162	5
1985	11069	154	5
1986	12	100	4
1988	9590	162	5
1989	573	NA	NA
1990	132	102	4
1991	138958	225	6
1994	170	200	5
1995	172	100	4
1996	545	70	3
1997	410	225	6
1998	233	112	4
2007	4234	250	6
2008	15	80	3
2009	197	95	4

Source: Haque, 2012

The table clearly indicated that the figures of death have been reduced from six digits to two digits in recent years after 1991 even though the severity of the cyclone was greater. This has been possible as local people prepared themselves to be resilient to climate change using their indigenous knowledge.

2.1. Climate Change Action Plans of Bangladesh Government

Bangladesh is an active member of United Nation Framework Convention on Climate Change (UNFCCC) and speaks out loudly in each of its Conference of the Parties (COP). Beside international negotiations, the government of Bangladesh has taken many initiatives to make the country climate resilient. The National Adaptation Programme of Action (NAPA) 2005 was one of the first reports of Bangladesh recognising the importance of climate change. The Bangladesh Climate Change Strategy and Action Plan (BCCSAP) 2009 was another strategic document prepared by Bangladesh to deal with climate change effects. The documents highlighted adaptation strategies and mitigation issues to outline climate change impacts in Bangladesh. Establishing Bangladesh Climate Change Trust (BCCT) in 2010 is one of the pioneering actions by the government of Bangladesh to respond against the negative impact of climate change. The country submitted Nationally Determined Contribution (NDC, 2021) and National Adaptation Plan (NAP) 2023-2050 to UNFCCC which proved that Bangladesh has been working actively both nationally and internationally to minimize adverse impacts of climate change.

2.1.1. Center for Environment and Climate Change Research (CECCR):

Centre for Environment, Climate Change and Research (CECCR) is a state-owned research centre established in 2018 under the Ministry of Environment, Forest and Climate Change (MOEFCC) of Bangladesh. CECCR is a knowledge-based centre of excellence to support environmental management and address adverse impacts of climate change issues in Bangladesh. The centre serves as a resource center and knowledge hub to the nation in general and particularly for MOEFCC. Environmental and climate change research are the prime job of the centre with focus on physical science, adaptation, mitigation measures, loss & damage and relevant other topics.

2.1.2. Why CECCR Launched this Project:

The MoEFCC being the focal point of the government needs to provide their opinions to relevant ministries and development partners regarding climate change issues and adaptation techniques in the localities. It is necessary for the government to know how people are practising adaptation measures which would support governmental agencies and development partners to work more comfortably with the locals. The CECCR was instructed to conduct a study to know the locally practiced adaptation measures during different climate change induced events. The study would generate a report for MoEFCC which would support them to provide effective opinions to relevant government agencies and development partners. Peer reviewed journal publications from the study would add value to CECCR as well.

2.2. Overview on Climate Vulnerability and Adaptation

People of Bangladesh have been successfully adapting themselves against the negative impacts of climate change using their indigenous knowledge and technologies. This indigenous knowledge is never formally appraised or institutionalized. To formalize their inherent knowledge and native technologies, the idea of Locally Led Adaptation (LLA) has emerged (GCA, 2022). It can be defined as the adaptation strategies that are socially acceptable and led by the local communities (Westoby et al., 2021). The locally-led adaptation (LLA) is led by the local community which enhances their capacity and resilience to a great extent (Westoby et al., 2021). For the root-level target population, this technique is most suitable as they can take part in their decision-making process and thus feel engaged in climate change action. It is necessary to work on how locally-led adaptation (LLA) can give more equitable, effective, and sustainable adaptation outcomes for coping with climate change effects. At the same time support local people to determine their future adaptation processes and ensure enough funding resources are available for them.

2.3. Why LLA Became So Important to Understand

Indigenous knowledge and technology have been crucial in helping the local communities adapt to the changing climate and build resilience against the adverse impacts of climate change. These traditional practices have been passed down from generation to generation and have been refined over time based on experience and observation of the environment. Indigenous knowledge and technology are based on a deep understanding of the local ecology and are adapted to the local context, making them highly effective in coping with the impacts of climate change. This research aims to assess the indigenous knowledge and technology used for climate adaptation and resilience in Bangladesh. The study will also focus on identifying the traditional practices that have been used to cope with the impacts of climate change and the challenges faced by the local communities.

2.4. Problem Statement

Bangladesh is a low-lying country which is considered as one of the hardest hits by climate change effects. The frequent hits of cyclone, increased shoreline erosion, salinity intrusion already evidenced the risks and vulnerabilities of over 35.1 million peoples living in 19 coastal districts (Mahmuduzzaman et al, 2014) and 6.5 million people living in the char areas (Alam et al., 2018) of Bangladesh. This project examined how Bangladeshi coastal and char area communities are responding to those substantial, and potentially unexpected climate-induced changes and impacts in their surrounding ecosystems. Considering the breadth and volume of the targeted population, we purposively selected communities living in 6 upazilas of three coastal districts and three districts with char areas of Bangladesh. We conducted an extensive one-to-one interview of over 780 people, 24 FGDs and 24 KIIs among people of Shymnagar (Satkhira), Maheshkhali (Cox's Bazar), Patharghata (Barguna), Phulchari (Gaibandha), Char Rajibpur (Kurigram) and Islampur (Jamalpur). The communities were requested to share their experiences of changing climatic conditions, associated threats and risks they were facing, and any adaptation strategies that might help them to

locally reduce the vulnerabilities. The participants were also asked to share their perspectives and governance suggestions that they think might better support them in fighting the escalated climate vulnerabilities.

3. How we collected data: research methodology



Figure 1: Focus Group Discussion with vulnerable people of char area. Photo Source: Field Visit, December 2022, Char Rajibpur, Kurigram.

3.1. Research methodology

The present study sought to understand the LLA in Bangladesh. Since the focus of this research is collecting LLA, in this study we combined knowledge and techniques that span over natural and social Sciences. We qualitatively collected perceptions of 1) local communities, 2) practitioners, and 3) policy administrators through FGD (figure 1), KII and questionnaire survey. The reason behind focusing on the perceptions and contexts of different stakeholders was to what they are experiencing and influencing their responses and attitudes towards climate related vulnerabilities. Collected perceptions also help us to reflect the individuals' lived experiences (Munhall, 2008), cultural practices (Adams and Sandbrook, 2013), mutually exclusive relationships and responses to each other (Evans and Cvitanovic, 2018), and to their place of living (Ingold, 2002; Miller, 2019). Investigation of

different stakeholders' perceptions thus provided us with a level of understanding of the practised adaptation that we needed to answer the elected research questions. We conducted 780 survey interviews to collect quantitative data to support the research questions and provide insights into the challenges and expectations related to climate change adaptation in coastal and char area communities.

3.2. Case Study Region

3.2.1. Char Area and its Communities

A char is a land strip or a bar that has formed due to the deposition and accumulation of silt and alluvium on the riverbed. Chars are formed by the deposition of sediment carried by the rivers, and their formation and evolution are closely linked to the hydrology and morphology of the river system. The GBM (Ganges-Brahmaputra-Meghna) river system is one of the largest river systems in the world, and it plays a significant role in shaping the physical and ecological characteristics of the chars. The geophysical setting of chars in Bangladesh is determined by the dynamics of the river system and the deposition of sediment. The common livelihoods of people in char areas are primarily dependent on agriculture, fishing, labouring, driving and boat-making.

Given the limited time and resources available for this project, we deliberately selected three case study sites from the char region to conduct a detailed and in-depth analysis. Field data was collected to gain insight into the local communities' struggles to survive under adverse climatic conditions using techniques of survey, FGD and KII.

