Evidence-based Assessment of Climate Induced Loss and Damage of Marginalized Coastal Community of Bangladesh: A Case Study of Vulnerable Manpura Island

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ABSTRACT

Manpura Island is highly susceptible to climate-induced hazards such as cyclones, salinity intrusion, riverbank erosion, hailstorm and extreme weather events due to its geographical location and low-lying deltaic environment. This study investigates the local level evidence from marginalized coastal community, and mapping of loss and damage (L&D) of Manpura Island, Bangladesh. It thrives to provide a comprehensive assessment of L&D from social perspectives as well as household level and valuation of both economic (ELD) and non-economic loss and damage (NELD).Combining both quantitative and qualitative methods, this study employed household surveys (HH survey), focus group discussions (FGD), and key informant interviews (KII). This study develops assessment of ELD mapping approach by applying Analytical Hierarchy Process (AHP) and geospatial techniques and examines the spatial distribution of local level climate change impact in Manpura Island. In the context of household level L&D assessment, results represent that extreme L&D affects 71.91% household in Dakkhin Sakuchia union. The most vulnerable regions are the southern and central zones, specifically Dakkhin Sakuchia and Hajirhat unions, which have suffered the greatest levels of economic loss and damage more than 3.331% household. On the other hand, Dakkhin Sakuchia also faces very high economic loss and damage which is greater than 2.925 USD. Non-economic loss and damage (NELD) encompass loss of tradition & culture, psychological well-being, migration and disruption of education and result reveled that Dakkhin sakuchia union suffers the most from NELD on Manpura Island.Results demonstrate that almost all the area in Manpura Island is experienced L&D due to climate change impact. Therefore, the findings of this study would be useful for environmentalist, policymakers and local authorities in formulating appropriate adaptation and mitigation plans to reduce climate change impact in coastal area.

Key words: Socioecological loss and damage; Non-economic loss and damage (NELD); Economic loss and damage (ELD); Analytic Hierarchy Process (AHP); climate change impact;

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1. Introduction

Climate change is a long-term change in the average weather patterns that have come to define Earth's local, regional and global climates. Climate change (CC) is an inter-governmental complex challenge globally with its influence over various components of the ecological, environmental, socio-political, and socio-economic disciplines (Adger et al. 2005; Leal Filho et al. 2021; Feliciano et al. 2022). Climate change is characterized by the comprehensive long-haul temperature and precipitation trends and other components such as pressure and humidity level in the surrounding environment. Besides, the irregular weather patterns, retreating of global ice sheets, and the corresponding elevated sea level rise are among the most renowned international and domestic effects of climate change (Lipczynska-Kochany 2018; Michel et al. 2021; Murshed and Dao 2020). The core goal of the Paris Agreement is to improve global response to the threat of climate change by keeping the global temperature rise. This century well below 2°C over pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5° C (Sharma et al. 2020).

Climate change vulnerability refers to the degree which system or population is susceptible to, and unable to cope with, the adverse effects of climate change. Vulnerability is a function of the sensitivity of system to climate impacts, its exposure to those impacts, and its adaptive capacity (IPCC, 2022). Several factors influence vulnerability to climate change, including geographical location, socio-economic status, and governance. Developing countries, particularly those in tropical and subtropical regions, are generally more vulnerable due to higher exposure to extreme weather events and limited adaptive capacity. Small island developing states (SIDS) are highly susceptible to sea level rise and extreme weather, threatening their very existence (IPCC, 2018).

Discussions on climate-related loss and damage (L&D) in the context of global climate governance first emerged during the United Nations Framework Convention on Climate Change (UNFCCC)'s initial planning and drafting. Although loss and damage (L&D) has been increasingly prominent in international talks at several Conferences of the Parties (COP) in recent years, it is still a friction and highly politicized subject (Calliari et al., 2019). The concept of loss and damage that has been put out by Warner et al. (2012): "Loss and damage refers to adverse effects of climate variability and climate change that people have not been able to cope with or adapt to."

Bangladesh is one of the most disaster-prone countries in the world, due to its geographical location and climate. The country is situated on the delta of the Ganges and Brahmaputra rivers,

making it vulnerable to flooding and cyclones due to climate change, More than 35 million people live along Bangladesh's coast, which is divided into 19 districts and occupies 32% of the nation (Rabbani et al, 2012).The coastal morphology of Bangladesh influences the impact of climate change on the area. In addition, two studies revealed that Bangladesh is increasingly vulnerable to large cyclones, especially between the months of November and May (Anwar et al, 2022).Bangladesh suffers from floods, cyclones, storm surge, river bank erosion, earthquake, drought, salinity intrusion, fire and tsunami. Cyclones and floods particularly caused massive damages. Cyclones occurred in 1970, 1991, 2007(Sidr), 2009(Aila),2013(Mohasen), 2019(Bulbul), 2020(Amphan), 2021(Yaas) & 2023(Mocha) and killed 364,000, 136,000, 3,363 and 190 respectively. The nation's shoreline is home to 185 little islands and chars (BBS, 2005).

Manpura Island is one of the narrow and elongated Island of Meghna estuary of Bangladesh, which is highly unstable, unprotected and suffers from natural disasters because of its geographical settings having low laying deltaic environment along the Northern Bay of Bengal; Due to the adverse effects of climate change, Monpura Upazila is one of the most vulnerable islands in Bangladesh's Bhola District. The Intergovernmental Panel on Climate Change (IPCC) highlights that low-lying coastal areas like Manpura are among the most vulnerable to local level climate change impacts due to their exposure to multiple climate hazards (IPCC, 2021).This is because the methods used for studying loss and damage due to climate change by analyzing some of the most popular image processing techniques and some image classification methods that are used for working on satellite images to know the intensity of climate change impact. This research assess spatiotemporal pattern of loss and damage by analyzing both social L&D (at household level) and ecological L&D. Also used quantitative (Household survey) to know the economic L&D and qualitative (FGD-focus group discussion, KII-key informant interview), e.g., ethnography and participant observation will help to understand non-economic L&D and data from these methods may help to identify the local level climate change impact in this coastal island.

This study is contributed to policy and program taking by local level, government & NGOs and their responses to addressing climate change loss & damage. It specifically addresses the way in which the impact of climate change on livelihoods leads to loss and damage for households' level and ecological condition in those zones of Manpura upazila. It contains specifying the objective of the local level climate change impact and identifying factors that are favorable and unfavorable

to achieve that objective of the area. The island faces significant environmental, socioeconomic, and health-related challenges due to rising sea levels, increased frequency of cyclones, and other climate-induced events. Understanding these impacts and the island's vulnerabilities is crucial for developing targeted adaptation and mitigation strategies to reduce climate-induced loss and damage.

1.1 Research questions

Climate change impacts the socio-economic resilience and vulnerability of communities in Manpura Island, Bangladesh. Their vulnerability to loss and damage brought on by climate change is further increased by poverty, poor infrastructure, and sociopolitical marginalization 4 (Haque et al., 2021). Marginalized communities in Manpura Island are particularly vulnerable to climate change due to their limited access to resources and lack of adaptive capacity (Ahmed et al., 2018).Analyzing how these climate change impacts affect the socio-economic fabric of the communities. Thus, this study will explore the following questions:

1. What are the social loss and damage (L&D) on Manpura Island, Bangladesh?

2. What are the economic losses and damages (L&D) experienced at the community level on Manpura Island?

3. What are the non-economic losses and damages (NELD) experienced at the Community level on Manpura Island?

By addressing these research questions, scholars and policymakers can gain valuable insights into the complex dynamics of climate-induced loss and damage in Manpura Island and develop evidence-based strategies to build resilience and reduce vulnerability in the face of ongoing climate change.

2. Study Area:

The study is conducted in Manpura Island which is the most climate-vulnerable Upazila. Manpura Island serves as an illustration of the broader vulnerabilities faced by coastal communities in Bangladesh. The research focused on understanding climate-induced L&D within four unions (Dakhin Sakuchia, Uttar Sakucha, Hajirhat, and Manpura), offering critical insights into the vulnerabilities and challenges faced by communities in the region. The high-resolution spatial analysis at 10m x 10m scale ensures that the data is functional and accurate at the smallest possible unit, enhancing the reliability of the findings.

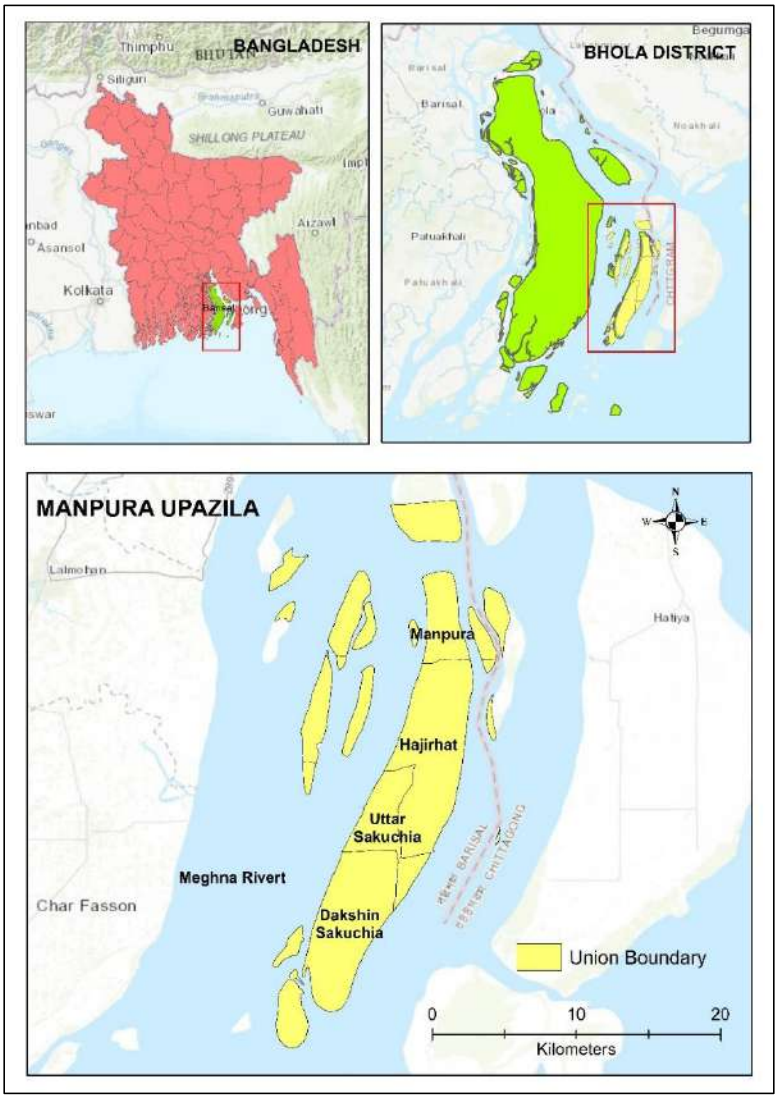

Figure 4 The study area (Manpura Island) is situated in the southern corner of Bangladesh.

(Source: Prepared by Author, 2024)

Manpura Island, situated in the Bay of Bengal, is particularly susceptible to the adverse impacts of climate change due to its geographical location and socio-economic conditions. The study area encompassed four unions, each representing unique socio-economic and environmental characteristics, providing a comprehensive understanding of the diverse challenges posed by climate change.

Geographically, the study area extended between 22.2986°N and 90.9792°E is the coordinates for Manpura.It's northern, southern, eastern, and western boundaries are formed by Tazumuddin Upazila, the Bay of Bengal, Hatiya Upazila, and Lalmohan and Char Fasson Upazilas. Irrespective of the Bangladesh and BFD administrative boundaries, environmentally, the study area fell within the very sensitive areas that cover ecosystems which are influential to both natural and anthropogenic environments.

Manpura was established as a Thana on December 25, 1970, and became an upazila on November 7, 1983.Four union parishads make up Manpura Upazila: Dakshin Sakuchia, Hazirhat, Monpura, and Utar Sakuchia are the first four. There are 18 mauzas and 30 villages in the union parishads.

Socio-economic context: Manpura had 89889 residents as of the 2022 census in Bangladesh. The population was made up of 51.63% men and 48.37% women. 20,940 people were over the age of 18. 75% of people in Manpura were literate on average.

Table 1 General Information of Manpura Upazila

Name of union and GO code	Area (acre)	Population		Literacy rate (%)
		Male	Female	
Manpura 47	28154	9309	8958	27.7
Uttar Sakuchia 71	19385	8636	8594	30.0
Dakshin Sakuchia 21	20218	7759	7836	29.5
Hajirhat 23	24420	13042	12448	38.1

(*Source*: Bangladesh Population Census 2011, Bangladesh Bureau of Statistics)

Main sources of income Agriculture 72.50%, non-agricultural labourer 4.30%, industry 0.19%, commerce 9.68%, transport and communication 0.86%, service 3.32%, construction 0.48%, religious service 0.32%, rent and remittance 0.03% and others 8.32%. All the unions of the upazila

are under electrification net-work. However 14.1% of the dwelling households have access to electricity.

Geo-physical context: The climate of Manpura Island is characterized by its tropical monsoon climate, typical of the region. It experiences distinct wet and dry seasons, influenced by the southwest and northeast monsoons. The wet season typically spans from June to October, bringing heavy rainfall and occasional cyclones, which can have devastating effects on the island. The dry season, from November to May, offers respite from the rains, with clearer skies and calmer seas.

The temperatures on Manpura Island remain relatively warm throughout the year, with little variation between seasons. During the hottest months, from April to June, temperatures can soar, reaching highs of around 32-35°C (90-95°F). The cooler months, from December to February, offer more comfortable temperatures, ranging from 20-28°C (68-82°F).Precipitation is abundant on Manpura Island, especially during the monsoon season. The island receives a significant amount of rainfall, with annual averages ranging from 2000 to 3000 millimeters. The monsoon season, which typically lasts from June to September, brings heavy rainfall, vital for the island's agriculture but also posing challenges such as flooding and soil erosion. Humidity levels on Manpura Island remain high throughout the year, owing to its proximity to the Bay of Bengal and the surrounding mangrove forests. Humidity levels typically range from 70% to 90%, creating a sultry and humid environment that is characteristic of tropical climates. This high humidity can often intensify the perception of heat, especially during the summer months.

Despite the challenges posed by its climate and geographical location, Manpura Island remains a resilient community, deeply connected to its surroundings and reliant on its natural resources for sustenance and livelihood.

3. Materials and methods:

3.1 Objective based Research Methods and techniques

Research techniques are essential for any scientific inquiry, providing a systematic approach to investigate, analyze, and understand phenomena in various fields, ranging from social sciences to natural sciences. These procedures and approaches are designed to make sure that the study process is methodical, focused, and aimed toward reaching particular goals. The following are some typical objective-based research methodologies and approaches.

