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Index

Climate Change Challenges for South Asia: The Need for a Regional Research Hub

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Abstract

South Asia, which is home to nearly a quarter of the world's population, is on the brink of a major environmental crisis. Climate change is not a distant phenomenon here but a stark reality that is already disrupting food security, human health, and the socio-economic fabric of the region. The diverse landscape of the region—from the towering Himalayas to the fertile deltas and long coastlines—are highly sensitive to the impacts of climate variability. In recent years, the vulnerability of South Asia to extreme weather events has significantly increased, with rising temperatures and humidity, erratic monsoon patterns, and frequent landslides and floods threatening its agricultural systems, human livelihoods, and overall development becoming the norm. As the region grapples with these challenges, the need for immediate action to build resilience to climate disasters and enhance food security has become more urgent than ever.

A Region under Climate Siege

The scientific consensus on climate change is unequivocal. Rising concentrations of greenhouse gases, particularly carbon dioxide, have accelerated global

warming, resulting in more frequent and more intense weather extremes. For South Asia, this means hotter and more humid summers, increased rainfall variability, and more severe storms. The frequency and intensity of extreme rainfall events (ERE) have already surged across India, Nepal, and Bangladesh. In some regions of these countries, extreme precipitation events that were once rare have now become annual occurrences.

The South Asian monsoon and the westerly winds, the lifeblood of the region's agricultural sector, and consequently of the economy, have become increasingly unpredictable. Changes in the onset, duration, and intensity of the monsoon and shifts in rainfall patterns cause both floods and droughts in the same year. In Nepal, flash floods triggered by heavy monsoon rains have devastated communities, while parts of Bangladesh face an increased risk of cyclones, storm surges, and inundation from rising sea levels. Himalayan glaciers, which provide freshwater to millions of people, are retreating at an alarming rate, jeopardizing water security for countries downstream. At the same time, glacial lakes are increasingly frequently breached, as the recent breach of two glacial lakes in the Everest region illustrated. These changes undermine local ecosystems and livelihoods.

As climate extremes become more frequent, they not only impact natural ecosystems but also place immense stress on critical infrastructure. Many of South Asian infrastructures, in both rural and urban areas, were designed based on historical climate patterns. They are not equipped to handle the new climate realities. Aging bridges, roads, and dams are increasingly vulnerable to extreme weather, and the economic costs of repair and replacement are soaring.

The Food Security Challenge

Agriculture in South Asia is inextricably linked to climate conditions. The region is heavily reliant on monsoon-fed agriculture, with rice, wheat, and pulses serving as staple crops. Climate change currently threatens the stability of food production. For example, even a small increase in temperature during the growing season can result in significant losses in the fields of crops such as rice and wheat. The warmer climate has already begun to reduce crop yields, and projections indicate that this trend will worsen in the coming decades.

In Bangladesh and coastal India, sea-level rise and saltwater intrusion have damaged arable land, rendering it less productive or entirely unusable. In the northern plains of India and Pakistan, erratic rainfall and heatwaves have put additional stress on water resources, exacerbating drought conditions. As crop yields decline, food prices rise, making it harder for the poorest segments of society to afford basic nutrition. According to FAO data, the number of undernourished people in South Asia has been rising steadily over the last decade, reversing years of progress in reducing hunger.

Furthermore, the region is witnessing a shift in cropping patterns. Farmers are increasingly abandoning water-intensive crops in favor of more climate-resilient varieties. Making this transition is not always easy, however. Many farmers lack access to resources, climate information, capacity-building support, and infrastructure needed and are consequently left vulnerable to climate-induced poverty. Moreover, the increased prevalence of pests and diseases due to changing weather patterns has exacerbated the challenges faced by farmers.

Human Health at Risk

The impacts of climate change on human health are profound and multifaceted. In South Asia, rising temperatures and humidity are already contributing to heat stress, which disproportionately affects vulnerable populations, particularly those living in urban slums. The urban heat island effect, where cities, due to human activities, are significantly warmer than surrounding rural areas, is becoming a major public health concern. In cities like Delhi, Mumbai, and Karachi, heatwaves have claimed thousands of lives in recent years. Even Kathmandu, which is situated in the Mahabharat hills, summers are becoming uncomfortable due to the rise in humidity and the effects of the urban heat island.

Beyond heat stress, climate change contributes to the spread of water- and vector-borne diseases. The increased incidence of floods creates ideal breeding grounds for mosquitoes, which in turn results in a surge in diseases such as malaria and dengue fever. The contamination of water supplies during flood events also increases the risk of diarrheal diseases, which are already a leading cause of child mortality in the region.

Food insecurity, driven by declining agricultural productivity, also poses significant health risks. Malnutrition is on the rise, particularly among children, a fact which has long-term implications for human development. Chronic malnutrition leads to stunting, which not only decreases physical growth but also impedes cognitive development. As more families struggle to afford nutritious food, the region is likely to face a growing burden of non-communicable diseases such as diabetes and heart disease which are linked to poor diets.

Climate-Induced Migration

One of the most visible human responses to climate change in South Asia is migration. As floods, droughts, and rising sea levels make it increasingly difficult for people to sustain their livelihoods, many are forced to leave their homes in search of safer and more stable environments. Bangladesh, with its low-lying coastal areas, is already experiencing significant internal displacement due to rising seas and more frequent cyclones. In India, rural populations affected by drought often migrate to urban centers, adding to the pressures on already overcrowded cities.

Migration often exacerbates existing socio-economic inequalities and puts additional strain on urban infrastructures. The influx of climate migrants into cities leads to the growth of informal settlements, where access to clean water, sanitation, and healthcare is limited. These settlements are highly vulnerable to both climate shocks and health crises, creating a vicious cycle of poverty and vulnerability.

Resilience and Adaptation: A Way Forward

Addressing the twin challenges of climate change and food security in South Asia requires a multi-pronged approach focusing on resilience and adaptation. Building climate-resilient agricultural systems is key to ensuring food security for the millions of people living in the region. Farmers need to adopt climate-smart agricultural practices such as the cultivation of drought-resistant crop varieties, improved irrigation techniques, and better soil management. In addition, governments must invest in agricultural research to provide farmers with the tools and knowledge they need to adapt to changing climate conditions.

Water management is another critical area. With precipitation becoming scarcer and more unpredictable, South Asian countries need to improve their water conservation and distribution systems. They must invest in modern irrigation infrastructure, promote rainwater harvesting, and protect watersheds. Regional cooperation in transboundary water management, particularly in the Ganges-Brahmaputra-Meghna (GBM) basin, is essential to avoid conflicts and ensure equitable access to water resources.

Urban resilience is equally important. Cities in South Asia must be equipped to handle the growing risks posed by climate change. Infrastructure must be strengthened to withstand extreme weather events, early warning systems improved, and disaster preparedness for floods, heatwaves, and air pollution enhanced. Governments should also prioritize building green infrastructure, such as parks and wetlands, to mitigate the urban heat island effect and provide natural buffers against floods.

In the realm of public health, governments must strengthen health systems to better respond to climate-related health risks. Efforts should include expanding access to healthcare in vulnerable communities, improving disease surveillance systems, and raising public awareness about the health impacts of climate change. Ensuring that urban planning takes health risks into account is also crucial to protecting the most vulnerable populations from the effects of climate change.

International Cooperation and Policy Action

Since the challenges posed by climate change in South Asia are not confined to national borders, regional and international cooperation is essential. South Asian

nations must work together to develop regional strategies for climate adaptation and disaster risk reduction. Organizations such as the South Asian Association for Regional Cooperation (SAARC) have a critical role to play in fostering collaboration on climate-related issues, including water management, food security, and health.

At the global level, South Asia needs increased support in the form of climate finance. The region is one of the world's most vulnerable to climate change, yet it has limited financial resources to invest in adaptation and mitigation efforts. Wealthier nations, which bear historical responsibility for the bulk of greenhouse gas emissions, must fulfill their commitments under international climate agreements to provide funding, knowledge, and technical support to developing countries in South Asia.

Furthermore, global efforts to reduce greenhouse gas emissions are essential for limiting the worst impacts of climate change in South Asia. The region is already experiencing the consequences of a warming planet, and, without drastic reductions in emissions, the situation will only deteriorate. The international community must prioritize ambitious action on climate change to ensure that South Asia and the world have a sustainable future.

Conclusion: The Necessity of a South Asian Research Hub for Tackling Climate Challenges

South Asia stands at a critical juncture. The impacts of climate change are already being felt across the region, with devastating consequences for food security, human health, and socio-economic stability. To address these challenges makes building resilience and adaptive capacity imperative. By investing in climate-smart agriculture, improving water management, strengthening

urban resilience, and enhancing public health systems, South Asia can adapt to the worst effects of climate change and thereby ensure a better future for its people. Meeting these objectives will require not only national action but also regional cooperation and international support. Climate change is a global problem, so only through collective action can we protect the most vulnerable and ensure a sustainable future for all.

As South Asia faces the escalating impacts of climate change, developing a coordinated, research-driven approach becomes ever more urgent. A South Asian research hub dedicated to climate change would be a critical pillar in the region's response to its growing environmental and climate challenges. Such a hub would foster cutting-edge research, bringing together the brightest minds from across the region and the globe to explore the emerging multifaceted challenges of climate change and to offer solutions in areas such as food security, public health, and resilient infrastructure.

A regional research hub would not only facilitate the sharing of knowledge and best practices but would also foster innovation in developing innovative climate adaptation strategies. By integrating scientific, technological, social, and indigenous knowledge, this research hub could develop context-specific solutions tailored to South Asia’s diverse landscapes and socio-economic conditions. Moreover, the hub could act as a conduit for policy recommendations, providing governments with evidence-based insights to shape their national adaptation plans and climate resilience policies.

A South Asian research hub would enable greater regional cooperation on shared challenge such as transboundary water management, disaster risk

reduction, and agricultural sustainability. Collaborative research initiatives would ensure that the region would be able to respond cohesively to shared climate risks and build resilience at the local, national, and regional levels. Furthermore, by partnering with international organizations and research institutions, the hub could secure the financial and technical resources it would need to scale up its efforts and enhance South Asia's capacity to address the global climate crisis.

In climate-vulnerable South Asia, the establishment of a research hub is not merely an option; it is a necessity. With the right resources, collaboration, and strategic direction, such a hub could play a transformative role in safeguarding the future of millions of people, both driving sustainable development and leading the region's fight against climate change.

Disability Inclusion in Climate Resilient Infrastructure: A Cross-Sectional Study in Four Coastal Sub-Districts of Bangladesh

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Abstract

Bangladesh's coastal region is extremely vulnerable to hydrometeorological and climatic disasters. A distinct group of marginalized population is disproportionately impacted by a disaster. Regardless of gender, "people with disabilities" (PWDs) face substantial challenges in a disaster scenario. The response mechanisms of people with disabilities are also different in a disaster situation. The purpose of this paper was to investigate the climate-resilient infrastructure of PWDs in Bangladesh's coastal zone during a natural disaster. A cross-sectional survey of 520 participants was conducted in the subdistricts of Khulna: Dacope, Koyra, Paikgacha, and Bagherhat: Mongla. The study found that only 8% of homes are made of concrete and are resistant to strong winds, cyclones, floods, and storm surges, while only 7% of homes are disaster-resilient. Only 5% of respondents indicated that their residences were accessible to PWDs, and there are no accessible WASH facilities. With disaster-resistant infrastructure, the study suggests that accessibility for PWDs should also be addressed.

Keyword: *PWD, Disaster Inclusion, Climate Change, Resilient, Infrastructure*

1. Introduction

Bangladesh is a climate-vulnerable country, and the most vulnerable population is the person with disabilities (PWD) (Nishat et al., 2022). According to Bangladesh's "Persons with Disabilities Rights and Protection Act" of 2013, 2.80% of the population is disabled, with gender-stratified prevalence of 2.322% for women and 3.28% for men. In terms of geography, the prevalence is 2.45% in urban areas and 2.89% in rural areas. In addition, the prevalence rates are broken down by age groups. For example, the rates for children ages 0 to 4 are 0.83%, adults ages 18 to 49 are 2.24%, and those 65 and older have a significantly higher incidence of 9.83%. The district of Khulna, in particular, has the highest prevalence rate of 3.62% (BBS, 2022). Many coastal residents are impoverished, and the population is vulnerable to both natural and man-made disasters (Ahmad, 2019). A significant correlation was found between poverty and the impact of natural disasters on the disabled (Mahmud et al., 2014). Individuals with disabilities are disproportionately affected by inaccessible evacuation, response, and recovery efforts in disaster, emergency, and conflict situations (King et al., 2019). Bangladesh is susceptible to both climate change and natural disasters. The country is ranked seventh globally in terms of extreme risk, according to the global Climate Risk Index of 2021 (Eckstein et al., 2020). According to the 2021 Climate Risk Index, which was developed based on data from 2000 to 2019, Bangladesh suffered substantial damages that were related to climate change. The country suffered 11,450 fatalities and $3.72 billion in substantial financial

losses during the same period. A total of 185 extreme weather events that were directly linked to climate change occurred in Bangladesh during this time (Al Amin, 2021; Eckstein et al., 2020). Due to insufficient planning and preparation, as well as inaccessible infrastructure, services, and transportation systems, people with disabilities are disproportionately vulnerable to being ignored or marginalized in disaster situations (Mahmud et al., 2014). Problems include disproportionate access to resources, inability to adapt to the built environment, and poor living conditions (King et al., 2019). The inadequacy of communication infrastructure in remote areas makes it more difficult for people with disabilities to mobilise communities during emergencies (Mahmud et al., 2014). Natural disasters (flood/cyclone/lightning) account for 0.46% of the disabled population in Bangladesh as a whole, and 0.67% in the Khulna division (BBS, 2022). Frequently, the extent to which individuals, communities, and countries are vulnerable or resilient is determined by the interactions between various structure-related problems (King et al., 2019). It is not always possible to find gender-friendly shelters because they frequently do not have separate lavatories for men and women (Mahmud et al., 2014). The CEGIS conducted a Comprehensive Disaster Management Programme (CDMP) survey across 10 districts, covering 1,705 cyclone shelters and killas. The survey results highlight serious deficiencies in vital infrastructure. Just 25% of the shelters that were surveyed have water supply infrastructure located in high-risk areas, and only 14% have facilities for storing perishable goods. Moreover, only 26% of these shelters have spaces exclusively reserved for women, and only 33% have separate restrooms that meet the needs of women. The surveyed shelters notably lack provisions for

providing physical accessibility for individuals with disabilities (Mahmud et al., 2014). A disaster may exacerbate the conditions of PWD, and they may lose interpersonal support and mobility aides (King et al., 2019). The majority of shelters are located beyond the prescribed reachable territory (Mahmud et al., 2014). Individuals with disabilities often experience disproportionately higher rates of morbidity and mortality during emergencies, making them among the most vulnerable to the lack of emergency support infrastructure (World Bank, 2017).

2. Objectives of the study

This research aims to carry out a comprehensive analysis of the effects of climate change-related disasters on people with disabilities (PWDs) and to assess the current state of climate-resilient infrastructure in Bangladesh's coastal regions during natural disasters. The study aims to

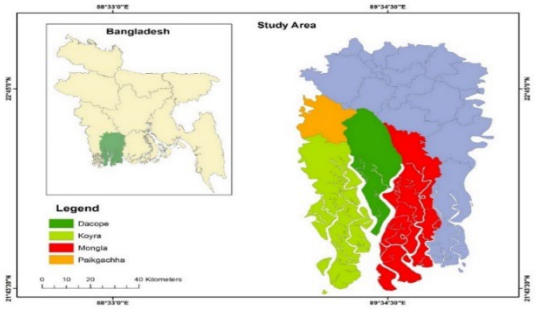
- Examine how the current climate is changing and how that affects people with disabilities.
- Determine how vulnerable people with disabilities are to disasters brought on by climate change.
- Examine how resilient the coastal areas of Bangladesh's infrastructure are to natural disasters for people with disabilities.

3. Methodology

3.1. Study Design

Using a quantitative approach, the study was conducted in one subdistrict in Bagerhat District and three subdistricts in the Khulna District **(Map 1)**. To further inform the study, relevant scientific literature was reviewed as secondary desk review. Using primary and secondary sources, the study has adopted a participatory, multidisciplinary methodology that integrates quantitative and qualitative data collection techniques. Key Informant Interviews (KIIs), Focus Group Discussions (FGDs), and the Household Survey (HHS) are the main methods used to collect data. Long-term meteorological and climate data, including rainfall and temperature, as well as data pertaining to disasters, were also examined. In particular, the study used a methodical approach, carefully classifying 520 households (130 per Upazila) in accordance with the Socio-Economic and Demographic (SAAD) framework. Community members participated in sixteen Focus Group Discussions (FGDs), distributing four FGDs in each upazila. Participating in these discussions were 168 PWDs (Persons with Disabilities) and 182 non-PWDs, who were both male and female. Additionally, a total of twelve Key Informant Interviews (KIIs) were carried out, with three interviews taking place in every upazila. Representatives from the Department of Women Affairs, the Department of Social Services, and Project Implementation Officers (PIOs) were among the key informants. Data was analysed with triangulation of the quantitative, qualitative and secondary information.

