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Climate-induced Shock Responsive Disaster Resilience Mapping for Adaptive Social Protection Programming of the at-Risk Population in the Sylhet Division of Bangladesh

Social Security Policy Support (SSPS) Programme
Cabinet Division, and
General Economics Division (GED) of Bangladesh Planning Commission
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Prepared by
Department of Disaster Science and Climate Resilience
University of Dhaka

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Executive Summary

In May-June 2022, an early-monsoon flood occurred in the north-eastern part of Bangladesh. Sylhet Division grappled with a severe humanitarian crisis due to heavy monsoon rains and upstream water flow in Northeast India that left millions stranded. Flash floods have led to the destruction of homes and farmlands, compelling families to seek refuge on higher grounds and temporary shelters. The situation was further exacerbated by power outages. Nearly 90 percent of Sunamganj district and more than 60 percent of Sylhet district were inundated. The flash flood and water congestion have impacted an estimated 4.3 million people across seven northeastern districts of Bangladesh, viz. Sylhet, Sunamganj, Moulivazar, Habiganj, Netrakona, Kishoreganj, and Brahmanbaria. The floods have dislocated many households, some of whom resorted to open areas for shelter that increased safety risks for women and girls. Nearly 25,000 people have been relocated to approximately 450 shelters in Sylhet, while another 65,000 have been evacuated to 200 shelters in Sunamganj.

The aim of this study is to map flood hazard scenarios corresponding to different levels of rainfall in upstream and catchment areas, and to establish the relationship between vulnerabilities and resilience within the framework of the damage-loss-need nexus resulting from flood hazards in the Sunamganj and Sylhet districts. It also aims to develop an adaptive social protection programming to integrate into the National Social Security Strategy (NSSS) 2026 in support to address the Bangladesh's graduation from the Least Developed Countries (LDCs), to attain the UN Sustainable Development Goals (SDGs) and "Vision 2041" of the country.

Flood Hazard Assessment

Sunamganj and Sylhet are the most flood prone districts of the country because flood occurs in these districts every year. The entire northeastern region is located nearby to the Meghalaya region in India which experiences the heaviest rainfall in the world. As a result, the entire region also experiences extreme and torrential rainfall events which causes flash floods during early monsoon between April and May as well as riverine floods during monsoon period which starts in June and ends in September. The great river Meghna and its two tributaries, the Surma and Kushiyara Rivers, historically flow through the northeastern region. During monsoon, excess rainfall leads to excess water flow in these rivers, resulting in floods in the districts of Brahmanbaria, Habiganj, Kishoreganj, Moulvibazar, Narsingdi, Netrokona, Sunamganj and Sylhet. The result of the flood hazard assessment modeling shows that Sulla upazila of Sunamganj district and Balaganj upazila of Sylhet are the most inundated upazilas of the two districts, respectively. In the Sylhet city, several places have been flooded. The maximum flood depth for Sylhet city is the same as the entire modeled region, which is more than 5 m, while the minimum depth is less than 1 m. All of the greater depth regions of the city, with the exception of a few water body locations, are situated along the main channel of the Surma river.

Vulnerability, Impact and Resilience

The results of household survey on randomly selected flood-affected 1,922 respondents in Sunamganj and Sylhet demonstrate that the onset of the flood caused a substantial reduction in food consumption. Women were consuming far less than males and for longer periods. Lesser food intake was also evident among the surveyed households in Sunamganj compared to their Sylhet counterparts. In this crucial first week, more than two-thirds of the individuals report consuming only up to one-third of their pre-flood food intake. As the flood persists into the second week, the trend of reduced food intake continues. In a glimmer of improvement, the third week witnesses a gradual recovery in food intake. Overall, about 45 percent of parents reported that their children's ability to acquire knowledge has decreased. A high proportion of

students (71-100 percent) remained absent from schools for a week or more following floods 2022 in several unions in both Sunamganj and Sylhet districts. An overwhelming majority of about 91 percent parents reported that floods caused negative consequences on their children's education.

The estimated monetary value of total damage and of floods 2022 was Tk.166 million for the responding households. The per household damage was estimated to be Tk.86,423. The highest damage occurred in the residential building or dwelling house, which was slightly higher than one-fourth of the damage. The other main damaged items were, furniture, grocery store, and livestock shed. The main items of loss were wage income, crop, cattle, poultry, food ingredients (preserved rice, pulse, etc.), cattle feed, and fisheries. A strong and negative correlation between level of income and damage to the dwelling house has been found.

More than half of the total respondents reported physical weakness due to floods (nearly 57 percent). About 60 percent of respondents reported that they suffered from mental weakness, irrespective of gender and region. The psychosocial issues include the widespread presence of depression, anxiety, and inertia that underscores the psychological toll following the flood. Nearly 55 percent of respondents faced challenges to be involved in work because of inertia. Overall, 40.7 percent of respondents reported unusual reactions to excessive stress. A positive and statistically significant relationship has been found between physical and mental weakness.

About 70 percent of individuals reported facing a shortage of safe drinking water during their shelter stay. More than two-thirds respondents reported facing a food crisis during their shelter stay (70 percent). Nearly two-thirds of respondents reported facing challenges related to inadequate safe sanitation during their shelter stay (66.4 percent). Unhealthy living conditions at flood shelters affect physical and mental health of the occupants. Overall, about two-thirds of respondents reported facing issues associated with unhealthy conditions during their shelter stay (66 percent). Females were especially sufferers due to unhealthy conditions as a higher proportion of them reported this problem compared to their male counterparts. Cleanliness, availability of clean are important indicators of flood shelter management and quality of living at the shelter. Overall, an overwhelming majority of the respondents (82.5 percent) were unhappy with the quality water, sanitation and hygiene (WASH) services at flood shelters. Overall, about 85.6 percent of respondents reported that the flood shelters did not have facilities to accommodate persons with disability (PWD).

Vulnerability and resilience indices have been developed using the MOVE framework. The the territory of five local government units in Sylhet and three unions in Sunamganj were suffering from the highest level of physical vulnerability, which were Maijgaon, Tahirpur, Fenerbak, Chhatak, Towakul, Sylhet and Kanaighat. Although both households in Sylhet and Sunamganj were highly physically vulnerable, physical vulnerability has been found more prevalent in Sylhet despite having less incidence of poverty compared to Sunamganj. High economic vulnerability was prevalent among the surveyed households in both Sunamganj and Sylhet districts nearly equally. Moderate to high institutional vulnerability has been observed among majority of the surveyed households in both Sunamganj and Sylhet districts almost equally. Moderate to high social vulnerability has been observed predominantly observed among the surveyed households in Sunamganj compared to their counterparts in Sylhet district.

It has been found that of poor households are more vulnerable to floods-induced damages than their non-poor counterparts. Less damage and loss of dwelling houses, businesss and other assets were related to higher years of education, which implies a positive role of education in reducing damage and loss. The households that took precautions before floods could lessen damage and loss, which has been found separately in the equations of the dwelling house, business, and other assets, and total damage and loss. The role of long-term plans was found to be positive in reducing damage and loss of business and other assets,

while early warning was associated with lower overall damage and loss. The households that did not take any measures were found to be ended up with a higher magnitude of per capita damage and loss.

The aggregate resilience index has been developed based on the capacity to cope, anticipate, and recover sub-indices. The results reveal that income, years of schooling, precautions taken, spending from savings and borrowing to cover expenses during floods had a strong and positive role in enhancing the coping capacity of the flood victims. Taking precautions before floods, having plans to counter negative impacts, and receiving assistance from the government to rebuild houses had a robust and positive role in strengthening the capacity to recover the flood-affected households. The households that received early warning from official sources and adopted long-term plans or measures before the onset of floods had greater capacity to cope with and recover from the floods in the Sylhet region.

Flood Resilience Mapping

The central part of the Sylhet district and the eastern part of the Sunamganj district have been found to be high resilience. On the other hand, the northern part of the Sylhet and the western part of the Sunamgaj are less socially resilient. The results also show that the Sylhet region is more resilient than the Sunamganj district, which corroborates the findings of the aggregate resilience index constructed based on household survey. Majority of the Sylhet district and the eastern part of the Sunamganj district have high economic resilience. The Sylhet region is more physically resilient than the Sunamganj district. Overall, Sylhet region is more flood-resilient than the Sunamganj district.

There are four building blocks of adaptive social protection: data and information, finance, institutional arrangements and partnerships, and programs. Using the physical modeling of the hazards' intensity, magnitude, frequency, and socioeconomic data, the resilience could be calculated for any spatial scale, and then a specific program could be implemented based on the resilience of the individual or community to enhance the resilience as a measure of social protection.

Towards a shock-responsive adaptive social protection for Bangladesh

The GoB has been spending a considerable amount of resources on social protection in Bangladesh. In fiscal year 2023-24, the allocation is 16.5 percent of the national budget in 115 schemes and 2.5 percent of the Gross Domestic Product (GDP). Such a high total allocation is consistent with the government's commitment towards implementing the NSSS 2015, which emphasises on life cycle approach to social protection.

The present study outlines a shock-responsive adaptive social protection (SRASP) that aims to give protection from and reverse the negative impacts of disaster- and climate-induced shocks in the life cycle of the vulnerable population.

Step 1: Conduct a national baseline to identify shocks. A comprehensive range of idiosyncratic and collateral shocks needs to be identified that emanate from climatic events and impact the life cycle of vulnerable households, especially those who live in climate hot-spots. The baseline of shocks and associated vulnerable households can be generated through conducting a nation-wide survey and mapping. Thereafter, the existing social protection schemes need to be modified in line with the temporary and life-cycle impacts, and assessed vulnerability, damage and loss.

Step 2: Assess vulnerability, damage and loss. The major drawbacks of the current social protection programmes are limited assessment of damage and loss, inadequate understanding and timely monitoring of risks and vulnerability, lack of robust scientific modeling and forecasting of major disasters for social protection schemes, and lack of rapid needs assessment to address shocks immediately through social

protection. Therefore, is important to identify who is most at risk and what are their specific needs. Assessing vulnerability, damage and loss could be conducted through developing a common baseline all over Bangladesh in line with the climate hotspot identified in the BDP2100, and constructing a resilience index for Bangladesh.

Step 3: Design and Modify Social Protection Programmes. For SRASP transformation, there is a need for intervention in the major streams of programmes for redesigning and modification. The major cross-cutting issues to be considered are gender, age, disability, ethnicity, income, occupation, spatial characteristics, nature-dependence, recurrence of exposure of the disasters and climatic events. The core agencies and organisations will include the Ministry of Disaster Management and Relief (MoDMR) at the centre, which would be accompanied by, among others, the General Economics Division (GED) of the Planning Commission, Cabinet Division, Prime Minister's Office, Finance Division and Ministry of Social Welfare. The other agencies would involve the Ministry of Environment, Forest and Climate Change; Ministry of Health and Family Welfare; Ministry of Labour Employment; Local Government Division; BBS, Bangladesh Bank, and development partners. Academia and think tanks can be involved in the design, monitoring, research, reporting, and developing technical instruments for the programmes.

Step 5: Monitor and Evaluate. To understand the effective implementation of the programmes and need for new programmes, data need to be collected at regular intervals by academia and think tanks. Third party monitoring is essential to ensure effective targeting and implementation. It will help measure outcomes and make adjustments in the schemes as necessary keeping in mind the drawbacks. In doing so, a comprehensive disaster atlas needs to be developed for entire Bangladesh to complement the two important national documents, BDP2100 and Bangladesh Disaster-Related Statistics 2021. In addition, inundation map, exposure map, damage and loss map, index-based shock-vulnerability and resilience map vs. poverty map, and simulation of future disasters and shocks should be conducted based on the baseline survey all over the country to effectively monitor and evaluate the programme implementation at the micro, meso, and macro levels. These exercises will help draw policy lessons for further improvement of the impact and efficiency of the interventions.

Step 6: Adapt and Scale up. It is important for devising strategy to expand coverage of SRASP. Some existing schemes are working fairly well to cover the poorest population of these districts to reduce vulnerabilities due to disasters and climate change. These programmes are being implemented only in rural areas while urban poor populations are also sufferer in those districts. Therefore, scaling up the existing programmes would be an interim solution before introducing a new programme for the same target group. Also, new measures need to be introduced to address emerging needs of the affected population.

Step 7: Coordinate and Collaborate. Coordination and collaboration among stakeholders, such as government agencies, NGOs, development partners, private sector and academia will be the final and most important part of an effective SRASP. Effective and meaningful coordination and collaboration will help design, mobilise resource and technical support, implement, monitor evaluate the programmes for scaling up after piloting some experimental schemes. Currently, the 'climate' component is available in the Overseas Development Assistance (ODA) of IMF, World Bank and ADB, which can be utilised for designing and implementing the SRASP. Finally, the Loss & Damage Fund can be a long term and viable source of funding for the SRASP.

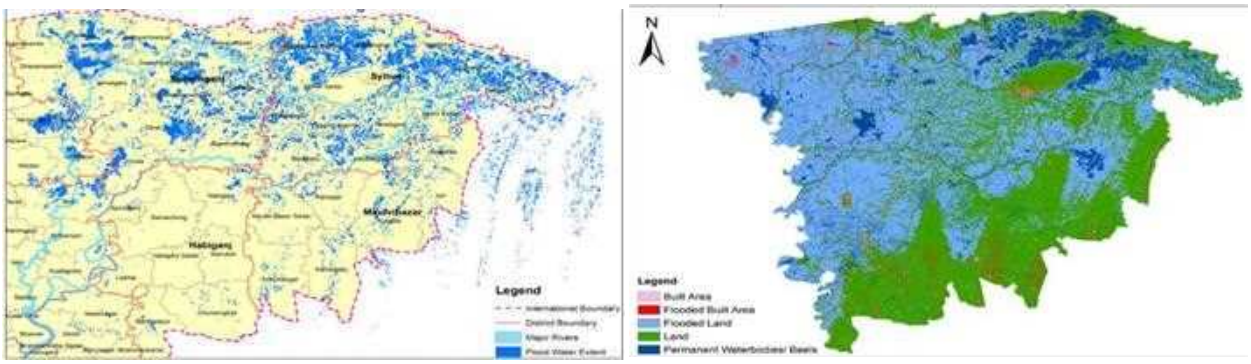
Chapter 1
Introduction

Bangladesh is one of the most vulnerable countries to climate change, facing immense difficulties in managing both natural and human-induced disasters. According to the Global Climate Risk Index 2021 report, Bangladesh ranked as the seventh worst-affected country by climate-related extreme weather events (Eckstein et al., 2021), despite contributing only 0.56 percent of global greenhouse gas emissions (ADB, 2023). The exposure and vulnerability levels of Bangladesh to disasters are also very high, as highlighted in the report. Globally, impacts of disasters on well-being are equivalent to a US$520 billion decrease in consumption, which is 60 percent more than the asset losses usually reported, and they force nearly 26 million people into poverty every year (Hallegatte et al., 2017). Bangladesh has been experiencing severe floods almost every year due to heavy rain and the river system of the Brahmaputra-Ganges-Meghna basin.

In May-June 2022, an early-monsoon flood occurred in the north-eastern part of Bangladesh. According to Indian Meteorological Department (IMD), the world's wettest place rewrote its June rainfall records held since 1940. The 24-hour rainfall recorded here on Friday (17 June) was 1,003.6 mm, surpassing the previous record of 945.4 mm in 1966. The second closest rainfall record was held by nearby Cherrapunji, another wet place, where the 24-hour rainfall on Friday (17 June) was 972 mm. For three consecutive days from June 15 to 17, the 24-hour rain recorded in Cherrapunji was 811mm, 673.6mm, and 972mm. These include the third wettest (June 17) and the eighth wettest (June 15) days in June in 122 years. Sylhet Division grappled with a severe humanitarian crisis in 2022 due to heavy monsoon rains and upstream water flow in Northeast India that left millions stranded (Maps 1.1 and 1.2). Flash floods have led to the destruction of homes and farmlands, compelling families to seek refuge on higher grounds and temporary shelters. The situation was further exacerbated by power outages. According to the Flood Forecasting and Warning Centre (FFWC), nearly 90 percent of Sunamganj district and more than 60 percent of Sylhet district were inundated. The floods were considered to be more devastating than those experienced in 1998 and 2004. The flash flood and water congestion have impacted an estimated 4.3 million people across seven northeastern districts of Bangladesh, viz. Sylhet, Sunamganj, Moulivazar, Habiganj, Netrakona, Kishoreganj, and Brahmanbaria. The floods have dislocated many households, some of whom resorted to open areas for shelter that increased safety risks for women and girls. Nearly 25,000 people have been relocated to approximately 450 shelters in Sylhet, while another 65,000 have been evacuated to 200 shelters in Sunamganj (United Nations Bangladesh, 2022).

Assuming that unprecedented rainfall occurred in the upstream region, causing flooding downstream, the destructiveness of the flood and the scale of damage and loss reported in the news media have prompted the scientific community to conduct an in-depth investigation of the phenomenon (Rahman, 2014). Along with the damage and loss assessment, it is also crucial to assess the needs of flood victims to ensure effective and efficient use of resources. Damage, loss and needs assessment (DLNA) have been identified as a major area in the disaster risk reduction process. Proper DLNA needs to be contextualised with the socio-economic and cultural vulnerabilities of the people at risk, and optimises the support strategies of the flood-victims.

Note: Sentinel 1 Synthetic Aperture Radar (SAR) data for 17th May 2022 is used to determine flood inundation extent.



The figure indicates that Sylhet and Sunamganj districts were severely affected by the flood.