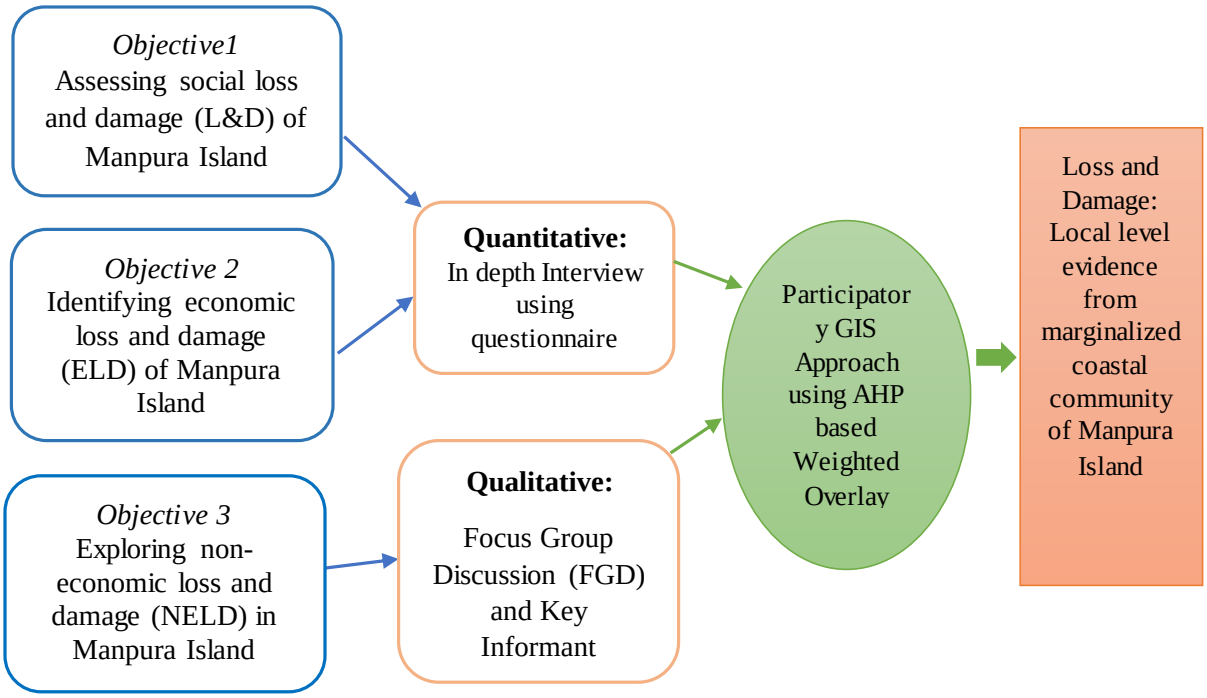

Figure 5: Objective based data collection methods

(Source: modified by Author, 2024)

3.1.1 Quantitative Data: Questionnaire survey and sampling strategy

Questionnaires are valuable tools in social science research for collecting data from respondents in a systematic and standardized manner. In this research use semi-structured questionnaires. Semi-structured questionnaires combine closed-ended questions with open-ended questions that allow respondents to provide additional comments or explanations.

The quantitative data was collected by survey questionnaire in different places of Monpura, Questionnaire survey was held with over 100 households in four unions. Households is selected using a random number generator tool. The questionnaire also includes questions aimed at assessing loss and damage of local people. And the questionnaire was developed to address in a systematic way issues such as the general socio-economic and demographic characteristics of the households, climate change impact, migration, coping and adaptation strategies, the types and levels of loss and damage incurred to land, housing, crops and livestock in addition to changes in livelihood options and impacts on health and community ideas about policy options to reduce

impacts and loss and damage. There are many formulas used for calculating sample size. One of the most common formulas used is Yamane's formula:

$$\mathbf{n = N/ (1+Ne^2)}\text{.....Equation 1}$$

Where, n is the required sample size from the population under study

N is the whole population that is under study

e is the precision or sampling error

The Sample size of **Manpura upazila,**

Here, N=89889 (BBS 2022); e= 0.1; e^2= 0.01

So, n=89889/ $(1+89889*(0.1)^2)$

n= 99.54 or 100

Therefore, the sample size of ***Dakkhin Sakuchia union,***

N= 4510*100/ 18560 = 24

Therefore, the sample size of ***Uttar sakuchia union,***

N= 4568*100/ 18560 = 25

Therefore, the sample size of ***Manpura union,***

N= 4267*100/ 18560 = 23

Therefore, the sample size of ***Hazirhat union,***

N= 5215*100/ 18560 = 28

Table 2 Household level questionnaire survey sample size per union in Manpura Island

Union	*Household Per union*	*Questionnaire Survey Size*
Manpura	4267	23
Uttar Sakuchia	4568	25
Dakshin Sakuchia	4510	24
Hajirhat	5215	28

Kobo Toolbox is used for data collection, management, and analysis. The platform supports various question types (e.g., multiple-choice, open-ended, GPS coordinates) and allows for the creation of skip patterns, validations, and constraints to ensure data quality. Data was collected using the Kobo collect mobile app, which is available for Android devices. It provides real-time monitoring of data collection activities. Collected data is securely stored in the Kobo Toolbox server. The platform allows to manage data, including viewing, editing, and exporting data in various formats (e.g., Excel and SPSS). Data can also be encrypted to ensure confidentiality and security.

SPSS (Statistical Package for the Social Sciences) is a versatile and user-friendly software package for quantitative data analysis. It has extensive range of features, robust statistical capabilities, and intuitive interface make it a preferred choice for researchers and analysts across disciplines. It offers a wide range of descriptive statistics to summarize and explore data. It uses for calculate measures such as mean, median, mode, standard deviation, variance, and percentiles for continuous variables(questionnaire data).Frequency tables and histograms can be generated to examine the distribution of categorical variables. It can easily create charts, graphs, and plots such as bar charts, pie charts, histograms, scatterplots, and boxplots as per requirement.

3.1.2 Qualitative Data: Focus group discussion (FGD) and Key Informants Interview (KII)

Qualitative data collection methods such as focus group discussions (FGDs) and key informant interviews (KIIs) are valuable tools for gathering rich, in-depth insights into people's perspectives, experiences, and behaviors. The qualitative data was collected by Semi-structured Interviews and Focus Group Discussion (FGDs). Here's an overview of these methods, including sampling methods and software commonly used for qualitative data analysis:

The sampling method for FGDs typically involves purposive or convenience sampling. Participants are selected based on their relevance to the research topic and their ability to provide diverse perspectives. The sample size for FGDs is usually small to facilitate meaningful group interaction, typically 4 FGD (per union) participants was conducted.

The sampling method for KIIs involves purposive sampling. Key informants are individuals who possess specialized knowledge or expertise relevant to the research topic. Sampling criteria includes occupation, role, experience, or influence in the community. The number of key informants interviewed based on the research objectives and the saturation of information which included 8 participants (2 in per Union).

Table 3 Sample size for interviews (both Key Informant Interviews and Focus Group Discussion (FGD)

SI.No	Methodology	Selected union	Number	Total Number
1	KII	Manpura	2	8
		Hazirhat	2	
		Uttar Shakuchia	2	
		Dhakhin Shakuchia	2	
2	FGD	Manpura	1	4
		Hazirhat	1	
		Uttar Shakuchia	1	
		Dhakhin Shakuchia	1	

NVivo is a popular qualitative data analysis software widely used by researchers for analyzing data from key informant interviews (KIIs) and focus group discussions (FGDs). The research FGDs and KII data are conducted, transcribed and analyzed by NVivo software. It is used for coding, organizing, and analyzing the data. NVivo software packages offer features for thematic coding, text search, memo writing, and visualization of qualitative data. Both FGDs and KIIs generate qualitative data that require systematic analysis to uncover themes, patterns, and insights. Qualitative data analysis software (NVivo) streamlines the process of managing and analyzing

large volumes of qualitative data, allowing to identify commonalities, differences, and nuances in participants' responses.

3.1.3 Ancillary data

Ancillary data, such as census data, are additional datasets that provide contextual information to support analysis or interpretation in various fields, including social science, urban planning, and public health. Census data often include demographic, socioeconomic, and housing characteristics of populations and households within specific geographic areas. Here's an overview of census data, including sampling methods used in data collection and software commonly used for analysis. Census population data provide information about the size, distribution, composition, and characteristics of populations within defined geographic areas. This research use census household data which provide information about housing units, households, literacy rate of Manpura Island.

Census data serve as a foundational resource for research, policy-making, and decision-making in various domains. Analyzing census data using appropriate software tools enables researchers, planners, and policymakers to understand population dynamics, assess social and economic disparities, and inform evidence-based interventions and policies to address community needs.

3.2 Methodological flow chart of evidence-based loss and damage (L&D) assessment

The assessment of climate change induced loss and damage needs to consider information about current and future hazards, exposure and vulnerability in coastal region. This requires decisions on a range of issues, including the assessment's time frame (e.g. which future impacts to consider), the type of climate scenarios to use, which hazards to cover, what impacts to investigate and what data to use(Mechler et al, 2019). In addition, there are several aspects that are particularly relevant to the assessment of climate change risks for social and ecological aspect. A review of the literature and survey of recent studies are needed to conduct successful research. Methodological flowchart mainly focused on detail information how research work is organized.

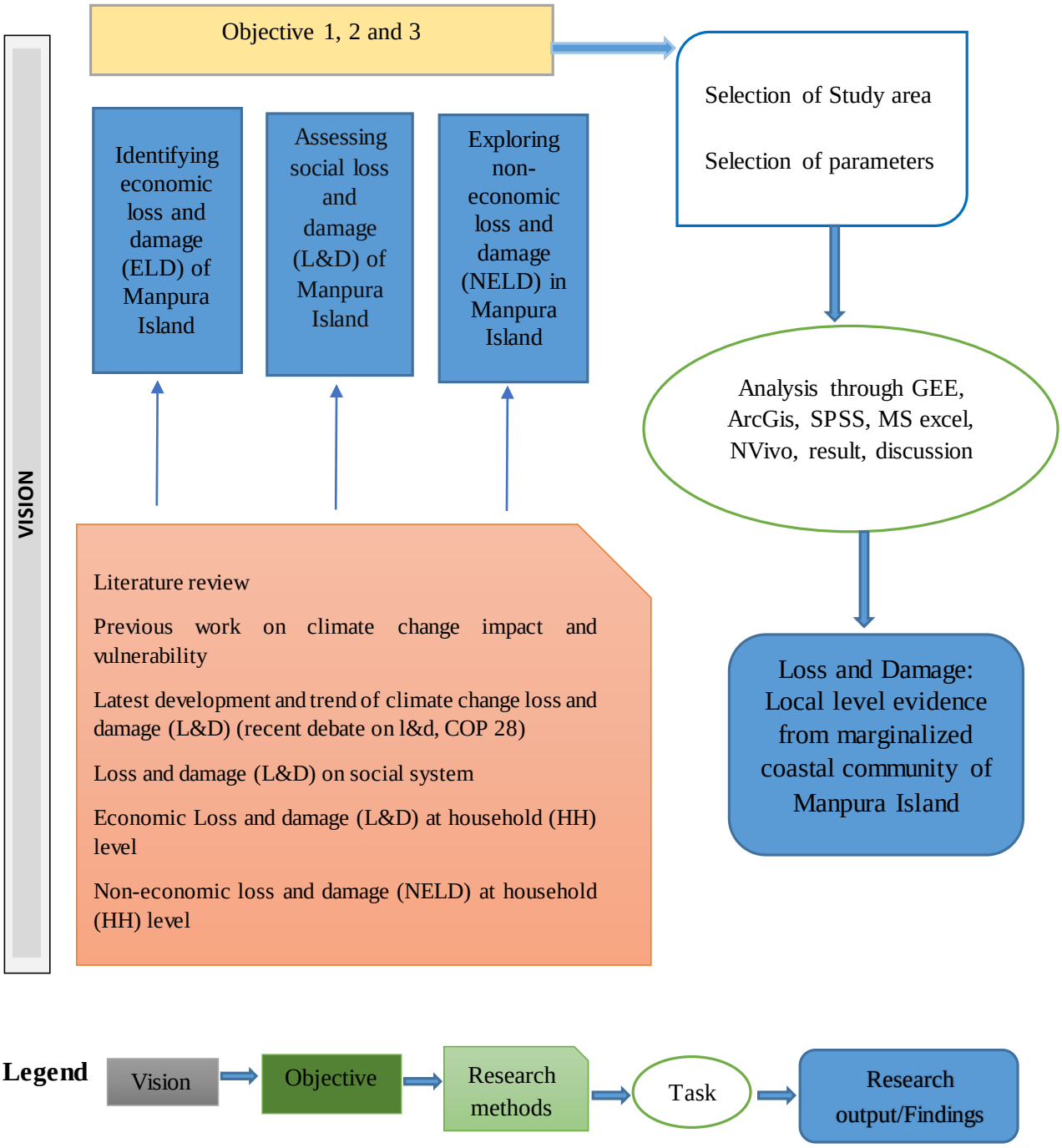

Figure 6: Research design and methodology for this study

(Source: modified by Author, 2024)

3.3 Data extraction procedure and relevant analytical techniques

3.3.1 Social L&D data

A desk study was carried out to collect and assess secondary data as well as previously published regional and thematic literature in order to inform final choices regarding research design and the relevant climate stressors to concentrate on L&D. The purpose of the survey instrument was produced to estimates populations in the research areas experiencing various impacts of climate change and their coping mechanisms for pressures and shocks resulting from these changes. The sample size for the case study is 100 households. All the social L&D data will be collected through HH survey, KII and FGD. To make indicators comparable, all the social data (household) will be spatially distributed into the study area.

The number of households in each research site that carried out coping or adapting strategies, the percentage of households experiencing residual loss and damage, and the percentage of households facing specific climate-related stresses and impacts on their household are all displayed in **Table 4**. In order to mitigate the negative effects of severe weather and slow-onset changes, the vast majority of survey respondents across research locations reported they have used coping or adaptation methods .

The following **Table 4** will be used to define L&D at social level and sector-wise L&D based on Warner and Geest framework (2013). In the following table, Column (b) is a proportion of the households in column (a); column (c) is a proportion of those in column (b); and column (d) is a proportion of those in column (c). 'Loss and damage' in column (e) is calculated as: e = (a * b * c * d) + ((1 – c) * a * b), where the letters stand for the percentages in the corresponding columns. In words, it is the proportion of the whole survey population that experienced adverse effects despite adopting measures to cope or adapt plus those who were affected but who did not adopt any measures in response.

Table 4 analyzes variations across locations (Manpura, Hajirhat, Uttar Shakuchia, and Dhakhin Shakuchia) to identify factors influencing the impact of Loss and Damage. Summarizing the impact of various climate stressors on households in four unions at Manpura Island. It appears to be based on survey or data collection effort. The table focuses on household level loss and damage in Manpura Island.