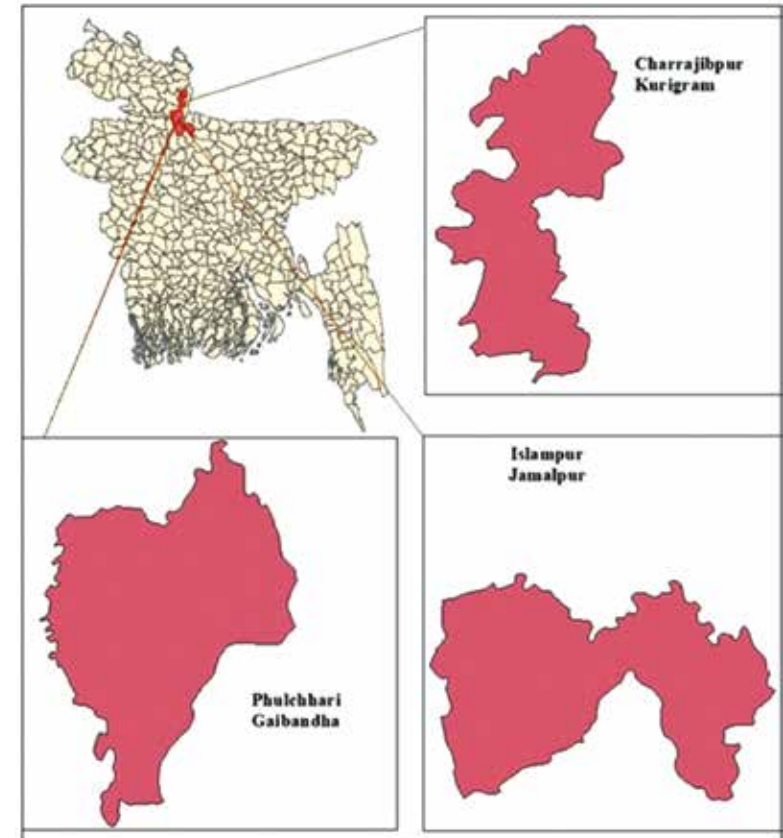


Figure 2: Selected district and elected char area sites

3.2.2. Coastal Areas and its Communities

Coastal ecosystems are well-known for their high productivity, diversity and enormous ecosystem services that support almost 41% of the world's population (Martínez et al, 2007). It is also widely recognized the impacts of rising global temperature – causing sea-level rise – on the world's marine ecosystems and their inherently vulnerable, and mostly marginalized communities (Satterfield et al, 2013). What we are still exploring is how these changes are and will be impacting coastal productivity, structure of community, their living patterns, and livelihoods. Bangladesh as a low-lying coastal country is considered as one of the hardest hits by climate change effects.

The frequent hits of tropical cyclones, increased shoreline erosion, salinity intrusion already evidenced the risks and vulnerabilities of over 35.1 million peoples living in 19 coastal districts (Mahmuduzzaman et al, 2014) of Bangladesh. We in this project examined how Bangladeshi coastal communities are responding to those substantial, and potentially unexpected climate-induced changes and impacts in their surrounding ecosystems. Considering the breadth and volume of the targeted population, we purposively selected communities living in 3 upazilas (Figure 1) of three (south-eastern) coastal districts, located between 21-23° N and 89-93° E of Bangladesh. We conducted an extensive one-to-one interview, 12 FGDs and 12 KIIs among 0.73 million people of three coastal communities and requested to share their experiences of changing climatic conditions, associated threats and risks they were facing, and any adaptation strategies that might help them to locally reduce the vulnerabilities. We also asked our participants to share their perspectives and governance suggestions that they think might better support them in fighting the escalated climate vulnerabilities.

3.3 Case Study Sites (Char)

Sampling locations of the charland zone has been selected purposively from the list of char zones of Bangladesh. Selected locations are as follows (figure 2):

- Phulchari (Gaibandha)
- Char Rajibpur (Kurigram)
- Islampur (Jamalpur)

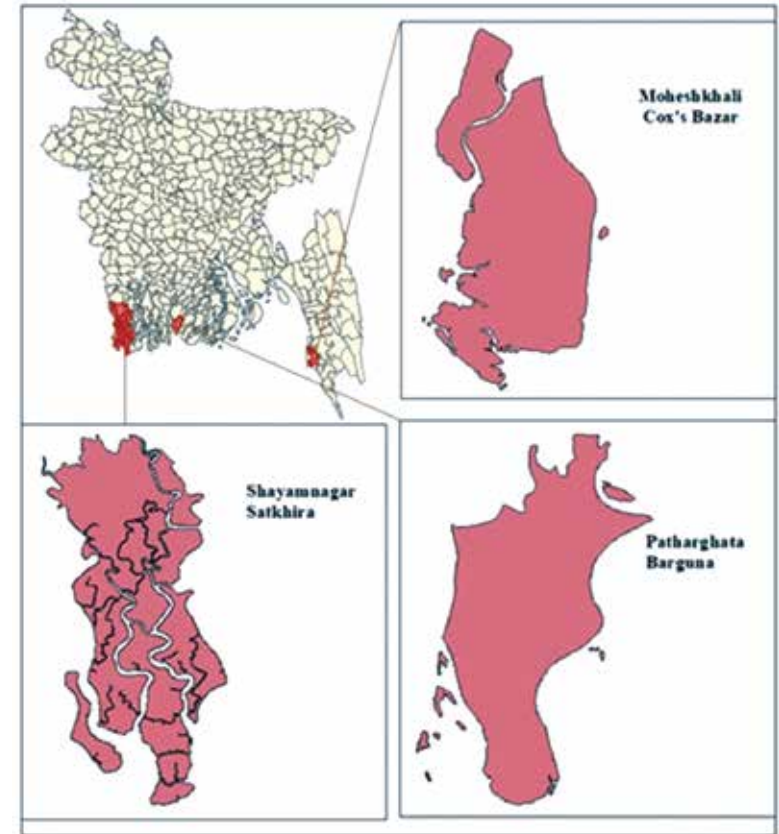


Figure 3: Selected district and elected coastal sites with

3.4 Case Study Sites (Coastal)

The government of Bangladesh has declared 19 districts near or facing the Bay of Bengal as coastal districts (Dasgupta et al, 2014). Out of these 19 districts, 3 upazila (figure 3) from 3 different districts were selected purposively for data collection. Selected locations are:

- Shyamnagar (Satkhira)
- Moheshkhali (Coxs Bazar)
- Pathorghata (Barguna)

3.5. A Mixed-Methods Study

The choice of methods or tools to collect data and analysis can execute the intention of a research into a logical construction (Creswell and Creswell, 2017; McCaslin and Scott, 2003; Moon et al., 2019). For instance, the qualitative approach selected for this study aiming to collect and understand our research participants' needs, their world view, and what experiences shaped their perceptions as well as behaviours. In contrast, the quantitative approach helped us to test specific experimental strategies or theories with a more focused perspective (Creswell, 2003). For example, the data collected on disaster events helped to get a clear view of the last 10 years of damage scenarios due to climate change induced events.

3.6. Preparing the Data Collector

This study mobilized 10 data collectors, majority graduated in the science field and some are 4th year students in different universities, they were selected through interview and recommendations from their teachers. They have been given a day long training including hands on experience on questionnaires to ensure the quality of data. They worked for 2 months. After data collection, everyday questionnaires were monitored by one research officer of this project to ensure the process was unbiased and transparent.

3.7. Overview of Field Data Collection

The fieldwork for this project was conducted between November 2022 and December 2022 following the needed ethical standards that require to engage participants to a study in the most convincing but non-based or coerced way. One special field visit for floating agriculture technique was carried out at Tungipara, Gopalganj in August, 2023. Field data were collected using techniques of in-depth interviews, Focus Group Discussions (FGDs), and Key Informant Interviews (KIIs).

3.7.1. In-Depth Interview/Household Survey

780 participants for in-depth interviews were selected for qualitative data collection of this study. The Participants were

selected using Stratified Sampling method (Charles, 2006). This sampling approach ensures that the sample is representative of the population and can provide more accurate and reliable results. The sample size was calculated as 380 for each of the coastal and charland areas based on the population size of the area, which was distributed to union level using a stratified sampling method. From each case study site, 130 persons (usually a senior member of the family) were interviewed through stratified sampling methods. The data was collected using a questionnaire developed and adjusted using literature and pre-testing methods. The respondent families living in the area for at least 30 years and facing vulnerability in terms of livelihood change, frequency of displacement, health vulnerability, and safe water scarcity were selected. A semi-structured questionnaire was used to conduct the survey, which covered the respondent family's economic strength and relevant information regarding resilience-building approaches.