Map 1.1: Extent of flood inundation (left) and floods in Sylhet region using Sentinel-1 SAR images (right)

Map 1.2: Inundation of the Sylhet region and Northeast India on 8 May (left) and 22 June (right), 2022
Source: NASA Earth Observatory

The level of damage and loss due to early monsoon flood is very high and economically destructive. Determination of the physical vulnerability is also important to assess the operational level of the critical infrastructures in place and to understand if the development processes amplify the inundation and extent of the flooding in the region. In-depth damage and loss calculation would support to make planning for the crisis management towards late response as well as short, medium, and long-term recovery and rehabilitation. Moreover, there is a strong relationship between the damage & loss and resilience of the exposed community and elements at risk.

Box 1.1: Snapshot of 2022 flash floods

- 9 districts impacted: Sylhet, Sunamganj, Moulivibazar, Habiganj, Kishoreganj, Netrakona, Brahmanbaria, Mymensingh and Sherpur
- 7.2 million persons affected
- 3.5 million children affected
- 16,84,607 households waterlogged
- 481,827 people evacuated/temporarily displaced
- 57 persons dead including 22 children: Most deaths due to drowning
- 106,727 water points damaged
- 283,355 sanitation facilities damaged
- 663,534 cattle affected
- 254,251 Hectares of damaged croplands
- 106,000 ponds inundated
- 17,000 metric tons of fish washed away
- 75,000 fish farmers severely affected from fish lost and pond damaged
- US$31 million total income loss in fisheries

Sources: Humanitarian Coordinator Task Team (HCTT) in collaboration with the Ministry of Disaster Management and Relief (MoDMR), 2022, United Nations Bangladesh Coordinated Appeal July-December 2022; UNICEF. 2022. Bangladesh Country Office Humanitarian Situation Report No. 5 North-eastern Flood, Report date: 7/07/2022

Although the Government of Bangladesh (GoB) and different Non-Governmental Organisations (NGOs) have attempted to support the affected population, these initiatives often fail to sustain due to a lack of capacity to withstand the natural shocks, which is related to the resilience of the community. Resilience refers to the ability of any community or system to face any negative phenomenon and to sustain efficiently with social, economic, environmental, and physical resources (Qasim et al., 2016). Resilience is frequently referred to as community resilience, signifying a combination of capabilities aimed at enhancing community capacity, disaster adaptation, and serving as a goal for community development (Islam, 2023). If the community becomes resilient to address the natural phenomena, it will achieve the capacity to absorb the shock and return to the previous condition for continuing activities. The Flood of the northeastern part of Bangladesh initially reflected that the natural system is disturbed to discharge the unprecedented rainfall, on the other hand, the capacity (socioeconomic and cultural point of view) of the population of the region to cope with flood hazards is yet to improve.

The overarching aim of this study is to map flood hazard scenarios corresponding to different levels of rainfall in upstream and catchment areas, and to establish the relationship between vulnerabilities and resilience within the framework of the damage-loss-need nexus resulting from flood hazards in the Sunamganj and Sylhet districts. Specific objectives of the study are to

a) Analyse and model the major causes and consequences of recent floods addressing inundation and depth, particularly in the major affected north-eastern district of the country;
b) Determine the ‘damage-loss-need’ of the elements at risk using various methods;
c) Identify relationship of ‘vulnerability-coping capacity-resilience’ nexus of the at-risk community with respect to the socioeconomic and cultural difference of the areas;
d) Analyse the impact of the existing infrastructures, such as roads, embankments and other anthropogenic elements in ‘Haor’ and surrounding at various scenarios of flood;

e) Draw inference on possible repeatable frequency of shocks in the region in future and determine possible climate-induced disaster-related shock responsive local resilience-focused social protection model(s)/programming to protect the people in disaster period.
f) Develop an adaptive social protection programming to integrate into the National Social Security Strategy (NSSS) 2026 in support to address the Bangladesh's graduation from the Least Developed Countries (LDCs), to attain the UN Sustainable Development Goals (SDGs) 1, 2, 5, 8, 10 and 13, and "Vision 2041" of Bangladesh.

The remainder of the report is structured as follows: Following this brief introduction, Chapter 2 outlines the methodology employed in the report. Chapter 3 conducts flood hazard assessment modeling, encompassing flood inundation mapping and flood modeling using the 1D-2D coupled hydraulic model. Chapter 4 presents the findings from the field survey, covering vulnerability, damage and loss assessment, response mechanisms, resilience, and the role of social protection. Chapter 5 details the results of flood resilience mapping, focusing on the social, economic, and physical resilience of the Sylhet and Sunamganj districts. Lastly, Chapter 6 examines the policy landscape for social protection concerning climate-induced large catastrophes and proposes a shock-responsive adaptive social protection system for Bangladesh.

Chapter 2
Research Approach and Methods

The investigations utilized all available observed data and pertinent satellite images. A comprehensive questionnaire survey, Focus Group Discussions (FGDs), and Key Informant Interviews (KIIs) were conducted to gather both quantitative and qualitative data. To achieve the *first objective*, the study used hydrodynamic modeling, a couple 1D/2D hydrodynamic model were developed using HEC-RAS software for flood (depth, velocity, and duration, etc.) simulation in the northeastern part of Bangladesh. The required river cross section, water discharge and height data were collected from Bangladesh Water Development Board (BWDB) of the various time period. The upstream boundary of the model was defined using discharge data, while the downstream boundary comprised of the water level data. The model was calibrated and validated using the observed water level data from (BWDB). Finally, the simulated results from the hydraulic model were used for flood risk assessment of the study area.

The following data are used to create the hydrodynamic model:

a) High-resolution Digital Elevation Model (DEM) data (30 m resolution SRTM data from NASA is freely available and can be used for this study)
b) River cross-section data (for the 1D model) and river bathymetry data (for the 2D model), River discharge data (for the upstream boundary of all major rivers and tributaries), River water level (for downstream boundary, model calibration, and validation), and Rainfall data (from BMD and BWDB)
c) Land use and land cover maps will be created using satellite data (e.g., Sentinel 2/Landsat 8).
d) The dimension of hydraulic structures (e.g., bridges and embankments) in the model domain.

The inundation maps were developed considering the projected scenarios of river bed level, water discharge and flood height as well as hydraulic and anthropogenic interventions happened in the study areas.

To achieve the second objective, the study used a quantitative questionnaire-based survey tool to assess the damage, loss and needs caused by the recent flood in the study area. The flood victims and other infrastructures (critical infrastructures and household conditions) worked as sample for this survey. Other than the field investigations, satellite images were interpreted using relevant software to figure out the level of damage of the inaccessible areas. Both the ECLAC method of world bank and D-Form of Standing Orders on Disaster (SOD) of the Ministry of Disaster Management and Relief (MoDMR), Government of Bangladesh (GoB) were used simultaneously to develop a realistic damage and loss calculation.

To achieve the third objective, MOVE Framework (Birkmann et al., 2014) was used in this study. According to this framework (Figure 2.1), the study developed a questionnaire to assess vulnerabilities and level of resilience of the flood affected communities. This framework helped

show the relationship between vulnerabilities and resilience. The main question here was, "Can reducing vulnerabilities improve the level of resilience of the flood affected communities?"

The study emphasised the socioeconomic and cultural vulnerabilities to understand the level of resilience of the communities at risk within the presence of physical vulnerability of the event. From previous studies, it has been observed that due to socioeconomic and cultural vulnerabilities the communities are facing difficulties to utilise available resources effectively and efficiently. Though the government agencies are introducing innovative actions to manage impacts of flood and reduce risk of flood, due to the socioeconomic vulnerabilities the actions are not producing effective results. This study assessed all the areas of vulnerabilities and provided special focus on socioeconomic and cultural vulnerabilities to indicate the process of achieving resilience. As part of qualitative method, FGD and KII tools were used. Checklists were developed to collect descriptive data through FGD and KII. Qualitative data supported quantitative data and also helped get an in-depth view of the risk scenario of flood.

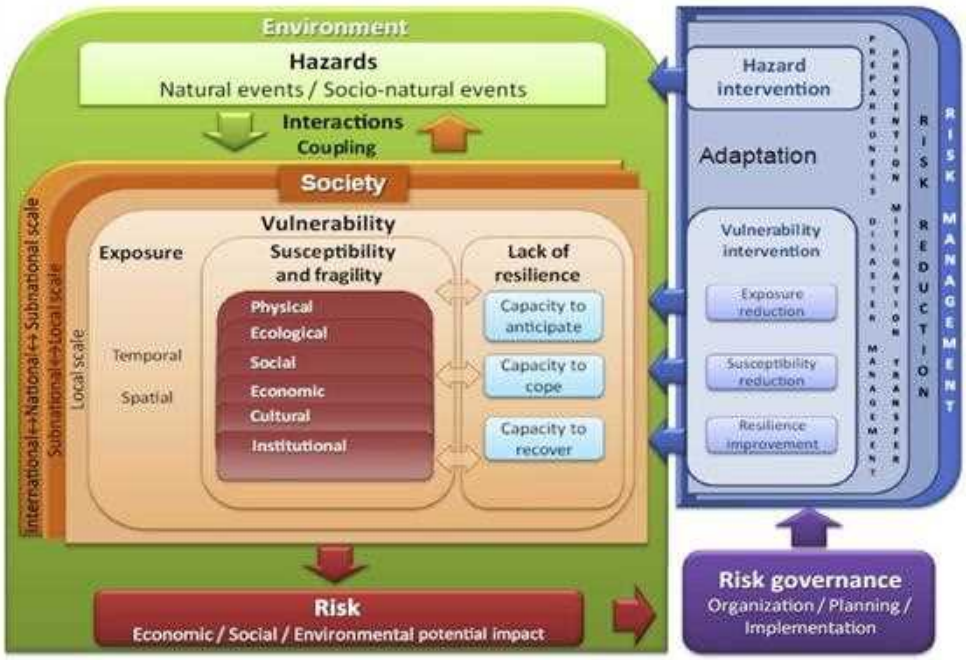


Figure 2.1: MOVE Framework

To *achieve the fourth objective,* this study analysed the existing development interventions in the Sylhet region. For this purpose, the eighth five-year plan and the recent budgets on social protection were reviewed. Afterwards, an attempt was taken to develop the various scenarios of the flood hazards to observe the impacts of the events overlaying the existing infrastructures on the developed inundation maps. Such observation developed the level of understanding what measures should be taken to reduce the risk of floods in-term of the reduction of physical vulnerability. The development data was used alongside the flood inundation model.

To *achieve the fifth objective,* this study conducted a gap analysis. For this purpose, a comprehensive analysis was conducted to examine the effectiveness of the mechanisms of NSSS 2015 in providing support to the vulnerable population in flood hazard prone areas. Afterwards,

the new challenges of poverty and social insecurity due to the flooding in the Sylhet region was analysed. The data for this part was collected through questionnaire survey, FGD and KIIs. The findings from the latter part was used to address the loopholes in the existing NSSS and develop a smart and new strategy.

To *achieve the sixth objective*, the existing national development plans and programmes, as well as the global development plans and programmes have been reviewed. Later, a comprehensive analysis of the development targets, objectives and timeline was developed. The findings from this analysis will be used to develop a comprehensive NSSS 2026 that will address the national and global development objectives within the standard timeline.

Study Area, Sample Size and Sampling

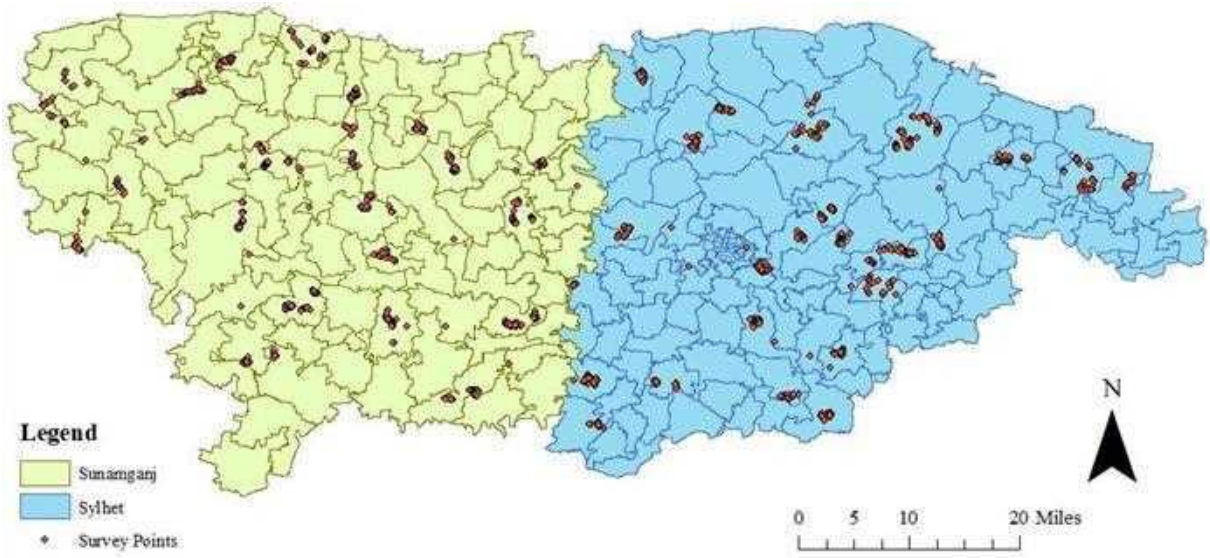
According to the United Nations Bangladesh (2022), two of the major floods affected area were Sunamganj and Sylhet. A total of 1,821,950 people were directly affected due to extreme level of flood in Sunamganj (61 percent of the district's population). On the other hand, a total of 1,547,560 people were affected by flood in Sylhet district (35 percent of population). Table 2.1 presents the sample size based on the population (Krejci and Morgan, 1970). Considering the relatively big sample of the flood affected area, this study used ±10 percent precision of the population in selecting the sample size.

Table 2.1: Sample Size by Upazila and Union/Municipality/City Corporation

Sunamganj	n	Sylhet	n
Tahirpur	**83**	**Jaintiapur**	**96**
Tahirpur	40	Darbast	56
Badaghat	43	Chiknagul	40
Biswamvarpur	**59**	**Dakshin Surma**	**34**
Dhanpur	35	Kuchai	10
Salukabad	24	Moglabazar	24
Chatak	**73**	**Kanaighat**	**61**
Chhatak	41	Kanaighat Municipality	28
Dakshin Khurma	32	Purba Dighirpar	33
Jagannathpur	**117**	**Sylhet Sadar**	**61**
Raniganj	52	Mogalgaon	39
Patali	65	Khadimpara	22
Sulla	**106**	**Gopalganj**	**107**
Atgaon	50	Bagha	30
Habibpur	56	Paschim Amura	38
		Bhadeshwar	39
Sunamganj Sadar	**49**	**Bishwanath**	**24**
Gourarang	20	Lamakazi	10
Laxmansree	29	Daulatpur	14
Dharmapasha	**52**	**Companiganj**	**99**
Dharmapasha	27	Islampur Purba	53
Joysree	25	Dakshin Ranikhai	46
Derai	**124**	**Gowainghat**	**94**

Jagaddal	60	Lengura	51
Rajanagar	64	Towakul	43
Madhyanagar	**39**	**Fenchuganj**	**91**
Madhyanagar	12	Ghilachhara	50
Dakshin Bangshikunda	27	Fenchuganj	39
		Maijgaon	2
Dowarabazar	**100**	**Beanibazar**	**74**
Mannargaon	56	Charkhai	33
Pandargaon	44	Alinagar	41
Jamalganj	**127**	**Osmani Nagar**	**86**
Sachna Bazar	88	Sadipur	23
Fenerbak	39	Osmanpur	17
		Umarpur	46
Shantiganj	**114**	**Zakiganj**	**23**
Joykalash	51	Kajalshah	23
Paschimbirgaon	63		
Purbabirgaon		**City Corporation**	**29**
Sunamganj	**1043**	**Sylhet**	**889**
Total		**1,922**	

The total sample size was **1,922** households.



Map 2.1: Distribution of sample households

In this study, a total 24 FGDs and 72 KIIs were conducted. The list of FGDs and KIIs is given below:

Table 2.2: Qualitative techniques applied in the study

Districts	Number of FGDs	Participants

FGD	11 in Sunamganj (One FGD per Upazila)	Women, Men, PWD, Elderly people, Local leaders, NGO representatives, Teachers, etc. FGDs were organised with the support of Upazila Chairman/UNO. The participants were selected by the Upazila Chairman/UNO.
	13 in Sylhet (One per Upazila)	Women, Men, Persons with disabilities, Elderly people, Local leaders, NGO representatives, Teachers, etc. (Minimum 20-25 participants in every FGD). FGDs were organised with the support of Upazila Chairman/UNO. The participants were selected by the Upazila Chairman/UNO.
KII	Total 72	Upazila Nirbahi Officers (UNOs), Project Implementation Officers (PIOs), and District Relief and Rehabilitation Officers (DRROs) of each district
Case study	Total 15	Both women and men from Sylhet and Sunamganj districts

Chapter 3
Flood Hazard Assessment Modelling

3.1 Introduction

Floods have posed a constant threat to human civilisation and existence since ancient times. Compared to other natural disasters, floods have increased in frequency during the last 20 years (Ferreira, 2011). They are responsible for 43% of the damage that occurs in a number of fields, including social, economic, environmental, and human sectors. Floods are common around the world and have devastating effects that are felt widely, leading to both large financial losses and fatalities. As a result, floods are thought to be the most damaging natural disaster in current times (Glago, 2021). Because of the recent increase in their frequency, floods have made human beings all over the world more vulnerable. The rapid and large growth of the human population, uncontrolled urbanization, changes in the land use pattern, the disappearance of forests and other vegetation, and human intervening upstream in river systems are all factors that contribute to this acceleration (Dewan, 2015; Huq et al., 2020). In addition, future projections indicate that the severity of this problem will worsen due to the acceleration of global warming and continued trends in climate change. Floods thus provide a problem for both economically developed and economically underdeveloped countries worldwide (Ongdas et al., 2020). Bangladesh, a developing nation deeply interconnected with this problem, therefore places high importance on the vulnerability to floods.