It measures the percentage of households that: experienced the stressor (a): this indicates the prevalence of the stressor in the area. Experienced impact (b): this shows how many households were affected by the stressor's consequences. Adopted measures(c): this reflects the efforts taken by households to cope with the stressor. Impact despite measures (d): this highlights the limitations of the adopted measures in mitigating the impact. Loss and damage (e): this column represents the percentage of loss and damage (% L&D) at the household level, likely due to the climate stressors (**Table 4**).

Table 4 stressor, impact, responses and loss and damage at household level (% L&D)

Climate related stressor	Experienced stressor (%)	Experienced impact (%)	Adopted measures (%)	Impact despite measures (%)	Loss and damage (%)
Union	a	b	c	d	e
Manpura	100	100	57	43	67.51
Hajirhat	97	93	53	39	61.05
Uttar Sakuchia	100	96	68	40	56.83
Dakkhin Sakuchia	100	92	42	48	71.91

(Source: Questionnaire survey data, 2023)

Across all unions, Dakkhin Sakuchia union has the highest impact on households' level loss and damage (% L&D) as measured 71.91% and Uttar Sakuchia has faced minimal L&D (56.83%).In the context of loss & damage**,** Manpura has the severe loss and damage (67.51%) even though Hajirhat has experienced percentage of households experiencing the stressor (97%).This suggests more stress due the impact of L&D in Hajirhat (61.05%). The "impact despite measures" column shows that adopted measures are not always fully effective. For instance, in Hajirhat, 53% of people taking measures against natural hazards, 39% still experience impact. Most of household feel stressor during natural hazards and many of them take adaptive measure. Uttar sakuchia union people take high adaptation measure 68% and Dakhin Sakuchia's respondents take less adaptation measure 42% only which is lower than others union. Uttar sakuchia union's people face less L&D due to natural hazards. Natural calamities seem to have the least impact on households in Uttar Sakuchia union. This might be due to factors like distance from the coast or adaptation measures taken by the community. This **table4** provides a valuable starting point for understanding the

impact of climate change on households in this region. It Investigate the types of measures adopted by households and their effectiveness for different stressors. Consider additional data on the severity of the stressors and the socio-economic characteristics of the households for more comprehensive analysis. Further analysis can help target adaptation strategies and resource allocation to improve community resilience.

3.3.2 Economic Loss and Damage

Economic loss and damage due to climate change in Manpura Island can be identified based on questionnaire survey. The quantitative data was collected by semi-structured questionnaire survey among four unions of Manpura Uapzila, Questionnaire survey was held with over 100 households. As per each unions Household size, questionnaire survey has been done based on calculation **Table2**.

Develop questionnaire that gathers relevant information on the Economic loss and damage at household level. Inquire about the type and amount of damage, the financial impact, the coping strategies used by households, etc. Determine the average household economic L&D four union for each of the following categories: infrastructure damage, loss of sanitation facilities, loss of water source, wages loss due to natural hazard, loss of livestock and poultry, loss of agricultural crops, loss of fishing Gher, expenditure increases due to drinking water scarcity, loss of homestead vegetation and fruit trees and aggregate the losses across all households in each union. Calculate the percentage of ELD for every household in every union and apply the current exchange rate to convert total losses from the local currency to USD.

Alternative ranking and standardization of criteria layers for economic L&D

The classification techniques was natural breaks and L&D ratings were graded on a 4-point scale, with 1 representing low ELD (rank 1) and 4 representing very high L&D (**Table 5**) for each alternative of spatial criterion. The contribution to L&D and AHP guidelines were taken into consideration when alternative ranking has been done.

To apply the weighted overlay technique, 10m×10m resolution raster layer was created for each criterion, changing them from vector to raster. To standardize the different ranking values, a linear scale transformation in Equation was applied to bring them all into the same range from 0 to 1. The process of normalization was carried out applying

Equation: P= x-min/ max-min

Here, x represents the cell value in each spatial raster layer, min and max stand for the minimum and maximum values linked with each dataset, and p stands for the normalization score.

Table 5 criteria ranking scheme based on the relative importance of Economic loss and damage due to climate change at household level (%HH)

	Ranking Based on ELD at household level (%HH)			
Criteria	Low(1)	Moderate(2)	High(3)	Very High(4)
Infrastructure damage	<78.26	78.26-91.66	91.66-92	>96.42
Loss of sanitation facilities	<56.52	56.52-60	60-71.43	>75
Loss of water source	<65.21	65.21-72.22	72.22-74.07	>81.81
Wages loss due to natural hazard	<72	72-78.26	78.26-78.57	>87.5
Loss of livestock and poultry	<76	76-85.71	85.71-86.95	>87.5
loss of agricultural crops	<70.83	70.83-76	76-78.26	>85.71
Loss of fishing gher	<80	80-86.95	86.95-89.28	>95.83
Expenditure increases due to drinking water scarcity	<69.56	69.56-72	72-79.16	>82.14
Loss of homestead vegetation and fruit trees	<71.42	71.42-82.6	82.6-84	>100
Expenditure increases in medical sector	<80	80-82.60	82.60-83.33	>85.71

Table 6 criteria ranking scheme based on the relative importance of Economic loss and damage due to climate change at household level (USD)

	Ranking Based on ELD at household level (USD)			
Criteria	Low(1)	Moderate(2)	High(3)	Very high(4)
Infrastructure damage	<406547	406547-530307	530307-60700	>682619
Loss of sanitation facilities	<125349	125349-182825	182825-300135	>328102
Loss of water source	<167700	167700-259927	259927-279766	>298336

Wages loss due to natural hazard	<350895	350895-361706	361706-396497	>563749
Loss of livestock and poultry	<214086	214086-271216	271216-350575	>526824
Loss of agricultural crops	<327043	327043-404434	404434-419021	> 5344484
Loss of fishing Gher	<361267	361267-503328	503328-666033	>682473
Expenditure increases due to drinking water scarcity	<220969	220969-245469	245469-348819	>390068
Loss of homestead vegetation and fruit trees	<180853	180853-250616	250616-256525	>469040
Expenditure increases in medical sector	<335838	335838-353104	353104-431610	>435966

AHP and criteria weighting for economic L&D

The criteria of ELD components were weighted in the current study in order to create ELD map using the AHP decision-making algorithm. Researcher contributed to create the pairwise comparison matrix for each ELD component, applying Saaty's (2008) "scale of relative importance" (Hoque et al, 2019).

All of them had considerable experience in coastal research, L&D factors and their influence on the study area. The total score of each ELD component was 1.

The estimated consistency ratio (CR) to identify the consistency of comparison determined by the experts and user. The comparisons are considered at the acceptable level if the CR value is equal or less than 0.1. The CR was calculated following Equation:

$$CR = \text{Consistency Index/Random Index},$$

Here, random index (RI) represents the randomly generated average consistency index.

The consistency index (CI) can be calculated as follows:

$CI = (\lambda max - n)/ (n-1)$

Where λmax is the largest eigenvalue of the matrix and n denotes the matrix order (Malczewski, 2010). Last steps involved using **Table 7** to convert the pair-wise matrix criteria weights into linguistic variables. The Chang (1996) methods was used to calculate the priority weights (**Table 7**).

Table 7 Criteria weights from pair-wise comparison matrices along with CR values for ELD

Criteria	Weight	Consistency Value
Infrastructure damage	0.24	14.5
Loss of sanitation facilities	0.22	15.24
Loss of water source	0.15	12.94
Wages loss due to natural hazard	0.13	11.66
Loss of livestock and poultry	0.07	12.19
loss of agricultural crops	0.06	11.21
Loss of fishing Gher	0.05	12.07
Expenditure increases due to drinking water scarcity	0.04	10.82
Loss of homestead vegetation and fruit trees	0.03	12.55
Expenditure increases in medical sector	0.02	11.28

Consistency ratio (CR): 0.09

3.3.3 Non-economic Loss and damage

3.3.3.1 Qualitative research design

The qualitative research method has been followed in this research. The qualitative research design employed in this study aims to explore non-economic loss and damage (L&D) due to climate change through in-depth interviews and focus group discussions. This approach allows for a detailed understanding of participants' experiences, perceptions, and insights regarding the impacts of climate change that are not captured by economic metrics. In contrast to quantitative research, which focuses on statistical analysis, qualitative research aims to learn more about the issue under investigation by gathering and analyzing subjective data (Patton, 2002).

Qualitative research is essential for exploring complex phenomena from the perspectives of those experiencing them. Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) are powerful methods within this design. FGDs facilitate interaction among participants, generating rich data through shared experiences and collective views (Morgan, 1997). KIIs, on the other hand, provide in-depth insights from individuals with specialized knowledge or unique perspectives, often offering more detailed information on specific issues (Patton, 2015). FGDs facilitate a comprehensive understanding of community perceptions and collective experiences, while KIIs provide expert opinions and nuanced insights from individuals with specialized knowledge. This dual approach ensures a rich and multifaceted data collection process (**Table2**).

In contrast to quantitative research, which often entails a predetermined list of questions, qualitative research enables researchers to modify their approaches and inquiries in accordance with the particular setting of the study. Researchers can better comprehend the experiences and viewpoints of the participants because to this flexibility (Creswell, 2014). Overall, qualitative method allows us to know about the experience of the older people during the cyclones; how cyclones impacted their life, and their (in) mobility decision as adaptation strategies.

3.3.3.2 Preparation of interview guide

The preparation of an interview guide is a critical step in qualitative research. An effective guide ensures that all relevant topics are covered while allowing flexibility for participants to share their experiences. To ensure comprehensive and consistent data collection, an interview guide was prepared. The guide included open-ended questions designed to derive detailed responses about various dimensions of non-economic L&D. Key areas of focus included health impacts, loss of cultural heritage, educational disruptions, social and community cohesion, psychological well-being, and biodiversity and ecosystem services. A methodical approach to creating an effective interview guide was used (Cope, 2016). The general processes to prepare an interview guide is listed below:

- The study question needs to be presented properly. This will help identify the key subjects and questions that the interview guide should cover.

- The relevant literature should be reviewed in order to identify the key concepts and issues that have been covered in the discipline. This will help in developing across suitable interview questions.
- Identifying possible volunteers is essential for researchers as they can help in their understanding of the study topic. The interview guide can then be modified to suit the specific population under consideration.
- Formulating the interview guide in accordance with the identified participants, literature review, and study topic. The guide includes open-ended questions that motivate participants to go into further detail with their responses.

An interview guide is meticulously prepared to ensure that all relevant topics are covered systematically during the discussions and interviews. The guide includes open-ended questions designed to elicit detailed responses and follow-up prompts to explore specific issues further.

3.3.3.3 Selection of interview participants

The sampling method that had been used for the research is purposive sampling method. This method is mostly adopted when the target population is not easily accessible, or when the researcher wants to choose participants who have a specific traits or experience that is related to the research. In qualitative research, when the goal is to comprehend the experiences, viewpoints, and behaviors of individuals or groups, this technique is frequently employed (Palinkas et al., 2015). The major benefit is that it allows researchers to choose participants who are most appropriate to the research topic, which can generate information that is more in-depth and useful (Patton, 2002).

Selecting participants for FGDs and KIIs involves purposive sampling to ensure a diverse and representative sample. Participants should be chosen based on their relevance to the research questions and their ability to provide varied perspectives (Creswell & Poth, 2017). This selection process aims to capture a wide range of experiences and insights, ensuring the data's richness and diversity **(Table3).**

3.3.3.4 Interviews and focus group discussions

Individual interviews and focus group discussions were conducted to collect qualitative data. Interviews provided an opportunity for in-depth, personal accounts of non-economic L&D, while focus group discussions allowed for the exploration of collective experiences and community-level impacts. Both methods facilitated the identification of common themes and unique insights into how climate change affects various aspects of life beyond economic measures.

Conducting FGDs and KIIs requires careful planning and skilled moderation. For FGDs, creating a comfortable environment where participants feel safe to share their thoughts is crucial. The moderator should facilitate discussion, manage group dynamics, and ensure that all voices are heard (Krueger & Casey, 2015). KIIs, conducted one-on-one, allow for deeper exploration of individual perspectives.

The interviews were conducted in different unions in Manpura upazila including Hajirhat, Dhakkhin Sakuchia, Uttar Sakuchia, and Manpura. The interview of the effected people was conducted at Manpura Upazila. Participants were contacted before an interview. Some local gatekeepers helped us to reach the participants. This made easier to find them and the interviews were conducted faster. Before taking the interviews and conducting FGDs, consent has taken from each participant. The participants were asked questions according to the interview guide. The questions were open ended. So that, the participants can answer the questions and share their experiences elaborately. Depending on the situation and context, interviews were a mix of informal and formal questions.

Interviewers should build rapport, follow the interview guide, and probe for detailed responses while remaining flexible to follow interesting leads that arise during the conversation (Rubin & Rubin, 2011). The data collection process involves conducting the FGDs and KIIs as follows:

- FGDs: Conducted in a comfortable and neutral setting to encourage open and honest dialogue. Each session is moderated by a trained facilitator, with discussions recorded and transcribed for analysis.
- KIIs: Conducted one-on-one, either face-to-face or via digital platforms, ensuring confidentiality and encouraging detailed responses. Interviews are recorded and transcribed verbatim.

Both methods are designed to create a trusting environment where participants feel safe to share their experiences and views.

3.3.3.5 Data analysis using NVivo software

Data analysis in qualitative research involves coding and categorizing data to identify patterns and themes. NVivo software is a widely used tool that supports the systematic analysis of qualitative data. It allows researchers to organize, code, and analyze large volumes of text, facilitating the identification of key themes and relationships (Bazeley & Jackson, 2013). The process typically starts with data transcription, followed by iterative coding cycles. Researchers can use NVivo to visualize data, run queries, and generate reports, enhancing the rigor and transparency of the analysis (Edhlund & McDougall, 2019).

The qualitative data collected from FGDs and KIIs are analyzed using NVivo software, which facilitates the systematic coding and thematic analysis of large text datasets. The analysis process includes:

- **Data Coding:** Transcriptions are imported into NVivo, where they are coded to identify patterns, themes, and categories. Initial coding is broad, capturing all relevant information, followed by more detailed coding to refine themes.
- **Thematic Analysis:** Codes are organized into themes that reflect the key issues discussed by participants. Thematic analysis helps to identify commonalities and differences in experiences and perceptions.
- **Content Analysis:** NVivo's query functions are used to conduct word frequency and content analysis, providing quantitative insights into the prevalence of specific themes and concepts.

This analytical approach ensures a rigorous and comprehensive analysis of qualitative data, allowing for the extraction of meaningful insights and the development of evidence-based conclusions and recommendations.