Map 1: Study area



3.2. Population Distribution in the Study Area

The population of the study area is 730,818 people in total, according to data from the Bangladesh Bureau of Statistics (BBS) from 2011 (BBS, 2011). Among this population, 11,693 individuals are identified as Persons with Disabilities (PWDs). Paikgacha Upazila stands out with the highest number of Persons with Disabilities, totaling 3,968 individuals residing with disabilities. **Table 1** shows the population distribution in the study area broken down by Sex, Age, and Disability (SAAD).

Table 1: Population by SADD in study area.

Upazila	Total population	Men	Women	Persons with Disabilities
Dacope	152316	76291	76025	2437
Koyra	193931	95393	98538	3103
Paikgacha	247983	123900	124083	3968
Mongla	136588	71492	65096	2185
Total	**730818**	**367076**	**363742**	**11693**

Source: BBS, 2011

3.3. Quantitative Method

The study's quantitative methodology is covered in this chapter. To choose participants for a household questionnaire survey, a non-probability sampling technique called convenience sampling was employed. Four areas and 520 participants in total were surveyed. Microsoft Excel's descriptive statistics were used for data analysis.

3.3.1. Sampling Design

Numerous sampling strategies, such as convenience, purposive, and non-probability sampling, were used in the study. The researcher used convenience sampling, a type of non-probability sampling, to choose units for the sample based on how easily accessible they were (Rahman et al., 2023). Yamane's formula was used to calculate the sample size (Yamane, 1968):

$$n = + \frac{N}{1 + N\ (e^2)}$$

Therefore, following this population and 0.05 error tolerance, the required sample size was around 400.
where n = sample size, N = population, e = error tolerance. Therefore, following this population and 0.05 error tolerance, the required sample size was around 400. For better representation of the targeted population, a design effect of 1.3 was implemented. The final sample size with design effect of 1.3 was found to be 520.

3.3.2. Sample Size and Data Collection

Homogeneous individual household survey was conducted in all four upazilas (Khulna: Dacope, Koyra, Paikgacha and Bagherhat: Mongla) **(Map 1)** with person with disability, children, men and women, total of 130 from each **(Table 2).**

Table 2: Household survey sample distribution in study area.

Upazila	Men	Women	PWD	Youth	Children	Total sample
Dacope	30	50	20	15	15	**130**
Koyra	30	50	20	15	15	**130**
Paikgacha	30	50	20	15	15	**130**
Mongla	30	50	20	15	15	**130**
Total	**120**	**200**	**80**	**60**	**60**	**520**

3.4. Qualitative Method

In addition to quantitative methods, the study incorporated qualitative approaches by conducting Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) with pertinent ecosystem actors. Sixteen focus group discussions (FGDs) were held in each of the four Upazilas, with four FGDs held in each location. The participants included both PWDs and non-PWDs. In addition, twelve KIIs were conducted, with three interviews taking place in every Upazila. Those interviewed included representatives from the Department of Womens Affairs, the Department of Social Services (DSS), and development organisations that work in the areas that were targeted.

Table 3: Qualitative Method of Data Collection

Qualitative Method	Respondents	Number
Focus Group Discussions (FGDs)	• PWDs • Non-PWDs	**16** (4 in each Upazilas)
Key Informant Interviews (KIIs)	• Department of Women Affairs • Department of Social Services (DSS) • Development Organizations	**12** (3 in each Upazilas)

3.5. Data Analysis

With a particular focus on the inclusion of people with disabilities, the research used a participatory and multidisciplinary methodology that integrated quantitative and qualitative data collection techniques to obtain a comprehensive understanding of the context surrounding climate-resilient infrastructure. The study examined the vulnerabilities faced by people with disabilities in the study areas, as well as the risks associated with climate change and natural disasters. The Bangladesh Meteorological Department (BMD) provided long-term disaster data, which were examined to look for patterns in the weather like rainfall and temperature. Microsoft Excel was used to perform a descriptive statistical analysis on household quantitative data.

3.5.1. Quantitative Data Analysis

Using Microsoft Excel, quantitative data from the household questionnaire survey were subjected to descriptive statistical analysis. To summarize and interpret the data, this analysis looked at means, standard deviations, frequencies, and percentages. Additionally, relationships between various variables were investigated using inferential statistical techniques like correlation analysis. The quantitative analysis's conclusions shed important light on the vulnerability of people with disabilities (PWDs) in the study areas as well as the prevalence of climate-resilient infrastructure.

3.5.2. Qualitative Data Analysis

Thematic analysis was used to examine the qualitative information obtained from Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs). Finding recurrent themes, patterns, and trends in the data was required for this. The FGD and KII transcripts were

meticulously examined and arranged to extract important information about disaster risks, climate-resilient infrastructure, and the inclusion of PWDs in the study areas. The study context was better understood overall thanks to the nuanced perspectives and experiences of stakeholders that were clarified through this qualitative analysis.

3.5.3. Integration of Quantitative and Qualitative Findings

To give a comprehensive picture of the state of climate-resilient infrastructure and the vulnerabilities of PWDs in the study areas, the quantitative and qualitative findings were combined. Deeper investigation of the study questions and objectives was made possible by the more thorough and nuanced analysis that resulted from the integration of both forms of data. The process of identifying potential gaps and opportunities to improve the resilience and inclusivity of infrastructure against natural disasters and climate change was made easier by this integration.

4. Result

Climate Change Vulnerability

Khulna and Mongla, two meteorological stations, encompass the study areas. The last 30 years (1990–2020) of climatic data (temperature and rainfall) from both locations were studied. Khulna and Mongla stations data analysis reveals that total rainfall patterns during this time are nearly the same in both stations. According to the temperature trend analysis of Mongla station, the temperature is increasing 0.0011 degree Celsius per year, whereas Khulna station's temperature per year is increasing 0.0219 degree Celsius **(Figure 3)**. With the increase of temperature, both the stations' rainfall also

follows an increasing trend **(Figure 2)**. Where analysis shows that Khulna stations' yearly increasing trend was 5.19mm and Mongla stations' rainfall increased 4.82 mm/year.

Figure 2: Total Annual Rainfall of Khulna and Mongla station (1992-2022)

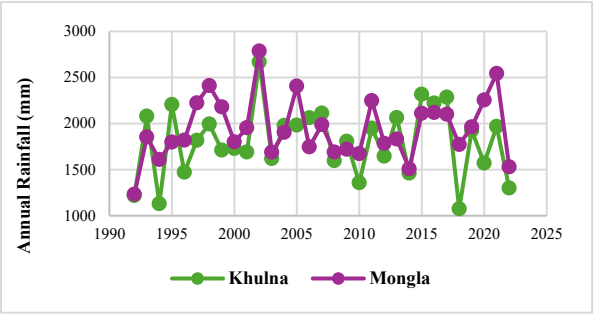
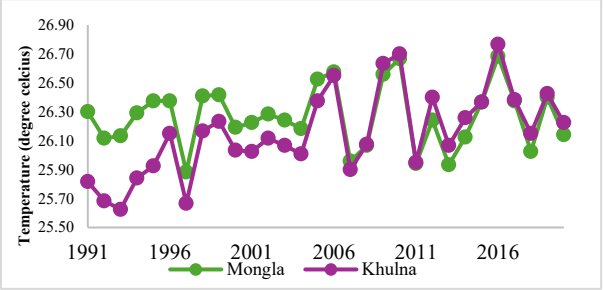


Figure 3: Average Temperature of Khulna and Mongla station (1990-2020)

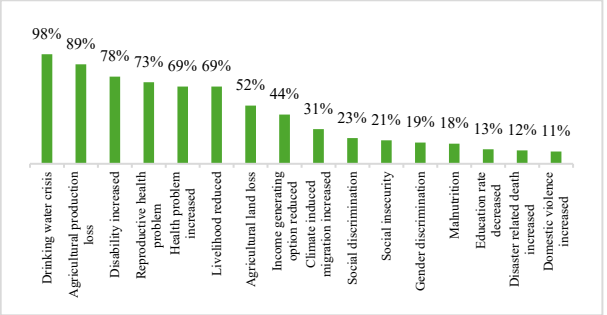


Climate Change and its Impact in the Study Area

Numerous facets of local livelihoods are impacted by the extensive and diverse effects of climate change in the study areas. The local population's life has already undergone tremendous changes because of climate change and disasters brought on by it. Notable inequalities and disturbances were noted in several areas, including water resources, agriculture, health, land use,

livelihood opportunities, and social dynamics. Reproductive health has become a significant concern because of climate change, especially because of increased salinity levels. About 89% of respondents expressed concern over declining agricultural productivity linked to the effects of climate change, and a significant portion of respondents reported difficulties getting access to drinking water during dry seasons. Furthermore, a sizable fraction of participants, comprising 69%, indicated a rise in health problems linked to climate change, whereas a similar 69% mentioned a reduction in employment prospects. 52% of respondents indicated that they had lost agricultural land because of salinity intrusion and climate change. Furthermore, the study found that there are fewer options for earning money because of climate change, with 31% of respondents mentioning an increase in migration brought on by the phenomenon. Surprisingly, 73% of respondents were women and adolescent girls, who expressed greater concerns about reproductive health disruptions brought on by climate-related disasters like salinity intrusion. Focus group discussions with women in Koyra and Paikgacha clarified a variety of reproductive health concerns linked to disasters caused by climate change. These included leucorrhea, Pelvic Inflammatory Disease (PID), Urinary Tract Infections (UTIs), low birth weight babies, premature delivery, infertility, recurrent pregnancy loss, compromised fertility, abdominal discomfort, obesity, complications during childbirth, and decreased sexual interest. Furthermore, social discrimination was also said to be increasing as a result of climate change, according to some respondents. These included increased gender discrimination, social insecurity, malnourishment, and domestic violence in their communities.

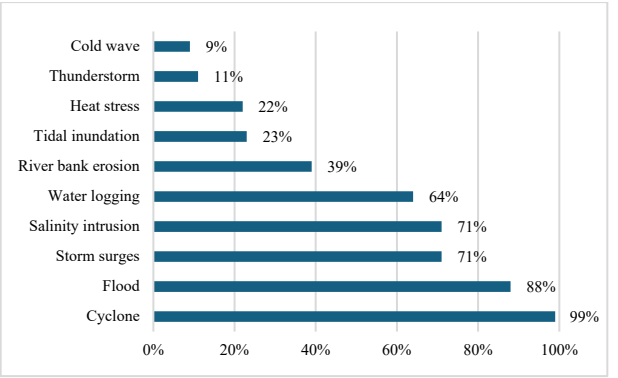
Figure 4: Impact of Climate Change in the Study Area



Climate Effects: Disasters in the Study Area

Cyclones are the most common climate-related disaster that affects their area, according to the vast majority of respondents (99%). Furthermore, flooding is the most prevalent disaster, according to 88% of respondents. Numerous additional climate-related hazards were also identified by the study. Tidal inundation and storm surges are also relatively frequent at 71%. Water logging occurs at a rate of 64%. Less frequent events include riverbank erosion (39%), heat stress (22%), thunderstorms (11%), and cold waves (9%).

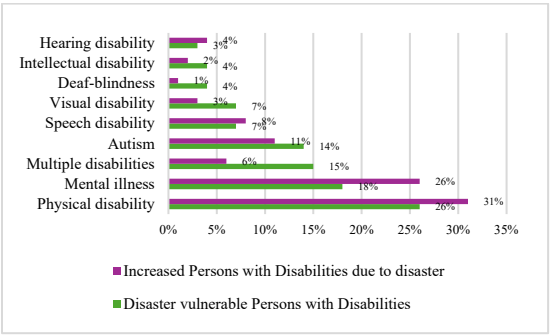
Figure 5: Climate induced disaster in the study area



Assessing Disaster Vulnerability Among Persons with Disabilities

Disasters brought on by climate change not only make people with disabilities more vulnerable, but they also increase the number of people with disabilities overall. Physical disability appears as the main factor linked to the effects of climate change in both cases. Disasters brought on by climate change not only make people with physical disabilities more vulnerable, but they also raise the overall number of people with disabilities in the study area. About two-thirds of respondents said that people with physical disabilities are more vulnerable to the negative impacts of disasters, and another third said that the frequency of physical disabilities is rising because of these events. Furthermore, as noted by 18% and 26% of respondents, respectively, mental illness emerged as the second most prominent type of vulnerability for people with disabilities who are vulnerable to disasters and those whose disabilities are exacerbated by disasters.

Figure 6: Climate change and disability nexus



Disaster Vulnerability Corresponding to Housing Structure

Disaster resilience at the household level is greatly influenced by the type of housing structure, especially for

individuals with disabilities who are frequently disproportionately affected by disasters. Houses built with concrete walls and floors tend to be the strongest, but the table shows that people of that region still have a relatively low percentage of concrete, potentially lowering their resilience. Conversely, materials like tin, commonly used in huts, offer little protection. This highlights how the type of materials and construction methods significantly impact how well a house can withstand a disaster. A worrying pattern in the population under study shows that a sizable majority of people with disabilities live in homes that are extremely susceptible to natural disasters. Only 8% of the households surveyed had concrete walls and floors, whereas 4% of the households had tin walls and concrete floors. This means that only a small percentage of homes are furnished with relatively sturdy building materials. On the other hand, it was found that a startling 88% of the households in each of the study area's four Upazilas had housing made of earthen materials or a mix of tin and hut, both of which are extremely prone to damage or destruction during disasters. This data emphasizes how urgent interventions to improve the housing infrastructure's resilience are needed, especially for people with disabilities, in order to lessen the catastrophic effects of disasters on communities that are already at risk.

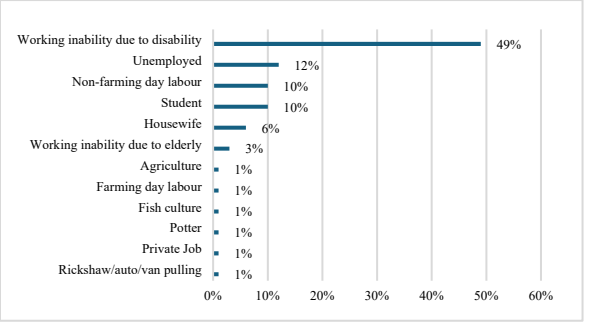
Wall	**Floor**			
	Concrete	Concrete	Earthen	Earthen
Concrete	8%			
Tin	4%			
Tin	34%			
Hut	54%			

Legend	
Low	
Moderate	
High	
Extreme	

Occupation of Person with Disabilities in The Study Area

In terms of occupation as well as employment, persons with disability are unemployed more than non- Persons with Disabilities and the study reveals that only 16% Persons with Disabilities are employed in different sectors including agriculture, fish culture, farming day labor, non-farming day labor, potter, rickshaw pulling and private job. Only 1% Persons with Disabilities is engaged with private job in all four studied upazila. Overall, the chart indicates that a significant portion are unemployed due to challenges related to their disability or age. Since the major focus of this study is to identify disability inclusive development opportunities and livelihood program design in the aftermath, the study team also tried to shed light on occupation or earning potentials for the persons with disability throughout the study locations.

Figure 7: Occupation of Persons with Disabilities

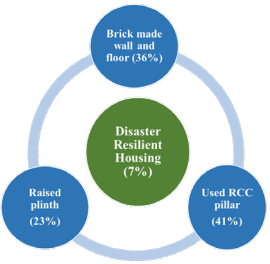


Disaster Resilient Housing

Bangladesh is highly vulnerable to natural disasters which cause widespread damage to infrastructure and homes, displacing people and impacting livelihoods. Disaster-resilient housing in BD incorporates features to minimize damage and ensure the safety of residents

during these events; **houses should be built to withstand disasters (disaster-resilient housing) and come with special features to keep people safe. These features include raising the house up off the ground (elevated foundations) and using stronger materials for the walls and roof, like concrete, reinforced brick, or special materials designed to handle cyclones. This makes the whole house much stronger.** It was found that only 7% houses are disaster resilient in the study area which is aligned with construction materials of houses. Whereas 8% houses are made of total concrete on wall and floor, 7% houses are found disaster resilient. Among these, raised plinth (23%), prepared wall and floor with bricks (36%) and RCC pillar made wall (41%) are found as disaster resilient houses in the study area. During the FGD with the community people of Mongla and Dacope, it was found that the houses which are made of concrete on floor and wall are safe from wind and storm surges as well as flooding.

Figure 8: Disaster resilient housing

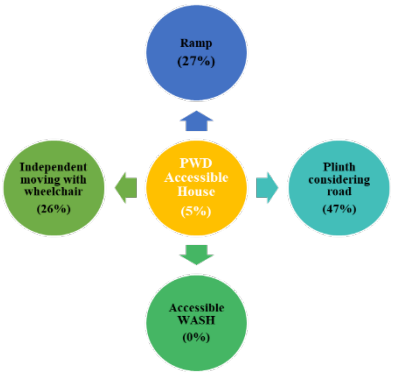


Persons With Disabilities Friendly Housing

The purpose of disability-friendly housing is to lower barriers and encourage self-sufficient living for people with a range of physical, sensory, or other impairments. Housing with features such as ramps, WASH

accessibility, and physical accessibility to allow independent wheelchair movement is adapted or intended to be comfortable and accessible for individuals with disabilities. 5% respondent said that their houses were accessible for People with Disabilities. Out of 5% respondents who have PWD accessible housing, among of them 47% respondents mentioned that they built their house plinth considering the road height. Out of this 5%, 27% respondents said that their houses were accessible for Persons with Disabilities because they had a ramp in their house. 26% of total 5% respondents mentioned that the Persons with Disabilities could independently move with wheelchair. But the main fact is one has the PWD friendly WASH facilitates in their household level **(Figure 9)**. For that reason, they thought their houses were accessible for Persons with Disabilities.