One of the most flood-prone countries on Earth is Bangladesh, a country located within the GBM river system, which experiences a yearly onslaught of catastrophic flooding (Rahman & Salehin, 2013). A vibrant and dynamic river delta formed by the confluence of the Ganges, Brahmaputra, and Meghna rivers makes up the majority of the landmass of the nation low-lying floodplains and is home to a network of over 230 rivers and tributaries (Baky et al., 2020; Basak et al., 2015). Bangladesh takes the brunt of the enormous water flow from this system despite only making up roughly 7% of the GBM basin overall (Munna et al., 2018). Its location between the Bay of Bengal to the south and the Himalayan Mountains to the north contributes to the peculiar scenery of the region, which is made up of depressions, flat topography, and a variety of hydrological compositions. Every year, considerable rain falls on Bangladesh due to the monsoon climate and the Himalayan shielding effect. Because of the combination of circumstances, the country is very vulnerable to flooding hazards (Jahid Hasan et al., 2012; Munna et al., 2018). Bangladesh, which has nearly 80% of its territory covered by floodplain, has at least 20% of its lands flooded each year, with the potential for up to 68% during severe occurrences (Huq et al., 2020). While floods provide certain advantages for an agricultural country like Bangladesh, such as improving soil fertility through nutrient-rich silt deposition and enhancing moisture levels, large-scale floods can be disastrous. They inundate massive areas of land, causing considerable agricultural and property destruction as well as severe financial and economic losses (Ahamed, 2010). Furthermore, a significant human presence in flood-prone areas, combined with major social and economic development initiatives, has contributed to a recent increase in the frequency, intensity, and severity of flood disasters (Kamal et al., 2018). As a result, Bangladesh gained global recognition as one of the countries being most vulnerable to flooding.

In a country with a vast number of rivers like Bangladesh, it is widely recognized that preventing or entirely eliminating floods is unfeasible, thereby leaving the nation vulnerable to recurrent flooding occurrences. As a result, it is critical to prioritize damage and loss mitigation over a comprehensive flood control strategy. This requires identifying the areas of the country that are most vulnerable to flooding (Yousuf Gazi et al., 2019). Efforts can then be aimed at lessening the impact of floods, which have severe consequences for the lives and livelihoods of individuals who live in or near flood-prone areas. Flood hazard, vulnerability and risk assessment, also known as the identification and mapping of the places most susceptible to flooding and damages due to flooding, is crucial to this procedure. This entails thoroughly investigating all prospective water bodies and the surroundings around them in order to predictably pinpoint and map out the area being most hazardous and vulnerable to flooding (R. Rahman & Salehin, 2013). Public awareness of the risks connected with flooding can be increased by generating maps that capture key flood hazard parameters such extent, depth, arrival time, duration, and velocity of floods (Munna et al., 2018). Additionally, these flood hazard, vulnerability and risk maps are useful resources for disaster response stakeholders such as engineers, government officials, and policymakers. These maps can be used by them to choose the best flood mitigation strategies based on the degree of flood susceptibility in certain areas, limiting the damages caused by floods (Mujiburrehman, 2015; A. Rahman, 2021).

The northeastern districts (Sunamganj and Sylhet) of Bangladesh considered in this project are the most flood prone districts of the country because flood occurs in these districts every year. The entire northeastern region is located nearby to the Meghalaya region in India which experiences the heaviest rainfall in the world. As a result, the entire region also experiences extreme and torrential rainfall events which causes flash floods during early monsoon between April and May as well as riverine floods during monsoon period which starts in June and ends in September (Jahid Hasan et al., 2012; Kamal et al., 2018; Munna et al., 2018). The great river Meghna and its two tributaries, the Surma and Kushiyara Rivers, historically flow through the northeastern region (Hoque et al., 2011). During monsoon, excess rainfall leads to excess water flow in these rivers, resulting in floods in the districts of Brahmanbaria, Habiganj, Kishoreganj, Moulvibazar, Narsingdi, Netrokona, Sunamganj and Sylhet. These floods have disastrous impacts by destroying houses, animals, and crops. Again, Old Brahmaputra River is the main distributary in the districts of Mymensingh, Gazipur and Kishoreganj districts which causes floods in these districts during rainy season. Cultivable areas, irrigation projects, and valuable infrastructure situated on the bank of the Old Brahmaputra River experience significant damage from the recurring floods in this river (Rakib et al., 2017). The historical flood records for 1988, 1992, and 1998 show that large-scale floods routinely occur and cause significant economic loss in this entire region (Yousuf Gazi et al., 2019). Recently, in 2022, three floods, including two flash floods in April and May and as well as a riverine flood in June, devastated the northeastern region due to torrential rainfall over the project area and adjacent Meghalaya region which caused unbound sufferings to the people and enormous damages to properties (Jasim, 2022). Following that, the possible effects of historical and likely future flood occurrences in these rivers in this region make the study on flood hazard, vulnerability, and risk mapping enormously significant.

In Bangladesh, flood mitigation plans have long included both structural and non-structural measures. While nonstructural practices concentrate on finding solutions and alternatives that avoid harms, injuries, and disruptions to people's lives and livelihoods, structural practices entail

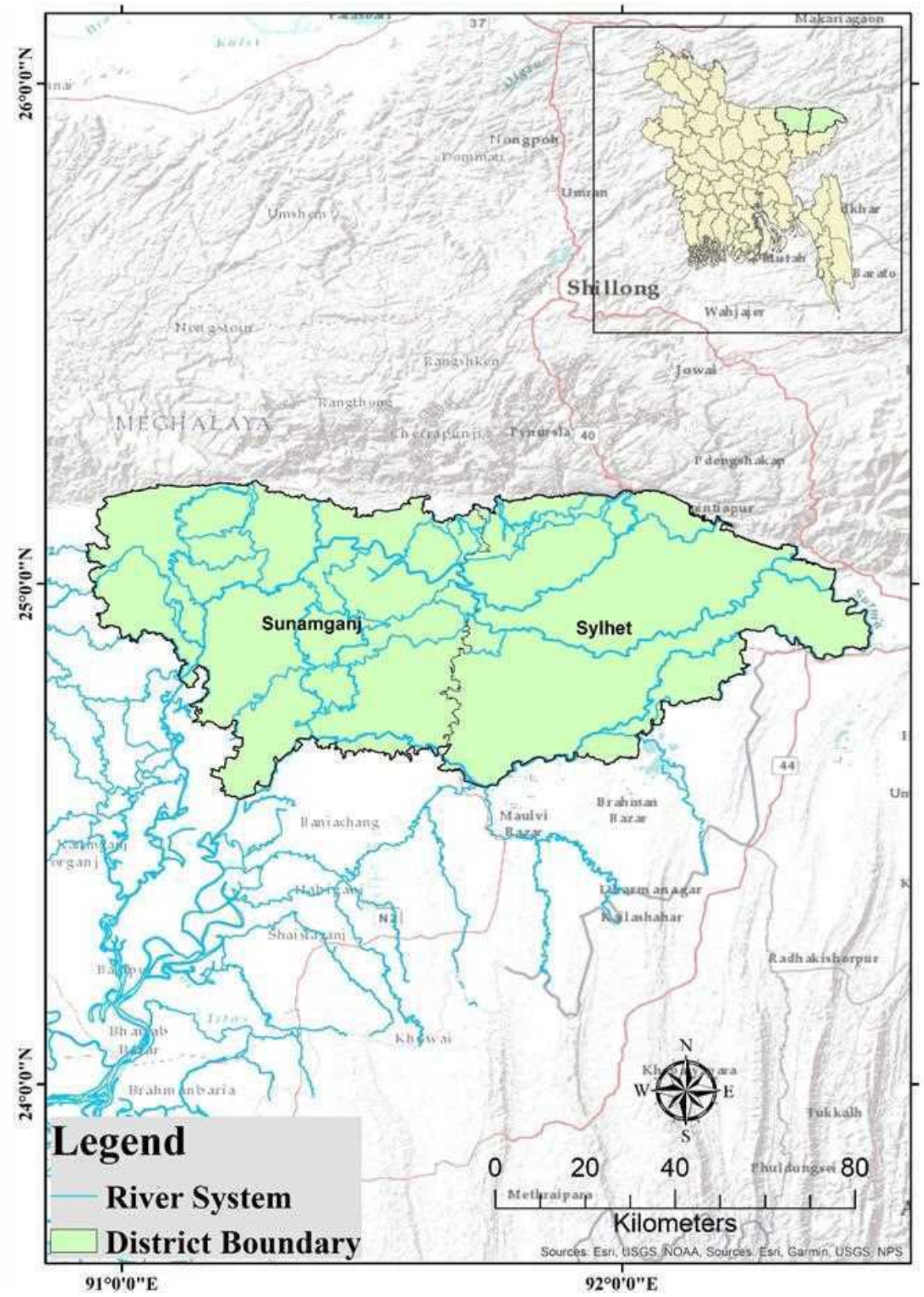
the construction of various engineering works (Baky et al., 2020; Paul & Routray, 2010; R. Rahman & Salehin, 2013). Despite the fact that structural interventions have been successfully applied in Bangladesh since the 1960s, they have been found to be less effective at lowering flood risks due to their adverse effects on river hydraulic systems, ecosystems, biodiversity, the environment, and socioeconomic factors (Baky et al., 2020; Mondal et al., 2021). Furthermore, structural flood protection techniques may not be advantageous to all facets of society (Sohel & Ullah, 2012). To successfully reduce the risks of flooding occurrences across the nation, it is now imperative to combine structural and non-structural solutions. The creation of flood hazard maps is a critical step before deploying non-structural flood mitigation measures (Bhuiyan & Baky, 2014; A. S. Islam et al., 2010; M. M. Islam & Sado, 2000). Administrators, planners, and politicians can use these maps to identify towns, regions, and infra structures that are vulnerable to flooding, enabling for prompt reaction and recovery activities in high-risk locations (Baky et al., 2020; Bhuiyan & Baky, 2014; Paul & Routray, 2010).

Flood hazard assessment can be done using many methods available in these present days. In Bangladesh, various diverse studies on rivers and tributaries, dynamics of floodplain processes, and flood hazard assessment have been conducted over the years by utilizing or combining mostly GIS and remote sensing-based techniques (. Dewan et al., 2007; Hasan, 2006; A. S. Islam et al., 2010; . Islam & Sado, 2000; Uddin & Matin, 2021; Yousuf Gazi et al., 2019). Food hazard assessment using hydraulic models is gaining popularity in recent days due to its accuracy in producing flood simulation in natural river channel as these models use river hydraulics by which more realistic output can be produced (Baky et al., 2020). In general, hydraulic models are divided into 1D and 2D categories depending on the modeling methodology where the simulation of the movement of floodwaters in a natural river under various flood situations can be conducted (Baky et al., 2020; Farooq et al., 2019; Hossain et al., 2022). Some of the most popular and extensively applied hydraulic models are HEC-RAS, MIKE, Delft3D, SOBEK etc. In 1D models, only longitudinal water flow along the main river channel is considered and flow to other directions are neglected (Teng et al., 2017). Thus, 1D models are not preferable in terms of inundation modeling of floodplain and urban built-up areas because, in reality, water flow has both longitudinal and lateral movement over land surface. As a result, inundation mapping by using 1D models has some limitations and create complexity in floodplain inundation mapping (Farooq et al., 2019; Hossain et al., 2022). On the other hand, 2D models take both longitudinal and lateral flow directions into account (Teng et al., 2017). Both 1D and 2D models can be interconnected to construct a 1D-2D coupled hydraulic model, in which the main river channel is portrayed as a 1D component and the river adjacent floodplain is shown as a 2D element (Hossain et al., 2022; Lea et al., 2019; Roy et al., 2021; Teng et al., 2017). This more integrated, advanced and comprehensive method is critical for inundation mapping in floodplains because it enables for the coupling between 1D and 2D models, which allows it to adequately illustrate the interactions between rivers and floodplains in a dynamic way (Lea et al., 2019; Vozinaki et al., 2017). Among all the mentioned hydraulic models above, HEC-RAS is also highly capable in simulating all these 1D, 2D as well as integrated coupled models (HEC-RAS, 2016). HEC-RAS has open access and any internet user can download and use it freely. As HEC-RAS has huge opportunity to assist hydrologists and engineers throughout the world in tackling challenges and difficulties related to flood events, it is particularly pertinent and acceptable among experts in floods (Patel et al., 2017). Despite the fact that only just few research works have been accomplished for several waterways throughout Bangladesh employing a 1D hydraulic model

(Masood & Takeuchi, 2012; Mehzabin, 2019) and 1D-2D coupled hydraulic model (Navera, 2018; Roy et al., 2021), the 1D-2D coupled hydraulic model has proven its efficiency and reliability in developing flood hazard mapping in order to create flood zoning maps. Thus, using the 1D-2D coupled hydraulic model, this study has aimed at main channel modelling of main rivers as 1D part and surrounding floodplain as 2D component in order to delineate the most flood-vulnerable areas of the entire northeastern region.

3.2 Study Area

The study area comprises two districts in the north-east of Bangladesh, which are Sylhet and Sunamganj districts (Fig 3.1). But for developing the hydrodynamic model with suitable boundary conditions at the monitoring stations, the model domain was extended to Habiganj, Moulvibazar, Netrokona, Kishoreganj, Narshingdi, and Brahamanbaria districts. The study area has a surface area of approximately 26,942 km^2 and shares borders with the Indian states of Assam, Tripura, and Meghalaya. The main rivers of the study area are Meghna, Surma, Kushiyara along with their tributaries and distributaries. The area is known for its varied geomorphological landscape, which includes elevated topography of Plio-Miocene hills along the border (Hoque et al., 2011). A sizable low-lying flood basin in the centre is there and is referred to locally as Haor Basin. Due to sporadic floods, the basin, which has a surface area of about 4505 km^2, is submerged for several months every year. Besides, the remaining areas are mainly plains, and some parts of Gazipur, Mymensingh and Narsingdi districts fall on Madhupur tract which is a upland area in the central part of Bangladesh. The soils are primarily clays and heavy silts on the hills and in the basins. The extent and intensity of flooding can fluctuate significantly over the course of a few days in this location since there is a certain possibility of flash floods throughout the Pre monsoon or rainy season. On the ridges where the elevation is generally higher, the flood depth is usually less than the basins where flood water depth is much higher (*Banglapedia*). The majority of exposed litho-formations from the Eocene to recent are found in the Surma basin. Along the northern and eastern edges of the Surma basin, the Kopili Shale and Sylhet Limestone (Eocene), the Barail group (Oligocene), the Surma and Tipam groups (Miocene-Pliocene) crop out (M. J. J. Rahman et al., 2014). Tropical monsoon climate dominates in the study area, with warm, rainy summers and cool, dry winters with an annual average maximum temperature of 23°C (August–October) and an average minimum temperature of 7°C (January). The average rainfall in the study area is 3833.7 mm, with average monthly rainfall ranging from 9.2 mm in January to 916.5 mm in June (Baki et al., 2008). All the river gauge stations situated in this study area are considered in this study for boundary conditions of the hydraulic model in which discharge data from upstream river stations are used in upstream boundary condition and water level data from downstream river stations are used in downstream boundary condition.