4. Results & Discussion:

4.1 Situation status of Social L&D

Manpura Island, situated in a low-lying deltaic environment in Bangladesh, is highly susceptible to climate change impact. Identifying local level climate change impact and climate-induced hazards such as cyclones, salinity intrusion, riverbank erosion, hailstorms, and extreme weather events at household level. Climate change leads the significant social loss and damage (L&D) that affect the island's communities on multiple levels.

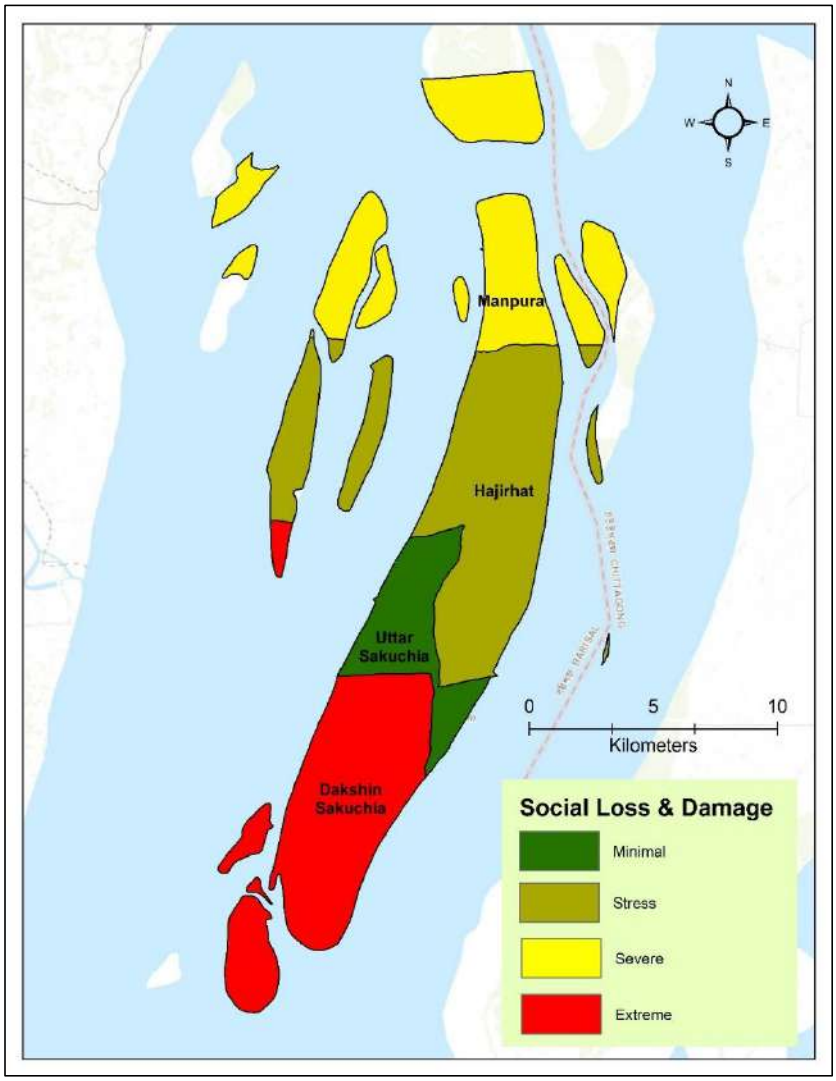

Figure 4 Social loss and damage (at household level) in Manpura Island.

(Source: Prepared by author, 2024)

In Maps, HH level L&D ratings were graded on a 4-point scale, with green color representing minimal L&D, light green color indicating stress L&D, yellow and red color representing severe and extreme L&D respectively. The percentage of households level L&D (**Table 4**) is indicated which causes due to climate change.

Figure 4 illustrate the intensity of L&D due to climate change across the unions of the study area, indicating how household is affected in each union. With almost 71.91% of households reporting L&D in Dhakkhin Sakuchia and it looks to be the worst-affected union (red color on map). Uttar Sakuchia appears to be the least damaged, with less than 56.83% of households reporting damage and financial loss (shown as green on the map).Others two union represents stress and severe L&D (Manpura, Hajirhat). Dakhin Sakuchia is situated in a region that is more exposed to the Bay of Bengal or along the direct path of cyclones, that's why it is naturally more vulnerable. Dakhin Sakuchia has lower elevation compared to Uttar Sakuchia, making it more susceptible to flooding. Manpura is relatively more sheltered or situated in a location less frequently hit by cyclones and experience less impact. In contrast, Hazirhat is located where the river flow is slower and less erosive. The union people have more sustainable land-use practices (crop cultivation, afforestation, fishing gher) that protect the riverbanks.

Overall, the maps show that Manpura Island's households are negatively impacted by climate change, with significant percentages of L&D resulting from cyclones, coastal inundation, riverbank erosion, and salinity intrusion. According to the assessment of L&D characteristics in Manpura Upazila, Hajirhat and Dhakkhin Sakuchia represent the most affected unions.

The map suggests that climate change is having a significant negative impact on the lives of the people who live on Manpura Island. The social loss and damage caused by climate change is likely to have adverse effect, making it more difficult for people to meet their basic needs and to live healthy and productive lives.

4.2 Economic L&D

4.2.1 Household level economic L&D

The maps of Manpura Island, Bangladesh, at the union level (Hazirhat, Manpura, Dakhin Sakuchia, and Uttar Sakuchia) indicate the economic loss and damage at households' level as a result of climate change.

The percentage of households with infrastructure damage **Figure 5(**a) is indicated with almost 96% of households reporting infrastructure damage, Hajirhat looks to be the worst-affected union (red color on map). Manpura appears to be the least damaged, with less than 78% of households reporting damage and loss (shown as green on the map).

Similar to infrastructure damage, the percentage of households (%HH) reporting loss of sanitation facilities **Figure 5** (b) is indicated in the map. Again, Dakshin Sakuchia seems to be the most affected with over 75% of households reporting ELD. Manpura appears to be the least affected with less than 56% of households. And Uttar Sakuchia, Hajirhat union represents moderate & high ELD which represented by 56.52-60% and 60-71.43% household experience L&D to climate change.

The percentage of households reporting loss of water source **Figure 5** (c) is ranges from under 65.21% to over 81.81%. Uttar Sakuchia again appears to be in the best condition with less than 65% of households reporting ELD, while Dakhin Sakuchia seems to be the most affected union with over 81% of households reporting loss of water source. The percentage of households reporting loss of wages due to climate change ranges from under 72% to over 87.5% of households. Dakhin sakuchia appears to have the most households experiencing wage loss over 87%, while Uttar Sakuchia appears to have the least affected with less than 72% of households.

Similar to wages loss, the percentage of households reporting loss of livestock and poultry, **Figure 5** (e) is represented in the map with four colour scheme. Dakkhin Sakuchia seems to be the most affected here as well, with over 87% of households. Uttar Sakuchia appears to be the least affected with 47% of households. Hajirhat upazila is moderately affected ranges from 76-85.71% and Manpura upazila is high affected with 85-86.95%.

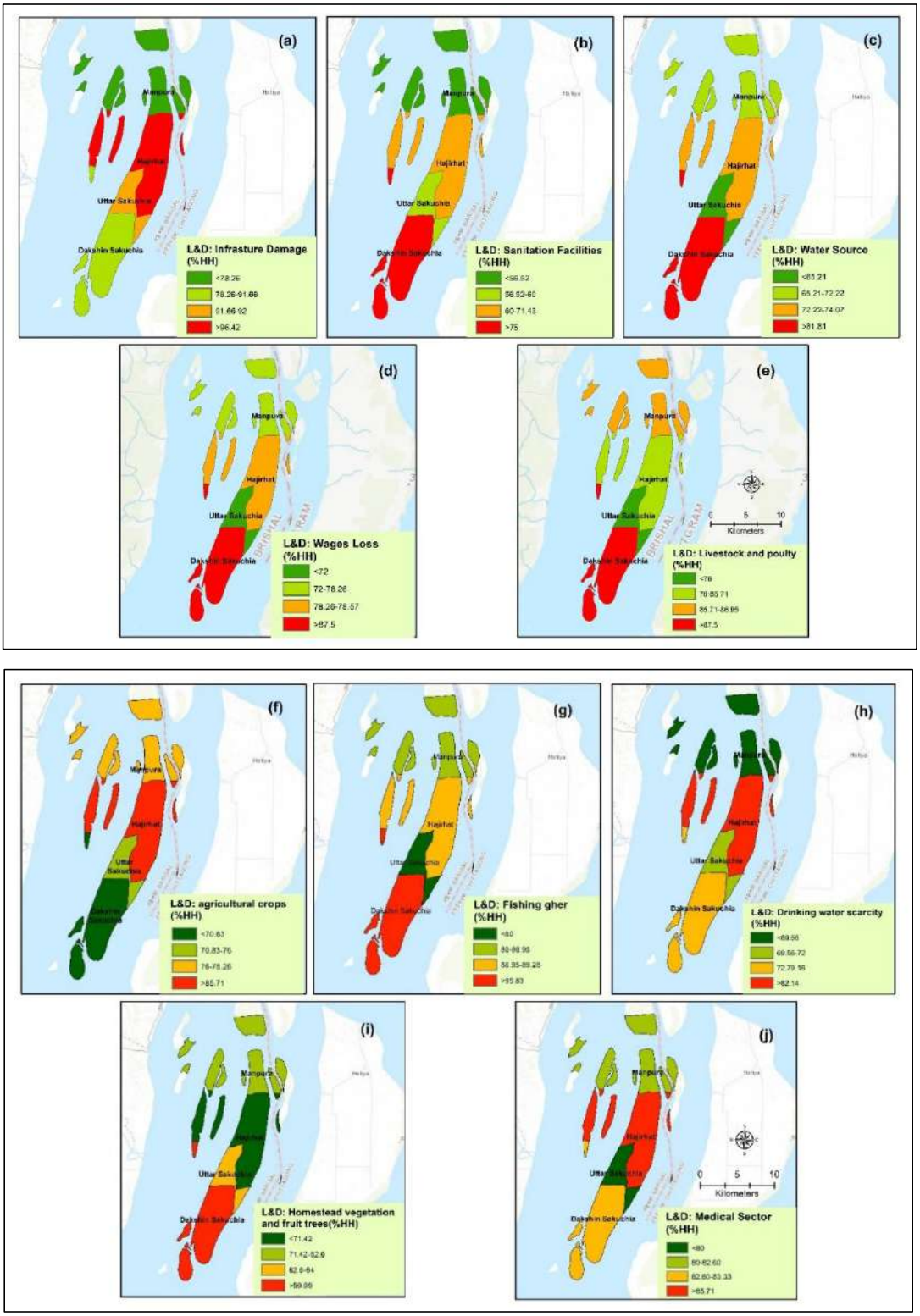

Figure 5 Household level economic loss and damage due to climate change in Manpura Island at union level: a) Infrastructure damage, b) loss of sanitation facilities, c) water source loss, d) wages loss, e) loss of

livestock and poultry, f) loss of agricultural, g) loss of fishing Gher, h) drinking water scarcity, i) loss of homestead vegetation j) expenditure increase in medical sector.

(Source: Prepared by author, 2024)

Figure 5 (f) appears to be highest ELD in Hajirhat union, with over 85.71% of effected households. Manpura and Uttar Sakuchia appear to be doing moderately loss and damage with 70.83% and 76% of households, respectively. Dakhin Sakuchia represents low economic loss and damage which has less than 70% of HH. **Figure 5** (g) Dakhin Sakuchia appear to more affected, with over 95% of households reporting loss of fishing gher. Hajirhat and Manpura appear ELD at 80% and 86.95% respectively. And Uttar sakuchia indicates low ELD which is less than 80%. **Figure 5** (h) represents that Hajirhat seems to be worst affected with over 82.14% of households reporting drinking water scarcity. Manpura appears to be doing better with 69.56% ELD reporting a scarcity of drinking water rather than other two union Dakhin Sakuchia (69.56%) & Uttar Sakuchia (79.16%). **Figure 5** (i) indicates almost all households (over 99.99%) in Dakhin Sakuchia appear to have reported loss of homestead vegetation and fruit trees. Uttar Sakuchia, Manpura and Hajirhat appear to be slightly better with 71.42%, 82.6% and less than 71.42% of households reporting ELD respectively.From **Figure 5** (j) Hajirhat seems to have the most households reporting an expenditure increase in medical sector, with over 85.71% of households. Uttar Sakuchia appears slightly better with 80% of households reporting an expenditure increase in medical sector.

The maps represent that climate change is having a significant negative impact on households in Manpura Island, with high percentages of households reporting loss of agricultural crops, loss of fishing Gher, drinking water scarcity, and loss of homestead vegetation and fruit trees. Hajirhat and Dakhin Sakuchia appear to be the most affected union according to economic loss and damage evaluation parameters in Manpura Upazila.

4.2.2Valuation of household level economic loss and damage

The effects of climate change on households' economic well-being are complicated with both direct and indirect consequences on people as individuals, families, and communities. Events carried on by climate change, such as severe weather, increasing sea levels, and temperature

changes, aggravate vulnerabilities and disrupt with economic activity, resulting in short-term and long-term damages as well as losses of wealth.

The legend for the map indicates the ranges for economic loss and damage in USD represented by different colors. Here's the household level economic loss and damage (ELD) in Manpura Island for Infrastructure damage (a), Loss of sanitation facilities (b), Water source loss (c), Loss of livestock and poultry (d), Wages loss (e), loss of agricultural crops (f), loss of fishing Gher (g), drinking water scarcity (h), loss of homestead vegetation and fruits trees (i), and expenditure increase in medical sector (j).Infrastructure damages due to adverse effect of climate change and people need to repair and reconstruct their residence for improve quality of house.

From **Figure 6** (a), find out the ELD at household level among four unions in Manpura upazila. Hajirhat union has spent less than 400,047 USD which represented by green color in map and most affected union is Dakkhin Sakuchia (682,019 USD), red colour in map.Manpura (406,647-5,303,337 USD) and Uttar sakuchia (5,303,337-8,070,000USD) union represented by light green and yellow color in map.

Figure 6 (b) represents Ranges from less than USD 128,340 to over USD 300,136 across the island. Uttar Sakuchia appears to be the most affected area, with L&D over USD 300,136 which represents in red color.

Figure 6 (c) Water source loss is Ranges from USD 167,700 to USD 279,757 across the island. Dakshin Sakuchia appears to be the least affected area, with ELD over 279,757 USD.Uttar Sakuchia appears to be the least affected area, with 214,056 USD; Dakkhin Sakuchia is adversely affected greater than 350,575 USD. **Figure 6**(d) represents wages Loss (USD) due to climate change that can be ranges from less than USD 350,896 to over USD 563,740 across the island; Dakshin Sakuchia appears to be the adversely affected area, Greater than 563,740 USD.