Figure 9: Persons with Disabilities friendly housing

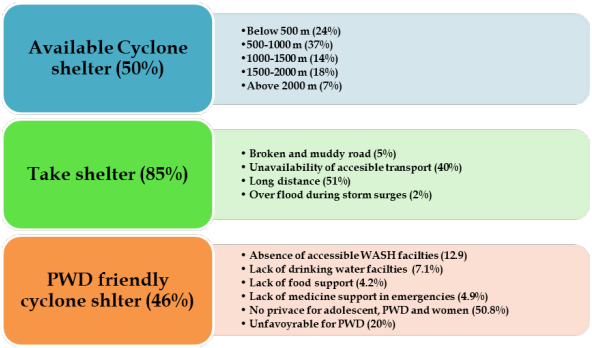


Status of Cyclone Center

It is critical to guarantee that cyclone shelters are handicap accessible in order to give individuals with disabilities appropriate housing and protect their safety during cyclonic events. The study's conclusions, however, point to a troubling dearth of suitable cyclone shelters in the study area that meet the needs of

vulnerable groups, such as people with disabilities. While half of the respondents indicated that there were cyclone shelters in their area where people could go to seek safety during cyclones, it is interesting to note that most of these shelters are located quite a distance away from the communities that are at risk. Due to this geographic difference, it may be difficult or impossible for people with mobility impairments or other disabilities to get to these shelters during an emergency. This presents a serious challenge for people with disabilities. The lack of accessible and well-located cyclone shelters increases the vulnerability of individuals with disabilities during cyclonic events. This highlights the pressing need for focused interventions to close this critical gap in disaster preparedness and response efforts. Only 24% respondents mentioned that they have cyclone center within 500 meters distance and 34% respondents mentions that they have cyclone center more than one-kilometer distance. 85% of respondents out of 50% who have cyclone center take shelter during cyclone center but instead of existence of cyclone center in the locality, 5% people don't take shelter because of broken center and muddy road whereas 40% don't take shelter because of unavailability of accessible transport during cyclone and 51% don't take shelter because of long distance. Most of the people (54%) who take shelter in the nearby cyclone centers mentioned that cyclone centers are not friendly for persons with disability because there are not accessible WASH facilities, lack of drinking water facilities, Persons with Disabilities friendly space, food support during emergency, lack of medicine support in emergencies, no privacy for adolescent, Persons with Disabilities and women

Figure 10: Overview of Cyclone shelter



5. Discussion

In the context of Bangladesh's coastal zones, the study's findings highlight the connections between the effects of climate change, disaster vulnerability, and disability inclusion. Data from meteorological stations in Khulna and Mongla show trends in temperature and rainfall caused by climate change, which shows a pattern of rising temperatures accompanied by rising precipitation levels, indicating the region's susceptibility to climate-related hazards. Significant effects of these climate shifts have been seen on local livelihoods, with disruptions seen in several areas, such as agriculture, health, and water resources. Notably, reproductive health became a major issue that was made worse by higher salinity levels, affecting not only people with disabilities but also the general public. The study also emphasizes how people with disabilities are disproportionately affected by climate-related disasters, with physical disabilities being recognized as a key vulnerability factor. It was discovered that the housing units occupied by individuals with disabilities were especially vulnerable to natural calamities, underscoring the pressing necessity for resilient infrastructure. Even though there are cyclone

shelters, people with disabilities still face significant challenges during emergencies due to their remote location and lack of accessibility, which highlights a critical gap in disaster preparedness and response efforts. The study furthermore highlights the heightened vulnerability of people with disabilities (PWDs) to climate-induced disasters. Their limited mobility and dependence on specific assistive technologies can be significantly impacted by damaged infrastructure during events like floods or cyclones. The lack of disability-friendly features in housing and public infrastructure are concerning. This creates additional barriers for PWDs during everyday life and further hinders their ability to evacuate or access support during disasters. The consideration of plinth height, ramp, accessible WASH, wheelchair movement independence in housing design demonstrates the community's awareness of disaster risks. Integrating such considerations into broader infrastructure planning, from shelters to evacuation routes, is crucial. Building climate-resilient infrastructure in Bangladesh cannot be achieved without ensuring its inclusivity for PWDs. By integrating their needs into every step of the planning and construction process, we can create safer and more dignified living environments for all coastal communities, fostering a more resilient future in the face of climate change. Promoting neighborhood-based projects to construct handicapped-accessible cyclone shelters is advised as a solution to these problems, highlighting the significance of inclusive infrastructure development in boosting resilience and guaranteeing the safety and inclusion of all community members, especially those with disabilities, in the event of disasters brought on by climate change.

6. Conclusion

In conclusion, this study clarifies the intricate intersections between the effects of climate change, the susceptibility of coastal Bangladesh to disasters, and the inclusion of people with disabilities. The study clarifies the growing susceptibility of nearby communities to climate-related hazards like floods and cyclones through an examination of climatic trends. In addition, the fact that people with disabilities are disproportionately affected by these disasters emphasizes how urgent it is to develop inclusive infrastructure. As the study's results demonstrate, infrastructure accessibility for people with disabilities is still a major challenge in Bangladesh, despite the country's development progress. People with disabilities are more vulnerable during disasters because they frequently lack resilient housing and sufficient infrastructural support. The study recommends the adoption of disability-friendly policies and strict oversight of their implementation to address these issues. Additionally, it highlights how crucial community-based projects are to the construction of handicapped-accessible cyclone shelters, guaranteeing the security and inclusion of every member of the community. Going forward, coordinated efforts are required to close the gap that exists between policy intentions and practical implementation, fostering resilient and inclusive infrastructure that meets the various needs of every person—including those who have disabilities.

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Multi-Hazard Vulnerability Assessment and its Impacts on Kishoreganj District

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Abstract:

This multi-hazard vulnerability assessment aims to comprehensively evaluate the susceptibility and potential impacts of various hazards in the Kishoreganj district, Bangladesh. The evaluation considered a range of hazards including heavy rainfall, floods, flash floods, erosion of riverbanks, heat waves, cold waves, and thunderstorms, and examines how they interact and composite to affect the district's social, economic, and livelihood aspects. This evaluation, which takes a multidisciplinary approach, uses geospatial analysis, sustainable livelihoods assessment qualitative or quantitative data collection, and community viewpoints to comprehend the vulnerabilities in the district. The findings show that most of the Unions of Itna and Mithamoin area are vulnerable to various dangers due to their geographical location, topography, and socio-economic variables. The disaster frequency is gradually increasing. Riverine and flash floods inundate extensive agricultural lands regularly, disrupting livelihoods and increasing food insecurity. Riverbank erosion, hailstorms, increasing trend heat waves, and cold waves

endanger settlements, resulting in population displacement. Moreover, these risks not only have an impact on livelihoods but can worsen disease and reduce the availability of drinking water.

The assessment also highlights how vulnerable populations, including women, children, and members of disadvantaged communities, are disproportionately affected by hazards. It emphasizes the need for inclusive and targeted interventions to address their specific vulnerabilities and boost resilience.

Keywords: Vulnerability Assessment, livelihood, Gender, Health, Was

Introduction:

Bangladesh's geographic and geophysical location makes it one of the most vulnerable countries affected by climate change.

South Asia's climate is changing, and the impacts are already being felt. (IPCC, 2022). Based on data from 2000 to 2019, the Climate Risk Index (GCRI) reports that Bangladesh lost 11,450 people, suffered economic losses worth $3.72 billion, and witnessed 185 extreme weather events from 2000-2019 due to climate change (GCRI, 2021). The country is experiencing the effects of climate change through a variety of disasters, including frequent floods, cyclones (including frequency, intensity, and seasonality) thunderstorms, torrential rain, salinity intrusion, rising temperature, erratic precipitation, sea level rise (Sattar et al., 2020). This Haor region is also a very endangered area with diversified problems shortage of food, and damage due to floods, erosion, excess rain, and loss of land (Islam et al., 2020). In the Kishoreganj haor region, natural disasters have increased due to climate change such as flash floods, soil erosion, heavy rainfall, drought, storm surges, etc. Large, spherical

floodplain depressions known as haor areas frequently experience floods because of extreme events like heavy upstream rainfall. Because of changes in rainfall and temperature patterns, regions are anticipated to undergo more stress increases in the years to come. (Nowreen et al., 2014). Pre-monsoon flooding in April and May raises the risks within the region's economic, social, and environmental sectors and results in the loss of crops during the entire year (Suman & Bhattacharya, 2015). The main objective of this study is to explore hazard multi-hazard vulnerability and the impact of climate change on the livelihoods of the communities in Itna and Mithamain Upazila**.**

Methodology:

2.1. Study Design

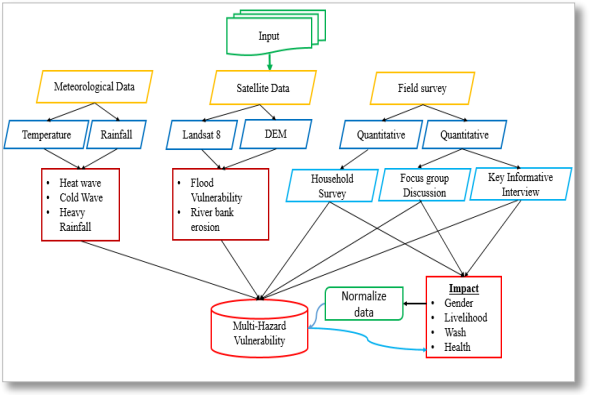
The study employed a participatory, multi-disciplinary approach, utilizing mixed methods encompassing both qualitative and quantitative data. Data collection methods included Household Surveys (HHS), Focus Group Discussions (FGD), and Key Informant Interviews (KII). Quantitative data was gathered from 399 households across two districts through HHS, comprising 150 male-led households, 150 female-led households, 75 youth-led households, and 24 households led by People with Disabilities (PWD). In addition, 30 community members—15 men and 15 women—participated in 12 focus group discussions (FGDs) that included farmers, fishermen, boatmen, small traders, and livestock farmers. Two FGDs were held in each Upazila.

Furthermore, the study employed multi-hazard risk assessment and resource mapping using GIS, with Landsat satellite images obtained from the U.S. Geological Survey Earth Explorer interface for land

cover mapping in 2022. A Multi-Disaster Vulnerability Index was developed, categorizing respondents' perceptions into high, medium, and low vulnerability, validated against the national disaster vulnerability database. Based on participant perceptions, a Composite Disaster Impact Matrix was constructed, normalizing responses across various factors such as domestic violence, gender discrimination, agricultural production loss, employment opportunities, water quality, reproductive and physical health, disability, and agricultural land loss, categorized into four impact sectors: Gender, Livelihood, WASH (Water, Sanitation, and Hygiene), and Health.

In addition to primary data collection, the study utilized secondary data obtained from sources including the Bangladesh Meteorological Department (BMD), and the Department of Disaster Management (DDM). The secondary data was gathered to supplement the original data and offer more background information for disaster management and hazard analysis.

Figure 1: Approaches and Methodology



2.2 Study Area:

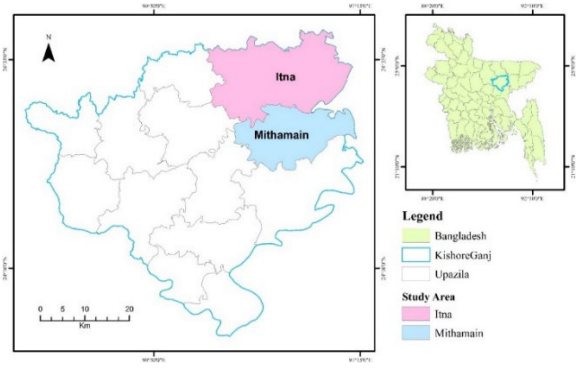
There are 423 haors in Bangladesh, spread over seven districts, including the north-central Kishoreganj district, which is impacted by climate change (Islam et al., 2020; Nath et al., 2010).

Agriculture is the main source of income for the people living in the district, employing 61,47% of the workforce (BBS, 2021) compared to 53.67% of the total haor area's population.

Generally, the population in Kishoreganj is mainly dependent on natural resources such as agricultural land for livelihoods. However, this district is a disaster vulnerable area characterized by problems like reduced crop production and livelihood opportunities, food shortage, and economic damage from water, sanitation, and housing infrastructures due to floods, erosion, and loss of land.

In the Kishoreganj district, the effects of climate change are directly felt on livelihood, fishery resources, crop output, and fish habitat (Ahmed, 2012). Rising temperatures, storm surge damage, wetlands loss, altered crops and livelihood patterns, decreased agricultural production, decreased biodiversity, and harm to community infrastructure are all results of climate change in the Kishoreganj district (Adger et al., 2005; Westlund, 2007).

Figure 2: Study Area



2.3 Qualitative Method

The study incorporated FGD with the local vulnerable community to identify and assess the Multi-Hazard Vulnerability.

Table 1: Quantitative Method of Data Collection

Participant Group	**Number of FGDs**
Farmers	2
Fisherfolk	2
Boatmen	2
Small Traders	2
Livestock Rearers	2
Total	**12**

Twenty Key Informant Interviews (KIIs) with representatives from the Department of Agriculture Extension (DAE), Department of Public Health Engineering (DPHE), District Relief and Rehabilitation Officer (DRRO), Project Implementation Officer (PIO), BDRCS NHQ, Department of Social Service (DSS), and Department of Women and Children Affairs (DWCA) were conducted to obtain information about current

climate vulnerability scenarios and significant issues of community resilience for the residents of the studied area.

2.4 Quantitative Method

The study's quantitative methodology is covered in this section. To choose participants for a household survey, a non-probability sampling technique called convenience sampling was employed. Two areas and 399 participants in total were surveyed.

2.4.1 Sample Design

Numerous sampling strategies, such as convenience, purposive, and non-probability sampling, were used in the study. The researcher used convenience sampling, a type of non-probability sampling, to choose units for the sample based on how easily accessible they were (Rahman et al., 2023). Cochran sample size formula was used to calculate the sample size (Cochran, 1977):

$$n_0 = \frac{Z^2 pq}{e^2}$$

Where,

- e is the desired level of precision (i.e. the margin of error),
- p is the (estimated) proportion of the population that has the attribute in question,
- q is 1 – p.

$$n_0 = \frac{(1.96)^2 \text{ X } 0.5 \text{ X } 0.5}{0.5^2}$$

$$n_0 = 385$$

Considering a non-response rate of 3.5% the sample size was determined. So, the non-response was found as,

$$n = 385 \text{ X } 3.5\%$$

$$n = 14$$

So, the new sample size would be,

$$N = n_0 + n$$

$$N = 385 + 14$$
$$N = 399$$

2.4.2 Sample Size and Data Collection

About household leadership types, the quantitative sample size distribution table offers a succinct summary of the households that were surveyed for the study. The sample consisted of 399 households in total, evenly distributed among the different leadership categories. There were 24 households headed by people with disabilities (PWD), 150 households led by females, 75 households led by youth, and 150 households led by males. A thorough examination of the research objectives across various demographic groups is made possible by this systematic distribution, which guarantees a thorough representation of a wide range of household compositions.

Table 2: Sample Size of Data Collection

Household Type	**Number of Households**
Male-led	150
Female-led	150
Youth-led	75
People with Disabilities (PWD)-led	24
Total	**399**

2.5 Data Analysis

Data analysis employs a comprehensive and multidisciplinary methodology to derive significant insights from the collected data. Quantitative data from household surveys is first statistically evaluated to find patterns, trends, and connections among various demographic factors like household leadership, socioeconomic status, and vulnerability indicators.

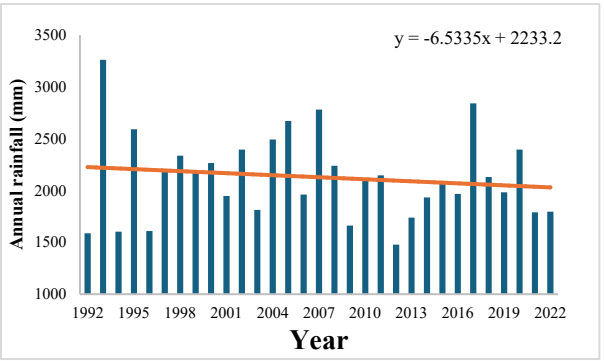
Descriptive statistics approaches are used to summarize and show the quantitative data in an intelligible manner. Thematic analysis is carried out concurrently on the

qualitative information gathered from key informant interviews and focus groups. To improve the quantitative results and provide context, this technique finds and analyzes recurring themes, viewpoints, and storylines. Furthermore, the distribution of resources, vulnerabilities, and hazards in the research region is depicted and evaluated geographically using spatial analytic tools like GIS mapping. The research aims to provide a comprehensive knowledge of the complex interactions between gender, the environment, and socioeconomic factors by utilizing this multidisciplinary analytical approach. This will make it possible for it to support initiatives and evidence-based policy recommendations that enhance community resilience and well-being.