Note: The study area shows the district boundary and rivers system

Map 3.1: Location of the study area

3.3 Materials and Methodology

3.3.1 Flood Inundation mapping using remote Sensing

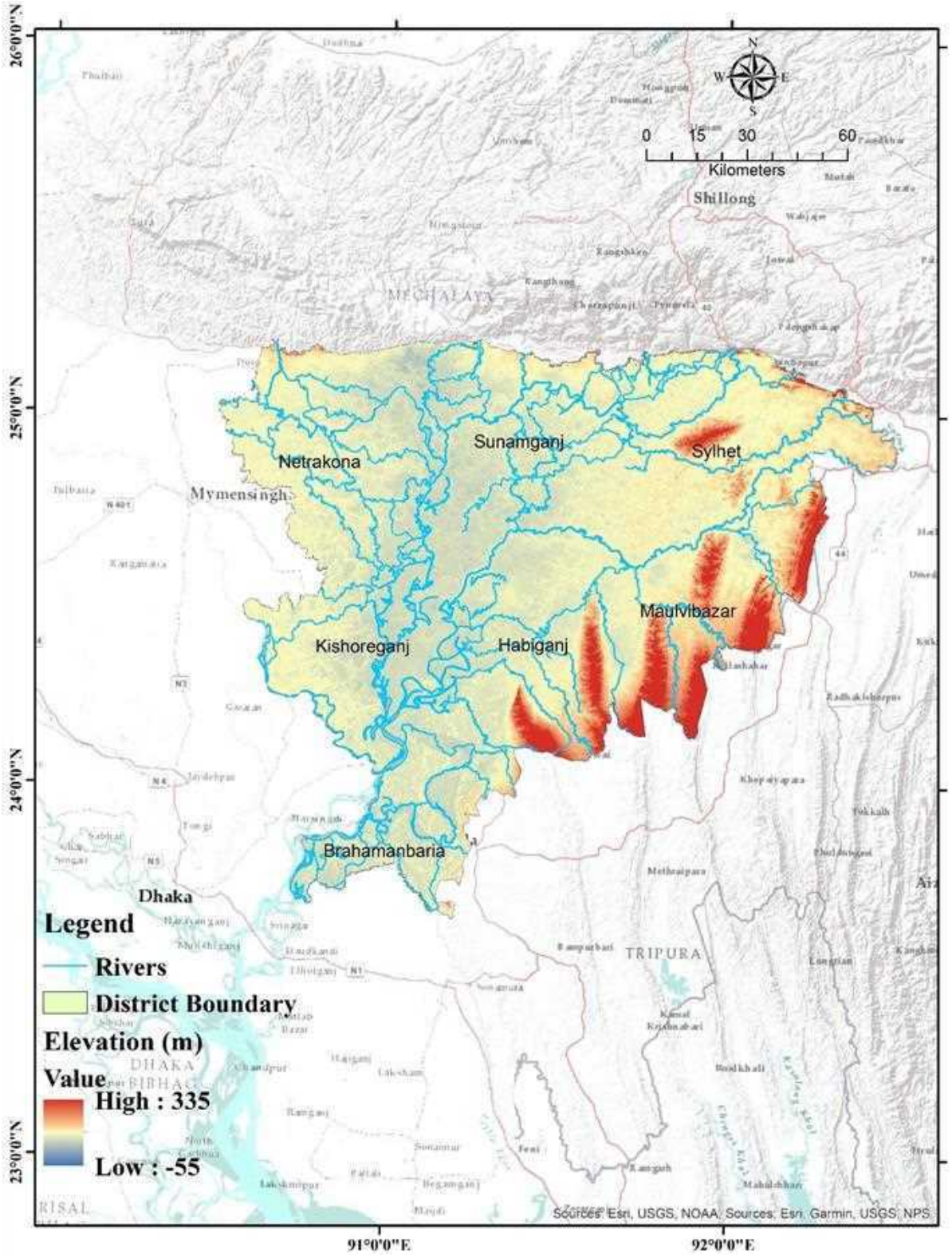
The flood inundation extent was delineated using Sentinel-1 satellite images for the date of June 18, 2022, when the flood peak was at its maximum. The Sentinel-1 Synthetic Aperture Radar (SAR) was used as it can penetrate the cloud and monitor the flood in rainy conditions. The European Space Agency devised the ESA SNAP toolbox, a robust and adaptable software suite for interpreting Earth Observation data. It is designed for use in a variety of applications and research projects, assisting researchers in easily accessing, managing, and evaluating massive volumes of satellite data. For experienced users, it offers an integrated programming environment that makes it simple and rapid for them to create complex algorithms for interpreting satellite imagery. The user-friendly interface of the software enables users to easily construct their own algorithms and analyze data with little effort. The toolbox offers a broad range of advanced features, from straightforward image processing to more sophisticated analytic methods. The graphical user interface (GUI), the Java Development Environment (JDE), the SNAP Extension Library (SEL), and the SNAP Algorithm Library (SAL) are the four parts that make up the toolbox. From atmospheric science to land cover mapping, it is suitable for a variety of scientific applications. Additionally, it is a great tool for remote sensing specialists and academic scholars, enabling them to swiftly conduct their research works (ESA). In this study, SNAP 9.0.0 version was used for SAR image processing.

3.2 Flood Hazard Assessment

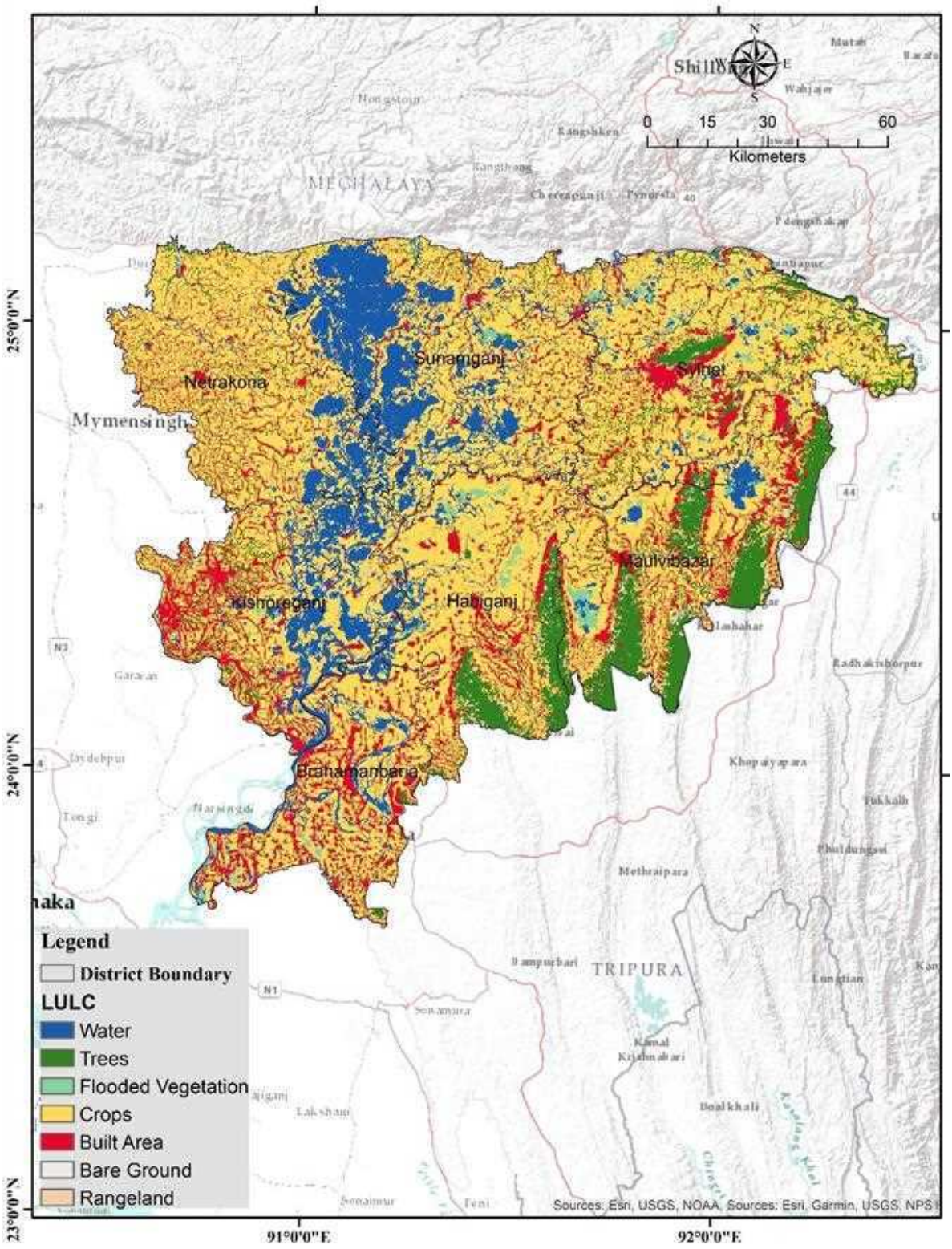
In order to accomplish the flood hazard assessment, the necessary steps for designing the flood hydrodynamic model are extensively presented below.

3.2.1 Data Collection

To set up the hydraulic model, various datasets are needed to be collected first. For this, several datasets were collected from different organizations. Then the data were used and processed in the model and lastly, the results were analyzed in order to undertake the flood hazard assessment. The hydraulic model requires various hydrological and spatial datasets to simulate the flooding events. Digital Elevation Model or DEM (Fig 2) of the study area were collected from USGS, and Sentinel-1 and Sentinel-2 satellite images were collected from Copernicus Open Access Hub. Sentinel-1 was used flood inundation mapping and Sentinel-2 satellite was used for land use mapping (Fig 3). Based on these requirements, datasets comprising and rainfall (Fig 4) water level (Fig 5), cross sections of rivers (Fig 6), discharge (Fig 7) data were collected from Bangladesh Water Development Board (BWDB).



Map 3.2: Topographic elevation of the study area prepared using Shuttle Radar Topography Mission (SRTM) data with 30 m resolution



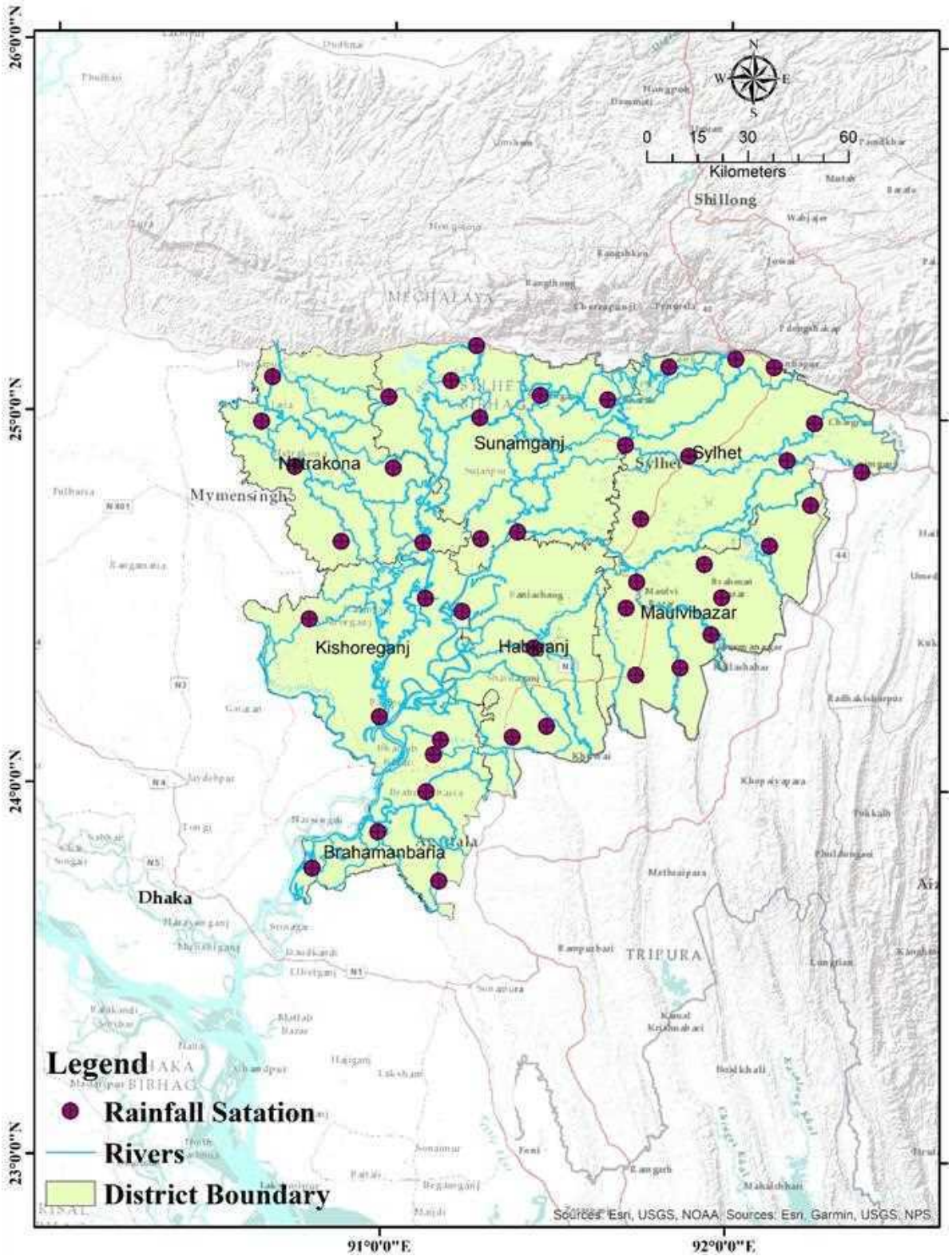
Map 3.3: Land use and land cover map of the study area prepared using sentinel-2 satellite images with 10 m spatial resolution.

3.2.2 Model Development Using HEC-RAS

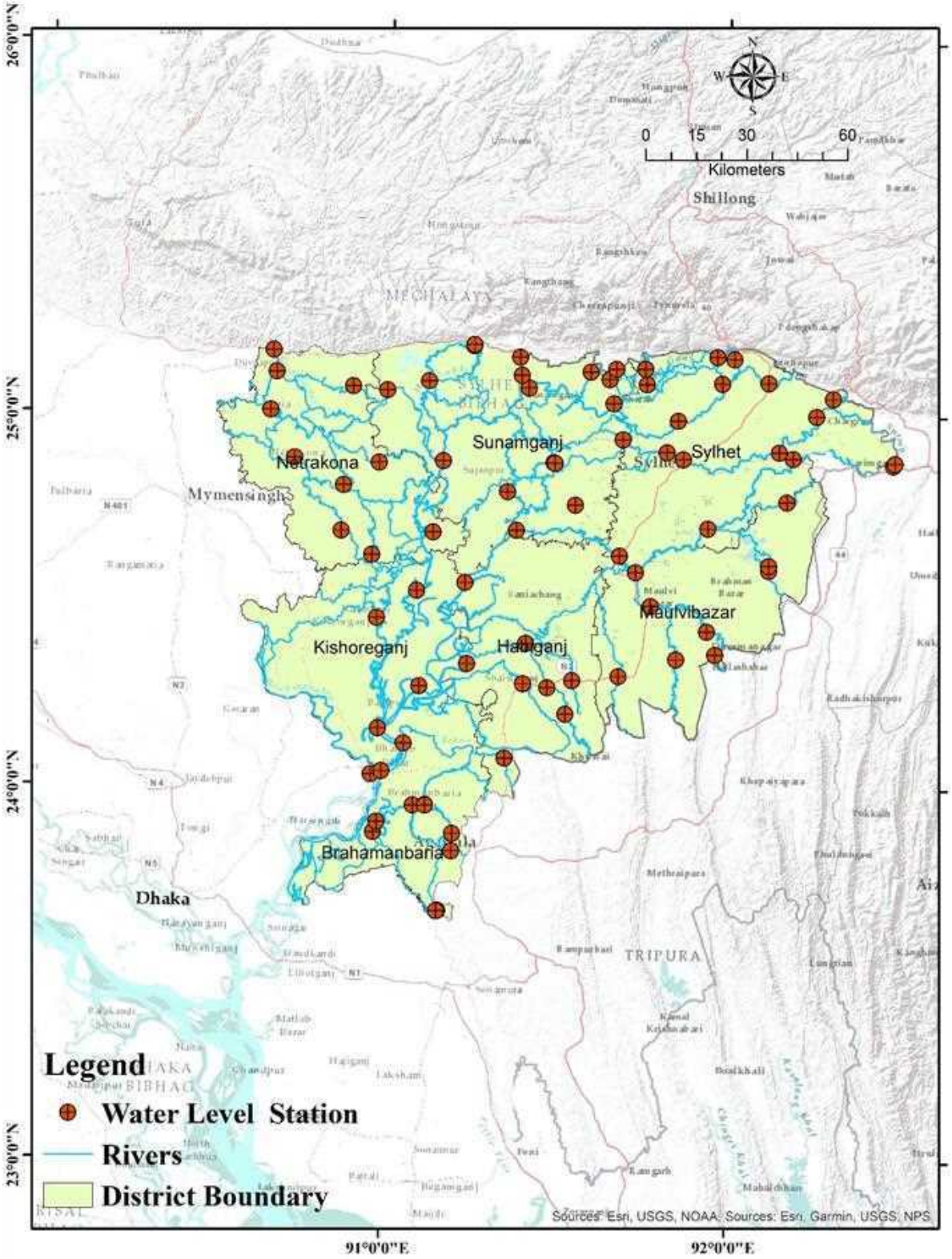
Developing the 1D segment of the model is the first step to generate the whole 1D-2D coupled hydraulic model. This procedure requires cross section, discharge and water level data of the river. Firstly, a project file and a plan file were created with selecting a directory. Then, all the river reaches of rivers, junctions, nodes were drawn from upstream to downstream station at Geometric Data Editor in HEC-RAS software. Within all those river reaches; all the cross sections were given according to the distance between them as model input to construct the channel's geometry of the river. The extra cross sections between two cross sections were interpolated. By this step, the geometric data of 1D model defined and then Geometry was saved. The next step was to give the boundary conditions of the 1D hydraulic model to run the simulation. Before running the simulation of desired scenario, the model was calibrated and validated by running unsteady flow simulations using previous year's observed discharge and water level data as upstream and downstream boundary conditions which is described in the next section. The forecasted precipitation data during the flood event is shown in Fig 8, Fig 9 and Fig 10.