From **Figure 6**(f), Hajirhat (534484 USD) have the highest range of economic loss due to loss of agricultural crops and Uttar Sakuchia (less than 327043 USD) has the lowest economic loss for this category. Hajirhat (greater than 682478USD) has the highest range of economic loss due to loss of fishing gear. Uttar sakuchia (less than 361267 USD) has the lowest economic loss and damage.

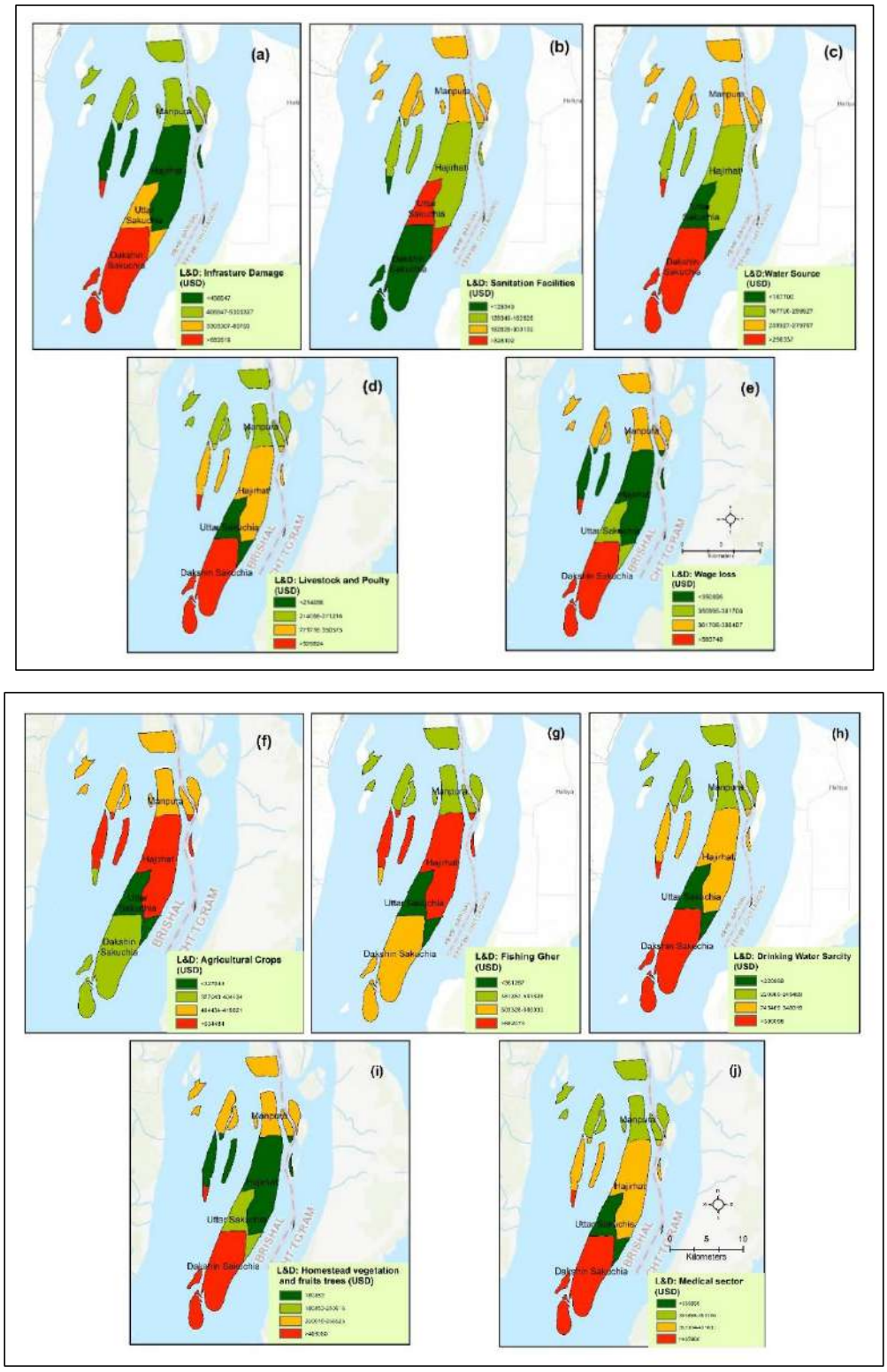

Figure 6 Household level economic loss and damage (USD) in Manpura Island: a) Infrastructure damage, b) loss of sanitation facilities, c) water source loss, d) loss of livestock and poultry, e) wages loss, f) loss of

agricultural crops, g) loss of fishing gher, h) drinking water scarcity, i) loss of homestead vegetation and Fruits trees j) expenditure increase in medical sector.

(Source: Prepared by author, 2024)

Figure 6(h*)* indicates that Dakshin Sakuchia (390668 USD) has the highest range of economic loss due to drinking water scarcity. Uttar Sakuchia (less than 220969 USD) has the lowest economic loss. **Figure 6** *(*i) shows Dakshin Sakuchia (greater than 489080 USD) has the highest range of economic loss due to loss of homestead vegetation and fruits trees. Hajirhat (less than 180853USD) has the lowest economic loss. **Figure 6** (j) represents that Dakshin Sakuchia (435968 USD) has the highest range of economic loss for medical sector expenditure. Uttar sakuchia (less than 355885 USD USD) has the lowest economic loss for this category.

The above maps indicates that climate change is having a significant impact on households in Manpura Island, with high economic loss & damage reported across all categories. Hajirhat union appears to have suffered the most significant economic losses in infrastructure damage and water source loss. Dakhin Sakuchia union represents to have suffered the most significant economic losses in water source loss, loss of livestock & poultry, and wages loss. Uttar Sakuchia union appears to have suffered the most significant economic losses in loss of sanitation facilities, loss of livestock and poultry, and wages loss. Dakshin Sakuchia appears to be the most affected union, followed by others.

4.2.3 Representation of economic loss and damge data at household level

Climate change can cause economic losses in various sector in Manpura Upazila.It causes more extreme weather events, such as floods, droughts, and cyclones. These events can damage infrastructure (such as roads, bridges, and buildings) loss of agricultural productivity, loss of fisheries, wages loss, loss of sanitation facilities etc.The ELD from climate change are already significant, and they are likely to continue to grow in the future. Different diagram and table show the economic loss due to climate change at household level in four areas: Hazirhat, Manpura, Uttar Shakuchia, and Dakkhin Shakuchia. The y-axis shows the amount of loss in thousands of taka, and the x-axis shows the categories of loss, ranging from no loss to 20,000 taka or more.

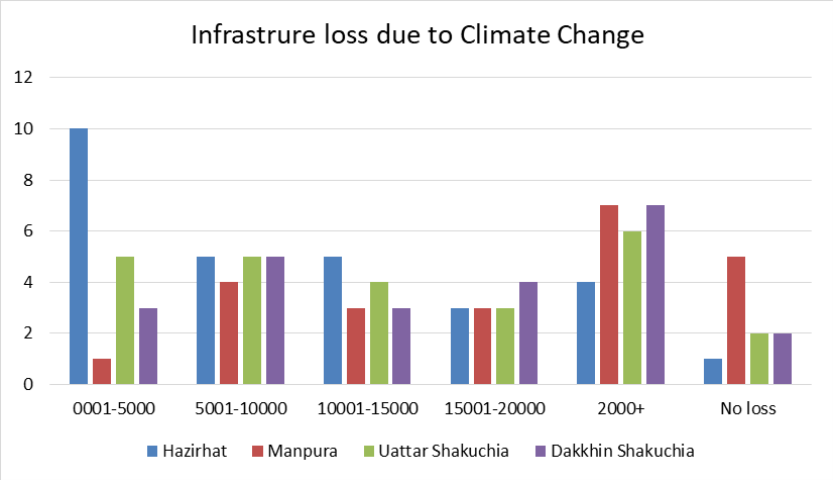

Figure 7: Infrastructure loss due to climate change

The diagram shows that all four areas have experienced some economic loss due to climate change. The highest losses were in Dakkhin Sakuchia, with losses of 20,000 taka or more in some cases. Manpura also experienced significant losses, with some areas losing between 15,000 and 20,000 taka. Hajirhat and Uttar Sakuchia experienced lower losses, but still some losses in the 10,000-15,000 taka range.Dakhin Sakuchia is near to coast and most of the people are engaged in fishing and agriculture. Their economic condition is poor so that they cannot able to construct disaster resilience house and strong embankment to protect form storm surges.

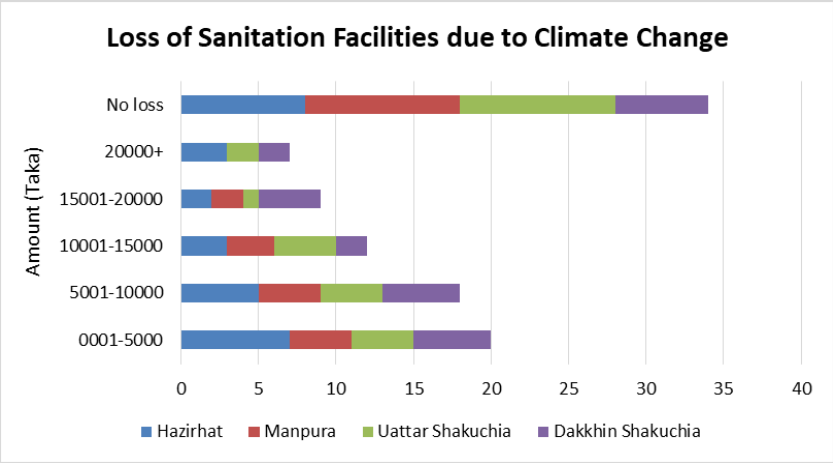

Figure 8: Loss of sanitation facilities due to climate change

The **Figure 8** bar graph showing the loss of sanitation facilities due to climate change in four areas of Manpura upazila: Hazirhat, Manpura, Uattar Shakuchia, and Dakkhin Shakuchia. The y-axis shows the amount of loss in taka, with the following ranges: No loss, 0-5000, 5001-10000, 10001-

15000, and 15001-20,000 & 20,000+.The x-axis shows the four study unions.The graph shows that Dakkhin Shakuchia has the highest loss of sanitation facilities, with over 20,000 taka in losses. Hazirhat has the least loss, with no loss at all.It is important to note that this graph only shows the loss of sanitation facilities due to climate change. It does not show the total number of sanitation facilities in each area, or the number of people who have been affected by the loss of these facilities.

According to 2019 report by World Health Organization and UNICEF, 2.4 billion people around the world lack access to basic sanitation facilities, and an estimated 673 million people practice open defecation. Climate change is expected to make this problem worse, as it can lead to more extreme weather events, such as floods and droughts, which can damage sanitation infrastructure and contaminate water supplies.The loss of sanitation facilities can have serious impact on public health, as it can lead to the spread of diseases such as cholera, diarrhea, and typhoid fever. It can also have a negative impact on the environment, as human waste can contaminate water supplies and soil.

The **Figure 9**shows the loss of water sources due to climate change in four areas of Manpura upazila. The y-axis shows the amount of loss in taka and x-axis shows the four unions.The graph represents that Dakkhin Shakuchia has the highest loss of water sources, with over 20,000 taka in losses

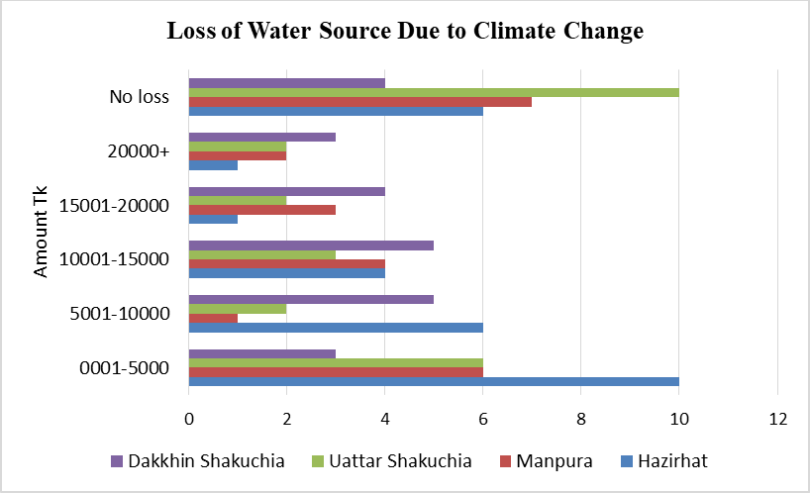

Figure 9: Loss of water source due to climate change

Manpura and Uttar Shakuchia also have significant losses, between 15,001 and 20,000 taka. Hazirhat has the least loss, with between 10,001 and 15,000 taka in losses.The loss of water sources can have a serious impact on people's lives, as it can lead to water scarcity, which can in turn lead to health problems, food insecurity, and economic hardship.Climate change is expected to make this problem worse, as it can lead to more extreme weather events which can damage water infrastructure and reduce water availability.

Table 8: Wages loss due to climate change percentage of household

	0001-5000	5001-10000	10001-15000	15001-20000	20000+	No loss
Hazirhat	29	18	14	14	36	21
Manpura	35	22	17	17	43	26
Uattar Sakuchia	32	20	16	16	40	24
Dakkhin Sakuchia	33	21	17	17	42	25

The **table 8** shows the number of wages lost due to natural hazards in four areas of Manpura upazila. It shows the data for four areas: Hazirhat, Manpura, Uttar Shakuchia, and Dakkhin Shakuchia. The table is divided into five columns: one for each category of wage loss (5001-10000, 10001-15000, 15001-20000, 20000+, and No loss). Each cell in the table shows the number of wages lost in that category for a specific area. Dakkhin Sakuchia seems to be the worst-affected area, with the highest number of wages lost in all categories except "No loss."Manpura and Uttar Sakuchia also have a significant number of wages lost, particularly in the lower categories (5001-10000 and 10001-15000).Hazirhat appears to be the least affected area, with the lowest number of wages lost in all categories.