3.7.2. Focus Group Discussions (FGDs)

Four FGDs were conducted in each of the selected areas, including residents from a new group of people. The FGDs were aimed at extracting information from a group of local people about their experiences with the effects of climate change and their responses to overcome the challenges posed by these effects. Each group consisted of 10-15 members from the locality with different professions based on their experience and knowledge, and the presence of female participants was ensured. In total, 24 FGDs were conducted in 24 unions across six Upazila of coastal and char areas. FGDs provided rich qualitative data on the experiences, perceptions, and knowledge of the participants. They were allowed for group discussions and interactions, which generated a deeper understanding of the issues related to climate change and traditional knowledge and technology.

3.7.3. Key Informant Interviews (KIIs)

Participants included local community leaders, local government officials, and NGO officials. Aim of conducting KII was to gain a comprehensive understanding of specialized responses to climate change. The key informants were selected based on their expertise in the relevant field, with renowned researchers and policymakers

being interviewed at the national level. At the local level, the Upazila Nirbahi Officer (UNO), Upazila Agriculture Officer, Livestock Officer, Upazila Medical Officer, Union Council Chairman and Member, and Upazila Chairman were selected for the interviews. In total, 24 people were interviewed as key informants for the coastal and char region. KIIs also provided in-depth information on the experiences and perspectives of key informants who have a unique insight into the use of traditional knowledge and technology in climate change adaptation and resilience. They provided a deeper understanding of the cultural, social, and economic factors that influence the use of traditional knowledge and technology.

Supportive data was collected from different government agencies of Bangladesh. We got data from the Department of Disaster Management (DDM), Center for Environment and Geographic Information System (CEGIS) and Bangladesh Meteorological Department (BMD) and Bangladesh Bureau of Statistics (BBS).

3.8. Data Storage and Analysis

The document was stored in a secure location to prevent unauthorized access. The documents were also scanned and stored digitally i.e. google drive to make them easier to search and analyze. This can also help us to prevent loss or damage to the original documents and for future use.

3.8.1. Quantitative Data Analysis

The primary data are analyzed using SPSS and presented in crosstab format using descriptive statistics. Frequency tables of the variables are done using SPSS. Statistics are calculated and graphs are drawn. Percentage of variables is shown in the table.

3.8.2. Qualitative Data Analysis

The descriptive statistics feature of SPSS can also give summary statistics such as Nvivo is used to analyze qualitative data which are in unstructured format. Auto coding is used to analyze the data and express it with figures.

The combination interviews, KIIs, FGDs and collected quantitative and qualitative data thereby has enabled us to capture the targeted findings and the multiple dimensions of the phenomenon explored and produced are sufficiently robust evidence to make a convincing strategic suggestion, which were unlikely to be captured by any narrower set of approaches.

Each data collection, analysis and storage technique used in this research is elaborated in more detail in the relevant empirical chapters. For instance, sampling techniques and relevant data collection techniques for in-depth interviews are discussed in Chapter 4 and 5, FGDs in Chapter 5, and KIIs in Chapter 6.

3.9. Challenges We Encountered During This Field Investigation

Several challenges were encountered during field data collection through surveys, key informant interviews (KII), and focus group discussions (FGD). Some of the challenges that we faced include:

- Access to participants: Access to indigenous communities was challenging due to their remote locations and cultural sensitivities. We faced difficulty identifying and recruiting the right participants for the study, and some participants felt hesitant to participate due to social or cultural reasons.
- Language and communication barriers: Language and communication barriers made this research challenging to collect accurate and reliable data. We overcame this by sending researchers who are capable of understanding that particular local language.
- Data quality: Data quality can be a significant challenge when collecting field data. Responses from participants may be incomplete, inaccurate, or biased, but researchers have taken steps such as proper monitoring of field investigators by daily follow up to ensure reliable and valid data.
- Logistics and planning: Arranging transportation, accommodation, and scheduling interviews and discussions with participants were challenging.

- Data management: Collecting and managing large amounts of data was challenging. We ensured that the data is properly organized and stored to avoid loss or corruption of data. We also ensured that the data is properly analyzed to draw accurate and reliable conclusions.
- Incorporating traditional knowledge into research: Incorporating traditional knowledge and indigenous perspectives into research was challenging. We also ensured that the data collected is not used in a way that harms the communities or undermines their rights.

4. Findings from the Fields

The coastal and char ecosystems of Bangladesh are different in nature. The sufferings of communities of both areas are recurring due to climate change induced events that pose significant threats and challenges to daily living and livelihoods. The following section represents findings of the study separately organized for coastal and char areas chronologically:

4.1. Climate Change Impact in Coastal Area

Our coastal participants noted some recurring climate events that were causing threats and challenges for their daily living and livelihoods that includes: flood, cyclone, tidal surges, seasonal variability, heavy rainfall and salinity intrusion. There is a strong correlation between the crucial events of climate change and their impacts. Cyclone and flood are the most crucial climate change induced events that cause the worst sufferings of coastal area people (figure 4).

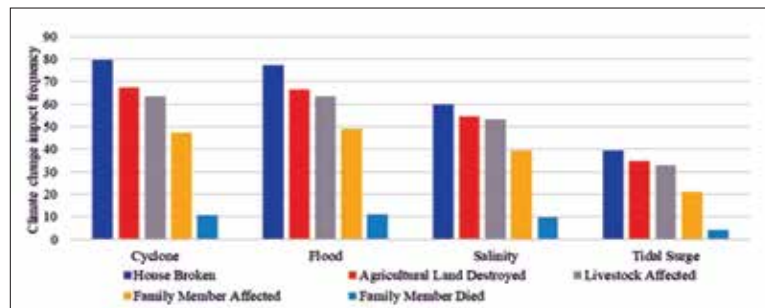


Figure 4: Climate change events occur in coastal areas and their impacts (source: Field visit).

Cyclone are the main climate change induced impacts in coastal areas. It damaged 79.5% of the respondent's houses, 67.5% of the respondent's agricultural land, 63.4% of the respondent's livestock got injured or died, 47.3 % of the respondent's family members were injured and most crucially 10.6% respondents reported that their family members were killed due to cyclone attack. Apart from the damages of houses and land, cyclones also have a negative impact on livestock. Tidal surge and also have greater impacts on human life.

Flood is another major climate induced event in coastal areas. The survey found that flood damaged 77.4% of the respondent's houses, 66.5% of the respondent's agricultural land, 63.6% of the respondent's livestock got injured or died. Flood cause a higher rate of criticality for injuring and killing human beings than cyclone. 49 % of the respondent's family members were injured and 11.1% respondents lost their family members were killed due to flood.

Salinity intrusion tops the list of climate change induced effects in coastal areas. It is connected with all sorts of livelihood components in the area. Salinity intrusion affects drinking water, agricultural crop production and health. Even buildings, construction of roads, bridges and other infrastructures are eroded due to salinity intrusion. The collected data presented that 60 % of the respondent's houses get spoiled, 55% of the respondent's agricultural land destroyed, 54% of the respondent's livestock affected and 39% of the respondent's family members physically affected through salinity intrusion.

4.1.1. Economic Strength of Respondents in Coastal Area

Economic strength of a family is closely connected with the climate change impact on the concerned family. It can be assumed that marginalized communities would be more affected by the climate change induced effects. The survey was conducted in the area where the climate change events hit frequently. The selected respondent families were marginalized with many professional groups including farmers, fishermen, day laborers, doing small business and many other professions. Most of the responding

family's annual income was below 120000 Taka and on average they are satisfied with how much they earn annually. Out of a total of 376 respondent families, 144 families have an annual income of below 60000 Taka, 164 families have annual income between 60000 Taka to 120000 Taka, 53 families have annual income between 121000 Taka to 240000, 15 families have annual income above 241000 Taka. For income satisfaction, 66 families are happy and 88 families are unhappy, while 222 families are quite okay with what they earn although their income is not at a satisfactory level (figure 5).