1. Climate Change in Kishoreganj District

During the monsoon season, approximately 80% of the 5,900 mm of total rainfall happens. (BMD, 2021). However, the district's time series analysis of annual rainfall patterns over the years 1992–2022 revealed that both of these metrics exhibit a decreasing trend in Kishoreganj (**Figure 3**).

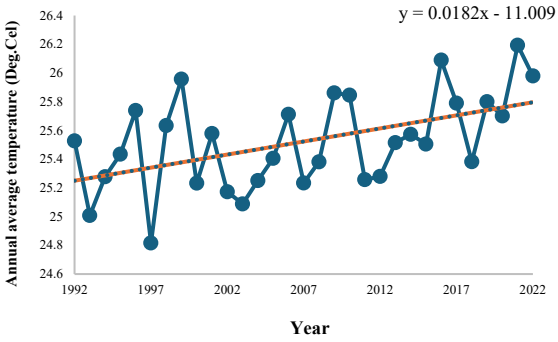
Figure 3: Annual Rainfall (mm) Distribution (1992-2022)



1.1. Temperature:

The average maximum temperature and average minimum temperature also showed increasing trends last 30 years **(Figure 4).**

Figure 4: Average Temperature (Deg. Cel) 1992-2022



1.2. Climate Extreme Components Vulnerability in Kishoreganj District

1.2.1. Heavy Rainfall

The data analysis indicates that the number of days with heavy rainfall is increasing in the Kishoreganj district, although there has been significant variation in this number from year to year.

Over the years, the frequency of heavy rainfall days has fluctuated. In 1990, there were approximately 37 heavy rainfall days. By 1995, this number had decreased to about 23 days. However, in 2007, the frequency increased significantly to around 43 heavy rainfall days. More recently, in 2021, the number stabilized at approximately 38 heavy rainfall days **(Figure 5)**. In the Kishoreganj district, the seasonal distribution of rainfall has also altered over time.

Figure 5: Number of Heavy Rainfall Days 1990-2020

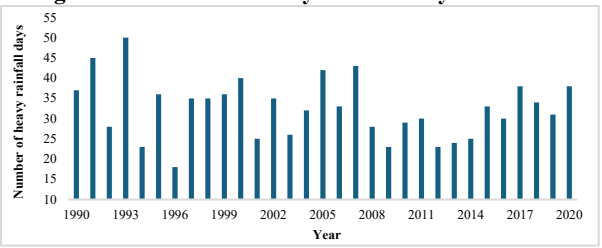
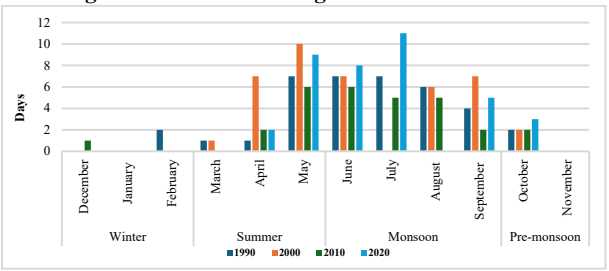


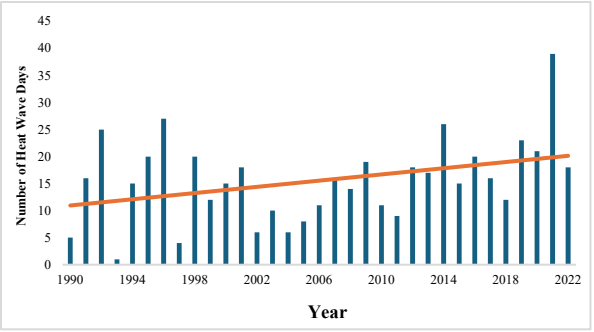
Figure 6: Seasonal Changes of Rainfall Pattern



1.2.2. Heatwave:

Heat waves increased in the Kishoreganj district **(Figure 7) during 1990-2022.** Two days of sudden, intensely hot air that swept across the country for two consecutive days in early April 2021 disrupted the rice's growth and destroyed the crop (Thomson Reuters Foundation, 2021).

Figure 7: Number of Heat Wave Days (1990-2022)

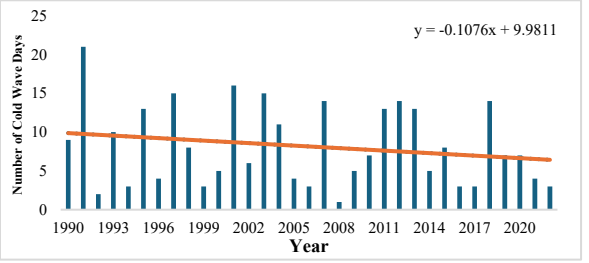


1.2.3. Cold wave:

Historically, Bangladesh has experienced many cold waves that have severely damaged agriculture, interfered with communications, and caused extensive suffering and deaths among impoverished and marginalized groups from illnesses related to the cold.

(Hasan et al., 2024). According to Health Directorate sources, 14 children died in 2006 in the northern Kishoreganj district. (Relief Web, 2006). According to the FGD, a mild cold wave is now a common scenario in the Kishoreganj district. However, **Figure 8** represents the decreasing trend of cold waves in Kishoreganj district

Figure 8: Number of Cold Wave Days (1990-2022)

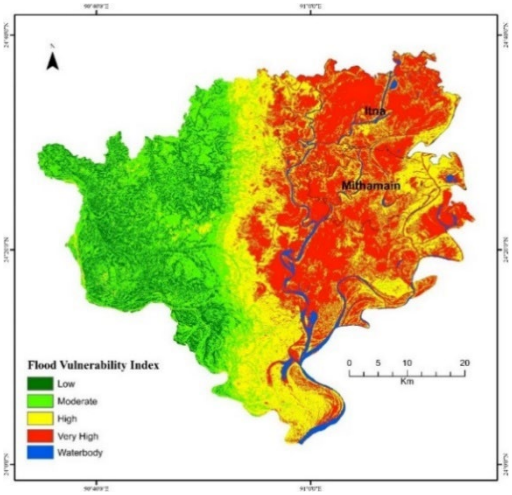


1.2.4. Flood vulnerability:

Flooding is a common phenomenon in the haor areas, and almost every year, people experience seasonal and flash floods. The Haors areas are suitable for *boro* rice cultivation, but early flash floods often wash away standing crops, and people lose their harvest. Early floods, hailstorms, and drought are the main constraints to growing modern *boro* rice (Kamruzzaman & Shaw, 2018). Early flash floods in Haor areas result from climate change, which has a destructive impact on agricultural productivity, natural fish breeding, land use practices, lifestyles, and livelihoods (Azizul & Kabir,

2022). The agricultural damage is causing a serious impact on the country's national economy. The flood vulnerability map **(Figure 9)** illustrated that Itna and Mithamain upazilas fall in a very high-risk flood-vulnerable zone. The red color represents the high-risk zone and the green color represents the low-risk zone.

Figure 9: Flood Vulnerability



1.2.5. River bank erosion

Seasonal monsoons, flash floods, and heavy rainfall are natural phenomena that significantly contribute to river swelling. These events increase water flow and accelerate erosion along vulnerable riverbanks. Approximately 1,000,000 people are affected by river erosion and 9,000 hectares of cultivable land are lost (Government of Bangladesh, 2014). Around 47 sq. km. of erosion occurred in the Kishoreganj district during the past 30 years. **(Figure 10 & Figure 11).**

Figure 10: Erosion and Accretion of Kishoreganj district

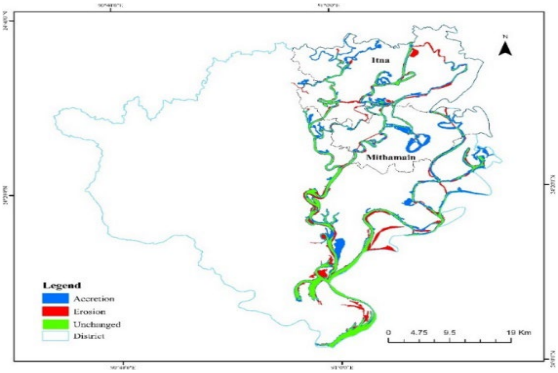
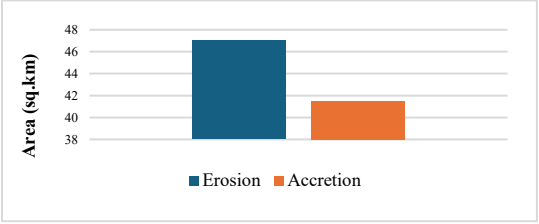


Figure 11: Erosion and Accretion Trend (1992-2022)

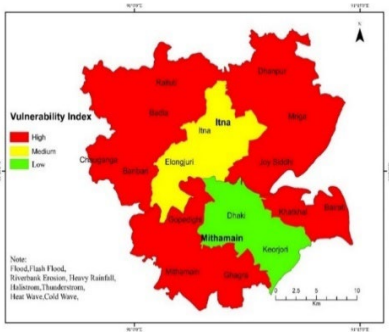


Result & Discussion

1.3. Multi-Disaster Vulnerability Analysis of the Study Area

Based on the **Multi-Disaster Vulnerability Index** assessment (**Figure 12**); Chauganga, Joysiddhi, Dhanpurn, Badla, Baribari, Mriga, Raituti, Khatkha, Gopedighi, Ghagra, Bairati, Dhaki, Mithamain unions of the study area are highly vulnerable to various hazards. Meanwhile, Itna and Elongjuri unions are medium-vulnerable. The rest of the unions like keorjori and Dhaki in the study area are low vulnerable. To consider resilient interventions, highly vulnerable unions based on multi-hazard exposure should be the top priority.

Figure 12: Multi-Disaster Vulnerability



According to the respondents' perceptions, this study observes a discernible trend over the past five years within the study area. Floods, flash floods, heatwaves, riverbank erosion, and thunderstorms have exhibited an increasing occurrence, while incidences of waterlogging, drought, wave erosion, and hailstorms have shown a decreasing tendency **(Table 3)**. The District Relief and Rehabilitation Officer (DRRO) of the Kishoreganj district also noted that thunderstorms are becoming a threatening hazard for the Haor area, including Kishoreganj.

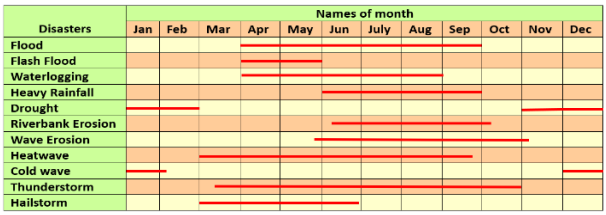
Table 3: Disaster Trends in the Study Area

Disaster	The trend in 2018-2022
Flood	
Riverbank erosion	
Waterlogging	
Heavy Rainfall	
Drought	
Flash Flood	
Wave erosion	
Cold wave	
Heat wave	
Thunderstorm	
Hailstorm	

Increased	
Decreased	

Almost all year, the study area is vulnerable to different disasters. In general, the Haor region is flooded from June-August. But according to FGD participants they mentioned that in recent years, flash floods start in late March and have prolonged up to May. On the other hand, during the dry and summer season (November, December and January, February), haor people suffer from drought **(Figure 13)** The FGD participants from three Upazilas noted drought hampers water availability and agricultural production during summer and winter seasons. For example, they mentioned that they could not irrigate their cropland or extract water from tubewell for drinking and domestic purposes.

Figure 13: Hazard calendar in the study area



Climate Impact and vulnerability of climate change

The effects of natural disasters and climate change have environmental and socio-economic impacts on the people living in the affected areas. Based on the perception of respondents, a Composite Disaster Impact Matrix was developed by normalizing the participants' responses into Four impact sectors, including Gender (domestic violence, abandoned women, gender discrimination); livelihood (agriculture production loss, land loss, employment opportunity,); WASH (water availability, water infrastructure, sanitation infrastructure); health (reproductive health, physical health, disability, death, mental health) (**Table: 4**).

Table 4: Disaster Impact Metrix

Upazila	Gender	Livelihood	WASH	Health
Itna				
Mithamain				

Index	Vulnerability
	Low
	Medium
	High

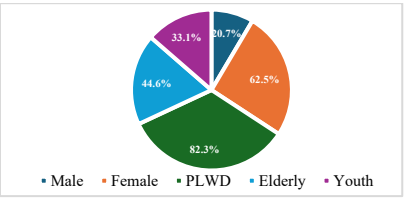
Climate Change Impact on Gender

Looking first at the findings on gender, FGD participants reported that domestic violence, abandoned women, and gender discrimination have increased. Women are facing many deprivations and inequities. Climate change was seen to affect women disproportionately due to their already weak position in society and limited or lack of earning capacity, physical and biological barriers, and religious barriers, lack of control of resources and property rights, leaving women to face more severe issues of food insecurity, water, and health problems, injury and death due to climate disasters. Women don't leave their houses during catastrophes because it is culturally and religiously inappropriate. As a result, during floods, the women's death toll is higher than men. Poor women, who control homestead-based livelihoods, lose income and suffer from chronic malnutrition when homestead vegetable production beds and livestock houses are washed away. Not only so, but also climate-induced disasters increase the malnutrition of women because disasters reduce food availability. As a result, women have limited access to food because they have the liability to feed male counters and children. Floods also increase women's workload regarding repairing homesteads and collecting drinking water. Floods destroy drinking water sources, so women must collect drinking water from long distances. Sometimes, women face gender-based violence to collect water from a far distance.

The climate change impacts also enhance human displacement and migration, where women and children suffer the most. Most female-headed households resulted from women becoming widowers or being left by their husbands. Families headed by women and single mothers were seen as more vulnerable than male-headed families. 88.5% of the respondents believed that female-headed families suffer more from climate extremes because they cannot quickly move to safe places during the flood. The FGD participants reported that because of limited income, they could not preserve food medicine and didn't have savings for emergency risk recovery. Most of the women migrate to brick field to work as cooking staff. In the brick fields, the migrated women face sexual violence.

(Figure 14) represents a breakdown of different vulnerable groups at the household level: PLWDs, male, female, youth, and elderly, based on the perceptions of the community members who participated in the household survey. PLWDs were believed to be the most vulnerable group at the household level (82,3% of respondents answered that they viewed the group as susceptible to climate changes), followed by women (62,5%) and the elderly (44,6%).

Figure 14: Household-level climate vulnerable group

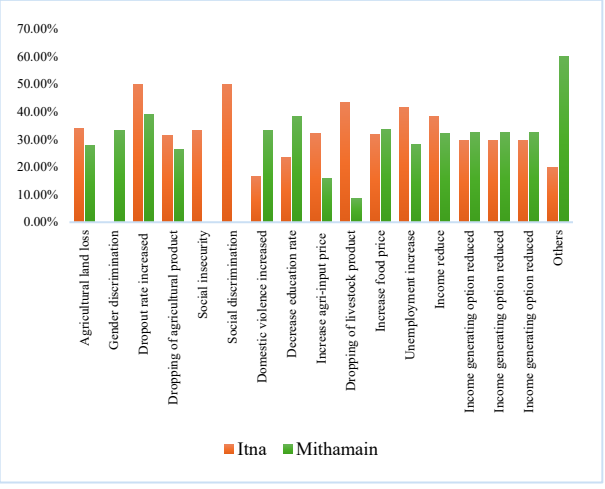


Climate change Impact on Agriculture and livelihoods

Climate-related disasters, lower crop yields, degradation of arable land, and deterioration of public resources such as water and fisheries drive smallholder and subsistence

farmers to work as day laborers and experience a sharp decline in income. (**Figure 15)** illustrates that the primary causes of the destruction of livelihood opportunities are land loss, shrinking employment opportunities, loss of agricultural production, and a decrease in the availability of livelihood options as a result of climate-induced hazards like heavy rains, floods, water logging, and land erosion. Nearly every respondent in the HHS and FGD raised this issue, emphasizing the yearly harm that crops and homestead farming sustain from monsoons and floods. Conversely, sources also clarified that inadequate irrigation water poses a problem to crop productivity in the summer.

Figure 15: Disaster Impact on Livelihoods



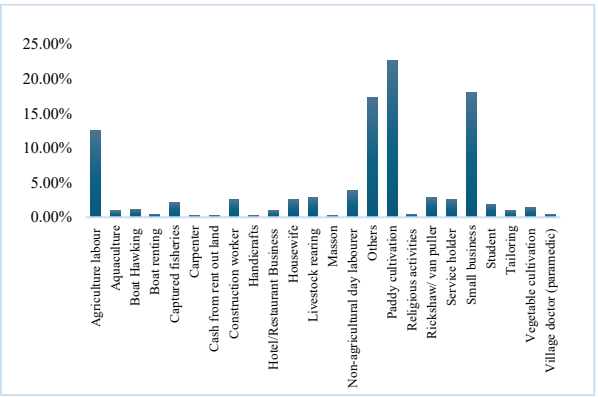
Occupation

Climate-related disasters raise health risks, significantly lower income, diminish crop yield, degrade agricultural land, and limit access to natural resources like fish and groundwater due to their depletion. The majority of the time, PLWDs and poorer women suffer greatly. People who are underprivileged, particularly those who work

directly in agriculture and crop production, frequently face dangerous circumstances that endanger their lives. The respondents claim that because they are unable to extract groundwater to irrigate their crops during this time, crop productivity is limited by increased soil dryness and fewer irrigation opportunities in the winter and summer. Farmers' livelihoods are hence unsecured.