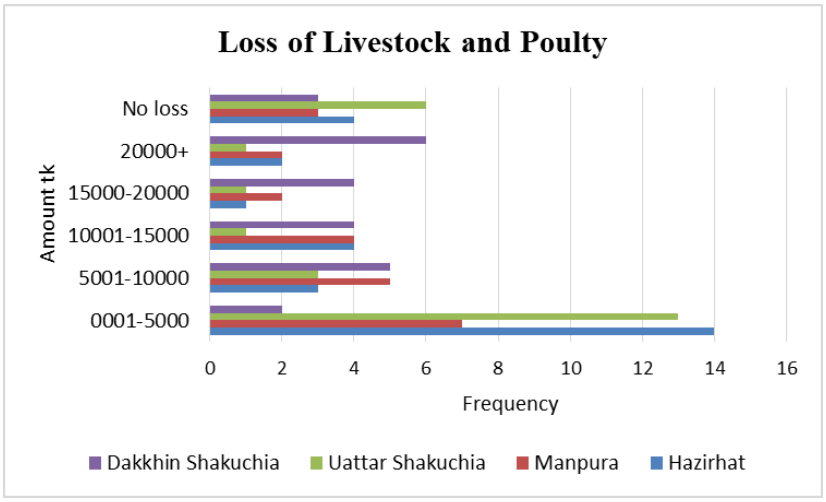

Figure 10 loss of livestock and poultry due to climat change

The diagram shows the loss of livestock and poultry in different union of Manpura Upazila. The x-axis shows the frequency of loss, while the y-axis shows the amount in tk. The union with the highest frequency of livestock and poultry loss is Hazirhat, with a frequency of 14respondents and ranges 0 to 5000.The union with the lowest frequency of livestock and poultry loss is Dhakkhin Shakuchia, with only 2 respondents among 25. 13 and 7 respondents responses with rang 0 to 5000tk loss are showed Manpura and Uttar shakuchia comparatively.

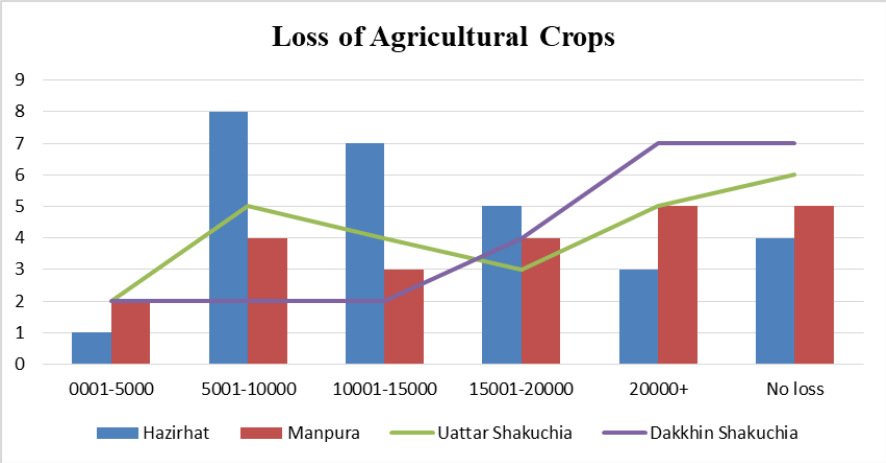

Figure 11 loss of Agricultural Crops due to climate change

In total, 100 households were interviewed during the fieldwork. The bar chart illustrates the loss of agricultural crops across different regions of Manpura Island due to climate change, segmented by the monetary value of the losses. From chart Hazirhat: Experiences significant losses in the

5001-10000tk and 10001-15000tk categories. Manpura shows more consistent losses across categories, peaking slightly in the 15001-20000tk range. Uttar Shakuchia: Losses increase steadily with the highest in the 20000tk category. Dakkhin Shakuchia: Significant losses observed in the 20000+ tk category, with the highest frequency in the no-loss category. Hazirhat and Uttar Shakuchia show high variability in losses, with Uttar Shakuchia experiencing the most substantial losses at the highest category.Manpura and Dakkhin Shakuchia have more evenly distributed losses across categories. Dakkhin Shakuchia has a notable frequency of no loss occurrences, indicating possible resilience or varied impact levels.

Table 9 Loss of fishing Gher due to climate change percentage of household

	0001-5000	5001-10000	10001-15000	15001-20000	20000+	No loss
Hazirhat	11	21	14	14	29	11
Manpura	13	26	17	17	35	13
Uattar Shakuchia	12	24	16	16	32	12
Dakkhin Shakuchia	13	25	17	17	33	13

The table shows data on the loss of fishing gear in various unions across Manpura unions.It seems like gear loss is quite frequent, with significant difference in the amount of lost gear between the unions. Hazirhat: This union has the lowest overall loss, with 11% respondents responses lost in the 0-5000 range and 11% in the "No loss" category. Manpura: Similar to Hazirhat, Manpura's losses are also on the lower end. Utttar Shakuchia: This union has a slightly higher loss count compared to the previous two, with 12% respondents in the 0-5000 range and 12% in the "No loss" category. Dakkhin Shakuchia: This union has the highest overall loss, with 13 % respondents in the 0-5000 range, 25% in the 5001-10000 range, 17% in the 10001-15000 range, 17% in the 15001-20000 range, and 33% in the 20000+ range. It also has the least number of entries in the "No loss" category, with only 1%.

The (**Figure 12)** bar chart shows drinking water scarcity across different unions of Manpura Island, categorized by the monetary value of the increased expenditure. Four union is represented Different color scheme in the bar chart purple, green, red and blue. Hazirhat shows the highest

frequency of increased expenditure which ranges within 5000/-. All regions experience significant increases, with Hazirhat and Uttar Sakuchia showing the highest and amount of loss ranges within 5000-10000/-. Notable increases in Dakkhin Shakuchia and Manpura which is between10000-15000/-. Moderate expenditure increases in Dakkhin Shakuchia and Uttar Sakuchia (15000-20000).

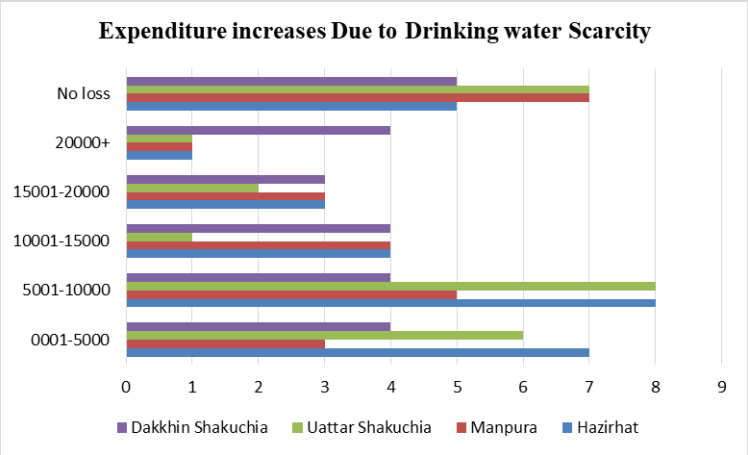

Figure 12 Expenditure increases due to drinking water scarcity

Dakkhin Shakuchia shows the highest expenditure increase over 20000. Expenditure increases due to drinking water scarcity are widespread, affecting all regions with varying degrees. Hazirhat and Manpura experience the most significant increases in the lower expenditure categories (0001-10000).Dakkhin Shakuchia faces the highest expenditure in the upper category (20000+), indicating severe water scarcity. The "No loss" category is relatively high across regions, suggesting some areas or households have resilient water supply systems or varying impacts.The chart highlights the varying economic burdens imposed by drinking water scarcity across Manpura Island, underscoring the need for targeted water management strategies and infrastructure improvements to reduce these costs.

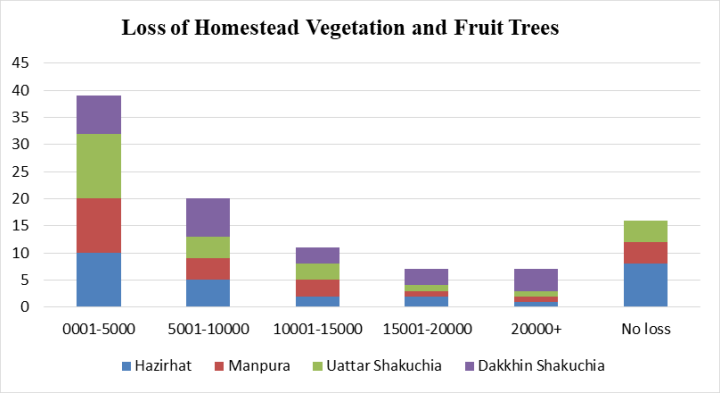

Figure 13 Loss of homestead vegetation and fruit trees

The bar chart titled "Loss of Homestead Vegetation and Fruit Trees" illustrates the extent of vegetation and fruit tree loss across different regions: Hazirhat, Manpura, Uttar Shakuchia, and Dakkhin Sakuchia. The chart categorizes loss into six groups based on the number of trees lost: 1-5000, 5001-10000, 10001-15000, and 15001-20000, 20000+, and No loss.

10 respondents in Hajirhat union faces largest contributor to loss 5000/- due to loss of homestead vegetation and trees. Manpura has significant impact with around 8 respondents and Uttar Shakuchia has the highest number with around 12 cases. But Dakkhin Shakuchia indicates moderate impact with around 5 cases. 5001-10000/- Trees Lost: Hazirhat and Manpura has minimal impact with about 1 and 3 cases respectively. Uttar Shakuchia is around 6 cases. And Dakkhin Shakuchia is the highest in this category with approximately 9 cases.10001-15000/- Trees Lost: Manpura and Uttar Shakuchia reported minimal with around 2 and 3 cases. On the other hand, Dakkhin Shakuchia is the highest in this category with approximately 6 cases. Minimal loss due to disruption of homestead vegetation and trees are mostly found in Hajirhat and Manpura with around 15000-20000/-. Highest vegetation loss are estimated in Dakkhin shakuchia which is over 200000/-.

The chart reveals significant regional variations in the loss of homestead vegetation and fruit trees. Uttar Shakuchia experienced the highest loss in the 0001-5000 category, while Dakkhin Shakuchia had notable cases in higher loss categories (5001-10000 and 20000+). Hazirhat showed the highest number of cases in the "No loss" category, indicating less impact compared to other regions. This data underscores the varying degrees of environmental impact across different areas, necessitating tailored strategies for mitigation and recovery.

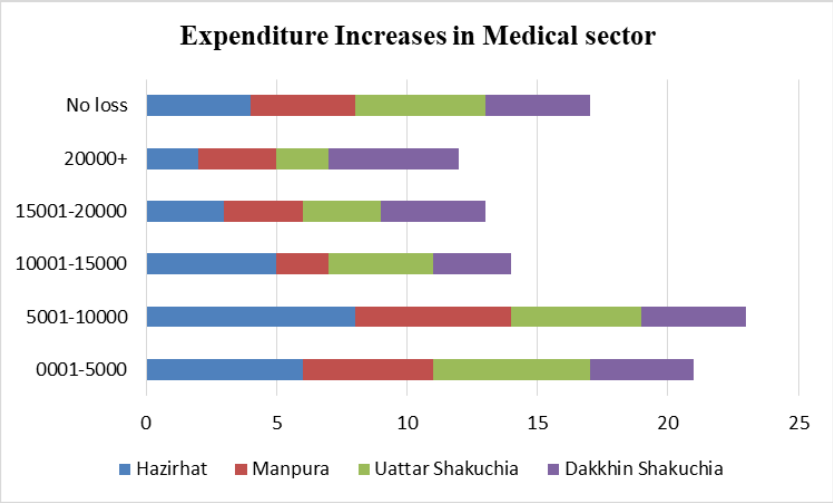

Figure 14 Expenditure increases in medical sector

Bar graph shows the increase in medical expenditure in four locations: Hazirhat, Manpura, Uttar Shakuchia, and Dakkhin Shakuchia. The X-axis of the graph represents different ranges of expenditure increase. The Y-axis shows four union in Manpura Island. The height of each bar indicates the relative amount of expenditure increase in that location.

Hazirhat has the highest expenditure increase among the four locations. From first category (below 5000), Manpura and Uttar Sakuchia represent high economic loss and damage in medical sector. Hazirhat unions people spend large amount of money in Medical sector which is ranges from 5000-10000/-.Highest expenditure in medical sector are estimated in dhakkhin shakuchia which is over 20000/-. As Climate causes various health problem to the inhabitants in Manpura Island. Medical facilities in this Island is very poor and people move nearby Upazila specially Char Fashion and Bhola for medical facilities. Expenditure increases in Medical sector among all the Upazila which is ranges in different categories.

4.2.4 Household level economic L&D assessment and mapping

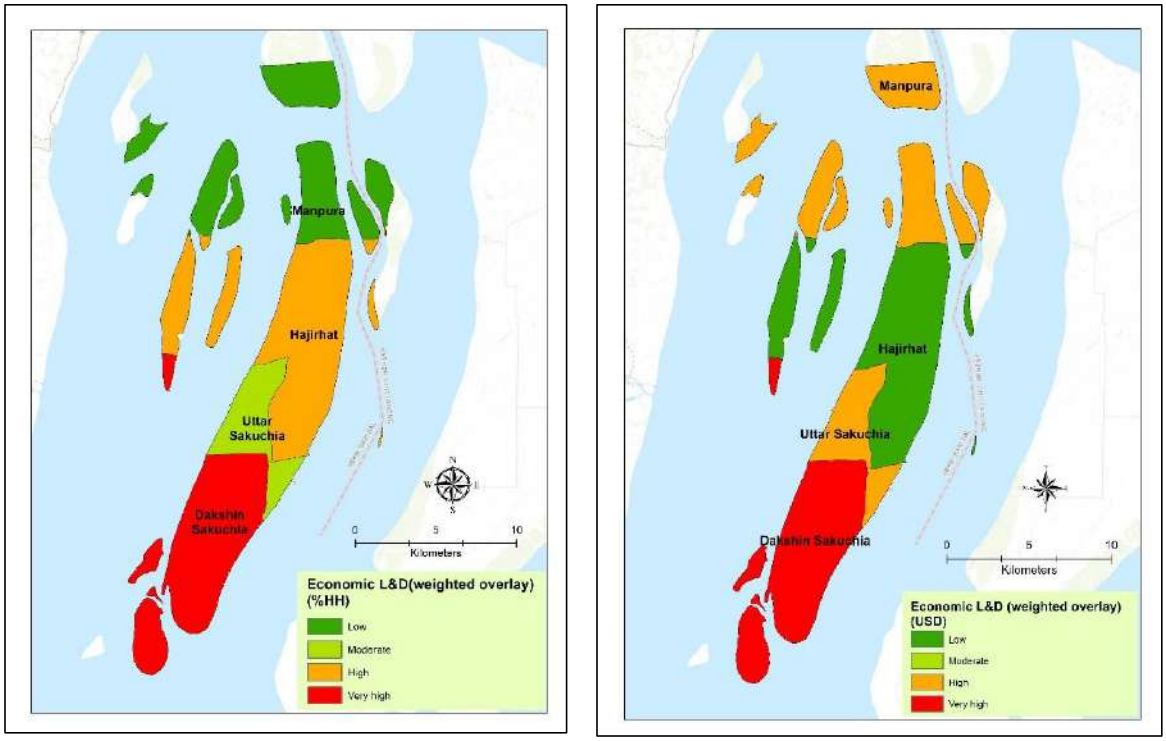

Figure 15: Weighted overlay map of economic loss and Damage at household level (%HH) & (USD) in Manpura Island.