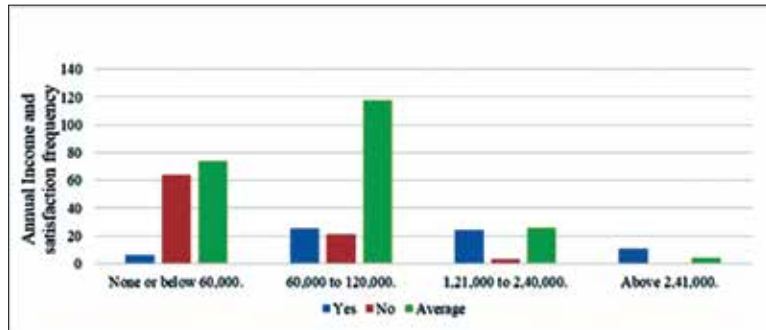


Figure 5: Income satisfaction level of the coastal area people (source: Field visit).

4.1.2. Climate Change Events Associated Problems

Three major problems are identified that the local people face in coastal areas due to the climate change impact. These are accommodation or housing problems, financial problems and livelihood problems. There are separate indicators or impact against each problem. The standardized values of those indicators have been measured as the respondents replied to multiple options.

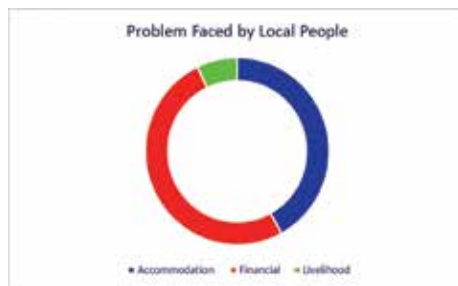


Figure 6: Most prominent problems faced by local people during climate change events (source: Field visit).

According to the graph (figure 6), people mostly face financial problems such as change in occupation, less income, indebtedness, unemployment etc. As climate change poses a great negative impact on the financial safety of the local people, they suffer much from the damage and loss. Unfortunately, there is no standard measure to calculate the holistic level financial loss of the affected community.

However, people face accommodation or housing problems as well. They need to change the residence as a cyclone hits and destroys the housing or makes infrastructural damage most commonly. People continuously adapt to their accommodation which brings negative consequences such as poverty, insecurities, financial loss, mental trauma, and stress etc.

As they face both accommodation and financial problems, they are bound to change their livelihood most of the time. For example, Fishermen lose their fishing boats due to major cyclone attacks and become penniless over the night. There is hardly any security margin or social safety net for the affected people. Therefore, they have to change their livelihood for the sake of living. Thus, a wealthy fisherman can turn into a petty vegetable seller due to climate change impact or natural disaster.

4.1.3. Loss of Life:

The worst sufferings of coastal people due to cyclone and storm surges was missing family members and relatives. They have gone through the deadliest face of nature a couple of times in their life where they could survive luckily but lost their family members and dearest ones. Sidr and Ayla were the very recent killer events. Majer Char is a small village surrounded by rivers in Patharghata, Barguna. A total of 98 people died in that village during Sidr in 2008. The FGD respondents of Majer Char informed that all of the people living at present in the village lost either their intimate family members or closest ones of their relatives. The respondents of FGD at Majer Char pointed out one person present there and quoted that “all of his family members had died during Sidr and he was the only surviving person in his

family”. Many of the survey respondents also mentioned that they have lost their family members during cyclones or tidal surge.

One of the survey respondents from Gabura Union of Shaymnagar Upazila in Satkhira literally cried expressing his emotions during the survey. The person mentioned to the surveyor “I lost my 13 years old son during Sidr. I didn’t expect water to rise so high and we didn’t leave our residence. Late at night when we discovered ourselves in tidal surge, we couldn’t find our son. Now it is so painful for us to think about why I didn't leave the residence. My son could have been alive”. The surveyor also became speechless and emotional about the incident. The person also mentioned that his sister in law died in Ayla in 2009. Currently he is living in poverty as he lost his properties as well during Sidr, Ayla and can earn little due to lack of work. Loss of domestic animals and birds are also a pathetic reality of the coastal people. Both FGD and survey respondents informed that they lost domestic animals and birds during cyclones and tidal surges.

4.1.4. Infrastructural Damage

Nature of a house is greatly dependent on the annual income of the houses. Majority of the respondent family houses are made of mud. These types of houses are extremely vulnerable to different climate change events in the coastal area. Houses, schools and other infrastructures in the coastal area are greatly affected by cyclones and tidal surge (figure7). In cases of cyclones, when the wind speed remains very high, the roof of the houses are blown away. Trees are uprooted and fall on houses. The houses were destroyed and sometimes people died and got injured. People have lost their ancestral home and had to move to a new place. The critical problem exists in the transport communication sector. Tidal surge and flood breakdown road communication. Emergency medical service greatly hampered. Serious patients can’t be hospitalized immediately, even pregnant women give childbirth on the way to hospital. Public infrastructures like schools, markets, roads, bridges, culverts etc. that are damaged due to cyclone and tidal surge remain unrepaired years after years. Sometimes water logging stays for a long time even for a couple

of years. It has been stated in FGD at Shaymnagar, Satkhira that people had to stay on Water and Power Development Authority (WAPDA) embankment for three years after cyclone Ayla due to waterlogging. Schooling of children is seriously disturbed in such situations.



Figure 7: Damaged community clinic and connecting road by tidal surge and cyclone. Photo source: Field visit, December 2022, Shaymnagar, Satkhira.

Tidal surge water goes away within a couple of days. People stay at cyclone shelters or high elevated places like embankments for those days during the waterlogged conditions. They come back to their home after the water goes away and try to repair the damaged house. They have to take out a loan for repairing their houses. The participants shared that to reduce flood and tidal surge effects they were increasing the basement heights of residential houses and livestock sheds than traditional practices. Our participants in Moheshkhali, Coxsbazar informed that currently they were making walls of houses with mud and roofs with polythene (figure 8). Participants claimed that since they have to repair houses almost every year in face of recurring cyclones, flood and tidal surge, these materials help them to reduce reconstruction cost than traditional tin-made walls. They informed us that at the time of cyclone, polythene is put off and folded and taken to a shelter house which is reused to repair the

house. For restoring public infrastructures like road communication, people work on a volunteer basis together with firemen, red crescent workers, and local government representatives. One of the KII who is fireman informed that the fire service officials conduct training sessions for local people on a regular basis to train up them so that they can act immediately in rescue work for cyclone, flood, tidal surge and any other difficulties.



Figure 8: House made of polythene in coastal area. Photo source: Field visit, November 2022, Maheskhali, Coxsbazar.

4.1.5. Drinking Water and Health Crisis

Salinity intrusion causes a drinking water crisis in the coastal area. People have very limited access to fresh drinking water as Tubewell gets saline water which is not safe for drinking, cooking and other domestic uses. Very often people consume saline and unsafe water which causes health crises with water borne diseases like cholera, typhoid and diarrhea. Other diseases such as fever, cold, pneumonia spread during and post flood or water logging times. Skin diseases are prominent in coastal areas. Hypertension and related heart diseases are also very common in the area. Mother and children's health are seriously in lean condition. Maternal health care is scarce, while children are suffering from malnutrition.



Figure 9: Storing rainwater in containers to use after the rainy season. Photo source: Field visit, November 2022, Patharghata, Barguna.

People try to collect drinking water from low salinity areas or nearby deep tubewell. Pond water is used for domestic purposes other than drinking. Deep tubewell above 950 feet depth get fresh water in some areas, which are very expensive and also not working in all areas. Government or NGO facilitates such one deep tubewell for a couple of hundred families. Harvesting rainwater during the rainy season is very popular. Some people store rainwater to use after the rainy season as well (figure 9). People also used to collect filtered pond water for drinking, cooking and other domestic use purposes. They keep the pond very clean so that tree leaves, bird excreta or other debris cannot contaminate the pond water. They usually make a community where each family shares 100-150 Taka per month to manage filtering costs (figure 10).



Figure 10: Pond water filtration using solar pump. Photo source: Field visit, November 2022, Patharghata, Barguna.

For health care they mostly depend on the services provided by local village medical practitioners (table 2).