3.2.3 2D Model Development Using HEC-RAS

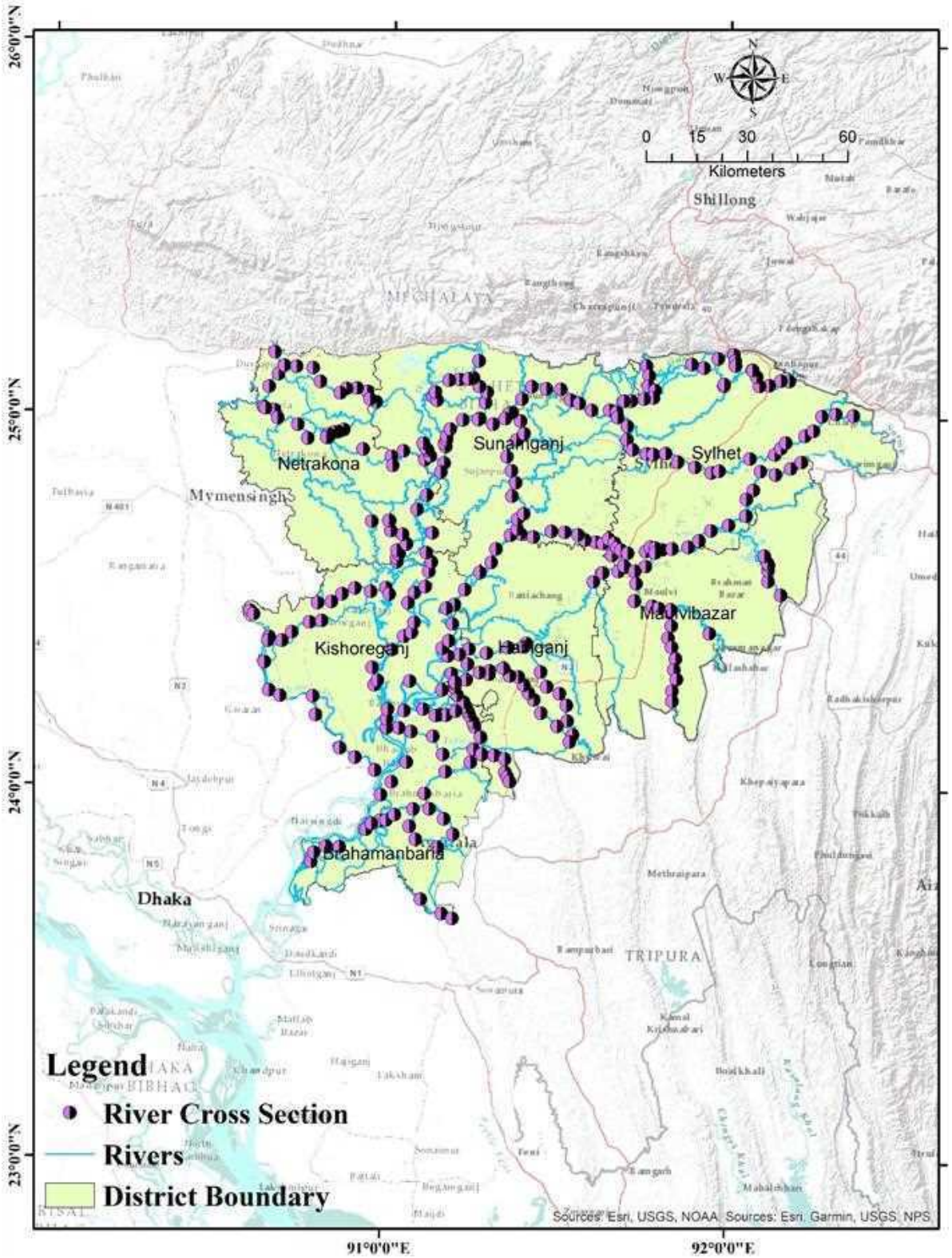
Creating the 2D portion of the model is the second step to build up the entire 1D-2D Coupled Hydraulic model. This step requires a Digital Elevation Model or DEM of the study area. For this, a SRTM 30 m resolution DEM file of whole Bangladesh as raster format was downloaded from USGS website which is freely available. The procedure required the pre-processing of the DEM file. This pre-processing was done by ArcGIS 10.5 software by clipping the DEM of the study area using a shapefile of the study area. The pre-processed DEM of the study area was used in 2D model development as a terrain of 2D floodplain area by opening it in RAS Mapper after setting an appropriate projection system. Then, 2D mesh was created at '2D Flow Area' option in HEC-RAS for the surrounding floodplain area in terrain file considering a cell size in which 2D model calculated the parameters. To completely develop the model, the Manning's n or roughness value for the model's 2D segment was determined for each land use of the study area using the available literature (Chow, 1959), pertinent earlier research works by notable researchers (Donnell et al., 1991; Mtamba et al., 2015), and the professional opinion from the experts. For this, a land use map of the study area was prepared in order to get the land use classes from a Sentinel-2 image. Then, the 2D model was linked with the 1D model in order to create the 1D-2D coupled hydraulic model by a lateral structure. Then, in the developed 1D-2D coupled hydraulic model, the upstream and downstream boundary conditions were given which were the discharge hydrograph and the water level hydrograph, accordingly, and unsteady flow simulations were run.



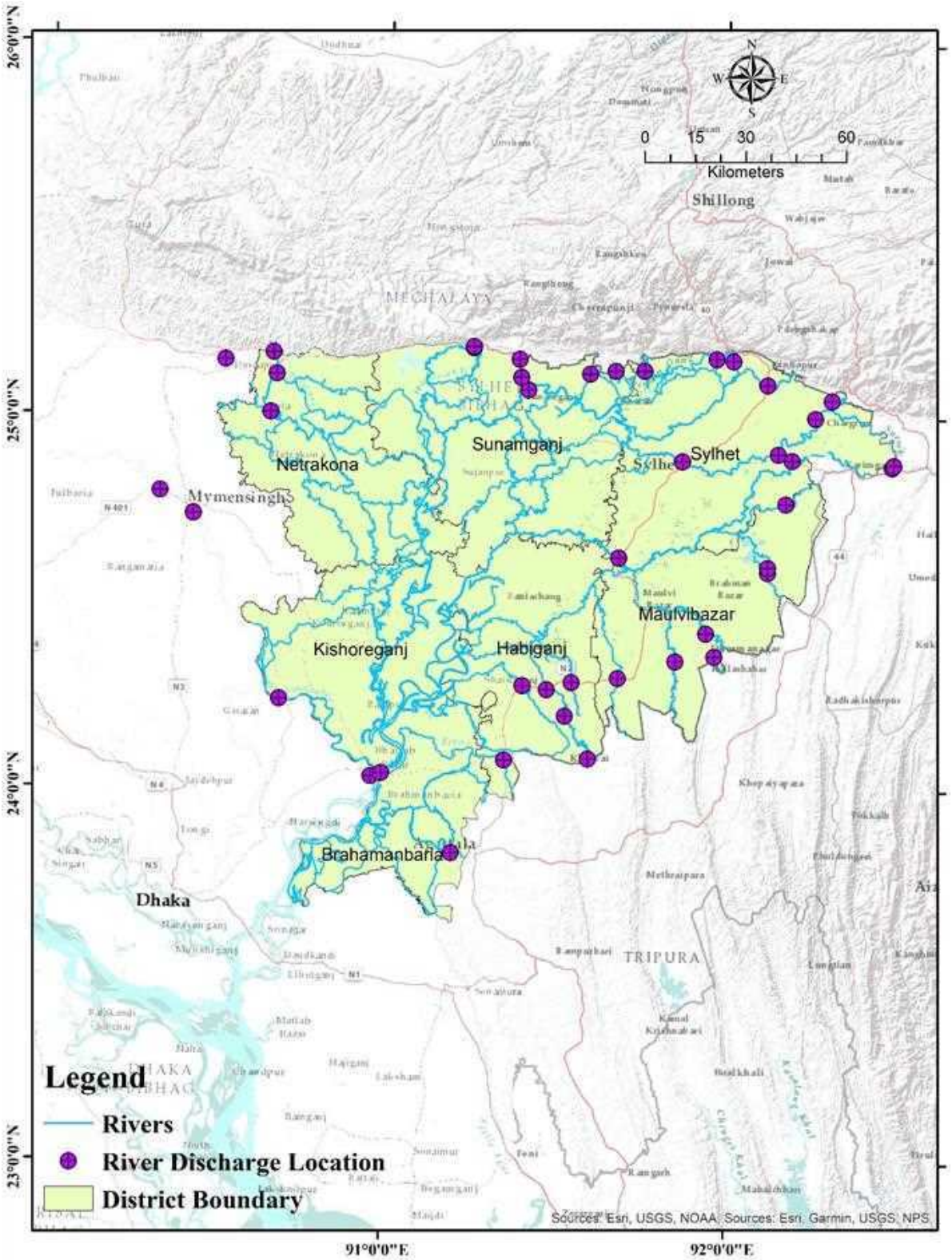
Map 3.4: Rainfall station location and data of BWBD within the model domain used in flood modelling



Map 3.5: Surface water level station location and data of BWBD within the model domain used in flood modelling.



Map 3.6: River cross section station location and data of BWBD within the model domain used in flood modelling.



Map 3.7: River discharge station location and data of BWBD within the model domain used in flood modelling

This study is concerned with the development of 1D-2D coupled hydraulic model where 1D and 2D models are for main channel of the river and adjacent floodplain, accordingly. For this, two-dimensional Saint-Venant equation needs to be solved where HEC-RAS is fully capable. These 2D Saint-Venant equations are in the following section in Equation 3, Equation 4 and Equation 5. 2D Saint-Venant equations include a continuity equation and two momentum equations in x-direction and y-direction, accordingly. These equations calculate water surface profiles and velocity in the 2D floodplain area of the river. These total three equations are written as below.

The continuity equation:

$$\frac{\delta h}{\delta t} + \frac{\delta (h u_x)}{\delta x} + \frac{\delta (h v_y)}{\delta y} = \gamma \quad (3)$$

The momentum equations:

$$\frac{\delta u_x}{\delta t} + u_x \frac{\delta u_x}{\delta x} + v_y \frac{\delta u_x}{\delta y} = v_y f - g \frac{\delta \varepsilon}{\delta x} + \frac{1}{h}\frac{\delta}{\delta x}\left(v_{t,xx}\, h \frac{\delta u_x}{\delta x}\right) + \frac{1}{h}\frac{\delta}{\delta y}\left(v_{t,yy}\, h \frac{\delta u_x}{\delta y}\right) - \frac{\tau_{bss,x}}{\rho R} + \frac{\tau_{sws,x}}{\rho h} \quad (4)$$

And

$$\frac{\delta v_y}{\delta t} + u_x \frac{\delta v_y}{\delta x} + v_y \frac{\delta v_y}{\delta y} = -u_x f - g \frac{\delta \varepsilon}{\delta y} + \frac{1}{h}\frac{\delta}{\delta x}\left(v_{t,xx}\, h \frac{\delta v_y}{\delta x}\right) + \frac{1}{h}\frac{\delta}{\delta y}\left(v_{t,yy}\, h \frac{\delta v_y}{\delta y}\right) - \frac{\tau_{bss,y}}{\rho R} + \frac{\tau_{sws,y}}{\rho h} \quad (5)$$

where

h = Water depth in m;
u_x = x-direction's velocity in ms^{-1};
v_y = y-direction's velocity in ms^{-1};
γ = A term associated with source or sink;
ε = Surface elevation in m;
g = Acceleration due to gravity in ms^{-2};
f = Coriolis force in s^{-1};
ρ = Density of water in kgm^{-3};
R = Hydraulic radius in m;
$\tau_{bss,x}$ = x-direction's shear stress on bottom in Nm^{-2};
$\tau_{bss,y}$ = y-direction's shear stress on bottom in Nm^{-2};
$\tau_{sws,x}$ = x-direction's wind stress on surface in Nm^{-2};
$\tau_{sws,y}$ = y-direction's wind stress on surface in Nm^{-2}.

3.2.4 Model Calibration and Validation

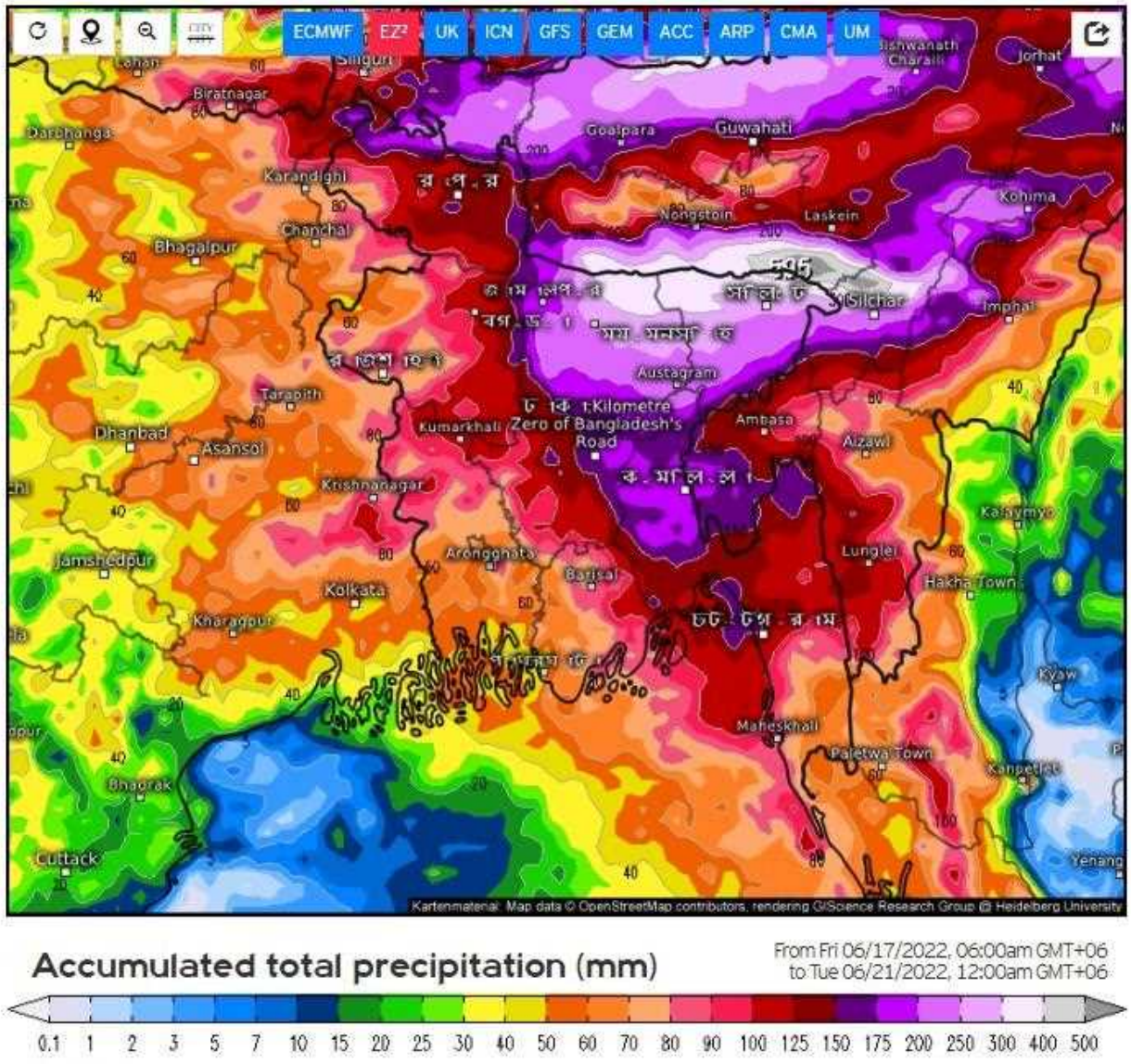
As 1D model was calibrated and validated using observed water level data, 2D model also went through the validation process. After performing the simulations in 1D-2D coupled model, the simulated results of this developed model were compared to a flood inundation map which represents real time scenario during the flooding period in order to observe whether the simulated

inundation results are similar to the real time inundation or not. For this, a flood inundation map of the study area was prepared from Sentinel-1 SAR imagery.

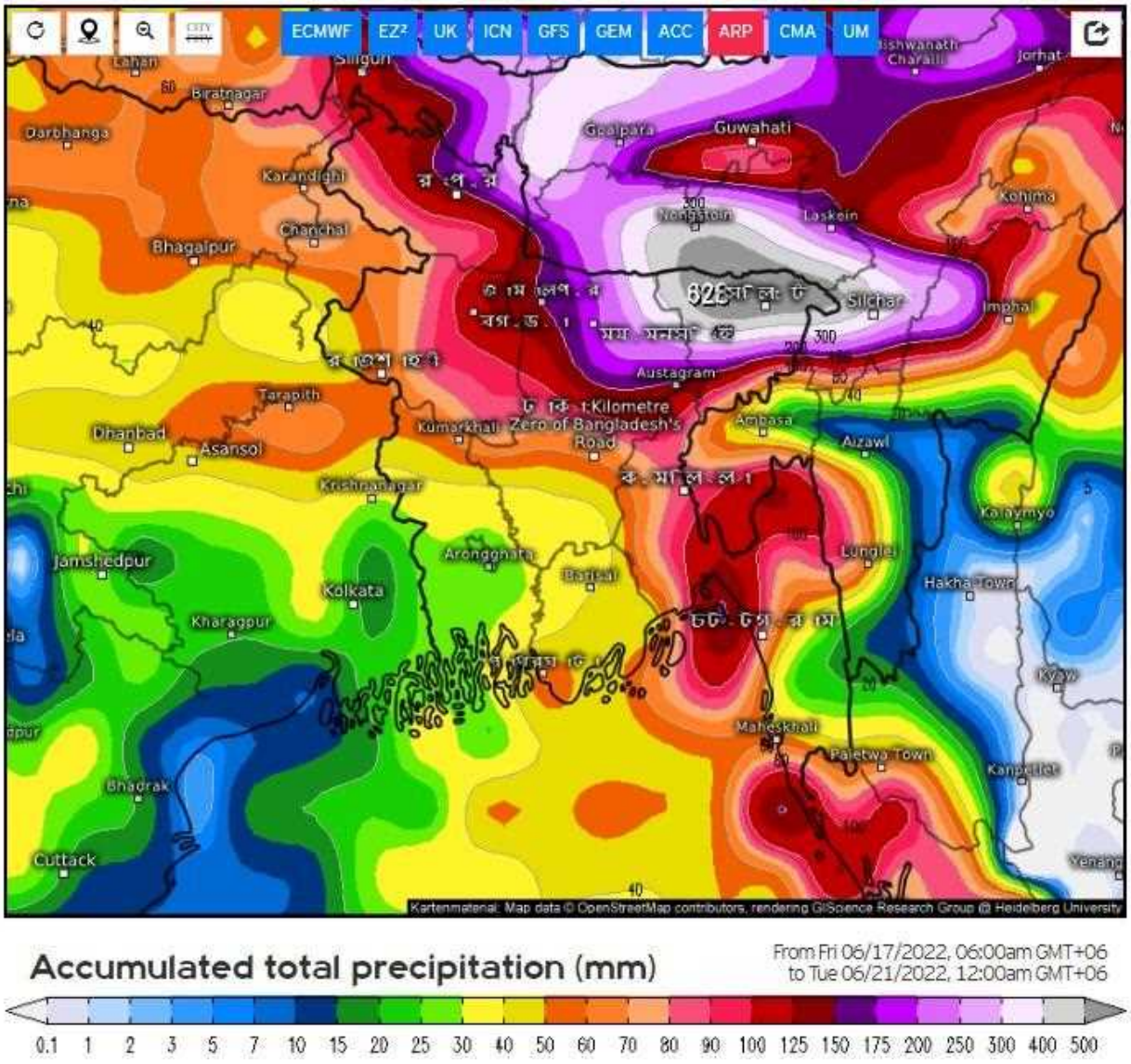
3.2.5 Post-processing in Arc-GIS

HEC-RAS 1D-2D coupled model generated raster layers (.tiff format) were imported to ArcGIS 10.5 software firstly. Then, all parameters of flood hazard (depth and velocity) were post-processed and mapped using ArcGIS 10.5 environment in order produce the final flood hazard map.