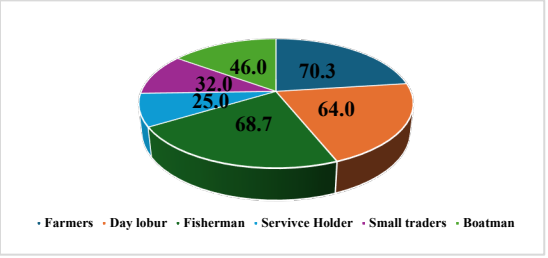
More than 40% of the crops are damaged during the monsoon because there are no fields for processing and drying collected products, according to the farmer FGD participants from two Upazilas. Because they happen before crop harvesting, early floods also reduce crop productivity. Furthermore, due to the delayed planting caused by late floods, crop productivity is also hampered. The respondents also raised the issue of people having to plant paddy at the appropriate time due to flood-related inability to buy seedlings. Because of this, most of the year, even though September is the ideal time to plant—they are unable to do so due to flooding, and the delay continues until November. Delays in the planting phase cause cold waves that hinder paddy development and reduce yield. However, during this period, heavy rain, flooding, and attacks by insects referred to as "current insects" in the area impede productivity.

Figure 16: Sources of Occupation



Based on the questionnaire responses, the study also identified various occupational groups that were considered vulnerable. It was discovered that farmers (70.3%) were considered the most vulnerable group because their work and income are constantly impacted by various types of climate extremes, such as heat waves, droughts, floods, and droughts. While 64% of respondents said that day laborers were vulnerable to climate change, 68.7% of respondents said that fishermen were especially vulnerable. In keeping with this, FGD participants from the fisherman group mentioned that they don't have any opportunity to fish during the dry season. They do have the chance to fish during the rainy season, but their options are restricted because of haor leasing. However, their ability to fish is limited by floods and high winds. Service holders were deemed the least vulnerable occupational group due to their fixed income and consequent year-round ability to purchase food.

Figure 17: Occupational vulnerable group



Agriculture

The study also demonstrates climate-induced calamities, including cold waves and fog, groundwater depletion, floods, severe rainfall downright damaging agriculture, homestead farming, etc. **Table 5** is developed based on the opinion of the studied people and finds that in the study area homestead vegetables and rabi crops (winter crops) are vulnerable because of cold waves and fog.

Groundwater depletion restricts homestead vegetable farming though rabi crops are under threat because of groundwater depletion. Homestead vegetables are fully vulnerable to flooding. Rabi crops (winter crops) are moderately vulnerable to floods (in terms of flash and late floods).

Table 5: Impact of climate-induced disasters on agriculture

Vulnerable sectors	Cold waves & fog	Groundwater depletion	Flood	Heavy rainfall
Homestead vegetable				
Rabi crops				
Livestock				
High				
Medium				
Low				

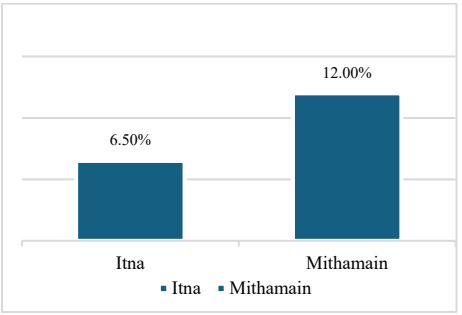
The increasing trend of temperature increases the rate of dryness in soil. It decreases water availability for irrigation, livestock, and drinking during the dry season and restricts crop production during summer and winter. The information provided by the study participants in the household survey and focus group discussion (FGD) shows that early floods damage crop fields and destroy crop production. In addition, late downpours also hamper farming. Usually, October is the month of planting the main crop (paddy) in the study area, but late flood delays planting. As a result, pests and diseases attack crops, reducing production yield. The damage is sometimes reinforced by heavy fog and cold waves. Cold waves and heat waves also increase diseases in livestock and poultry. During summer and winter, the informants cited that many livestock (cattle, goat) and poultry (hen, duck) die from diseases. However, there is no specialized veterinary support from the government or non-government sector. As a result, most livestock farmers

depend on local unskilled veterinary medicine sellers, which causes more livestock death toll. Consecutive crop and livestock production failure has decreased the employment rate amongst smallholders who experience limited access to food and suffer from seasonal hunger. Reduction of livelihood options and food insecurity causes poor nutrient intake for climate-vulnerable people, which leads to poor health and lessened immunity.

Migration

Day by day, livelihood options are shrinking, and as a result, seasonal migration is on the rise as people search for new livelihood opportunities. The study found that the seasonal migration from the study area is 12% (out of 399 respondents) which is highest in Mithamain and 6.50% from Itna upazila. **(Figure 18)**. The participants of FGD in Mithamain mentioned that mainly male family members undertake migration to primarily urban areas, especially Dhaka and Chittagong, to secure livelihoods in the informal sector like rickshaw pulling, hawking, vendor, van pulling, etc. However, the male FGD participants from all three Upazilas noted that they could not afford household expenses with this income. Because they work hard with low income and also need to pay for their purpose, they cannot send enough money for their household expenses.

Figure 18: Migration Pattern



Impact of Climate Change on Health

Climate change-induced hazards are not just about flash floods, river floods, cyclones, and riverbank erosion; changing and erratic weather patterns have also affected the people in the study area's physical and mental health. The evolving climatic conditions have had detrimental effects on people's physical and psychological health, increasing the prevalence and variation of infectious diseases and mental health issues such as depression and anxiety disorders. The study reveals that diseases, especially waterborne diseases, malnutrition, and neglected health and sanitary systems in the study area, are common phenomena. Due to drinking and bathing in polluted water, most women and adolescents

suffer from reproductive health problems. During the dry season, most women don't wash (or wash in contaminated water) their clothes used for menstruation because they lack fresh water. Heat stress and cold waves also increase hypertension among community members, especially newborn babies and the elderly. About 98% of respondents suffered from fever and 77% from cold, followed by 47% and 41%, respectively, from hypertension and diarrhea. 6% of women and adolescents suffer from reproductive health problems, which the respondents mentioned (**Figure 20**). During the Focus Group Discussion with women and Key Informant Interview with UHC, it was found that Early or delayed menarche, Infertility or compromised fertility (pregnancy), recurrent pregnancy loss, pregnancy compromise, congenital disabilities, congenital abnormalities, and low birth weight babies, premature delivery, Leucorrhea, Pelvic Inflammatory Disease (PID), Urinary tract infection (UTI), Abdominal Discomfort, are a major reproductive health problem.

Figure 19: Suffer from Diseases

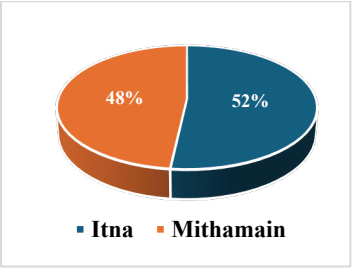
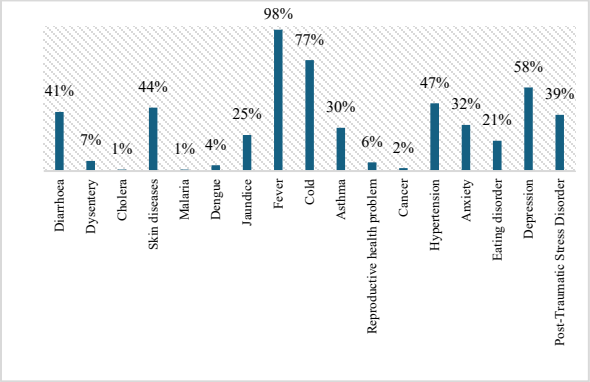


Figure 20: Disease Types Suffered by Respondents

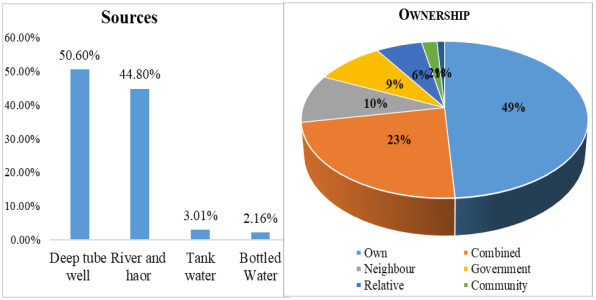


Impact of climate change on WASH

WASH infrastructure damage is a common scenario in the study area, making this sector the most vulnerable. Floods and erosion are mainly liable for WASH infrastructure damage because floods wash away and submerge the infrastructure. Also, water pollution is a usual scenario in the haor area; almost all toilets become submerged during floods, causing water pollution. Floods and flash floods, the regular occurrences in the study area, mainly affect the safe water availability and sanitary system. During monsoons, an increase in infectious diseases is usually associated with severe flooding and a breakdown in the sanitation system. On the other hand,

during the dry season (summer and monsoon), people don't have access to drinking water due to groundwater depletion and drying up Haor. About 50% of respondents depend on deep tubewell for drinking water, but 44.80% get drinking water from the river and Haor. Other sources, like reserved tank water (rainwater harvesting) and bottled water, are drinking water sources **(Figure 21)**. The participants of the FGD in all three Upazilas mentioned that the people with the financial capacity drink bottled water around the water. As a result, those people don't suffer from waterborne diseases. Only 49% of the respondents have their drinking water sources like deep tubewell, rainwater, and harvesting systems. The remaining respondents (51%) depend on neighbors and public and relative drinking water sources to meet their demands **(Figure 21)**.

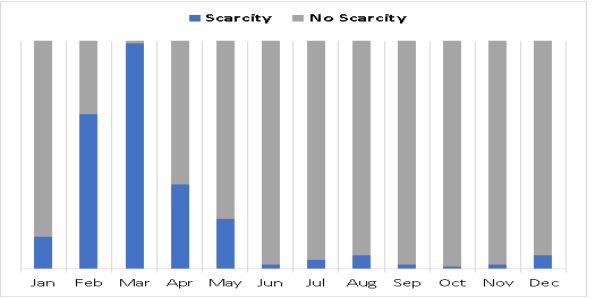
Figure 21: Sources and Owner of Drinking Water



The study revealed that from January to May, there remains water scarcity, and it reaches a peak in March **(Figure 22)**. From June the water table increases and stays saturated. During the rainy season, most people get drinking water from the tube well. However, in the Key Informant Interview with the Department of Public Health Engineering (DPHE), it was found that during the flood period, most of the people suffered from a drinking water problem because of water pollution. DPHE

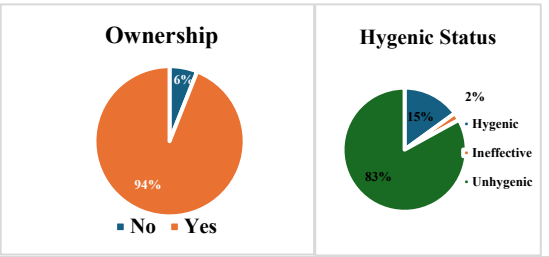
provides bottled water and water purification tablets during each flood, but it is insufficient.

Figure 22: Drinking Water Crisis Months



The FGD participants of Itna and Mithamain mentioned that the tubewells installed above 800 feet depth provide saline water. They also utter that in some tubewells, water does not taste good. Though 94% of respondents have latrines, only 15% are hygienic (Pit latrines consist of a pit, slab, and water seal) (**Figure 23**). About 83% of respondents noted that their latrines are not hygienic, which reveals that most households live in unhygienic conditions and pollute the environment. Some community people also defecate in open spaces found in FGD. DPHE mentioned that, though they provide sanitary latrines in the haor area, most toilets were damaged during the floods.

Figure 23: Latrine Ownership and Hygienic Status of Latrine



Conclusion:

The assessment of multi-threat vulnerability and impacts in Kishoreganj district exhibits a complex interaction of things that contribute to the region's susceptibility to numerous dangers. The analysis considered quite several natural and anthropogenic threats, such as but no longer constrained to floods, heatwaves, bloodless waves, and socio-financial vulnerabilities. The findings underscore the pressing want for comprehensive and context-specific techniques to beautify the district's resilience. A one-length-suits-all approach will not suffice, given the particular geographical, socio-economic, and environmental traits of Kishoreganj. Tailored interventions should be developed to address the unique vulnerabilities diagnosed throughout the take a look at. Furthermore, the influences of those dangers on the network are profound and multifaceted. The vulnerability evaluation indicates that inclined populations, which include low-income households and marginalized communities, bear a disproportionate burden throughout and after hazard activities. As such, any mitigation and edition strategies should prioritize inclusivity and fairness, making sure that the maximum inclined companies are actively worried in choice-making strategies. A holistic and collaborative technique related to government groups, non-governmental businesses, nearby groups, and different stakeholders is crucial for powerful chance reduction and sustainable development. The creation of early warning structures, infrastructure upgrades, and network-based catastrophe preparedness initiatives need to be included in the district's improvement plans.

In conclusion, addressing the multi-danger vulnerability of the Kishoreganj district calls for a proactive and integrated technique that combines scientific understanding, network engagement, and policy

implementation. The insights received from this evaluation should serve as a basis for knowledgeable selection-making, fostering resilience, and in the end, developing a more secure and more sustainable destiny for the citizens of Kishoreganj.

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Tides of Change: Understanding Climate-Induced Migration in Bangladesh's Coastal Regions

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Abstract

Bangladesh faces several climatic hazards/disasters due to its geographical location. The country suffers from natural disasters regularly, resulting in the loss of human life and livelihoods and the forced migration of people or whole communities to nearby areas. Research was conducted in the three coastal districts: Barguna, Patuakhali, and Cox's Bazar with the following goals: 1. To identify the causes of coastal climate-induced displacement; and 2. To identify the socioeconomic elements that contribute to forced migration. 3. Determine probable areas of Bangladeshi coastal relocation due to climate change. A combination of qualitative and quantitative methods is used for the study. Primary data was collected from the Household Questionnaire Survey, Focus Group Discussion (FGD), and Key Informant Interview (KII) with relevant people and institutions. In addition, secondary data and relevant

policies, documents, and books were reviewed from different sources. The study findings reveal that frequent cyclones, flooding, erosion, loss of land, and crop production are the primary causes of climate displacement in coastal areas. Internal migration and external migration are both common situations found in the three coastal districts. Increasing temperatures, drought, and losing crops in the Varendra regions are the leading causes of internal migration. The paper reveals that the coastal region of Patuakhali has the highest displacement threat, where ~39.6% of the people said that they would be interested in migrating immediately.

Keywords: Climate Change, Disaster, Migration, Livelihood, Coastal

Introduction

People who live along Bangladesh's coasts are forced to migrate due to climate-related disasters and fragile livelihoods. Climate migrants are increasing in the coastal districts. Moreover, internal migration rose from 4.80% during 1991-2000 to 11.30% during 2000-2010 (Brennan, 2020). Results from a study conducted in Patuakhali show that seasonal migration increases by 33.90% (Rahaman, et al. 2022). Due to climate-induced disasters, about 15 million individuals in Bangladesh could be migrants by 2050, causing the greatest forced migration in the history of human life (Rashid, 2020). Impact of Climate change on several aspects including health, education, child protection, nutrition, and water and hygiene, all of which are affected by migration or residing in urban slums (UNDRR, 2016). Families are being displaced and pushed further into poverty because of longer-term climate change issues including sea level rise and saltwater intrusion. As a result, children's access to resources for healthcare and education is severely limited. (UNICEF, 2019). From 2014 to 2020, caused by the fifteen specified disasters including floods, cyclones and storm surges, salinity, riverbank erosion, etc. displaced 9.4 million people, and damaged 4.6 million

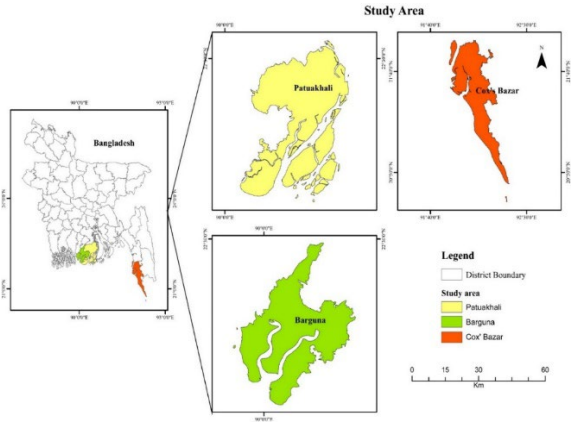
houses either fully or partially (NIRAPAD, 2021). In terms of migration frequency, permanent migration is lower than the temporary and seasonal migration rate, and most migrants choose urban areas as their prioritized destination. Extremely poor, and poor migrated people from these locations due to economic scarcity and insecurity (Rashid, 2020).

Methodology

3.1 Study Area

The three coastal Bangladeshi districts of Patuakhali, Barguna, and Cox's Bazar provided the basis for the research article. (Map 1)

Map 1: Study Area



3.2. Data Collection

3.2.1. Secondary literature review

Data collection, literature review, and long-term weather and climate data analysis of key climate parameters and disaster data to show the trends of change of climate and impacts on biodiversity, natural resources, water

resources, agricultural practices, food security, and livelihoods.