Table 2: Healthcare services available in the coastal area (Source: Field visit)

Healthcare services	Responses	Percent
Home primary health care	132	25.10%
Close doctor service	291	55.40%
No close doctor found	49	9.30%
No service provided	1	0.20%
Local traditional treatment	15	2.90%
Other treatment	37	7.00%
Total	525	100.00%

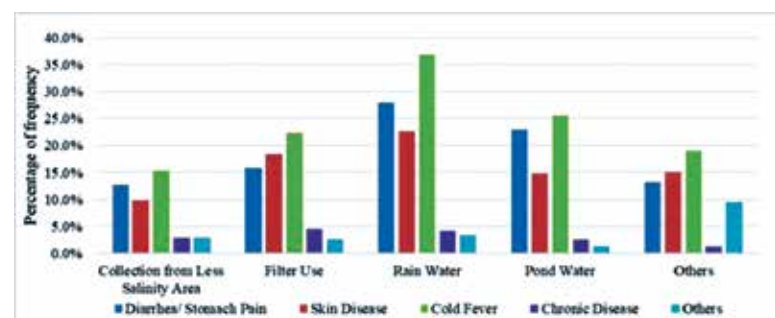


Figure 11: Adaptation strategies to overcome salinity in drinking water and impact on diseases (source: Field visit).

There is a strong positive correlation between adapting salinity in drinking water and diseases. The frequency of diseases varies depending on the adaptation strategies used to get fresh water. The bar shows (figure 11) use of rainwater is associated with a higher frequency of most diseases, with the exception of chronic disease. Filter use is associated with a higher frequency of skin disease and cold/fever, while pond water collection is associated with a higher frequency of diarrhea/stomach pain and skin disease.

4.1.6. Agricultural Loss:

Cyclone, tidal surge, flood and salinity intrusion all of these climatic events greatly affect agriculture in coastal areas. Field

crops like Paddy, Kalai, Maize and other Rabi crops are damaged due to flood and tidal surge. Saline water intrusion and water logging reduced crop production. Farm animals and birds get in shortage feed supply in such situations. People also got great loss as animals and birds washed away during floods and tidal surges.

To overcome the loss of flood or tidal surge, they immediately plant new crops as soon as they get the field free from water logging conditions. Coastal people do an interesting way of planting trees or vegetable cultivation, digging the canal/trench of low-lying fields and aggregating soil near the canal/trench to shape the place higher elevation (figure 12) and then plant trees or vegetables on highly elevated land. They don't put land uncultivated, rather cultivate crops round the whole year one after another. Crop rotation techniques are utilized with varieties so that soil nutrients can be utilized at maximum level. Salinity and waterlogging tolerant varieties are adopted to get better yields.



Figure 12: Trench/canal system to plant trees and vegetables in the coastal area. Photo source: Field visit November 2023, Patharghata, Barguna.

Floating agriculture (figure 13) is getting popular in the coastal area. The waterlogged lands are taken under cultivation using floating agriculture techniques. Cropping in gunny or plastic bag techniques are also used. Waterlogged fields are used for shrimp culture which is more profitable.



Figure 13: Floating agriculture practices in coastal area. Photo source: Field visit August 2023, Tungipara, Gopalganj.

4.1.7. Socio Economic Crisis:

Climatic events create devastating socio-economic crisis in the coastal area. People become jobless or income reduced due to cyclone, tidal surge or during flood and the entire family falls in economic crisis and in debt (table 3). The unemployed person became engaged with different crime activities. The family also became unstable with hassle and dispute. One of the KII who is an advocate in Patharghata, Barguna mentioned that divorce rates, cases reporting family violence and suicidal cases are prominent in the area compared other part of the districts. FGD respondents also reported divorce cases mentioning cause as the women had to collect water for the entire family from a long distance. FGD respondents also reported that the people try to avoid areas with transportation problems and scarcity of safe drinking water for new marriage.

Table 3: Problems related to profession in the coastal area (Source: Field visit)

Problems related to profession	Responses	Percent
Be unemployed	189	19.10%
Earnings down	327	33.00%
In debt	291	29.40%
Profession change	163	16.50%
Other professional problems	20	2.00%
Total	990	100.00%

The survey, FGD, KII found that people take necessary actions to survive in the area and earn livelihood. They switch profession from farmer to fisherman, or rickshaw/van puller or day laborer or any other available profession or move to big cities to find a job. It has been reported in Shyamnagar and Patharghata that people move to bigger cities like Chittagong or Dhaka and work as day laborers on contract basis for six months to one year. Government and NGOs distribute relief food, construction materials for restoring living places and cash money for buying daily necessities immediately after any natural harsh events. Even cows/goats are distributed among affected people for rearing.

4.1.8. Adaptation Techniques and Relevant Problems

There is a strong correlation found between local adaptation measures and existing problems. Financial problems, infrastructural problems and warning systems are the most prominent issues for local adaptation measures like constructing high elevated accommodation and sustainable infrastructure and rainwater harvesting. When people plan to build a high elevated house, strong infrastructure and store rainwater, financial issues come as the top most problem. Although warning systems have developed in recent years, sometimes the local people don't respond to the warning properly. Popular adaptation techniques together with their pros and cons in responses to climate change induced crises are listed in table 4.

4.1.9. Local Expectations in Coastal Area

People of coastal areas have been suffering from climate change induced events since their entire life. Their sufferings changed very little. The local reported that they get some support from the government and NGO after a hazardous incident happens, but long-term planning is scarce to make their life better. There is a moderate correlation between the local people's expectation and government adaptation actions (figure 14). Government has taken different initiatives to accelerate economic cooperation, training, education and enhance adaptations.

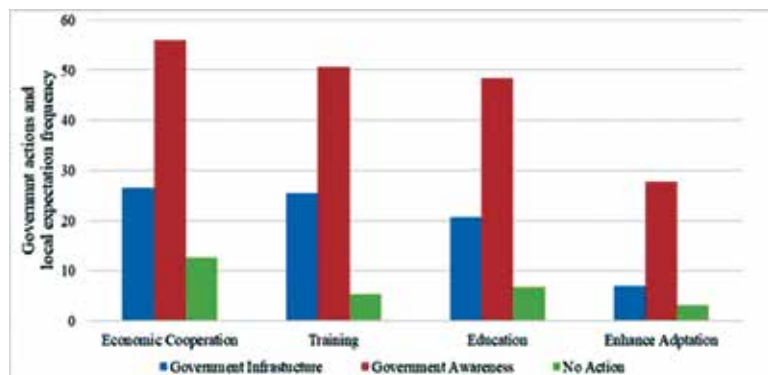


Figure 14: Government actions and local people's expectations in coastal areas (source: Field visit).

The government basically conducts awareness activities among the study area people and focuses on rehabilitation by constructing or renovating dilapidated houses after any disaster. But people expect to get training alongside the awareness campaign only. The hands-on training of the volunteers like CPP is very effective to them rather than just listening to the instructions. The affected people also expect economic contribution from the government agencies rather than just getting relief or reconstruction. For their long-term resilience against the climatic impact, they want to be economically solvent and empowered. The government should take long term capacity building programs for this purpose.

People expected that the government shall take more initiatives to build awareness and more infrastructures. They mentioned that climate change education, training and awareness building are of utmost necessity which shall be implemented by the Government. The respondents informed that they need quick support of repairing houses immediately after cyclones and other events. They asked for excavation of canals to drain rain water to reduce flooding. Construction of sustainable embankments, culverts, sluice gates are their desperate requirement to minimize damages of tidal surge and flood. They also asked for easy access to low interest loans from the government banks. Roads need to be elevated as they are submerged under flood water. Availability of

safe drinking water must be ensured. They need big drums to store rainwater for drinking purposes round the whole year. Easy access to hospital and treatment facilities specifically for maternal and child health care are their crying demand. They demanded that the cyclone shelters need to be friendly for children, women, elderly and handicraft people. These infrastructures shall have proper lighting. They expect regular and seasonal job opportunities as they switch profession from farmer or fisherman. Training should be arranged in the field of agriculture to cope with disaster.