(Source: Prepared by author, 2024)

The weighted overlay map of economic loss and damage (at household level) in Manpura Island. The island is divided into four unions: Manpura, Hajirhat, Uttar Sakuchia, and Dakshin Sakuchia. The economic loss and damage is measured as percentage of households (%HH) affected and amount of money (USD). The color coding indicates the severity of the economic loss and damage.

From **Figure 15**(Left Map), Very high ELD affects more than 3.331% of households and High levels of ELD impact between 1.874% and 3.279% of households respectively (**Table 10**). The southern, and central parts, more specifically, the part of Dakkhin Sakuchia and Hajirhat union revealed high, and very-high ELD at household levels to climate change impacts.

Table 10: Weighted overlay score in economic loss and damage at household level (%HH) & (USD) in Manpura Island.

	Economic Loss and Damage at (%HH)	Economic Loss and Damage (USD)
Low	<1.657	<1.721
Moderate	1.657-1.874	1.721-2.070
High	1.874-3.279	2.070-2.339
Very High	>3.331	>2.925

Several important factors, such as sanitation facilities, wages loss, water source loss , loss of livestock and poultry, loss of fishing gher and very close to the coastline, an immense number of cyclone tracks and vulnerable land cover classes, are accountable for very-high Economic loss and damage in those unions. On the contrary, Uttar Sakuchia and Manpura, depicted moderate to low ELD at household level, moderate level of economic loss and damage affects between 1.657% and 1.874% of households and less than 1.657% of the total households.in northern and south-western union.

Again from **Figure15** (right map), Dakkhin Sakuchia faces very high economic loss and damage (USD) and Hajirhat union represented Households experiencing economic loss and damage of less than 1.721 USD are considered to have low economic impact. Moderate and low economic L&D are shown in Uttar Sakuchia and Manpura union comparatively. Most of the respondents are financially effected due to climate change and they have to spend large amount of money for recover their L&D. the largest portion of the southern, south-western, and northern parts are classified as very high to high category and indicate Greater than 2.925USD and 2.070-2.339 USD loss which found in Dakkhin Sakuchia, Uttar Sakuchia and Manpura unions. The dispersed areas of central part (**Table 10)** exhibits that the low ELD has Less than 1.721 whereas moderate ELD class covers about 1.721-2.070 of the study area. The combined analysis of %HH and USD categories provides a comprehensive picture of economic loss and damage at the household level in Manpura Island. Households in the "Very High" category for both %HH and USD are the most vulnerable (Dakkhin Sakuchia).

The findings indicate a pronounced variability in the impact of climate change across different unions in the study area. The southern and central parts, particularly Dakkhin Sakuchia and

Hajirhat unions, are the most vulnerable, experiencing the highest levels of economic loss and damage. Factors such as proximity to the coastline, frequent cyclone tracks, and inadequate infrastructure contribute significantly to their vulnerability. In contrast, Uttar Sakuchia and Manpura unions show lower levels of ELD, suggesting better resilience or lesser exposure to the same factors. Addressing the challenges posed by climate change in these areas requires targeted interventions.

4.3 Household level non-economic loss and damage

4.3.1 Physical and psychological wellbeing

Food insecurity, diseases spread by water, and heat stress are just a few of the health issues that climate change may aggravate. In addition, the psychological strain of moving, losing one's job, and experiencing environmental changes can be highly damaging to one's mental health. The effects on people's physical and mental health are among the most obvious connections between environmental problems and vulnerable populations. Regarding the natural disasters that occurred between 2015 and 2023, community members suffering direct experience of cyclones, floods, and riverbank erosion among four union in Manpura Upazila. Based on the number of fatalities and injuries, the two unions (Dhakkhin sakuchia, Manpiura) in Manpura Island were the most severely affected in the study. The elderly, women, and children were among those most at danger of death and injury as a result of climate change. These groups were frequently discovered drowned as a result of storm surges, flooding, and saline intrusion. The input from participants in KII and FGDs is displayed in the table below:

Table 11 Number of death and inquries due to climate change based on respondents resposes during FGD and KII

union	***Physical***	
	Deaths	Injuries
Manpura	02	4-6
Hazirhat	0	1-2
Uttar Shakuchia	1	5-6
Dhakhin Shakuchia	3	7-8

The physical health of populations was also affected by a number of additional injuries, including as limb loss, fractured bones, and hearing loss, which were directly linked to climate disasters. An ageing informant stated that,

> "During cyclone Mocha his close relative's house was destroyed and everything washed away. One of her relatives had broken arm by falling trees due to cyclone. This is because during the flood and cyclone, everyone is affected by many diseases such as cholera, diarrhea, dysentery, fever, sore throat, skin diseases. My son is still scarred from the itch he got because his skin turned black from the itching."

The most severe cases of skin conditions were in the Uttar Shakuchia Union, where many of the small children we observed also had bad skin conditions. A female participant from FGD stated the condition,

> "Due to natural disaster, we face number of diseases of the skin, appendicitis, and uterus infections. The skin disease left scars on my face. Even though the infection is gone, the scars are a constant reminder of the disaster and the hardship we went through."

The argument that skins conditions were caused by rising salinity in freshwater sources was common in this context. However, due to the study's time limits, the investigation was unable to conclusively prove a link between salinity and skin conditions.

There is a significant psychological impact. Following natural disasters, PTSD, anxiety, and depression are common among the local inhabitants. Losing one's home, source of income, and close relationships can cause severe and permanent pain. The male informants said that,

> "My father suffered from psychological stress, which caused him to become mentally ill and disabled. Wherein another man experienced the same tragedy. In my village, many individuals have experienced skin and waterborne illnesses, despite the fact that no one has died."

Regarding the mental well-being of those impacted by natural disasters, it is crucial to recognize that catastrophes with sudden or slow onsets can have diverse impacts on persons and the community. Even though every community looked at had suffered severe psychological effects from cyclones and other natural disasters. One of the young adults said that,

> "Whenever we start to plan, we feel like another hazard may come and take it all away."

Although there are a number of potential causes for this, including changes in nutrition, hygiene practices, pesticides and fertilizers, water supply modifications, and nutrition levels, this study is unable to make any inferences from its findings. Rather, it is recommended that additional research be undertaken.

4.3.2 Education

The relationship between education and climate change has mostly been on the use of education as a vehicle for increasing public awareness of the issue. Following the November 2007 Cyclone Sidr that hit Bangladesh, 74 government elementary schools were destroyed and 8,817 more were damaged (UNESCO, 2012). As a result, an estimated 103,664 children were impacted. Das (2008) estimates that the cost of renovation and restoration will exceed US$82 million

Bangladesh has become one of the first countries to start constructing cyclone shelters that also double as schools for children in nearby villages. While this has advantages as well as disadvantages, the focus on education as an individual level impact in this study was concerned with immeasurable loss that comes with children not having access to school either due to environmental factors or due to insufficient household incomes. In our community, child marriages usually happen when a girl's family cannot afford to send her to school. In addition, comparable cyclones and floods happen every year, which is reason our financial situation is not good. When there is a flood, the roads fall, the water rises, and the kids are reluctant to go to school. A male informant said that,

> "Girls in our area have not seen on the street. We think that when the girl grows up, she will get married and start a family. Many of our children do not have that kind of money to continue schooling, so they go fishing with the fisherman. If they want to study, they go to the city or to char fashion. Our education system here is not so good."

Although all the communities had mentioned an increasing trend of sending their children to school, beyond primary school most households could not afford to continue sending their children to school. This was mainly due to tuition fees and due to the distance of secondary schools from the villages.

4.3.3 Traditions/religion/culture

The effect of climatic stressors on traditions, religions and customs in the communities was incredibly diverse and not all villages expressed the same concern to changing traditions. In Manpura Island, respondent's response during in the FGDs and KIIs mentioned that they have number of cow but due to climate change impacts, most of them losses their domestric animal. In the small village of Dakkhin Sakuchia, the nearby area of sea and increasing tidal storms have become vulnerable to effects. During FGD, the inhabitants are highly belive in Allah as male participants said that,

> "The river is our main source of earning, but now it feel like ghost, when disaster come the river & sea water submerge the nearby area and washing away our houses. But we believe this is a test from Allah, it will unsatisfactory sign from Allah."

People who have difficulty financially are unable to take part in social gatherings, which has made it harder for families to strengthen their connections to friends and family and to develop neighbor relations in Manpura union. Religious events are celebrated on Bhola in a big manner, but due to adverse impact of climate change they minimize their arrangement. Male informant said that

> "It is difficult for us poor people to eat and survive, and it is not possible to organize such a big mahfil or to celebrate Eid-ul-Miladunnabi. In winter season, local people in shakuchia arrange mafil in big manner but due to adverse effect of cyclone, flood them unable to arrange Mafil."

Because cyclone affect this area adversely, one significant aspect that should be taken into account that all unions, with the possible exception of one have moved from farming to fishing as their profession of choice. Climate change can affect fisheries, agriculture, and tourism, all of which are important parts of the island's economy and culture. This can lead to unemployment, displacement, and a loss of traditional knowledge and skills.

4.3.4 Biodiversity and ecosystem

Ecosystem services are a popular way to describe the consequences of climate change on the environment in discussions. Here, the IPCC states that it is almost certain that ecosystems

worldwide, particularly those in low-lying and coastal regions, would be severely strained by climate change (2014).Climate change can damage ecosystems, leading to a decline in plant and animal life. This loss of biodiversity not only affects the natural environment but also the vital services ecosystems provide, such as food security, coastal protection, and cultural significance. A fisherman stated that,

> "In past we could cultivate coral fish, shell fish, sharpoot in the pond but now most of the fish are killed due to salt water. Now we change our cultivation like tilapia, roe, cuttlefish, and shrimp."

In each union, the disappearance of freshwater species was discussed. The fish species and domestic animals that were lost throughout our investigation came from emotions and numerous talks because we didn't have a list of species at the time. Because of this, the table below could not be totally accurate, as we would anticipate that more species would have become extinct in more communities.

Table 12: Fish Species that have become extinct

Union	**Fish Lost**								
	Bengali name	Ruhi	Katla	Magur	Shoul	Ilish	Koral	Sorputi	Pangas
Manpura	√		√	√	√	√	√	-	-
Hazirhat	√		-	-	-	-	√		-
Uttar Shakuchia	-		√	√	√	-	√	√	
Dhakhin Shakuchia	√		-	√	-	√	√	-	-

Part of our exercise to get individuals to share with us their story was to ask individuals what their favorite memories of their childhood were. In a number of cases we had memories of food of which came up because such foods/fish no longer existed. This particular story came from the farmer who said that,

> "Earlier used to cultivate aush paddy after planting almonds in winter but now aush paddy is not yielding well because the soil salinity has increased due to rising tidal water during floods and surge. We used to cultivate paddy twice but now only have to do it once. We used to grow different types of vegetables like spinach, cowpea, brinjal etc. But when the tide comes in these three months of monsoon

> vegetables are disrupted and washed away. When the month of Kartik- Agrahayan comes, again we cultivate red vegetables, sweet pumpkins, and puishaks in the backyard."

Natural disasters can also impact biodiversity and ecosystems. Immediate disaster relief efforts, such as clearing debris or building new infrastructure, can lead to further habitat destruction and deforestation. A female informant stated that,

> "Earlier we used to see white bucks here, guest birds came and sometimes deers were seen. But now that the forest has been destroyed due to the cyclone, floods, as a result of which there are no more guest birds like before, deer are hardly seen anymore."

Similarly, the participants argued that construction of embankment is not enough to protect the area from tidal surges. Embankments are essential for flood protection and land reclamation, which can have significant environmental and social implications. By altering natural water flows, embankments can impact ecosystems, affecting wildlife habitats and fish migration patterns. An older male participant said that,

> "The embankments we have are 10 feet high, so when there is a cyclone, the water rises up to 12 feet and floods our area. There are fish enclosures that are flooded. Our fish traders and crab traders are the most affected in this regard."

In all the unions analyzed, biodiversity and species loss were mentioned to some extent. While this might be the result of a number of factors such as salinity intrusion, deforestation, overfishing, river bank erosion, sudden onset events, extreme heat, and loss of ecosystems.

4.3.5 Migration

The connection between migration and non-economic losses and damages was a topic of significant discussion over the study. Apart from forced migration, households have generally employed migration as a means of diversifying their sources of income. As a result, its main purpose was to prevent more losses and damages.

However, there was debated about the non-economic losses that those who are left behind suffer as a result of migration. Although this was reasonable criticism, our focus group participants might have experienced the "loss" of a family member as a result of migration given the study's methodology. Second, there were questions on migration-related reasons on the checklist. Finally, rather than viewing migration as non-economic loss and damage in and of its own identity, the

decision was made to maintain it as an overall issue after consulting with other experts. In Dakkhin Sakuchia union, male participant said that,

> "Due to the migration of relatives, friends, and neighbors, our society, community and family have broken down. I feel sorrow for them who are not now with us. We had a close connection with each other."

In winter season, fisher man decidated to go outside place because river has not enough fishes for sale.For which fishermen go outside Manpura in search of livelihood. A similar story was shared in Manpura where the male informant stated that,

> "One of my cousin left and settle in Bhols, they left with family and increase their financial fund. When we remember them, we feel sorrow for them, they also feel unhappy for us. We had a strong relationship with them but to due disaster effects they area far away from us."

Many people have gone from our village whose houses and lands have all fallen under the Meghna river bank erosion and have become destitute. They leave village and drive rickshaws in the city and work as daily laborers, but the money they earn is not enough to sustain their families, for which many of them return to the village.

It is very sad that our relatives are leaving this island. Which is very painful for us because the way we lived together was a good bonding among us. Now the migration has created a gap in the relationship. Such stories were common in all the four union however the correlation with environmental impacts was far removed and was one of several factors encouraging them to leave.

4.3.5.1 Success/failure of the respondents due to migration

Migration can lead to both significant successes and notable failures for individuals and communities. The outcomes depend on range of factors, including economic conditions, legal status, social support systems, and individual resilience. Many migrants experience higher wages and better job opportunities in their new location. This can lead to improved living standards for themselves and their families. Migrants often gain better access to healthcare, education, and other essential services. Everything has both positive and negative side also migrants faces many challenges of adapting to a new environment , missing family life, birth place, dealing with uncertain job prospects can cause significant stress and anxiety.