Analysis of long-term data on weather and climate, disaster and water data were collected from the Bangladesh Meteorological Department (BMD), Department of Agricultural Extension (DAE), Disaster Management Bureau (DMB), Bangladesh Water Development Board (BWDB), and other relevant organizations.

Table 1: Reviewed Documents

Methods	Documents/Quantity
Relevant Policies and Acts	Migration policy, Agriculture Policy, Gender Policy
Relevant Articles	National Plan for Disaster Management (NPDM, 2021 to 2025), IPCC Sixth Assessment Report (AR6), Bangladesh Climate Change Strategy and Action Plan (BCCSAP), Bangladesh, Delta Plan, Standing Order on Disaster -2019, 8th Five-Year Plan of Integrated Coastal Zone Management Plan, National Plan on Water and Sanitation for hard to reach area, Coastal Embankment Improvement Plan, Mujib Climate Prosperity, and other relevant articles were reviewed and analyzed.
Relevant Stakeholders and Institutions	Department of Agriculture Extension (DAE), Dept. of Disaster Management (DDM), Ward Disaster Management Committee, Union Disaster Management Committee (UDMC), Bangladesh Water Development Board (BWDB), Union Disaster Management Committee (UDMC), and other relevant organizations

3.2.2. Primary data collection

Primary data like quantitative and qualitative data were collected following steps:

1. Participatory actual data, experiential knowledge, and perspectives of the susceptible individuals and communities on climate-induced disaster, livelihoods, and existing absorptive, adaptive, and transformative

capacities collected through the Household Questionnaire Survey (HHS).

2. Analyzing the Participatory ability of individual, family, community, and institutional levels to knowledge, and practice, to adapt to climate change, unseen impacts on women, and children (especially girls) of climate-related shocks, existing coping mechanisms and perceived as positive (contributing to resilience) or harmful in the long term (ex. selling productive assets might be negative) through Focus Group Discussion (FGD) and Key Informant Interview (KII).

Table 2: Sample Segregation

Methods	Quantity
Household Questionnaire Survey	**Total 620** Cox's Bazar- 248 (M 112, F 112, PWD 24) Barguna- 155 (M 70, F 70, PWD 15) Patuakhali- 217 (M 98, F 98, PWD 21)
Focus Group Discussion (FGD)	**Total 27** (9 in each district) Men, women, youth, mixed groups (male and female), farmers, persons with disability, market actors, and fisherfolk
Key Informant Interview (KII)	**Total 21** (7 in each district) Department of Livestock Services (DLS), Dept. of Disaster Management (DDM), Department of Agriculture Extension (DAE), Ward Disaster Management Committee, Financial Institute, Union Disaster Management Committee (UDMC),

Primary data were collected from the Household Questionnaire Survey (HHS), Key Informant Interview (KII), and Focus Group Discussion (FGD)
The household sample was determined using Slovin's Sample Determination Formula:
$\mathbf{n = N/ (1+Ne^2)}$
SAAD (Sex, Age, and Disability) segregated (adult, youth, and PWD) 620 households' samples were identified and surveyed in the research area **(Table 3)**.

Table 3: The household survey sample

Districts	Adult		Youth		PwD	**Total**
	M	F	M	F		
Cox's Bazar	80	80	32	32	24	**248**
Barguna	50	50	20	20	15	**155**
Patuakhali	70	70	28	28	21	**217**
Total	**200**	**200**	**80**	**80**	**60**	**620**

3.3 Data analysis

Statistical Analysis was applied to quantitative data. The numeric data was processed by SPSS software. Qualitative data from different sources and combined and cross-checked against the results. The research team explored the potential connections and relations among several categories of data.

Migration Policy and Climate Change Landscape in Bangladesh

The government or its authorized authority shall oversee all operations connected to the hiring and emigration of people from Bangladesh for employment abroad. No citizens may relocate abroad for employment or permit others to do so unless they do so in conformity with the requirements of this Act **(Ministry of Law, 2013).** According to **LFS (Labour Force Survey), 2016–17,** migrants affected by natural catastrophes make up 0.6% of the overall population, (BBS, 2018). These will help achieve zero migration by preserving or improving the way of life for those who reside in vulnerable locations **(MUJIB CLIMATE PROSPERITY PLAN, 2021).** In inland and marine waters, extreme temperatures and unpredictable rainfall **(Ministry of Environment, Forest and Climate Change, 2022)** directly affect the physiology of fish, growth, mortality, dietary habits, migratory patterns, and reproductive systems. Rural areas

may migrate more internally to metropolitan areas because of climate change's negative effects. The most vulnerable members of society are those who relocate to metropolitan areas because of disasters caused by climate change. Due to disaster-driven migration from coastal areas, many young people are compelled to work; this pattern is also seen in other effects of climate change **(MoEF&CC, 2022).** Internal migration and climatic displacement are now greatly influenced by environmental catastrophes also; the impact of climate change in Bangladesh is increasing **(MoDM&R, 2020).** River erosion, which is a major cause of rural-to-urban migration, people are moving from disaster-prone, vulnerable areas to urban centers in search of work, which is one of the main reasons why slums in big cities and small towns are expanding quickly **(LGED, 2012).**

The first validated document of the government of Bangladesh is the 2015 **National Strategy on the Management of Disaster and Climate-Induced Internal Displacement (NSMDCIID)** which concentrates entirely on displacement, climate change, and environmental issues. It is also recognized that displacements have a significant impact on the rights and entitlements of those who experience them as well as the communities (MoEW&OE, 2020). Additionally, due to climate-related disasters, the Bangladesh Delta Plan 2100 prioritizes on integration of climate change adaptation into current policies, institutional capacity building, effective management of migration, and institutional reform **(MoEW&OE, 2020).** However, the migration issue is not covered by the Bangladesh Climate Change Strategy and Action Plan (BCCSAP) -2009. The Ministry of Environment, Forests and Climate Change (MoEF&CC) and its associated organizations handle the Climate change issues. However, climate-induced migration is not clear to the institutional management and not mentioned the covered the BCCSAP 2009

(MoEW&OE, 2020). Migration from rural communities to urban areas can be sparked by land erosion and the loss of rural livelihood. Therefore, as part of the Eighth Five Year Plan (**8FYP)**, the Government will continue to be dedicated to designing cities that are more hospitable by putting in place effective systems for facilitating migrant integration into the city, adequate housing for new populations, and employment opportunities for those who are looking for work (8FYP, 2020).

Climate and disaster vulnerability in the study area

5.1. Climate vulnerability

Based on the respondents' perceptions, the study reveals that temperature trends are rising across all three coastal districts, while rainfall is decreasing (Table 4). Participants in the FGDs also reported similar observations for Patuakhali and Barguna.

Table 4: Climatic parameters trend in the study region, 2012 to 2021

Climatic parameters	Patuakhali	Barguna	Cox's Bazar
Temperature	+	+	+
Rainfall	-	-	-

Here (+ means Increased and – means Decreased)

5.2. Disaster vulnerability

Climate-related disasters like storm surges, cyclones, droughts, and salinity intrusion have historically occurred in the study areas. Considering the five years from 2015 to 2020, the cyclone was found to be the most prevalent hazard/disaster in the study area. Specifically, cyclones impacted 73,976 households in Cox's Bazar, 103,488 households in Patuakhali, and 112,163 households in Barguna, highlighting the increased vulnerability of these

areas to future cyclones. In the same period, the districts of Patuakhali and Cox's Bazar, had 62,136 and 49,103 households affected by flooding, respectively. The main climatic and natural extremes in Patuakhali, Barguna, and Cox's Bazar districts are waterlogging, storm and tidal surges, thunderstorms, lightning, and river and coastal erosion. Furthermore, hailstorms became a major worry for impacted households in these districts between 2015 and 2020 **(Table 5)**.

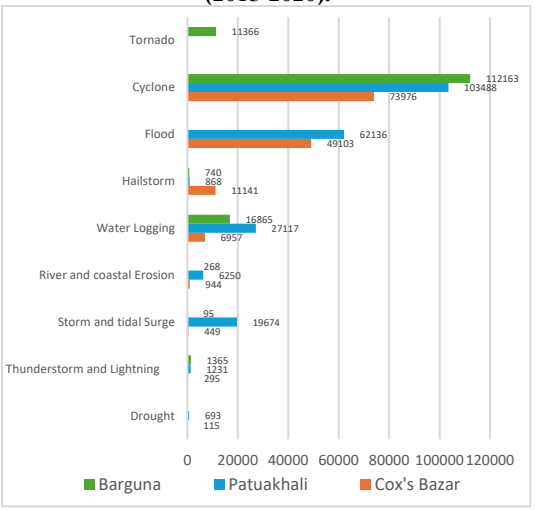
Lightning has been identified as a growing hazard in the study area, by the Patuakhali Disaster Risk Reduction Office (DRRO). Additionally, participants in Focus Group Discussions (FGDs) across all three districts have highlighted the substantial risk that hailstorms pose to agriculture.

In the Patuakhali district, the female FGD participants shared that at least ten ducks per household die from weather-related diseases every winter and summer. Disaster-induced loss and damage are almost similar in all six districts which were also found in the national disaster statistics. In Patuakhali, the Bangladesh Disaster Related Statistics (BDRS) estimates 30917.174 hectares of crops damaged during 2015-2020 which is the highest crop damage from all three study areas (BDRS, 2021) **(Table 5).**

At the same time, the district lost 2053.10 million BDT from livestock and 1147.86 million BDT from poultry due to the disaster.

Similarly, in Barguna, BDRS estimates that 24150.02 hectares of crops were damaged, 367.65 million BDT from livestock, and 225.15 million BDT from poultry due to the disaster in 2015-2020.

Figure 1: Disaster-affected households in the study area (2015-2020).



Source: (BDRS, 2021)

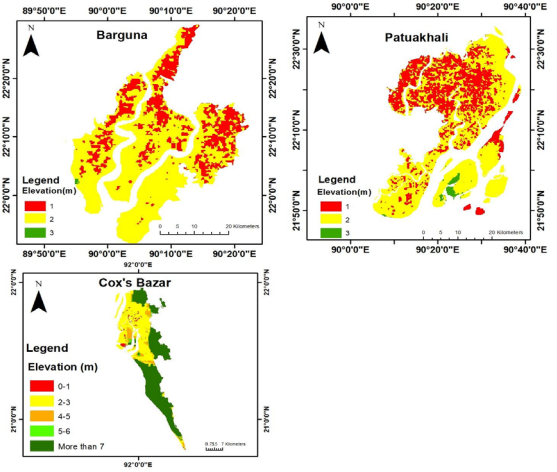
Table 5: Disaster-induced loss in 2015-2020 (BDRS, 2021)

District	The disaster affected loss (2015-2020)		
	Crops (Paddy) (acres)	**Livestock** (BDT in a Million)	**Poultry** (BDT in a Million)
Patuakhali	76398	2053.10	1147.86
Barguna	59676	367.65	225.15
Cox'sbazar	26436	673.35	134.13

Despite being a coastal district, Patuakhali has some areas where the highest elevation is three meters above Mean Sea Level (MSL), as demonstrated by DEM analysis. The northeastern portion of the district has lower elevations, whereas the majority of it stays at an average elevation of two metres. Lower elevations are found in regions like Dasmania Upazila's northern region, Galachipa, Patuakhali Sadar, Dhumki, and Mirzaganj. Due to its low

elevation, the district is more susceptible to storm surges. Conversely, Barguna has a maximum elevation of three metres and is mostly found in small areas in Patharghata Upazila's southwest. The southern part of Patharghata, Barguna Sadar, and Amtali Upazila are mostly two metres above sea level, while Betagi, Bamna, and the northern part of Amtali are one metre below sea level. Among the three coastal districts, Cox's Bazar has the highest elevation due to its hilly terrain. Nonetheless, Maheshkhali has lower elevations in some places, ranging from 0 to 1 metre. Minimum elevations in Cox's Bazar are found in Chakaria, Pekua, and Kutubdia Upazila, and range from 2 to 3 metres. The other upazilas, which are Ramu, Ukhia, Teknaf, and some northern Chakaria, all continue to be higher than metres **(Map 2).**

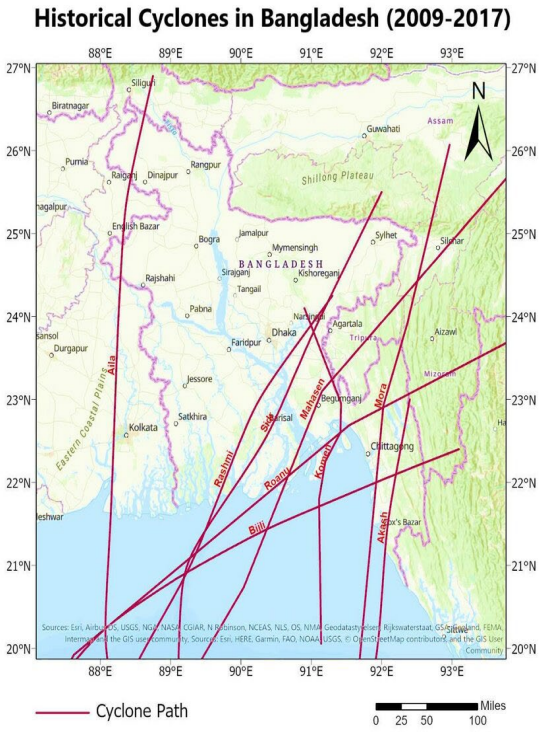
Map 2: Study Area Elevation (Barguna, Patuakhali, and Cox's Bazar)



Cyclone Jawad, which hit Cox's Bazar during the most recent ten-year period (2013–2022), had the lowest storm surge height ever measured; Cyclone Mohasen, which affected Cox's Bazar, Barguna, and Patuakhali, had the highest storm surge height (**Figure 2**). A comparison of the elevation of the three coastal districts and the storm surge height indicates that parts of Cox's Bazar

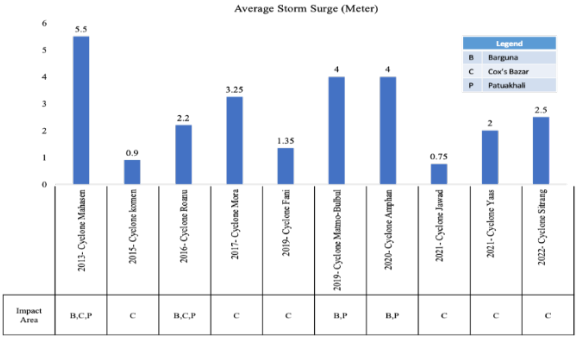
(Maheshkhali, Ramu, Teknaf, and a small portion of Ukhia) are comparatively safe from flooding during storm surges. However, Patuakhali and Barguna districts are more vulnerable to storm surges than Cox's Bazar district when taking into account variables like storm surge height, the rising trend of Mean Sea Level (MSL), and land elevation. The historical cyclone map 3 indicates several cyclones heated at various times in Bangladesh. Among them, Akash, Roanu, Mora, Mohashen, and Rashmi were heated directly in the study areas.

Map 3: Historical Cyclones in Bangladesh



Source: (Hassan *et al*. 2020).[1]

Figure 2: Impacted storm surge in the study area (2013-2022)



Findings and Discussion

6.1. Impact of climate change and disaster in the study area

To standardize participant insights and create a Composite Vulnerability Matrix, the perceptions of respondents were utilized to measure vulnerability in the study areas. This study made it clear that some industries and professions are more vulnerable than others in particular regions. In Patuakhali and Barguna, for example, agriculture was found to be highly vulnerable, whereas Cox's Bazar showed a marked vulnerability in the education sector. Interestingly, Patuakhali and Barguna both mentioned how vulnerable the livelihood sector is, especially agriculture. In addition, the water sector showed high vulnerability in all study areas but Cox's Bazar (Matrix 1). Focus group discussions (FGDs) with participants from these areas revealed persistent issues, like drinking water shortages that occur in both the summer and the winter. In addition, Patuakhali and Barguna participants emphasized how the scarcity of drinkable water is made worse by the rising salinity levels in surface and groundwater during these seasons.

Matrix 1: Sector-wise vulnerability matrix of the study area

Sectors	Barguna	Cox'sbazar	Patuakhali
Agriculture			
Education			
Health			
Livelihood			
Water			
Legend			
Low	0-33%		
Medium	34-65%		
High	66-100%		

6.2 Occupational Vulnerability

Climate change and natural disasters have a substantial impact on the socio-economic environment and livelihood activities in the areas under study. A Composite Vulnerability Matrix was created using the insights of the respondents, normalising their comments. Different occupational groups were found to be vulnerable in this analysis, with farmers being the most vulnerable across all districts (Matrix2). Farmers are the main victims of climate-related disasters, especially in Barguna, where farmers and fishermen are more vulnerable. Focus group participants in every district consistently identified farmers as the most vulnerable group.

Farmers in Cox's Bazar, Barguna, and Patuakhali reported major problems with salinity intrusion and insufficient irrigation during the dry season, which caused disruptions to agriculture. However, during the monsoon season, crops suffer severe damage because of tidal flooding. Due to unfavorable climatic conditions, many respondents who fished in these areas highlighted that they were unable to access fishing grounds during the

rainy and dry seasons alike. Even though there are fishing opportunities after the monsoon, access to resources is hampered by fishing restrictions, especially along riverbanks. Shahporir Dwip participants emphasized other difficulties that have arisen since the Rohingya inflow, such as fishing bans along the Naf River that worsen food shortages all year long.