4.2. Livelihood in Char Area:

The char ecosystems of Bangladesh are also recognized for their high productivity and the enormous ecosystem services they provide, which are critical to the livelihoods and well-being of millions of people. However, like coastal ecosystems, these char ecosystems are also vulnerable to the impacts of climate change. Rising global temperatures, sea-level rise, changes in river flow patterns, and frequent floods are all contributing to the degradation of char ecosystems in Bangladesh. These changes are having significant impacts on the structure of the communities that rely on these ecosystems, including changes in their living patterns and traditional livelihoods. As with coastal ecosystems, there is a need to further explore and understand how these changes are affecting the productivity and structure of char ecosystems in Bangladesh, as well as their associated communities due to climate change.

Similar to the coastal ecosystems, extensive one-to-one interviews, 12 focus group discussions (FGDs), and 12 key informant interviews (KIIs) were conducted among members of the char communities in Bangladesh, particularly in Char Rajibpur (Kurigram), Fulchari (Gaibandha), and Islampur (Jamalpur). The participants were asked to share their experiences of changing climatic conditions, associated threats and risks they were facing, adaptation strategies that might help them reduce their vulnerabilities and their expectation to the governments to cope up with climate change. In the following section, we are representing these results chronologically:

4.2.1. Socioeconomic Status of Char Area

People living in char areas are mostly marginalized people. They are mainly farmers and fishermen. People engaged with small business and other minor professional people also live in the char area. Most of the people's annual income is below 120000 Taka (figure 15). As the annual income of the char area people is in a low economy that reflects in construction houses in the char area are made of mud, wood and tin (table 4).

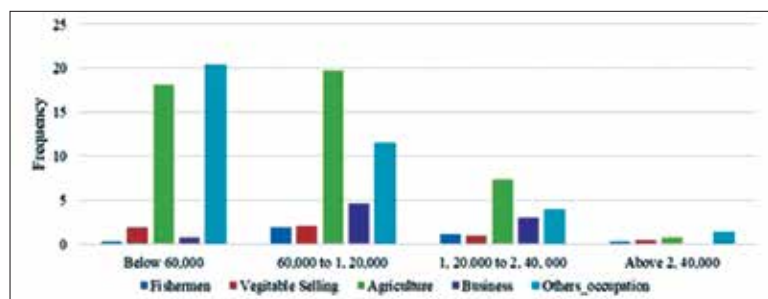


Figure 15: Profession and annual income range of char area (source: Field visit).

Table 4: Housing materials used in char area people (source: Field visit).

Housing materials	Responses	Percent
Wood Brick Cement	53	13.50%
Tin and wood	66	16.80%
Clay wood tin	181	45.90%
Bamboo wood tin	94	23.90%
Total	394	100.00%

4.2.2. Climate Threats and Vulnerabilities

The char ecosystems of Bangladesh are also facing recurring climate events that pose significant threats and challenges to the daily living and livelihoods of the communities that depend on them. These events include floods, riverbank erosion and drought. The participants in the char communities shared their experiences of frequent floods, riverbank erosion, lightning and drought. These events have resulted in loss of life, damage to homes and infrastructure, and loss of agricultural crops. The communities

also reported changes in temperature, rainfall patterns, and river flows that have affected their livelihoods, particularly agriculture and fisheries. People fell in wide ranges of problems from most occurring like change of residence 37.1% to least occurred problems like other professional problems (1.3%) (table 5). Flooding causes the destruction of houses; hence, residents need to shift their houses from vulnerable areas to a safer place or migrate. Again, agricultural production decreases due to floods and the overall earnings or income of the people get reduced by its impact. Besides the above-mentioned issues, physical injury, unemployment gets increased during disaster and as a result the rate of indebtedness gets boosted. According to the above table 23.7 % of the respondents' face indebtedness after the flood. Especially the farmers who take loans from the Mahajans (loan giver) and fail to pay back the interest. Moreover, drinking water crisis, housing problems with major and minor infrastructural damage, occur by 21.6%, 20.6% and 18.7% among the respondents. They need to change their occupation from the traditional one. For example, farmers have to change their occupation if they lose their cultivable land or face crop damage.

Table 5: Ranking of problems occurs in char areas due to flood (source: Field visit).

Problems	Percentage
Residence Change/ Relocation	37.10%
Reduced crop yield	37.00%
Loss of income	34.40%
Physically Harmed	29.10%
Be Unemployed	23.90%
Increased Financial Liability	23.70%
Drinking Water Shortage	21.60%
Damage of Mud Houses	20.60%
Infrastructural Damage	18.70%
Shift in Traditional Livelihoods	16.60%
Biodiversity Destruction	10.80%

4.2.3. Displacement, Loss of Life and Properties

People in char areas are suffering the most by losing houses and other properties due to flood and river erosion. A wealthy family becomes poor within a very short time when flood or river erosion washes away all of their belongings. People have to leave their house becoming landless and have to get settled in a new place. The most terrible suffering of char people is loss of life during flood. People affected with different diseases during floods which cause death as proper treatments are scarce. Snake bites cause death of people during flood and rainy season. Sometimes little children who can't swim sink under floodwater. Lightning also causes death of farmers and livestock animals in the field.

4.2.4. Drinking Water and Health Issues

Availability of fresh water is a big crisis in the char area during floods and drought. People collect fresh water from far away or use Alum (fitkari) to clean river water. They try to install tubewell in high elevated places to protect them not to submerge under water during floods (figure 16). Harvesting rainwater is practiced for drinking purposes during the rainy season.



Figure 16: Installing tube well on high elevated place in char area. Photo source: Field visit, November 2022, Phulchari, Gaibandha.

Water borne diseases like diarrhea, skin diseases, cold fever, chronic diseases occur during all types of climate change events

in char areas. Cold fever and diarrhea are the most prominent diseases which spread most during flood, drought and river erosion (figure 17).

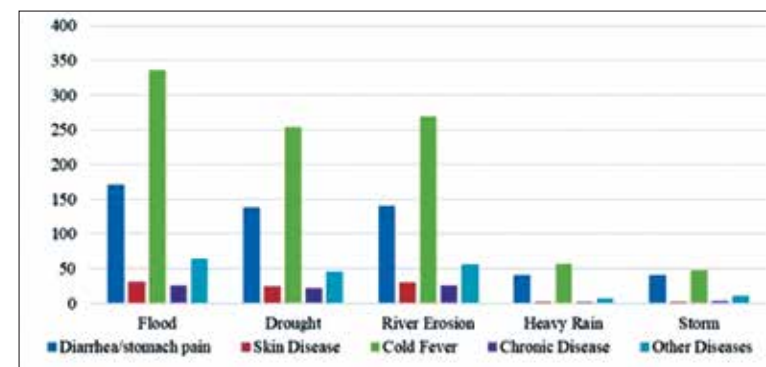


Figure 17: Occurrence of diseases during different climate change events in Char area (source: Field visit).

Types of toilets used in char areas are also a great cause for diseases to spread. Most of the families use primitive types of raw toilet (73%) during dry season and floating toilet (43%) during floods which are unhygienic (table 6).

Table 6: Types of toilet use in char areas at normal time and during flood (source: Field visit).

Types of Toilets	Normal time (%)	During flood (%)
Open toilet/Floating toilet	7	43
Paved toilet	18	5
Raw toilet	73	20
Other types of toilet	2	32

People suffer a lot to get proper healthcare, as treatment facilities are scarce in char areas. Hospital facilities are located far away from many of the local communities. Suffering of pregnant women is noting to say. People reported that often child delivery happens in the boat on the way to the healthcare centre. People adopted to accept treatment mostly either from a local village medical practitioner or take care themselves at home during disease (figure 18).

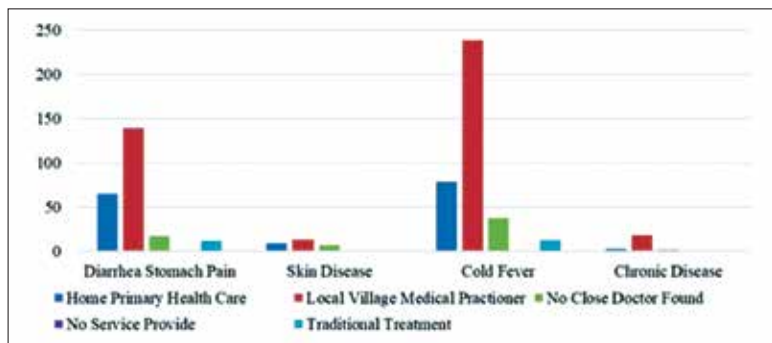


Figure 18: Treatments adopted in response to different diseases in the char areas (source: Field visit).