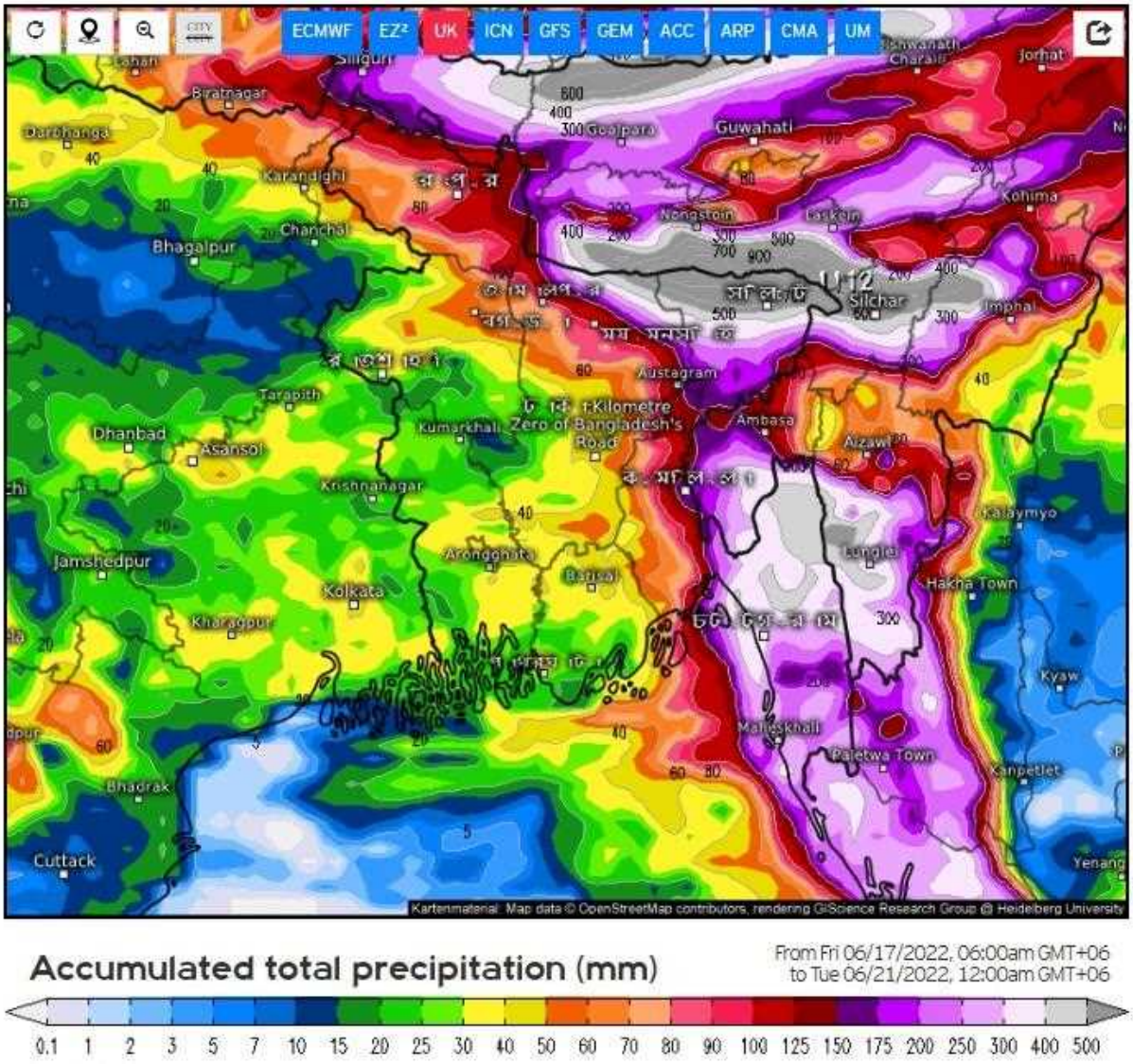
Map 3.8: Three days forecast of accumulated total precipitation (mm) based on European Centre for Medium-Range Weather Forecast (ECMWF)



Map 3.9: Five days forecast of accumulated total precipitation (mm)



Map 3.10: Seven days forecast of accumulated total precipitation (mm)



4 Preliminary Results

4.1 Flood inundation mapping using remote sensing

In order to perform the simulation for the required cases, the flooding event in 2022, by the built 1D-2D coupled hydraulic model, the 2D hydraulic model underwent a qualitative validation process as the 1D hydraulic model was calibrated and validated prior to that. Using freely accessible Sentinel-1 image and the SNAP toolbox from the ESA, a real-time flood inundation map (Fig 11) during floods has been prepared to validate the 2D model. The Sentinel-1 image was taken on June 18, 2022. By taking a raster layer out of the model, an inundated area from the same date has modeled, and the area was then produced as a map. The flood inundation map from the Sentinel-1 image and the model-simulated flood inundation map (Fig 13) have then been compared qualitatively. This qualitative comparison aims to determine if the results of the simulated inundation are identical to those of the actual inundation or not. This qualitative comparison has

been done on the basis of flood extent which has mapped in those two flood inundation maps produced by different methods. For 2D domain floodplain area, different Manning's n or roughness values have used for different land uses as a tuning parameter in order to match the flood extent area for both the Sentinel-1 image produced and the model-simulated flood inundation maps. A land use map of the study domain has also created by using Sentinel-2 image for this purpose. The results show that the Sentinel-1 imagery inundation map and model-simulated inundation map look almost identical in terms of flood extent. Since the flood extent on these two maps were nearly identical, the validation process of the 2D hydraulic model may be utilized to more reliably and confidently construct other flood hazard parameter maps. The flood inundation extent map (Fig. 11) was post-processed using ArcGIS to find upazial-wise flood inundation extents (Figs. 12 and 13) in Sylhet and Sunamganj districts. The result shows that Sulla upazilla of Sunamganj district and Balaganj upazilla of Sylhet are the most inundated upazillas of the two districts, respectively.

Map 3.11: Flood inundation mapping using Sentinel-1 satellite images for north east of Bangladesh

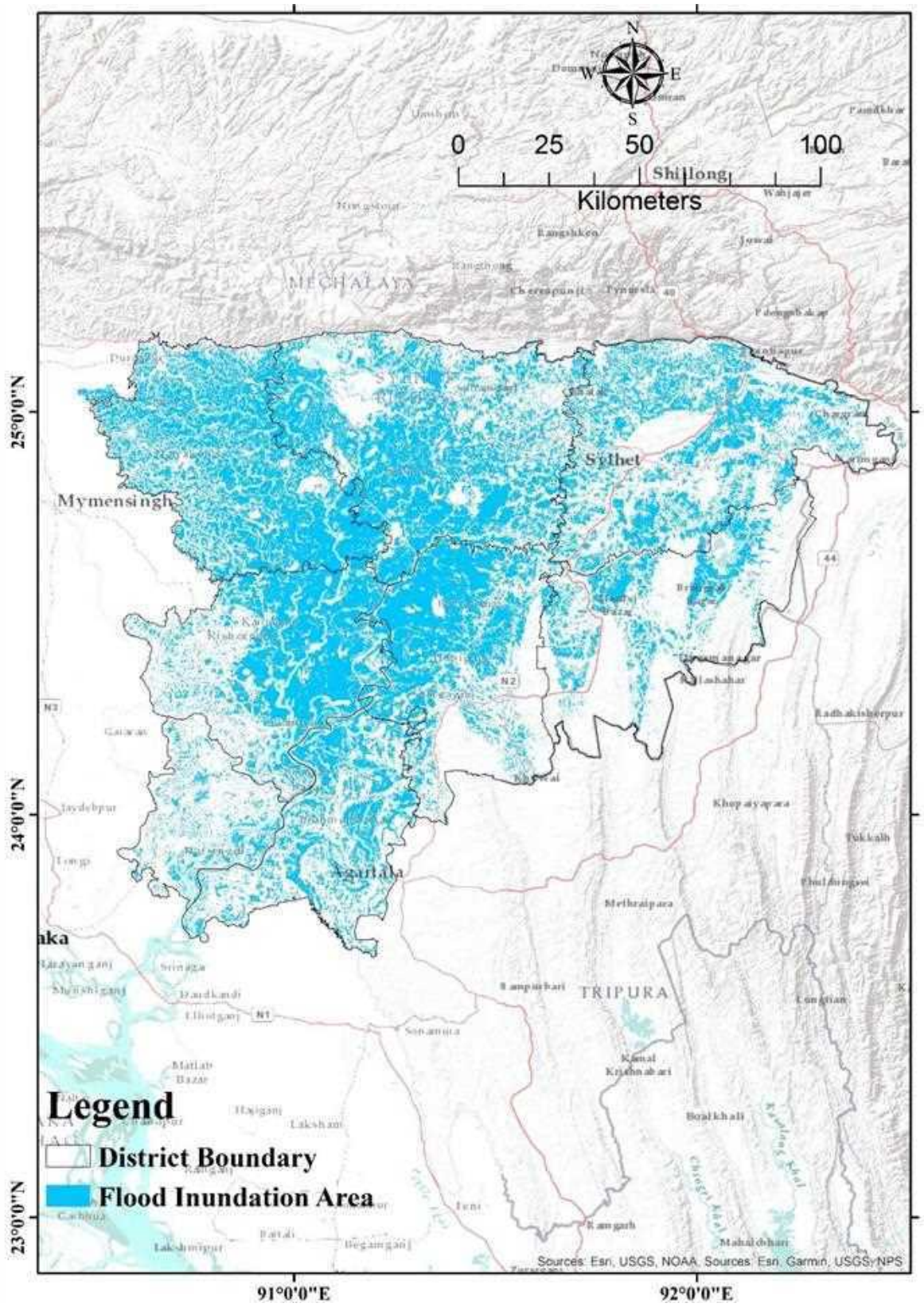

N
W
E
S
0
25
50
100
Kilometers
Shillong
MEGHALAYA
Sylhet
Mymensingh
Agartala
TRIPURA
Legend
District Boundary
Flood Inundation Area
25°0'0"N
24°0'0"N
23°0'0"N
91°0'0"E
92°0'0"E
Sources: Esri, USGS, NOAA, Sources: Esri, Garmin, USGS, NPS

Figure 3.1: Flood inundation area derived from Sentinal-1 satellite images at different upazila of Sylhet district

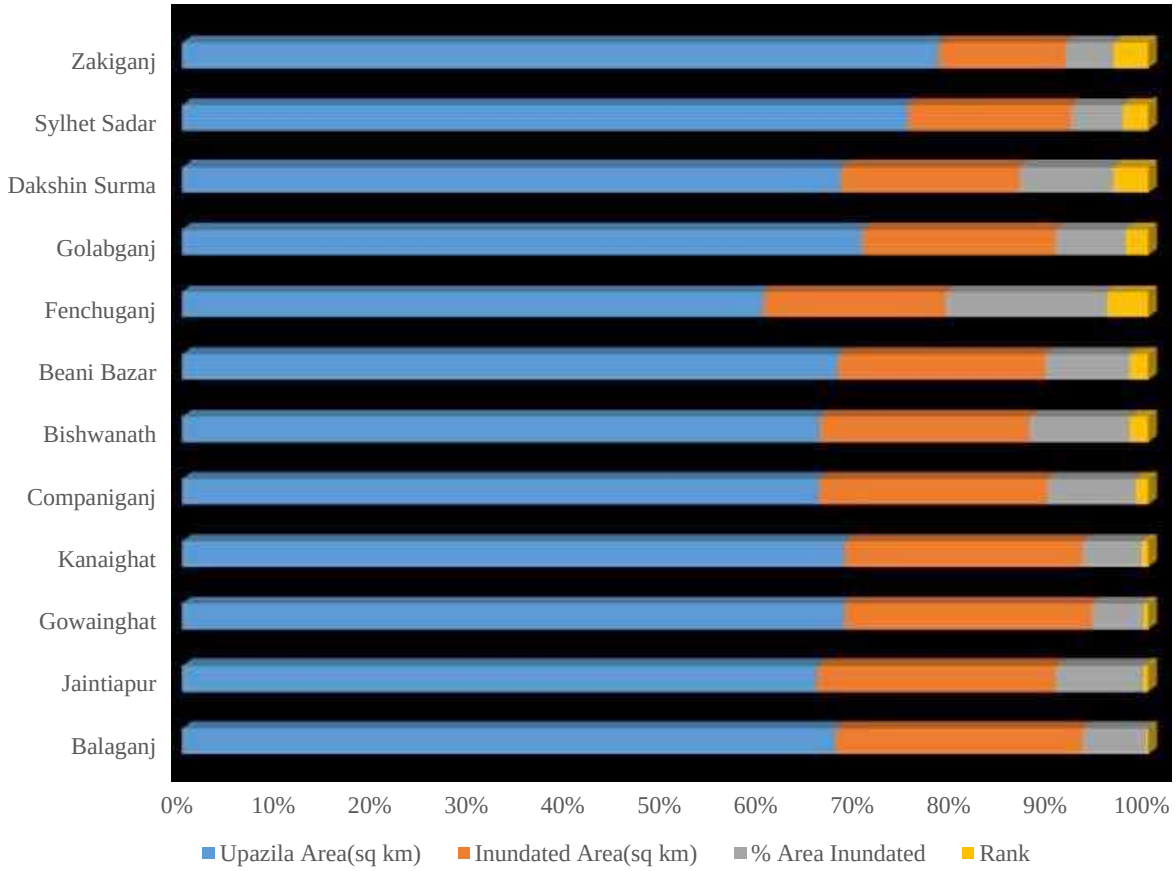
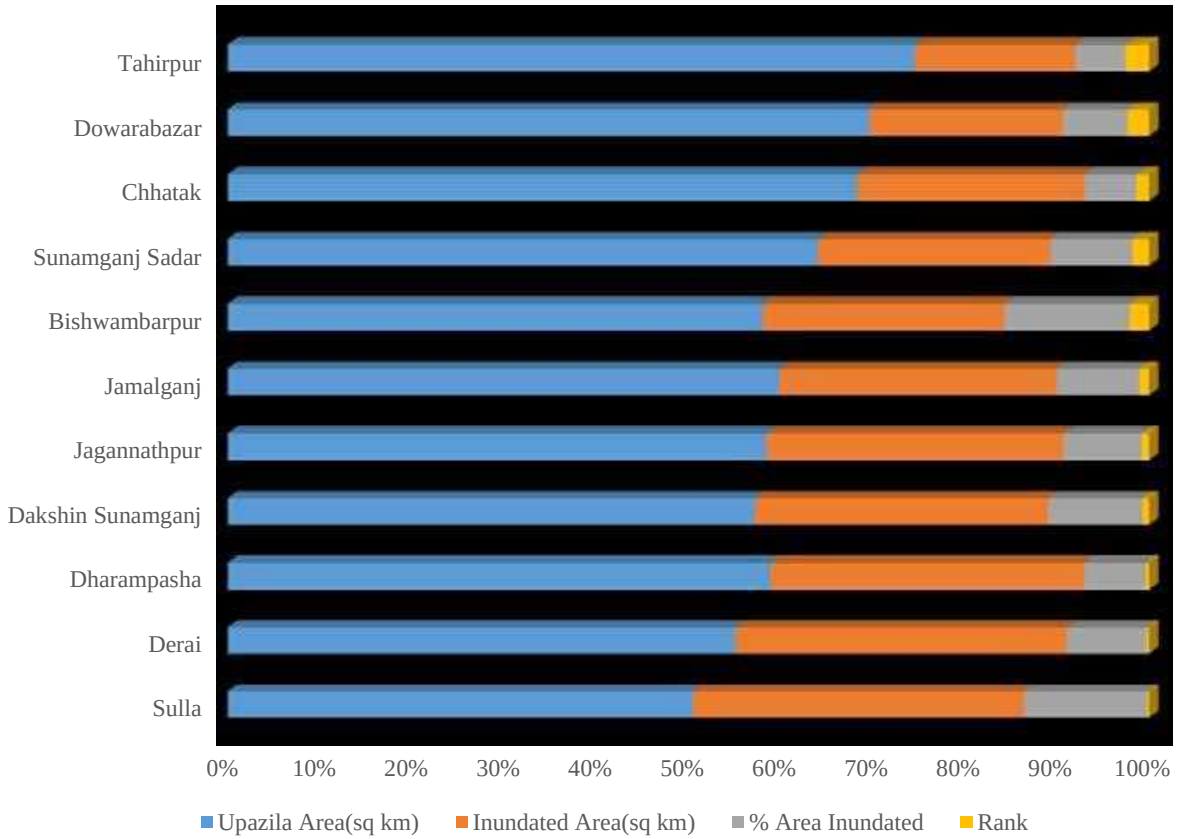


Figure 3.2: Flood inundation area derived from Sentinal-1 satellite images at different upazila of Sunamganj district



4.2 Flood Modelling

By using the 1D-2D coupled hydraulic model via HEC-RAS that has been constructed based on the Sylhet flood event in 2022, five flood parameters, including depth and velocity have been taken into account, mapped out, and assessed in this study. Results on these flood parameters are shown and discussed in the following sections. Any flood incident will result in more dangerous conditions as the flood water extent increases. As a result, the flood extent area is a critical factor in assessing the hazard of floods which shows how much the flood has spread over the land area. As the flood extent area increases with increased water level height, a flood extent map has been prepared, shown in Fig 14, by recalassifying a model-produced raster layer for a date at which water level was in peak by performing unsteady flow simulation from 1st April to 6th August, 2022 using the developed calibrated and validated 1D-2D coupled hydraulic model via HEC-RAS. Unsteady flow simulation has been conducted by using discharge and water level hydrograph as upstream and downstream boundary conditions, accordingly, from 1st April to 6th August, 2022 from the data of Kanairghat station (SW266) and Chhatak station (SW268), respectively. This simulation result has shown that higher discharge and water level values correspond to larger flood extent areas which vary from date to date within the simulation running period. In 18-06-2022, water level was highest at Sylhet station (SW267) near Sylhet city which was 11.69 mPWD, so the flood extent map has been prepared for that day in order to observe the maximum flood extent area within the study area.