Matrix 2: Occupational Vulnerability Index

Occupation	Barguna	Cox's Bazar	Patuakhali
Boatman			
Day labor			
Farmer			
Fishermen			
Small trader			

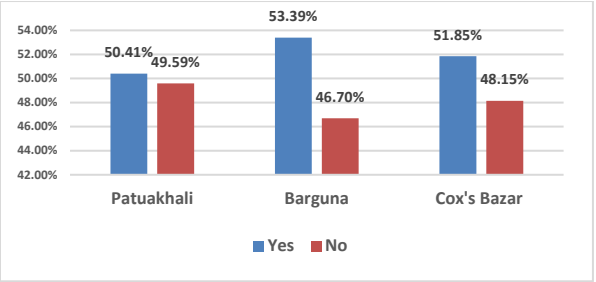
Legend	
Low	0-33%
Medium	34-65%
High	66-100%

6.3 Livelihood Opportunity

The problems facing agriculture are made worse by climate change, which results in lower crop yields, eroding arable land, and declining shared property resources like fisheries and forests. Smallholder and subsistence farmers are forced by this situation to both significantly reduce their income and modify their methods of subsistence. Sadly, the most defenseless members of society, especially those who work directly in the food industry and have low levels of resilience—are the ones who suffer the most from these effects. As a result, opportunities for living are gradually dwindling, which eventually leads to a reduction in job opportunities. The results of the study highlight the severity of unemployment, with Barguna reporting the highest

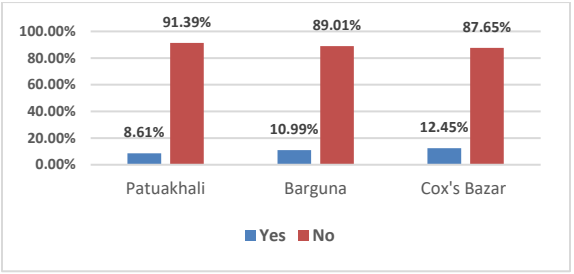
percentage of respondents (53.39%) who were unemployed (**Figure 3**)

Figure 3: Employment scenario in the study area



As a result, within the last ten years (2012-2022), many people are changing their livelihood activities. In all six districts, primary livelihood-changing scenarios are found. The highest number of respondents from Cox's Bazar (12.45%) and the lowest number of respondents from Patuakhali (8.61%) have changed their main livelihood option within this period **(Figure 4).**

Figure 4: Primary livelihoods option changing scenario



By this period, day labor has increased drastically in all three coastal districts. In Barguna, by this period, laborers increased by 55% which was 31.57% ten years ago

(Table 6). Day labourers increased the most in Patuakhali districts (23.97% to 61.90%). The data reveals that, a huge livelihood-changing scenario in Farming sectors of all three districts. Lower-income people are not involved with farming because of landlessness, drought, and a lack of irrigation which was reported by the FGD participant. The day laborer FGD participants reported that ten years ago, most of them were engaged in agriculture or fishing from nearby rivers and sea for their wages. Some of the day laborers of Patuakhali and Barguna also reported that they were engaged with crab collection and honey collection from Sundarbans. But the resources being scarce and farming being challenging due to salinity forced them to engage in daily labor. The transport laborers mentioned in the FGDs that they have no alternative income source and lack skill; they are involved with auto-rickshaws, and taxi driving though previously they were engaged with farming.

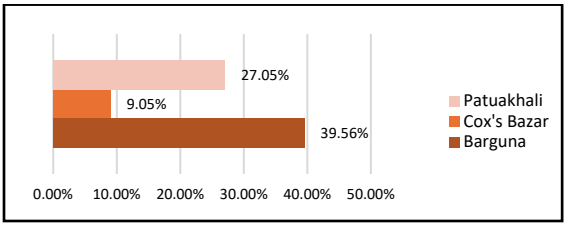
Table 6: Livelihood-changing scenario

Livelihood opportunities	Barguna		Cox'sbazar		Patuakhali	
	Present	Previous	Present	Previous	Present	Previous
Farming	10.00%	41.05%	4.76%	21.66%	4.76%	38.84%
Fishing	10.00%	7.37%	0.00%	21.67%	9.52%	9.10%
Small trading	20.00%	16.84%	38.10%	21.67%	23.81%	22.31%
Day Labour	55.00%	31.57%	52.38%	28.34%	61.90%	23.97%

6.3 Migration threat

Migration and displacement are common occurrences in the study area, with notable instances of both internal and external migration in each of the four upazilas. In addition, changes in the population are visible. According to the study, Barguna faces the greatest threat from migration, with 39.56% of respondents saying they would like to migrate right away. On the other hand, the least amount of migration threat is present in Cox's Bazar, where only 9.05% of respondents said they would be prepared to relocate to a safer area **(Figure 5).**

Figure 5: Migration threat



Focus group discussions (FGDs) in all six districts revealed that participants blamed climate change-related factors like salinity and drought for their current situation of not being able to earn a living wage. They also emphasized how the growing water crisis was forcing them to relocate in pursuit of food and water security. Significant homestead losses because of riverbank erosion were also mentioned by respondents from Kutubdia and Char Montaz, which forced migration.

The study employed binary logistic regression analysis to assess the influence of different factors on the probability of participants reporting relocation to new areas. With an odds ratio of 3.78, the analysis showed that employment status was the best predictor of migration. More specifically, people who had no work prospects were more likely to leave quickly **(Table 7).**

Table 7: Regression Analysis: Examination of Land Ownership, Employment, and Migration Trends

Indicators	Coefficients	Lower 95%	Upper 95%	t Stat	P-value
Employment	3.781757	3.781757	3.781757	65535	0.545
Land ownership	-0.48496	-0.48496	-0.48496	65535	0.044
Migration trend	-6.21642	-6.21642	-6.21642	65535	0.001

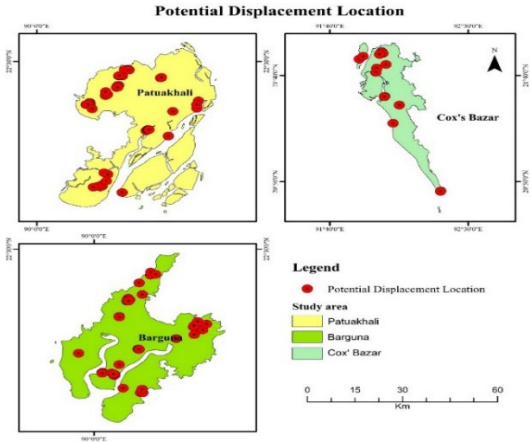
Significant mitigation efforts are expected among communities residing in several unions due to a variety of factors, including the loss of homestead land, the decline in agricultural production, economic downturns, livelihood crises, and the scarcity of freshwater. By applying Agent-based Models (ABM), large-scale mitigation initiatives have been pinpointed areas. Widespread mitigation efforts have been prompted by homestead land loss, agricultural difficulties, economic crises, and freshwater scarcity in the unions of Boga, Dashmina, Bashbaria, Pangasia, Lebukhali, Itbaria, Motherbunia, Kakrabunia, Baliatli, Mithaganj Galachipa, Ratandi Taltoli, and Bara Baishdia. Due to comparable climate-related hardships, residents of the unions of Betagi, Kazirabad, Mokamia, Bamna, Burir Char Naltona, M. Baliatali, Chowra, Kukua, Borobagi, and Chotobogi are also leaning towards mitigation techniques. Significant mitigation efforts are also noted among the people living in the upazilas of Pekua, Ramu, Kutubdia, Maheshkhali, Ukhia, Teknaf, and Cox's Bazar Sadar. These efforts are motivated by similar issues such as the loss of homestead land, agricultural difficulties, financial difficulties, and freshwater shortages. On the other hand, groups living in the unions of Hujuri Para, Baragachhi, Badhair, Pachandar, Jahanabad, Mougachhi, Baneshwar, Sardah, Yousufpur, Jhaluka, Basupara, Subhadanga, and Bajubagha indicate that they would like to move. This is mainly because of the combined effects of losing homestead land, facing challenges in agriculture, experiencing economic downturns, facing livelihood crises, and a shortage of freshwater. Furthermore, people from the unions of Baliyadanga, Nezampur, Gomostapur, and Chhatrajitpur are also inclined to migrate, with their decision being motivated by issues related to climate change **(Map 4).**

The effects of climate change disproportionately affect women and children as they increase human migration and displacement. Focus groups (FGDs) with women and Key Informant Interviews (KIIs) with local government

representatives, the Department of Women and Children Affairs, Department of Social Service revealed several issues related to women's increased vulnerability to the effects of climate change. The majority of those are:

- Limited access of women to productive resources and services;
- The limited adaptive capacity of women;
- Unequal condition and position of women in family and society
- Lacking decision-making power
- Limited access to early warning information, services, and facilities
- Women-headed family,
- Limited access to market and communication,
- Social insecurity and violence against women

Map 4: Potential climate-displacement location in the study area



Conclusion

Climate change's effects worsen migration and human displacement, disproportionately harming women and

children. Changes in ecosystem services have a big impact on local livelihoods, income levels, and migration patterns. Notably, the requirement of permanent residency is a prerequisite for receiving Social Security Net (SSN) benefits, which deprives migrated individuals of vital support networks. People are forced to leave their homes due to the displacement brought on by climate change. The dynamics of displacement can be affected by climate change, but paradoxically, it can also impede or obstruct efforts at sustainable development, human mobility, and access to fundamental rights. The complex interactions among poverty, conflict, and climate change make displacement even more complicated, especially in long-term situations where planning and financing mechanisms are frequently insufficient to meet long-term needs.

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Importance of Indigenous Adaptation Practices inEcosystem-based Adaptation at Medir Haor, Bangladesh using DPSIR framework

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Abstract

Indigenous Adaptation Practices in the wetland basin have proven evidenceof coping with climate extremes. Since the 80s the intensity of the hydro-meteorological hazards has increased. The community of the Medir Haor under Nasirnagar upazila of Brahmanbaria district, Bangladesh. Primarily farmers and fishermen are practicing indigenous adaptation practices since the structured adaptation projects are yet to be implemented in this area. The study wasconducted from January 2017 to September 2022 in the villages of the Medir Haor having community consultations, Focus Group Discussions, and Key Informant Interviews. The DPSIR (Driver-Forces-Pressures-State-Impacts-Responses) framework has been used to identify the responses toward the betterment of the ecosystem and the Ecosystem-based Adaptation options. The community has identified (1) Protection of fisheries resources and diversification of fisheries-based livelihoods; (2) Crop diversification and introduction of winter crops in thecrop fields of Haor; (3) Strengthen the communication

system including the roadnetworks; (4) Make available the extreme weather information for community preparedness; (5) Improve the health supports as Ecosystem-based Adaptation options where tradition practices like dry sowing of paddy; Seedbed sowing for the second time; Bhura, a roundish water hyacinth floating bed; Early harvesting for diga dhan; Cultivating Dhaincha, Sesbania bispinosa; Khola; Bathan, the grazing land; Peritana, taking out the mud from the deep pools; Mana, traditional fishing is forbidden side; Changari and Airbandh may have potential uses. The study has identified the contribution of indigenous knowledge towardEcosystem-based Adaptation.

Keywords: Adaptation to Climate Change, Indigenous practice, Ecosystem-basedAdaptation, (Haor) Wetland Basin, DPSI

Introduction

Bangladesh is one of the most vulnerable countries to climate change. To survive the communities have been practicing a wide range of adaptation options, both planned and spontaneous. Planned adaptation initiatives by development actors in implementation were in different forms. The Ecosystem-based Adaptation (EbA) in Bangladesh initiated science in 2012. EbA is a strategy for adapting to climate change that harnesses nature-based solutions and ecosystem services. EbA uses sustainable management, conservation, and restoration of ecosystems to provide services thatenable people to adapt to the impacts of climate change. It is a people-centric concept. The traditional practices are community resources and skills that were gained over hundreds of years by a community. Local and traditional knowledge and skills are increasingly being recognizedas vital resources for adaptation. The purpose of this paper is to explore traditional coping

practices that may enhance EbA in the wetland basin of Bangladesh.

Literature Review

The scope of study of using indigenous knowledge towards executing the EbA actions is an attempt to analyze the scope of integrating community knowledge with the EbA. There were some studies conducted on documenting Traditional knowledge, but the potential of traditional practices in coping with climate vulnerabilities was studied a little. Kumar (2015) highlights some indigenous mitigation and adaptation skills that have been practiced in North-western India. Indigenous Knowledge is also used in cultivation techniques in extreme climatic conditions. Rahman and Rahman (2015) studied natural and traditional defense mechanisms to reduce climate risks in coastal zones of Bangladesh and suggested the integration of traditional coping practices and wisdom with modern approaches. Laths Kid (2018) has suggested Indigenous knowledge that helps the agricultural production of the communities to develop sustainably for generations. UNEP (2018) has compiled the knowledge of indigenous communities regarding climate actions. Ghosh (2021) studied the contribution of indigenous knowledge towards community resilience in the Indian state Meghalaya, adjutant to the Haor basin of Bangladesh. Adaptation responses with Indigenous knowledge

and local knowledge influence recorded higher evidence of risk reduction compared to responses without Indigenous knowledge and local knowledge. Many African countries have included indigenous knowledge and local knowledge in adaptation planning in the

intended nationally determined contributions (iNDCs). Barua and Rahman (2018a) studied the role of indigenous knowledge in coastal resource management addressing Climate Change. They also have studied the traditional ecological knowledge in the coastal island of Bangladesh (Barua and Rahman, 2018b). The scope of EbA in Bangladesh was first explored by the Bangladesh Climate Change and Environment Outlook 2012, the Hakaluki Haor area and the coast of Shyamnagar were studied to identify the opportunity. Ahmed (2013) studied the opportunities for ecosystem-based adaptation in the coastal zone in Bangladesh. The study recommended the stabilization of coastal lands with appropriate mangrove species plantation as cost-effective and long-term biodiversity conservation measures in Bangladesh that are relevant to EbA. Haq et. al. (2013) noted that the EbA approach has the potential to significantly increase the functionality of current adaptation practices and reduce the tension between the" hard" and" soft" approach by following three major ways: a) valuing ecosystems and biodiversity in adaptation b) promoting development in adaptation and c) building long term resilience with multiple socio-economic benefits. Vulnerability and Impact Assessment to Climate Change and Ecosystem-based Adaptation in the drought-prone area of Bangladesh was studied by Rahman et. al. (2014). The study was conducted by applying DPSIR Framework. The nature-based solutions through EbA were given as a potentially cost-effective means to cope with drought and protect the environment. Re-excavation of traditional ponds and integrated fish farming were suggested as EbA to increase capacity and maintain ecosystem services. EbA's effectiveness in terms of how such approaches support community adaptive capacity and resilience at two sites in Bangladesh: Chanda Beel Wetland and

Balukhali Village in the Chittagong Hill Tracts was studied by Raid et. al. (2017). Results show that the many diverse natural resources available and utilized at each site have increased the number of different subsistence and livelihood options available in the community and hence local adaptive capacity, especially for poorer households. Saroar et. al. (2018) studied the Opportunities and Challenges of EbA. According to the study, EbA is linked to cropping practices, soil and nutrient management, water management, erosion control, and food and livelihood security. It proposes integrated institutional approaches to bolster EbA's potential. This study also suggests that EbA strategies should conform to scientific knowledge, which would help improve community resilience and ecosystem health.

Materials and Methods

The study has been conducted in Medir Haor. The Medir Haor is located in Brahmanbaria district under Nasirnagar Upazila. It is swallowed Haor compared with the northern Hoars. The area of Medir Haor is around 17.38 square kilometers and the population dependent on the resources is about 25,000 The Haor is connected with the river Meghna. The Indigenous practices of the community to cope with the extreme climatic events were identified by observing the community practices and consultations

with the community. The villages (1) Nasirnagar, (2) Monoharpur, (3) Goalnagar, and (4) Kistopur were visited frequently to study the indigenous community practices from January 2017 to September 2022. The Driving Forces-Pressures-State-Impacts- Responses (DPSIR) framework was used to assess the ecosystem

and the sustainable management approach against climate vulnerability. The DPSIR is an analytical framework to trace the changes in and to look at the drivers of these changes, and to evaluate the impacts of these changes. Within this model, drivers are defined as the underlying factors causing or influencing a variety of pressures in an ecosystem. Pressures are defined as the variables that directly cause the changes and the state is the measure of the physical, chemical, and biological conditions within the eco-system. Impacts describe the effects of changes in coastal wetland states on measures of ecosystem function. The response is defined as the efforts of society to solve the problems resulting from changes in wetland function. There are four major steps in the DPSIR framework; (1) interpreting the drivers and the pressures; (2) describing the state changes; (3) describing the impacts; and (4) reviewing the human response. The DPSIR Framework was launched by the European Environmental Agency, and it has been used by the United Nations. Furthermore, the framework has been adopted by the US Environmental Protection Agency (EPA) in the Sustainable Puerto Rico initiative (Kristensen, 2004). The DPSIR framework is a tool by which the cause-effect relationship between social, economic, and environmental issues can be joined to perform their functions (Omann et al., 2009). The DPSIR framework has been used for many environmental resource applications, including the management of agricultural systems (Omann et al., 2009), and water resources (Laura et al., 2009). In recent years DPSIR has most commonly been used for ensuring environmental management to connect ecological and socioeconomic factors (Yee and Bradley, 2015) for taking decisions on environmental issues (Gari et al., 2015). Ahmed et. al. (2020) used this framework for ecosystem services in the

Mekong Delta for coping with mining challenges. Based on the response identified in the framework the Ecosystem-based Adaptation (EbA) options are being identified by the community. The DPSIR Framework has been used by Rahman et. al. (2016) to suggest EbA in a River Bank Erosion Prone Area of Bangladesh. UNEP, UNDP, and IUCN have conceptualized Ecosystem-based Adaptation in the DPSIR framework (UNEP 2012). The EbA involves conservation, sustainable management, and restoration of ecosystems that can help people adapt to the impacts of climate change. Ecosystem-based Adaptation EbA is a nature-based solution that harnesses biodiversity and ecosystem services to reduce vulnerability and build resilience to climate change. Data Collection and Analysis: This paper is based on the data collected from 9 community consultations, 6 Focus Group discussions (2 with Fisher, 2 with farmers, 1 with women, and 1 development actor), and 12 Key Informant interviews.