4.2.5. Agricultural Loss

Respondents from all three Upazilas of char area mentioned that flood, drought, river erosion greatly affect their field crops. River erosion causes complete loss of entire crops as well and land. Farmers have to suffer long term due to consequences of river erosion. The consequences of flood cause crop loss either entirely or decreased yield. The drought causes increased production cost due to more requirements of irrigation which consequences reduction of crop cultivation. Farmers also suffer greatly to rear domestic animals. Shortage of livestock feed is common during floods and droughts. The animals become bones and skinny and the owner sells the animals at a very low price. Livestock diseases spread a lot during floods which sometimes causes death of animals. Sandy soil is a challenge of char area agriculture. Farmers can grow little crops in sandy soil as this type of soil is infertile having low water holding capacity.

Farmers in the char area have been combating climate change induced stressors with their local knowledge and traditional practices to grow agricultural crops. They cultivate short duration crops like vegetables for quick harvest during floods. They are cultivating long crops like sugarcane, maize, banana (figure 18) which are succulent plants requiring low irrigation to tolerate drought and don't submerge easily under water during floods. The farmers are growing crops that require less water like almonds, mustard, and vegetables instead of rice. They also adopted crop

varieties which can bear waterlogging and drought conditions. Cultivating vegetables in plastic bags (figure 19) is an interesting adaptation both for flood and drought which require minimum irrigation and the farmers can easily move the bags to high places during floods. Varied methods of irrigation are used to deal with drought like irrigation through a shallow machine or deep machine, irrigation provided through pipe lines from nearby rivers or storing water in earthen pitchers.



Figure 19: Banana cultivation in sandy soil (upper), vegetables cultivation in portable bags (lower). Photo source: Field visit, December 2022, Char Rajibpur, Kurigram, November 2022, Phulchari, Gaibandha.

4.2.6. Transport Communication Problem

Transport communication is a critical crisis in the char area. Road communication is scarce. No road exists in many places. Recurrent floods damage existing roads every year which are not repaired frequently. Boat communication (76%) is the major

transportation way in the char area (figure 20). People cannot move anywhere without a boat during the rainy season. Each family shall have their own boat to access easy communication which is not possible for economic reasons. Temporary boats made of banana plants are often used to access easy communication. Boat communication is greatly affected during the dry season due to decreased navigability of rivers. Transportation becomes tough in the dry season. People have to walk a long way to get a rickshaw/van or engine or battery driven vehicle. Riding horses and use of horse cart is an interesting means of transportation during the dry season, as horses can walk through muddy and sandy ways (figure 21).



Figure 20: Adaptation techniques for transportation through horse cart and protecting river erosion using concrete block in fulchhari area (Source: Field visit)

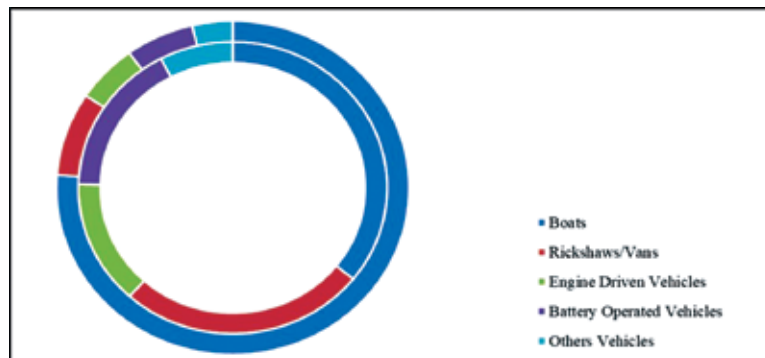


Figure 21: Transportation facilities in char area at normal time and during flood (source: Field visit).

4.2.7. Adaptation Techniques in Char Area

The char area people are continuously adapting themselves to survive under the challenges of climate change induced extreme events. They use their indigenous knowledge and traditional practices as well as they adopt improved technologies. They raise their homesteads (figure 22) so that their houses remain safe during floods. They are trying to engage themselves in alternative livelihoods to support their families during difficulties. People could bring very little things with them from their original home when they were displaced due to flood or river erosion. They built the roof and wall of the house in a way so that they could open those easily and take those with them to the new place. The respondent stated that try to store dry food like puffed rice (Muri), roasted rice (Chira), treacle (Gur), biscuits etc. to eat during flood, heavy rainfall or during transitional period of displacements. Unemployment becomes a big frustration during all types of climate change induced events which enhances social conflicts and family unrest. Unemployed people migrate to other cities like Dhaka and Chittagong to find work.



Figure 22: Local adaptation to protect houses from flood at Charrajibpur (Source: Field visit)

However, the respondents stated that their capacity cannot be advanced due to financial constraints, infrastructure problems and lack of access to developed warning systems. More than 190 respondents reported that they are facing financial crisis and infrastructure problems for construction on high elevated places,

while more than 130 participants stated problems for sustainable construction. People also reported that the lack of an improved warning system affected them.

4.2.8. Expectations of Char Area People

The survey respondents, FGD and KII identify the need for government support in addressing the long-term impact of climate change for the vulnerable communities in char areas. The respondents recommended long-term planning by the government to create job sources, including climate change education at school, training on adaptive agriculture techniques, naval channel excavation, canal irrigation, and crop insurance.

5. Our Thoughts on the Study

5.1. Major Findings of the Study

The study found that farmers and fishermen are the most vulnerable to the impacts of climate change, including cyclone, floods, drought and river erosion. The most common problems in char areas due to climate changes are flood and river erosion. Climate change has also resulted in a shortage of food and safe drinking water, problems with transportation and communication during floods, and sanitation issues. There is a lack of doctors and health services, even pregnant women giving birth on the boats during floods.

This study found that houses are getting damaged due to floods and cyclones, and it is one of the main problems in coastal areas. They have to repair their roofs of houses every year. The study also found that the biggest problem faced by the locals was the crisis of drinking water in coastal area, and even pond water became dry in summer. The sea level rise forced people to change their settlement twice in the last two years due to floods and dams collapsed under pressure from the overflowing flood water. Children stopped attending school, and different diseases like cholera, typhoid, and dysentery spread in the locality. The temperature had changed, and farmers couldn't work in extreme hot temperatures. The salinity had increased, and agricultural production had decreased, and domestic animals died due to cyclones. Climate migration is very dominant in this area.

Mentalities of people living in climate vulnerable areas are set to accept any terrible situation. They continuously try to adapt themselves to the changed conditions. The locals used various adaptation techniques to combat the climate change impact, such as switching professions from fishermen to others, going to the deep sea for fishing, taking shelter at a shelter house during cyclones, making homes with portable polythene material and soil, filtration of pond water for drinking water, collecting drinking water and irrigation water from non-salt affected areas, rainwater harvesting, and short duration crop cultivation etc.

5.2. Assessment of Best Adaptation Techniques

The study areas have different geographical settings. People have different lifestyles and cultural practices. However, their sufferings have similarities in broad sense. Many adaptation techniques are unique in a specific area which could be replicated in other areas. The qualitative data analysis provided a clear idea about best practices of adaptation techniques both in coastal and char areas (table 7&8).