It is already known from literature review that the rainfall event that causes flooding in 2022 in Sylhet region is the largest in the history of last 122 years. Thus, most of the areas within the region experienced this devastating flooding event and the flood extent map in Fig 14 generated by the 1D-2D coupled HEC-RAS model also shows almost the similar result. It has observed that most of the modeled areas are flooded during the event. It has been calculated that nearly half of the modeled areas are inundated while most of the land areas of entire Sylhet and Sumnagganj districts were inundated during that flood event. The reason for this difference in the results between model and actual scenario is due to the higher elevation of the area in the north-east of the modeled area, as a result, there is no flooding there.

4.2.1 Flood Depth

In a broader sense, it can be said that the amount of damage is expected to increase with the depth of the flood. An essential parameter of a hydraulic model is the flood depth, which determines how accurate the depth-damage function, a linear equation, can estimate the costs of flooding damage. Consequently, the depth of the flood may be used to describe how severe a flood is.

The flood depth map has been produced in this study using the model, which has been built, calibrated, and validated. Data from the Kanairghat station (SW266) and Chhatak station (SW268) were used to simulate unsteady flow from 1 April to 6 August 2022. The upstream and downstream boundary conditions were discharge and water level hydrograph, respectively. Following simulation execution, the maximum flood depth map has exported as a raster layer from the HEC-RAS and undergone additional post-processing in Arc-GIS 10.5 software. Finally, Fig. 14 displays the flood depth map for the whole model domain of the flood event in 2022. Additionally, the output of this simulation has also demonstrated that higher discharge and water level values equate to greater flood depth values, which fluctuate from date to date during the course of the simulation. It is generally assumed that as the aerial extent of flood water increases, so will the flood depth. The constructed 1D-2D coupled model has computed depth values for each and every computational cell or mesh in the 2D domain floodplain region using the equation of unsteady flow which is already built up in the model in order to produce an overall flood depth map of the study area.

In the flood depth map, the maximum depth of flood is higher than 5 m where the minimum depth is less than 1 m for the whole modeled area and these values of depth are presented in the map as a difference between the model-calculated elevation of water surface and the elevation of that particular ground location containing in the model-used DEM. As shown in the map in Fig 14, sites with higher flood depths likely to be lower elevation depression regions, whereas those with lower depths are higher elevation areas. These less elevated depression regions are often the main channel of the Surma and Kushiyara and other rivers or other topographic depressions such as large water bodies such as lakes or ponds, haor areas, and so on, as shown in the DEM of the study area. The north-eastern part of the modeled area is not flooded due to higher elevation. It is also assumed that the elevation of roads and other flood protective barriers or structures within the modeled area is low resulting in devastating flooding by overtopping those structures. The depth of flood is more than 1 m in most of the modeled areas. From this result, it can also be said that the entire area has suffered a lot of damages as a result of 2022 flood event.

In the Sylhet city, several places have been flooded. The maximum flood depth for Sylhet city is the same as the entire modeled region, which is more than 5 m, while the minimum depth is less than 1 m. All of the greater depth regions of the city, with the exception of a few water body locations, are situated along the main channel of the Surma river. In general, less elevated regions of the city that experience floods overtopping flood protection systems are when more than 2 m of flood depth occurs. Since the rest of the city is often more elevated, this model cannot depict flooding in such places. Therefore, other factors, such as urban flooding caused by drainage issues, localized rainfall, etc., which are not considered in this study, contribute to the flooding event of 2022 in those locations. Because the topographic data utilized in the model had a somewhat coarse resolution (30 m), there could be some anomalies in the flood depth maps for the research region. The historical flood hydrograph and predicted flood hydrograpph during the flood event are shown in Fig. 16 and Fig 17 respectively. The result of the model will be improved in future incluing the more observed data and realistic field situation in the final report.

4.2.2 Flood Velocity

Flood velocity is a crucial flood hazard parameter since it establishes the speed of water movement and the intensity of the force of the flood. In regions having steep slopes, even a lesser depth flood with a higher velocity can inflict damage to structures. Due to the increased power of the water, high velocity floods can produce more destruction to structures and increase the number of fatalities. Knowing the velocity of a flood enables better planning and preparation for evacuation and rescue efforts. It also aids in estimating the amount of destruction that the flood might cause. Flood velocity is generally dependant on the amount of discharge and flood depth, if both increase so does the flood velocity.

The flood velocity map has been produced in this study using the 1D-2D coupled HEC-RAS model, which has been designed, calibrated, and validated. Data from the Kanairghat station (SW266) and Chhatak station (SW268) has used to simulate unsteady flow from 1 April to 6 August 2022, with discharge and water level hydrograph serving as the upstream and downstream boundary conditions, respectively. After simulation performance, the maximum flood velocity map has been exported as a raster layer from the 'RAS Mapper' option in HEC-RAS and undergone extra post-processing in Arc-GIS 10.5 software. The flood velocity map for the Sylhet flood event in 2022 is finally shown in Fig 15.

In the flood velocity map, the maximum flood velocity is higher than 2.09 ms^{-1} which indicates higher velocity and steep sloppy area, while the minimum flood velocity is less than 0.1 ms^{-1} which indicates a standing body of water without movement within the modeled area. The region at which the flood velocity is maximum is generally a steep-sloppy region, besides, the discharge amount may be higher on that particular area. On the other hand, most of modeled areas have generally lower value of flood velocity because the topography of these areas are usually flat having gentle slopes which can also be observed in the DEM of the study area. The model simulated flood velocity result also shows that the flow velocity in the eastern part of the model area is higher due to steep slope of the area.

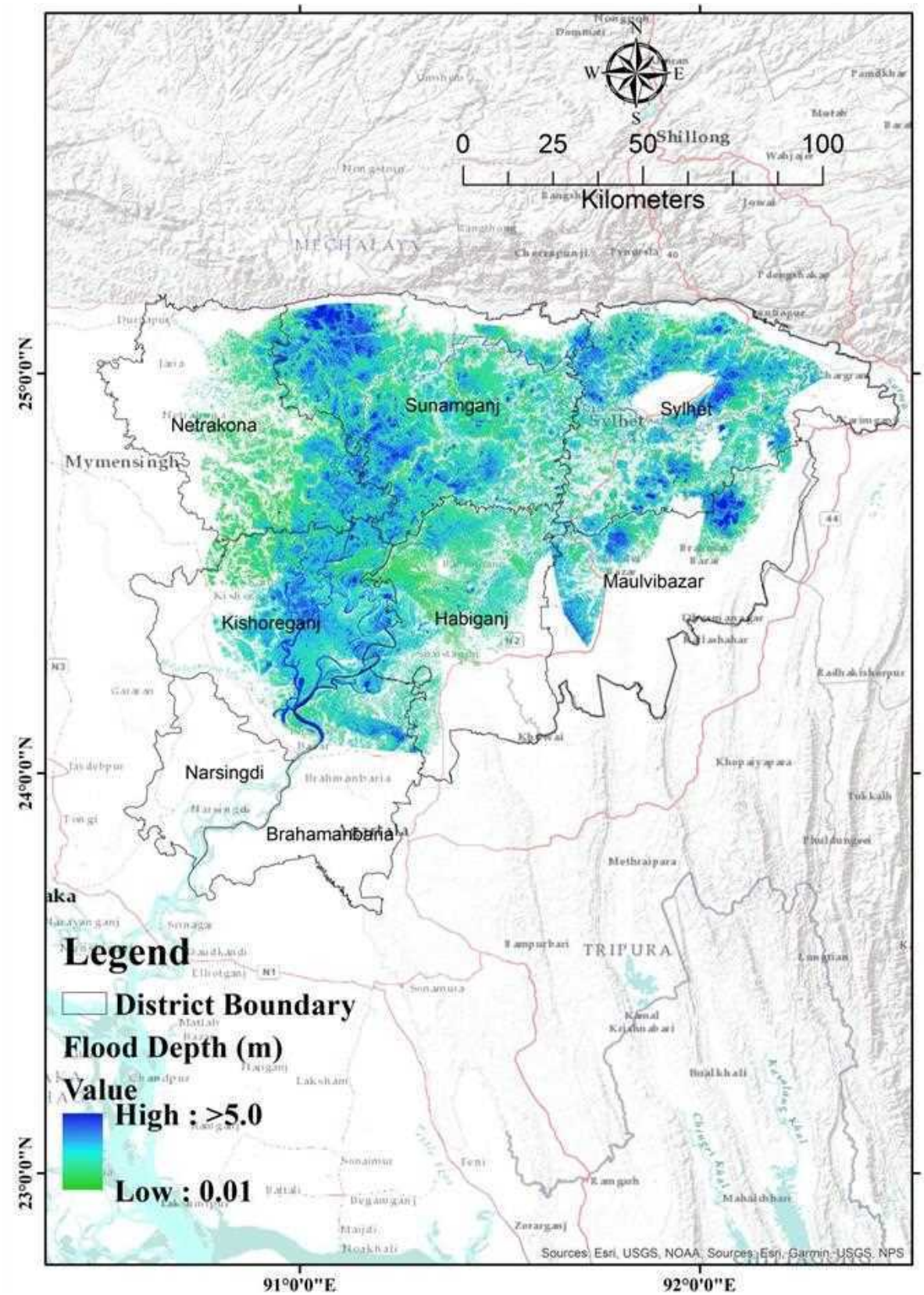


Fig 12: Preliminary result of simulated flood depth from hydrodynamic modelling

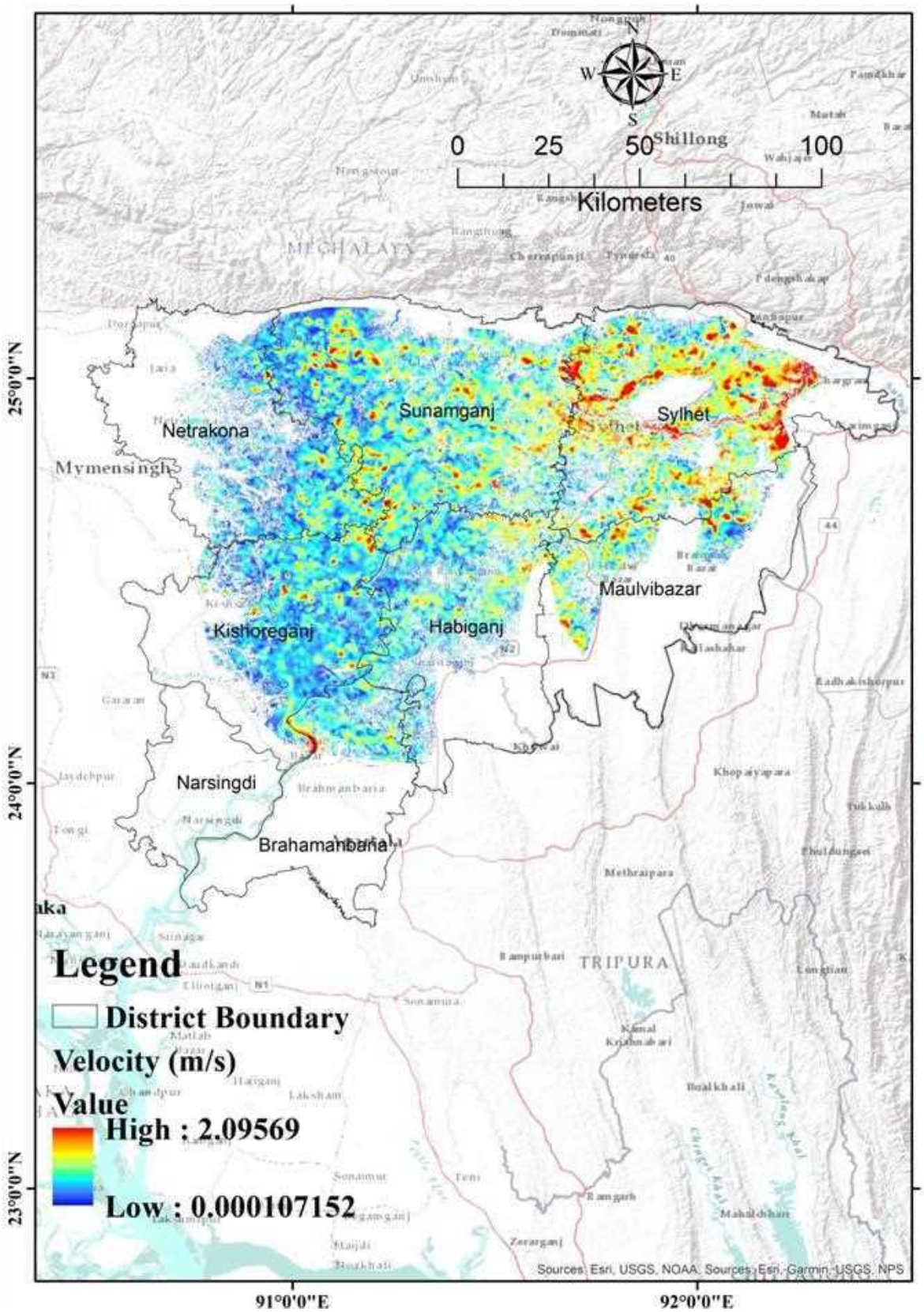


Fig 13. Preliminary result of simulated flood velocity from hydrodynamic modelling

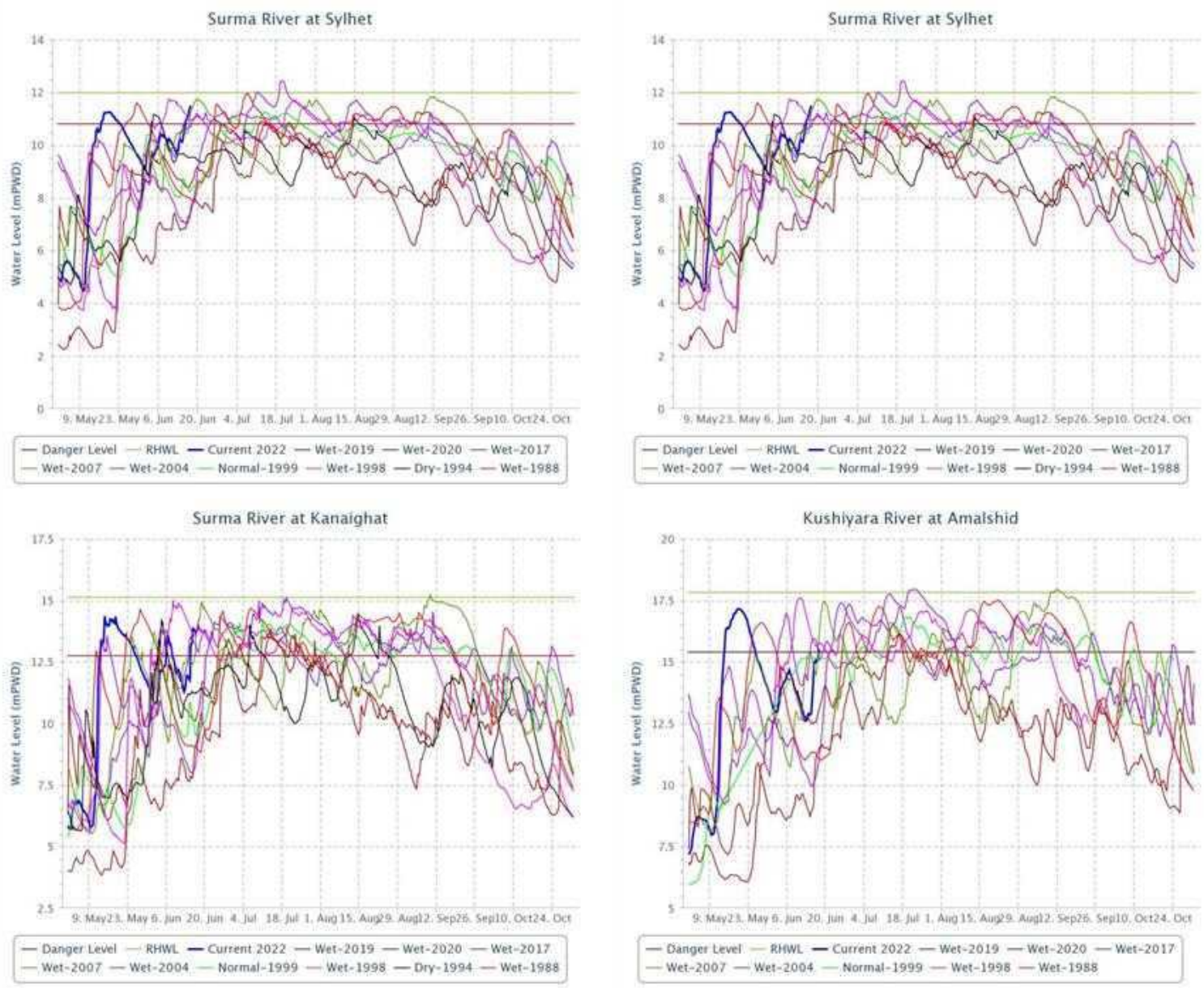


Fig 14: Monsoon flood hydrograph of Surma and Kushiyara rivers at different locations for different flood events (Source: FFWC).