Results and Discussion

Historic Climatic Extreme Events in Medir Haor: The erratic rainfall has increased inthe Medir Haor areas after the flooding of 2004. Before that early flooding and late flooding was the major livelihood concern. The cultivation of high-yielding rice varieties started in Haor on the year 1963 but cultivation on a wide scale started in 1974; before that only the local boro, specifically the varieties (1) tapi Boro and (2) Jagli dhan being cultivated. For the cultivation of the high-yielding variety of rice under a government scheme two canals were excavated in the Medir Haor, namely Abbair Khal and Nilokhiar Nala. Table 1 details the extreme event and the community's coping mechanism. Up to the 80s, the livelihoods of the Medir

Haor community were mostly natural resource based. In 1982 urbanization started centering the administrative town of Nasirnagar.

Table 1 Table1: Extreme climatic events and community coping followed in the Medir Haor

Year	Extreme event	Community Coping mechanism
1998	Flood	Take sheltered in school, No cultivation
2004	Flood	Harvested green paddy, cultivated in water hyacinth made a small floating bed
2006	Late monsoon	Dry sowing of paddy
2012	Late monsoon	Dry sowing of paddy
2018	Late monsoon	Sowing of germinated seeds
2021	Thunderstorm	Seedbed sowing for the second time

Community Responses to the Climate Extremes:

1. Dry sowing of paddy: The transplanted and the broadcast Aman paddy are sowing germinated in the common practice, but when there was no rain or less rain the farmers spread the non-germinated rice on the paddy field. The amount required for such sowing is around 1.5 times that of regular germinated sowing. Such sowingis called Doilla Bain since it is put in dry plowed soil. By the first rain, it grows. According to the farmers, weed growth is comparatively less in such dry sowing.
2. Seedbed sowing for the second time: This practice of creating a seedbed for a secondtime is done to cope with prolonged inundation during the early stage of paddy cultivation. The study found that such a practice is very common in thewestern part of the Medir Haor which is close to the river Meghna.
3. Bhura, a roundish water hyacinth floating bed: Haor basin is wave prone. Such heavy wave action is

locally known as Afal. The floating bed that the community of the Beel Basin is practicing traditionally is not a traditional one in theHaor. Though different development interventions are willing to promote such long rectangular floating beds in Hoar but not working as assumed; according to the local community not even functioning as those were documented. Haor has its formof floating bed, locally known as Bhura, which is a roundish water hyacinth-made floating bed of 1 to 1.5 meters in radius. The objective of such a bed was to cultivatewater guard at the right time since the early seventies.

Early harvesting for diga dhan: If there was less production in paddy caused forany reason the Haor community harvested only the top of the Sheaf of paddy and Then another new paddy sheaf grows. Cultivating Dhaincha, *Sesbania bispinosa* to protect wave action: Haor village mounds look like islands in the sea during the rainy season. Since there are no berries common in such a widespread waterbody, heavy wind causes strong high waves in the Hoar that result in land erosion of the village mound. To reduce the wave speed, the community of Haor planted Dhaincha surrounding the village. The Dhaincha plant is high and an grow in water. The biology of the Dhaincha is that the stem part that teaches water becomes puffy. Dhaincha was used as a float in the nets.

4. Khola: The first regular flash flood in the Medir Haor comes just after the harvestingseason. The community does not have a big yard in every family but the harvesting season too short; there are some common harvest processing sites in the Haor. Those sites are usually close to the village mound and also well connected with waterways. Such a harvesting site is

called Khola. A few Kholas are on the raised plinth.

5. Bathan, the grazing land: The comparatively high lands of the sallow Hoar wereused as grazing lands. Those grazing lands are known as bathan. Bathan land is not good as cropland as it is undulating and usually sandy. There was no cultivationand changes in landscape allowed in the bathan land. The connecting road from villages to the bathan is named go-pat, literally meaning path for the cows
6. Peri-tana, taking out the mud from the deep pools: In Hoar, there are scattered many beep pools of an average 5-meter radius. Such pools are perennial, and water remains year-long. Usually, no irrigation is allowed from those pools, locally knownas Koa. If in any year the siltation is high due to the flash flood community removesthe mud using bamboo-made pots, which is called Peri-tana, meaning take away the mud, otherwise, it was done every 3 to 4 years based on the sild stored in the bottom.
7. Mana, traditional fishing forbidden side: in the Haor conservation of fish and fish- series is a traditional practice. In the Medir Haor, there are around 12 Manas recorded. Mana means forbidden, and an area marked by Bamboo with leaves and branches is demarcated as no fishing area. The demarcation of the area has no boundary, but the fisher believes and respects the center of it as the core area and the periphery as a buffer zone and has no fishing
8. Changari: Since the fish-drying land of the Haor basin goes underwater regu larly. The practice of making bamboo-made platform for sundry fishes is called Changari. Usually, it is made close to the village mound and its size varies from400 square meters to 1000 square meters.
9. Airebandh: The village mound is subject to wave

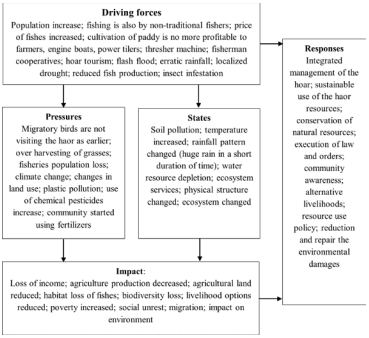
action and land erosion. To protect the village, mound the community using the bamboo railing. Also, use different grasses and straws inside the bamboo fence.

Changes recurring in the Medir Haor and theircauses and impacts

The forces-Pressures-State-Impacts-Responses (DPSIR) framework for the Medir Haor has been detailed by the Hoar community as follows:

Fig. 1 The Forces-Pressures-State-Impacts-Responses (DPSIR) framework for the Medir Haor

Ecosystem-based Adaptation Options in the



Medir Haor:

This is noted that no adaptation projects are being implemented in the Medir Hoaryet. The following are the proposed EbA options identified by the community for the MedirHaor

1. Protection of fisheries resources and diversification of fisheries-based livelihoods: Conservation of the fisheries to increase production and promote sustainable harvesting. Diversification of fisheries business. In the Medir haor fish-drying is one of
2. the most common practices. There is sun-drying of fish and making the farmed fish which is known as “Shidol”. According to the local community, diversification of the fish market by introducing external knowledge and practices will increase the income of the community
3. Crop diversification and introduction of winter crops in the crop fields of Haor: The paddy production in the Medir Haor is dominated by the BRRI Dhan 28, and there are a few native varieties. During the winter many cropping possible lands remain uncultivated where cultivation of vegetables is possible. For that technology and farming techniques need to be promoted.
4. Strengthen communication system including the road networks: The village mounds are scattered as isolated islands during the rainy season. The boat is only transported during the rainy season. But the current boats both equipped with a powerful engine named engine beat and regular boats are not strong enough to cope with the high Afal.
5. Make available extreme weather information for community preparedness: The flash flooding in the Medir hoar is devastating since it is located in the down of the Haor basin. The lead time for flash flooding from the Tanguar Haor is 3 days. But other hazards have increased in intensity. If the community has the climate change projection as well as weather prediction with a good lead time the community can plan the adaptation action properly. The hazard calendar identified by the Medir Haor

community is noted in Table 2. The hazard calendar identified by the Medir Haor community is noted in **Table 2**.

6. Improve health support: According to the community, the major challenge for the Hoar Basin is health services. Treatment and medicine availability are the major concerns of medical service. Floating hospitals and water ambulances were recommended by the community.

1.1 Hazard calendar:

In the Medir Haor Early flood is a common hazard. There is a riverine flood. Local- ized drought is becoming a common phenomenon nowadays. Only a small area in the crop field suffers from drought. Huge fog is a new phenomenon that started in 1984.

1.2 Newly formed livelihoods options

In the Media Hoar earnings from the marketing of snail and cow-dung-made cooking fuel are blooming after the Covid19 pandemic. Snail collector: The snail collection for duckery is increasing drastically since duck rearing is increasing in the community.

There are more than 200 snail collectors collecting snails in the Medir haor dailythough it's illegal by law. The average collection is around 4 kg per individual. They are mostly hand-picking and also there is the use of nets. Cow dung collector: The cow dung collection is for household-based cooking fuel-making industries. The cow dung is collected from the grazing land to make fuel. The average harvesting is 22 per collector kg per day. More than 400 cow dung collectors are collecting dung from theMedir Haor.

Table 2 Hazards of the Medir Haor

Hazards of the Medir Haor	
Jan	Dry
Feb	Drought
Mar	
Apr	Early Flood,Insect,Infestation
May	Flood, Northwestern sides
Jun	Flood
Jul	Flood
Aug	Standing water
Sept	Standing water,Thunderstorm
Oct	Standing water,Drought
Nov	Dry weather, Fog
Dec	Dry weather, Fog

1.3 The potential of the traditional practices towards EbA:

To achieve the target of the EbA the traditional practices of the community can have potential use. The mana is a conservation action for fisheries. Since the early monsoon the harvesting of the fish Punti (Swamp barb), Puntius chola is high the market price for that goes down. The Punti is the most preferable fish for making the Shidol. But in the Haor sun-drying is a challenge as no ground is available as drying land. The Changari since made in the inundated areas serve the purpose. Changari is made of bamboo and longevity is usually one year. Using treated bamboo canstrengthen the quality of the Changari and that will last for longer days. To protectthe fish breeding sites and to increase the number of fisheries breeding sites Peri-tana is very important. In the Medir Hoar

around 35 deep perennial water bodies, namely Kuya, were reported as important fish breeding sites. Through the use of Kanta, thatis putting branches of the trees Hijol, Barringtonia acutangula, and Sheora, Streblus asper is a practice of harvesting more fish but also plays an important role by creating habitat for fisheries, specifically the small fishes, mollusks, and turtles. There is poten- tial for winter vegetable cultivation in Haor. It was found that considering the weather warming and climate change prediction the community can choose the crop- ping pattern. It was estimated that by creating a culture of winter crop cultivation in the Medir Haor and adding an area size of around 15The highest use of the Dhaincha plant was as a float for the net. The availability of alternatives, like plastic floats, has challenged the market of the Dhaincha and its cultivation as well. The Dhaincha is bio-degradable and environment friendly whereas the practice of pollution is a major threat to the ecosystem. Dhaincha is a good fuel. Collecting cow dung for making cooking fuel is challenging the natural manuring process. In the Airband there was a use of Chailla grass, *Hemarthria protensa*, which has been reduced in practice because of its unavailability. Protection and facilitation of growing Chaillagrass will benefit nature, it creates a habitat for many birds and also the ecological balance. Chilla grass reduces the risk of erosion. The community has its own belief in weather prediction. The local proverbs like Khonar bachon (Verse of the philosopher Khana) and folk poetries give an assumption of weather and a short period, which is not more than one year. But for long-term climate change projects such proverbs were

Fig. 2 Table 3: Scope of using indigenous practices towards Eb

Table 3: Scope of using indigenous practices towards EbA

Ecosystem-based Adaptation	Indigenous practices that can contribute
Protection of fisheries resources and diversification of fisheries-based livelihoods	Peri-tana; Mana; Changari
Crop diversification and introduction of winter crops in the crop fields of Haor	Dry sowing of paddy; Seedbed sowing for the second time; Bhura; Early harvesting for diga dhan; Khola
Strengthen the communication system including the road networks	Cultivating Dhaincha to protect wave action; Airband; Hijol plantation
Make available the extreme weather information for community preparedness	Bathan; Airbandh; Dry sowing of paddy; Bhura
Improve the health supports	Medicinal plants gardening

not reported. The use of mobile phones is common, it will be a path of sharing early warning predictions. Increasing health services was identified by the community as an EbA for the Haor. Though there was no historical evidence available where traditional medicine resulted in coping with extreme health crises, the use of medicinal plants wasfound common by the community. In the remote isolated villages, the use of medicinalherbs though common through the practice of gardening the medicinal plants is not common.

Discussion

The study found that traditional practices have potential output on the EbA. Rahman et al. (2014) have identified the re-excavation of traditional ponds, and integrated fish farming as EbA to increase capacity and maintain the ecosystem in the Barind ecosystem. The community in the Haor basin also identified sustainable fisheries asthe EbA opportunities where they have a wide number of practices that maintain the ecosystem. Department of Environment (2015) noted that changes in the climate are affecting the traditional

cropping patterns and cycles. Rahman et. al. (2016) found that river bank erosion, increasing population, elevated use of fertilizers and Agro-chemicals, siltation of land, lack of technological support for irrigation, the irritating pattern of temperature, and the late arrival of monsoon rainfall, excessive monsoon rainfall, land-use changes, and flow alterations are the major driving forces in the riverine ecosystem; the current study also identified same for the Madir Haor. Like other areas, the COVID-19 pandemic has created threats to natural resources too. Collecting snails in huge numbers will hurt the demographic composition of the population of the species and there will be an impact on the hoar ecosystem. The fast observation of the ecosystem of the Medir Haor shows that the sail may not be the keystone species of the Medir Haor but the Ghechu, Aponogeton spp. Collecting cow dung will interfere with the natural fertilizing process. Crop diversification to minimize the risk of har- vest failure is an adaptation strategy in many indigenous communities (Macchi, 2008). Some of these varieties are adapted to different environments/field locations, like near rivers, high on mountains, close to a primary forest, etc. Identification of such crops and crop varieties have more market value. For example, the wild chailla variety Naga Morich, which was wild in the hillocks near the Haor basin in Sylhet and Sunamganj, is being cultivated now in farms and kitchen gardens. The use of chailla grass for erosion control is a common practice in the Haor basin. Due to the current scarcity of chailla, villagers find it hard to protect their homesteads against wave erosion. The project Sustainable Environment Management Programme piloted the use of both geo- textile and chailla together (IUCN Bangladesh 2004). According to the UNEP (2012), the implementation of EbA

remains hampered by three key challenges: lack of information, lack of financial resources, and institutional resistance. Lack of information includes uncertainties in future projections of climate impacts, ecological and societal vulnerability, and economic growth. These forecast uncertainties are exacerbated by the relative paucity of information from monitoring and evaluation of the effectiveness of past and ongoing EbA interventions. Developing climate risk analyses and vulnerability assessments that make use of scientific and traditional knowledge on ecosystem services and adaptation potential are possible solutions. The importance of Traditional Ecological Knowledge in climate change adaptation is not in doubt, but still, there is a limitation of awareness besides the scientific and some local communities. Scal ing up Traditional Ecological Knowledge is very important in resource management as well as in minimizing the effect of climate change. (Lemi, 2019). There is a rapid decline of wetland-related traditional knowledge amang the indigenous communities. Degradation and loss of wetlands, which are also accelerated by the effects of climate change, pose a threat to communities whose livelihoods are derived from wetland-based products (Adhikaria Poudel, 2018). Revitalization of environmentally friendly traditional values and formulation of effective environmental protection policies are required to improve management that would promote ecological and economic benefits for local communities and national interests. (Barua Rahman, 2018a). Barua Rahman, 2018b identified these traditional practices are becoming unpopular in the coastal island areas in recent years because of modern technology, which seems similar in the Medir Haor too. Despite knowing about these practices, the community is relying more

on information technology, but it is for knowledge management only.

Conclusion

Since EbA solutions are cost-effective solutions, they can be incorporated to address issues related to water management in the developing region. The worldwide scientificcommunity has recognized the importance of integrating nature-based solutions for long-term policy planning in the context of climate change, soil, and water conservation, and so on (Khaniya, 2000). The traditional practice of a community is not onlythe skill of the community but also an identity and pride. The traditional coping mechanism of the community is derived from the local environment. It was found that the 11 traditional practices in coping with the climate extreme have proven effective. There is a gap in transfer of Indigenous knowledge between the generations. The indigenous practices of the rural community need to be documented. The practices that have significant impact and effectiveness could be an activity towards aching the EbA out- come. If required, a blended combination of modern technology may be incorporated with traditional practices to make it more effective and appropriate in the current climate change context. For that more empirical and action research are necessary.

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