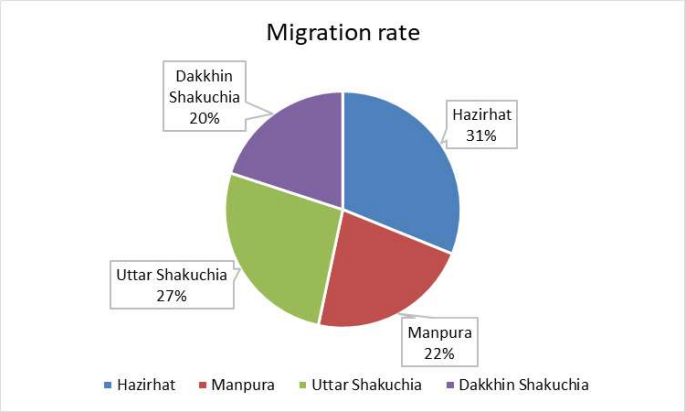

Figure 16 Migration rate in Manpura Upazila

The pie chart represents titled "Rate of migration". Here are some observations about the data presented: The pie chart shows the migration rates for four areas: Dakkhin Shakuchia, Uttar Shakuchia, Manpura, and Hazirhat. Hajirhat: This area has the highest migration rate, with a slice representing approximately 31% of the whole pie chart.Uttar Shakuchia: This area has the second-highest migration rate, with a slice representing approximately 27% of the whole pie chart.Manpura: This area has the third-highest migration rate, with a slice representing approximately 22% of the whole pie chart.Dakkhin Sakuchia: This area has the lowest migration rate, with a slice representing approximately 20% of the whole pie chart.

Overall, the pie chart suggests that Hajirhat has the highest migration rate among the four areas.This means that Hajirhat unions people has low income that's why they can not survive with this extreme climatic condition. They move outside for diversified their profession. Dakhin sakuchia migration rate is low because most of the people in this union are attracted with fishing.

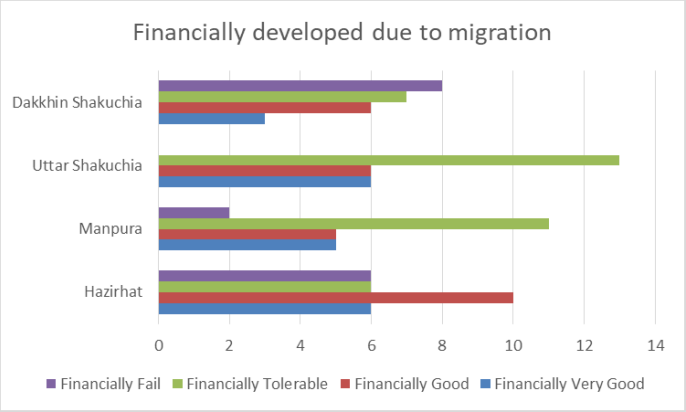

Figure 17 Financially developed due to migration

The graph is titled “Financially developed due to migration” shows the percentage of people who are financially well off (financially developed) in four unions: Dakkhin Shakuchia, Uttar Shakuchia, Manpura, and Hazirhat.The y-axis shows the percentage of the population that is financially developed.The x-axis shows five categories: financially fail, financially tolerable, financially good, financially very good.Based on the graph, here are some observations:

Hajirhat appears to have the highest percentage of financially developed individuals, followed by Uttar Shakuchia, Manpura, and Hazirhat with reaching the "financially very good" category. Around 6% of migrants in Uttar Shakuchia are financially very well off.Dakkhin sakuchia has the most significant portion of its population in the "financially fail" category. This union has the lowest rate of financial success among migrants, with only 6% reaching the "financially very good" category.Manpura seems to have the most balanced distribution across the categories. Approximately 8% of migrants achieve financial success in Manpura.

Overall, the graph suggests that Hajirhat has the most financially successful population due to migration, while Dakkhin sakuchia has the least. Because from previous **Figure16** indicates highest migration rate is shown in Hajirhat union and people migrant one place to another for better facilities. That’s why this **Figure16** represents Hajirhat as financially successful union.

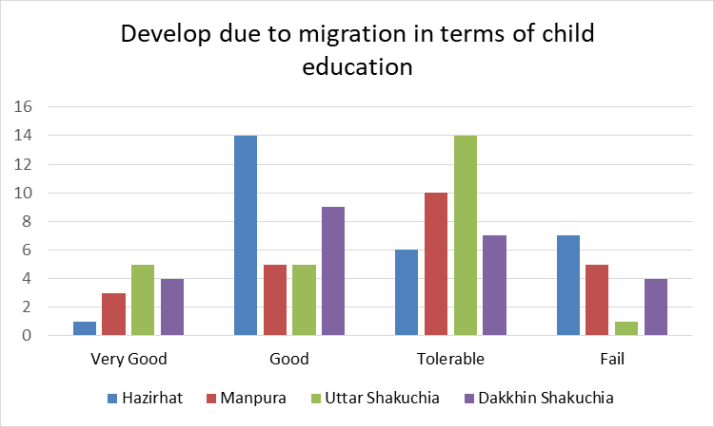

Figure 18 Develop due to migration in terms of child education

Manpura Island, affected by natural disasters, faces significant challenges in providing adequate educational facilities. Migration from Manpura to areas with better educational resources can have profound effects on child education.

Figure 18 shows "Develop due to migration in terms of child education". The graph represents the success and failure rates of child education for four locations: Hazirhat, Manpura, Uttar Shakuchia, and Dakkhin Shakuchia. Hazirhat has the highest percentage of migrant's children who did "Very Good" (around 16%) and the lowest percentage who "Fail" (around 2%). Compared to Hazirhat, a slightly lower percentage of children in Manpura did "Very Good" (around 14%) and a slightly higher percentage "Fail" (around 4%). Uttar Shakuchia: This has an even lower percentage of children who did "Very Good" (around 12%) and a higher percentage who "Fail" (around 6%). Dakkhin Shakuchia has the lowest percentage of children who did "Very Good" (around 10%) and the highest percentage who "Fail" (around 8%).

From **Figure 18** in terms of child education facilities hajirhat migrants are successful rather than other three union. Moving to areas with fewer disruptions ensures that children have a more stable and continuous educational experience, essential for maintaining academic progress. Children from Manpura Upazila may face difficulties integrating into new cultural and social environments, impacting their emotional well-being and ability to focus on studies. Leaving behind familiar surroundings and possibly family members can cause emotional stress, affecting their mental health and academic performance.

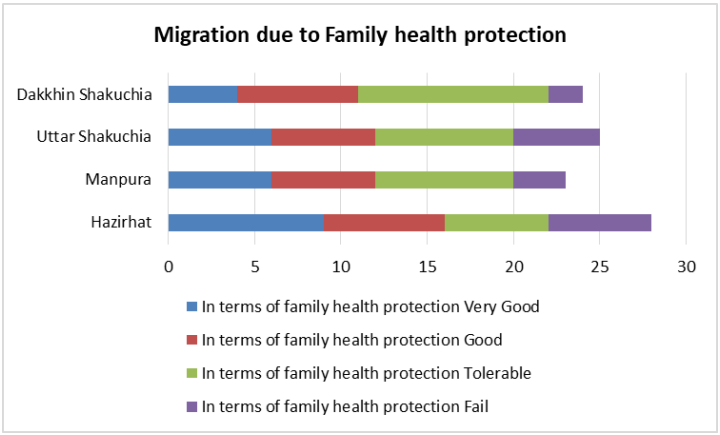

Figure 19: migration due to family health protection

The graph shows the success rate of migration in terms of family health protection for four locations: Hazirhat has the highest percentage of people reporting "Very Good" family health protection (around 35%). Compared to Dakkhin Shakuchia, a slightly lower percentage of people in Uttar Shakuchia report "Very Good" family health protection (around 25%).Manpura has an even lower percentage reporting "Very Good" family health protection (around 15%). Hazirhat

has the lowest percentage reporting "Very Good" family health protection (around 5%). It also has the highest percentage reporting "Fail" (around 20%).

Migration due to health protection refers to the movement of individuals or groups from one location to another to safeguard or improve their health. Changes in climate can affect health by increasing the prevalence of heat-related illnesses, waterborne diseases, vector-borne diseases (e.g., malaria, dengue), and food and water insecurity. People might migrate to areas less affected by climate changes.

Migration due to the protection of properties, often termed "climate migration" or "environmental migration," is an increasingly significant phenomenon as climate change and environmental degradation impact the habitability and safety of various regions.The graph **Figure 20** shows success and failure rates of migration in terms of property protection.Dakkhin Shakuchia has the highest percentage of people reporting "Very Good" property protection (around 25%). Compared to Dakkhin Shakuchia, a slightly lower percentage of people in Uttar Shakuchia report "Very Good" property protection (around 20%).Manpura has an even lower percentage reporting "Very Good" property protection (around 10%). Hazirhat has the lowest percentage reporting "Very Good" property protection (around 5%) and the highest percentage reporting "Fail" (around 30%).

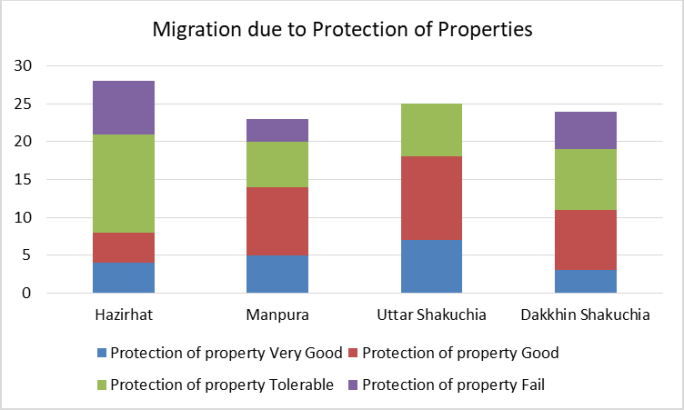

Figure 20: Migration due to protection of properties

The graph suggests that Hazirhat has the highest success rate in terms of property protection after migration, while Manpura has the least. Migration due to the protection of properties is a complex issue driven by a combination of environmental, economic, and policy factors. It requires a multi-

faceted approach involving local, national, and international cooperation to mitigate risks and support affected populations effectively.

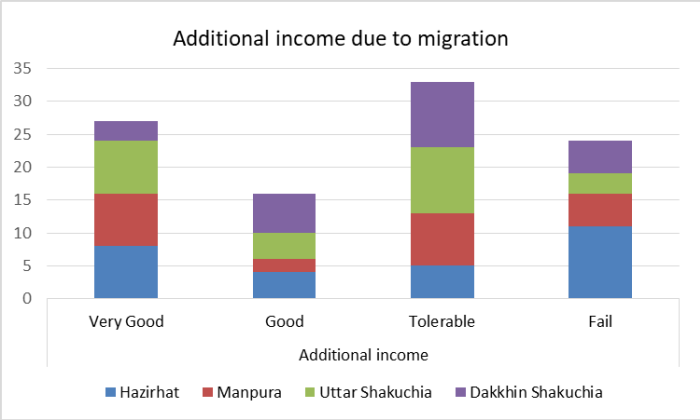

Figure 21: additional income due to migration

"Additional income due to migration" of the graph regarding success and failure due to migration: **Success:** The majority of immigrants in all four locations (Hazirhat, Manpura, Uttar Shakuchia, and Dakkhin Shakuchia) appear to have experienced an increase in income due to migration. Dakkhin Shakuchia has the highest percentage of immigrants who gained "Very Good" additional income (around 35%).Uttar Shakuchia and Manpura follow with a lower percentage (around 30% and 25% respectively).Hazirhat has the lowest percentage of immigrants gaining "Very Good" additional income (around 20%).**Failure:** A smaller percentage of immigrants in each location appear to have not seen an increase in income due to migration. Hazirhat has the highest percentage of immigrants who reported failing to gain additional income (around 15%).Manpura and Uttar Shakuchia have a lower percentage (around 10% and 5% respectively). Dakkhin Shakuchia has the lowest percentage of immigrants failing to gain additional income (around 2%).

The graph suggests that a higher percentage of immigrants in Dakkhin Shakuchia gained additional income compared to the other three locations. Migrants may have better opportunities to utilize and develop their skills, potentially earning higher wages than they would in their home country.

5. Conclusion:

This research developed a comprehensive assessment of climate induced loss and damage in vulnerable Manpura Island (178.12sq. km) of Bangladesh. This study has considered multiple issues and factors that added in-depth characteristics of local level climate change impacts. In

general, although existing studies have focused on the social L&D dimensions, highlighting the human communities in this study, also focused on the economic loss &damage (ELD) and non-economic loss & damage (NELD) at household level. Extreme loss and damage cover most of area in Manpura Island, particularly affecting Dakkhin Sakuchia union which faced 71.91% L&D. Severe L&D also identified in Manpura union which covers 67.51 % area. Hajirhat union faced stress due to natural disaster and their stress level found within 61.05% L&D. Minimal loss and damage are shown in Uttar Sakuchia union and it covers 56.83% L&D. Most of the union in Manpura Island faced extreme, severe and stress due to climate change that means this region is turned into vulnerable condition.

Economic loss and damage are particularly studied in the southern and central parts of the island, notably in Dakkhin Sakuchia and Hajirhat unions. Factors such as loss of livestock, wages, water sources, fishing ghers and agriculture productivity contribute significantly to these economic L&D. People in this area specially Dakkhin Sakuchia union cannot take proper adaptive measure to mitigate the climate change effects because their financial condition is not sufficient. These households are severely impacted, likely facing extensive damage to property, loss of income, and higher costs of recovery and adaptation. On the other hand, Uttar Sakuhcia union face low ELD in the context of local level climate change that indicates they are less exposed to climate hazards and have better adaptive capacities. Manpura union, Households has experienced significant economic L&D, with potential long-term effects on their livelihoods and economic stability.

Non-economic loss and damage, including climate-induced disruption of education, loss of tradition & culture, migration, further evaluate the vulnerabilities of the affected populations. Specially people in Dakkhin Sakuchia and Uttar Sakuchia suffer most in NELD. These L&D cannot recover with funding. In Manpura and Hajirhat unions, people face lower NELD than Dakkhin Sakuhcia and Uttar Sakuchia. The southern parts, particularly Dakkhin Sakuchia, are most vulnerable due to their proximity to the coastline, frequent cyclone tracks, and inadequate infrastructure. Hajirhat union represents medium level L&D. This union is significantly developed then others three because it contains govt office, health care centre, number of school, college, Cyclone shelter etc.These things are helpful for local people durind In contrast, Uttar Sakuchia and Manpura unions show lower levels of ELD, suggesting better resilience or lesser exposure.

These findings underline the widespread and varied nature of local level climate change impacts across the island. The research underscores urgent need for targeted interventions to address the challenges posed by climate change in Manpura Island. Policymakers, local governments, and NGOs must prioritize adaptation and mitigation strategies tailored to the specific vulnerabilities identified in this study. Measures should include improving infrastructure, enhancing adaptive capacity, and developing sustainable livelihoods to reduce the adverse effects of climate change. Overall, this study contributes valuable insights into the complex dynamics of local level climate change impacts and address climate-induced L&D in coastal island populations.

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Annexures

Figure: FGD with female participants

Figure: In-depth interview