Table 7: Local adaptation techniques with relevant pros and cons against climate change induced crisis in coastal areas

Crisis	Adaptation Techniques	Pros	Cons
Damage of houses	Changing location and building new houses	Protection from disasters.give new hope to live again	Costly. Emotional to leave ancestral home.
	High elevated house and livestock shed	protection from flood	Costly
	Making walls of houses with mud and roofs with polythene	Low cost	Temporary step
	Use of Asbestos	Protect home	Costly
	Houses made with enlarged roofs	Protect mud walls	Not sustainable
	Home wall made with painted tin	Protect walls from corrosion	Costly for them
	Use of net above the roof.	Protect from strong wind	Not sustainable

Crisis	Adaptation Techniques	Pros	Cons
Drinking water crisis	Filtration of pond water ensures very clean conditions of the pond.	Easily accessible	Costly
	Collecting water from non-salt affected areas.	Temporary solution	Hard work required
	Storing rainwater during the rainy season.	Safe than other sources	Challenging to store the whole year
	Collecting water from a deep tube well	Safe than other sources	Costly and doesn't work in all areas.
Crisis	Adaptation Techniques	Pros	Cons
Loss of agricultural production	Re-cultivation immediately after an event causes crop loss.	Fast adaptation	Costly and laborious
	Cropping round the whole year. Never left fallow land	Get more crops.	Not possible all the time
	Improved quality of seeds and agricultural tools are used	Beneficiary to them.	Not available all the time
	Cultivating salinity and waterlogging tolerant varieties	Can grow crops in salinity and in water logging situation	All farmers are not aware of it
	Cropping in gunny or plastic bag techniques.	Beneficiary to them	Costly than conventional farming
	Adopting floating agriculture techniques.	Beneficiary to them	Costly

Table 8: Local adaptation techniques with relevant pros and cons against climate change induced crisis in char areas.

Crisis	Adaptation Techniques	Pros	Cons
Breakdown of houses	Changing location	Give new hope to live again	Losing ancestral homes which is emotional. Costly
	Making high elevated house and livestock sheds	protection from flood	Costly. Doesn't work when flood exceeds expected level.
	Raising their bed above water level inside house during flood	Temporary step helps them to rescue their life	Risky for children and causes health crisis for all
	Domestic animals shifted to the relative's house during floods	Temporary step helps them to rescue their life	Low space
	Building bamboo scaffolding on which to cook and store necessities during flood	Temporary support	Not sustainable
	Crisis	Adaptation Techniques	Pros
Food shortage	Storing enough dry foods like flattened rice (Chira), puffed rice (Muri).	Emergency food during the flood.	Food crisis
	Cooking one curry during flood	Emergency support	Can create lack of nutrition
	Use of movable clay stove (matir chula) to cook during flood	Emergency support	Very sensitive

Crisis	Adaptation Techniques	Pros	Cons
Drinking water crisis	Two headed tubewell line	Use of upper headed tubewell during flood	Require more space
	Keeping rainwater for cooking and drinking purpose during flood	Emergency support	Low storage capacity
	Using ALUM (Fitkiri) to clean flood water during flood	Emergency support	Low ALUM supply
	Collecting drinking water from the tube well which has not flooded yet from another area	Temporary solution	Need vast hard work
Crisis	Adaptation Techniques	Pros	Cons
Loss of agricultural production	Crop cultivation in portable bags.	Easily movable	Not applicable for all types of plants
	Cultivation of flood resistant varieties like BR-11	Crops can survive up to 7 to 10 days under water	All farmers are not aware of it
	Low cost crop at lower land area and high cost crop at higher land area	Protect from large investments	Depends on luck
	Migrating to short timing crops like vegetables, maize	Save crops from frequent flood	Lower production
	Using drought - resistant variants like 'Bina Dhan 21'	Temporary support	Not suitable for longer period, Lack of availability of seeds
	Irrigation from river water	Temporary support	Costly
	Irrigation water through shallow water pumps	Temporary support	Costly

5.3. Policy Recommendations

The study came up with some recommendations picked from the discussions of FGDs, expectations from survey respondents and observation oh KIIs.

- ◆ **Emergency Support:** The affected people expect quick economic support from the government agencies rather than just getting relief or reconstruction. Although the Government of Bangladesh has taken initiative to support the affected people in emergency situations named “National Emergency Operation Centre” in 2015 (Standing order on Disaster, 2019). It will serve a critical role in every phase of emergency management, from being the hub for all coordination during an incident to facilitating and directing recovery. Engagement of this institution with local people can meet up the problem in an emergency situation at post-disaster time. Establishment of more institutes like it can reduce sufferings.
- ◆ **Transport:** Tidal surge and flood destroys roads and culverts affecting road communication and hamper emergency medical services. People expect elevation of roads as the roads are submerged under water. From National Adaptation Plan we have found that our Government has taken initiative excavation of 590.60 km canals to pass out the flood water. Proper management of these initiatives can minimize the sufferings of local people.
- ◆ **Dam Embankment:** Construction of sustainable embankments, culverts, sluice gates are their desperate requirement to minimize damages of tidal surge and flood in the proper place. Initiative for construction of 231.40 km of dams in coastal areas has taken (NAP). Local people now expect the proper implementation of the plan of government. It is their crying need to reconstruct the damaged embankments.
- ◆ **Drinking Water:** The most important problem is unavailability of safe drinking water in both coastal and char areas. Safe drinking water is a dream for them. The problem

turns acute in the time of flood. People need big drums to store rainwater for drinking purposes round the whole year but unable to store for the whole year. Government has installed 4184 deep tube-wells over the years (MoEFCC,2021, country paper for COP 26 and sectoral ministries). But the Government or NGO facilitates one deep tubewell for a couple of hundred families and it is very painful to collect water from distant places. So installment of abundant deep tubewell can give emancipation from the untold sufferings of drinking water.

- ◆ **Health:** Very often people have to consume saline and unsafe water which causes health crises with water borne diseases like cholera, typhoid and diarrhea. Other diseases such as fever, cold and pneumonia spread during and post flood or water logging times. Quick supply of medicines from the GoB can lessen the sufferings of the people. Government can provide them ambulance facilities as children and pregnant women are suffering for lacking of vehicles to go hospital at emergency time in the remote areas.
- ◆ **Agricultural Support:** Climate stress tolerant varieties are practiced both in coastal and Char areas. It is mentioned in NAP (2023 Goal 2, Section 2.1) that promoting of Climate Smart Agriculture (CSA) should be increased to the farmers to cope up with climate change effects. It is necessary to take awareness programs and give them training opportunity from Government so that the farmers can practice different types of adaptation technique.
- ◆ **Permanent Employment Creation:** Coastal and Char area people become climate migrants to find jobs in city and create pressure on cities. Capacity building programs of local people can develop their skills and they can also be successful entrepreneurs. Government shall encourage entrepreneurs and industrialist with easy bank loan, subsidies, power and gas supply to create new business and industries in Coastal and Char area.

- ◆ **Improvement of Cyclone Shelters:** The GoB has constructed over time nearly 4530 cyclone shelters in the coastal area and 14 schools cum cyclone centres for evacuation of people threatened by cyclone or flood (NAP, 2023). The cyclone shelters are not full of amenities according to our respondents. Most of the shelters remains unattended except crisis period. Therefore, the shelters remain dirty and water, power supply do not function whenever people arrive during crisis. Lack of proper lighting system make them uncomfortable and insecure especially for female. The cyclone centre should be friendly for children, women, elderly and handicraft people. Lack of these facilities, people don't feel interested go to the cyclone shelters. Regular maintenance of the shelters is required as well as it is necessary to make sure proper lighting, water, toilet facilities are functioning properly.
- ◆ **Climate Change Education at School:** Climate literacy is a necessity in this perilous phase of climate change and environmental collapse. Climate and environmental education at all stages of our school curriculum will enable the young generation to live through this crisis with more resilience, insight and awareness.

5.4. Future Research Direction and Concluding Remarks

The study finding shows that most climate vulnerable communities living in the study areas are farmers and fishermen. They have been suffering from the consequences of climate change events for a couple of generations of their descendants. Although they adopted themselves with the cruelty of nature, their suffering knows no bounds. They are trying to cope with the adverse impacts of climate change with their indigenous knowledge, but their situation is like a soldier without a sword. Education, healthcare facilities, climate adaptive agriculture, construction of sustainable shelter houses and rapid rescue response during climate change induced events are priority demands from the respondents. Therefore, the government shall take necessary research to find out what curriculum shall be included to teach climate change education at school level. Proper

background studies are required to construct sustainable dams and embankments in appropriate places. Further research is needed for climate smart agriculture, climate resilient constructions. Research is also required to figure out accessible mechanisms of healthcare facilities in the vulnerable area. Continuous researches are also required to figure out changing patterns of climate change events.

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