Fig 15: days deterministic flooding forecasting in Surma and Kushiyara river in Sylhet and Sunamganj districts in Bangladesh (Source: FFWC)

5. Conclusion

The study area is situated in the Surma river basin, which is in northeastern region of the country and is one of the most prone areas to both flash floods and monsoonal riverine floods. Due to extreme and torrential rainfall events from pre-monsoon to post-monsoon period in the basin area, lower elevation, flashy properties of the rivers, etc., floods constitute a significant natural hazard in the area. Recent heavy floods that occurred at low-lying areas in Sylhet region in May and June of 2022 severely damaged the infrastructure in the region and left floodplain residents with significant financial and other losses. The region around Sylhet has not experienced a flood like it in previous 122 years. As a response, determining the flood hazards in the basin is crucial for managing flooding and lowering risk. In order to do this, this study focuses on an assessment of the overall flood hazards for the study area based on the Sylhet flood event 2022 using a 1D-2D coupled hydraulic model.

At first, all the necessary data were gathered from the appropriate sources to construct the model, including discharge, water level, cross sections, and rainfall data from BWDB, a DEM of the study

area from the USGS website, and essential satellite imageries from the Copernicus Open Access Hub. Using these data, a 1D-2D coupled hydraulic model was then developed using HEC-RAS and the model went through calibration and validation procedures. The 1D model was calibrated using datasets of 2004 from May 2 to August 8 at Sylhet station (SW267) to determine tuning parameter of the model, Manning's roughness coefficient (n), and the preferred Manning's roughness coefficient was determined for the model to be in the range of 0.013 - 0.015. Using this found value of Manning's roughness coefficient, the model 1D was validated for the datasets of 2010 from May 10 to August 16 at the same Sylhet station (SW267). Using a flood inundation map produced from Sentinel-1 imagery, the 2D model was validated by qualitative comparison between the model simulated and the Sentinel-1 SAR image produced flood inundation map. Then, using the developed model, an unsteady flow simulation of the Sylhet flood event in 2022 was carried out from 1 April to 6 August, taking into account discharge hydrograph as the upstream boundary condition and water level hydrograph as the downstream boundary condition at Kanairghat station (SW266) and Chhatak station (SW268), respectively. After accomplishing the simulation by the model, the raster layers of five flood parameters which have considered in this study, including depth, and velocity were extracted from the model and further post-processed, analyzed and mapped in the ArcGIS environment in order to generate final flood hazard maps based on the Sylhet flood event 2022.

The maximum and minimum depths in the entire modeled area and within the model domain are higher than 5 m and less than 1 m, respectively, in which higher depth values are located in river channel or in less elevated depression areas. Again, in the model-generated flood velocity map, the maximum flood velocity is higher than 2.09 ms^{-1} and the minimum is lower than 0.1 ms^{-1} in the entire modeled area. As a summary, after conducting this study and analyzing the results, it is said that the areas with higher depth value, higher velocity, and higher flood duration are the most hazardous and vulneralbe to floods based on the 2022 Sylhet flood event. The conclusions of the study can be important for identifying flood hazard areas in the Surma river basin. These maps of the hazard parameters can assist decision-makers, planners, and concerned authorities in identifying the hazard zones of a specific river (Surma river for this study) and incorporating suitable, affordable, and long-term flood control plans and strategies.

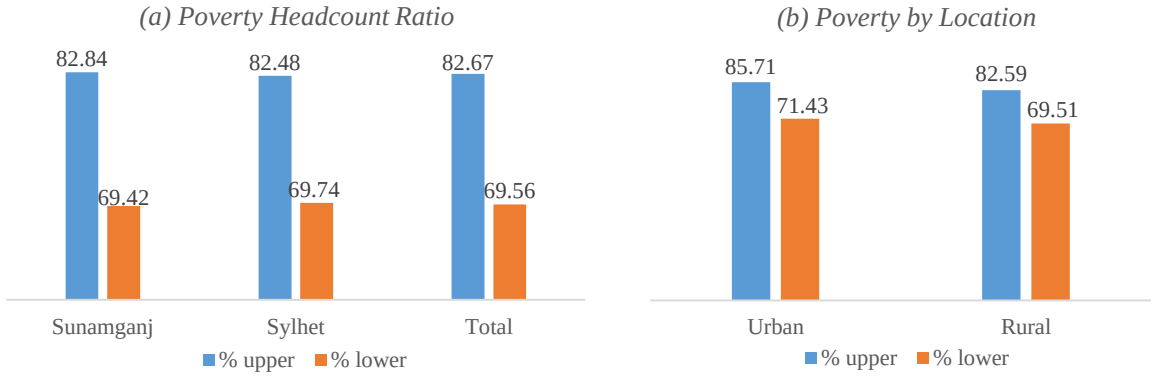
Chapter 4
Vulnerability, Impact and Resilience: Evidence from Household Survey

Floods are associated with the vulnerability of the affected populations, especially the ones who are from poor and backward segments of society. The impacts of the flood are manifold, which include damage, and negative effects on physical and mental health as well as education. The immediate response includes shifting to flood shelter, protecting livestock and assets, and distributing relief social protection benefits. This chapter presents the results of the household survey on the vulnerability and impacts of the devastating floods of 2022 in Sunamganj and Sylhet, response through social protection, and resilience.

4.1 Incidence of Poverty

To understand the basic socio-economic background of the surveyed households, poverty headcount ratios have been calculated by district and gender, and further differentiated by upper and lower poverty lines. The study results demonstrate that about 83 percent of respondent households of both Sunamganj and Sylhet districts belong to the upper poverty line, while around 70 percent of the households belong to the lower poverty line (Figure 4.1a). It implies that despite having dissimilar sub-sample sizes of the two districts, samples were randomly chosen from similar flood-affected households. The incidence of poverty among rural households was lower than that of their urban counterparts (Figure 4.1b). However, the poverty estimates of the present study are significantly higher than those of the Household Income and Expenditure Survey (HIES) 2022 (BBS, 2023).[1] It is because the surveyed households were mostly from low-income segments, located remotely in haors and remote areas for which they were affected severely by 2022 devastating floods.

Figure 4.1: Population of surveyed households living under poverty line (percent)



Source: Field survey (2023)

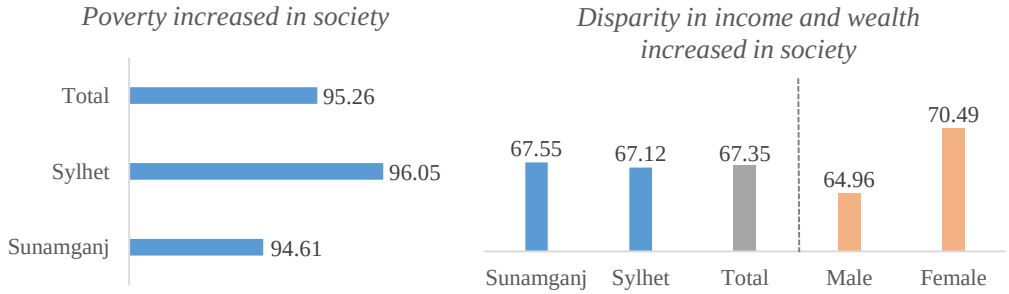
Natural disasters can change distribution of household income vertically and horizontally as well as livelihoods and welfare as the vulnerable population became more vulnerable while and the non-vulnerable population became less vulnerable because of their adaptive capacity. Bista (2022)

[1] According to HIES 2022, proportion of population living under upper poverty at total, rural and urban areas of Sylhet division were 17.4, 18.1 and 14.4 percent, while the corresponding figures for lower poverty were 4.6, 5.2 and 1.3 percent, respectively (BBS, 2023, p.64).

examined change of poverty and inequality after floods through a household survey in the Sot Khola (stream) water basin in Nepal. It has been found that both poverty and inequality have increased following floods and landslides because of changes in the distribution of income and wealth through the disproportion impact on the poor and vulnerable households.

The present study intends to assess the perceived increase in poverty within the surveyed society or community. About 95 percent of the total respondents believed that poverty levels increase after floods, with nearly equal opinions by male and female respondents. About 94.6 percent of respondents from Sunamganj, while Sylhet and 96 percent of Sylhet reported increasing poverty in their respective localities. This result is supported by MoDMR (2023) which found that the income of the floods-affected households has decreased significantly in both Sylhet and Sunamganj by 61 and 71 percent, respectively. Such a sharp drop in income of the affected households increased poverty

Figure 4.2: Perceived change in poverty and inequality (percent)



Source: Field survey (2023)

The result portrays the perceived increase in the disparity in income and wealth within the surveyed society or community, categorised by gender and region in Sunamganj and Sylhet. The total 67.35 percent suggests a prevailing awareness of growing inequality in income and wealth. Among the respondents, 64.96 percent of males and 70.49 percent of females perceived that the 2022 floods increased inequality in their respective localities. These variations may be influenced by distinct economic structures, disparities in economic opportunities, or differing impacts of external events that influenced the perception of growing income and wealth inequality after the floods. However, while about two-thirds of respondents of both Sunamganj and Sylhet districts reported increased inequality after floods. The results can be explained by the fact that the incidence of poverty is higher in high-risk areas and poor households experience higher environmental risks than their non-poor counterparts as evident in Narloch and Bangalore (2018) for Vietnam on eight environmental risks based on household survey data of 2010-2014.

4.2 Impact on food intake and education

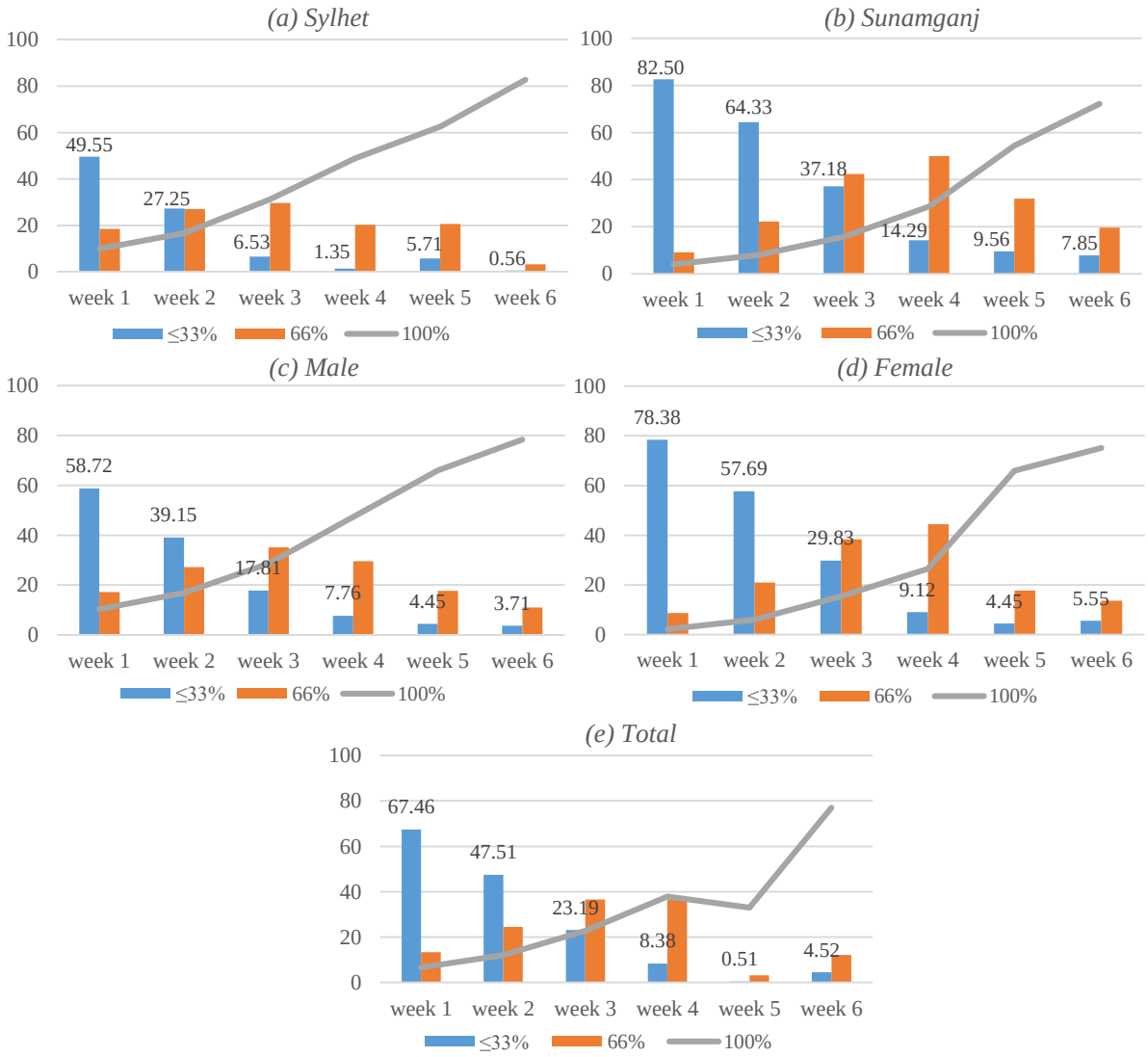
4.2.1 Food intake during floods

Extreme climatic events threaten households' cereal food consumption in areas where moderate and severe events occur (Islam et al., 2022).[2] Floods affect households' food security through obstruction of agricultural production, destruction of transport and communication infrastructure; and disruption of livelihoods (Sam et al., 2021). Food consumption in flood-affected households usually decreases, which is mainly because of decreased access to food support, limited availability, and lack of income, especially among poor and remotely located households. Salvucci and Santos (2020) found that consumption of flood-affected households decreased significantly in the short term ranging between 11–17 percent. Du et al. (2010) argued that starvation is an intermediate effect of flooding. Chakraborty et al. (2024) found that 80 percent of the survey respondents in Sunagmanj reported food insecurity among the inhabitants of the flood-affected area. According to HCTT (2022), most of the affected population was dependent on limited minimal stocks of dry foods since flood water damaged food stored in private warehouses, households, shops, and chatals. Sixty percent of women, who depend mostly on day labour and tending livestock for their livelihoods, lost their income, while 40 percent of women experienced damaged cooking utensils. Many of them depended on dry food relief to get half a meal per day since they did not have food stock in their households.

In the present study, poorer households were affected at a significant level, especially households that are located in rural areas. In the present study, it has been found that the onset of the flood caused a substantial reduction in food consumption among the surveyed households. Women were consuming far less than males and for longer periods. Lesser food intake was also evident among the surveyed households in Sunamganj compared to their Sylhet counterparts. In this crucial first week, more than two-thirds of the individuals report consuming only up to one-third of their pre-flood food intake. This immediate drop reflects the acute impact of the flood on nutrition. As the flood persists into the second week, the trend of reduced food intake continues. In a glimmer of improvement, the third week witnesses a gradual recovery in food intake. While challenges persist, there is a shift as the majority no longer report consuming only up to one-third of their pre-flood food intake. This positive change indicates that adaptive measures, community support, and external interventions started to make a positive impact. Despite ongoing challenges, the fourth week reveals a mixed picture of food consumption by the members of the affected households. The patterns suggest fluctuations in food intake proportions, with males showing higher intake than women. In the fifth and sixth weeks of the flood, a significant shift is evident in the overall food intake landscape. The proportion of individuals consuming only up to one-third of their pre-flood food intake diminishes notably, replaced by a considerable increase in the intake of full meals. This signals a potential return to more regular food consumption, implying adaptive strategies, potential external support, or improved access to food resources as the flood situation persists.

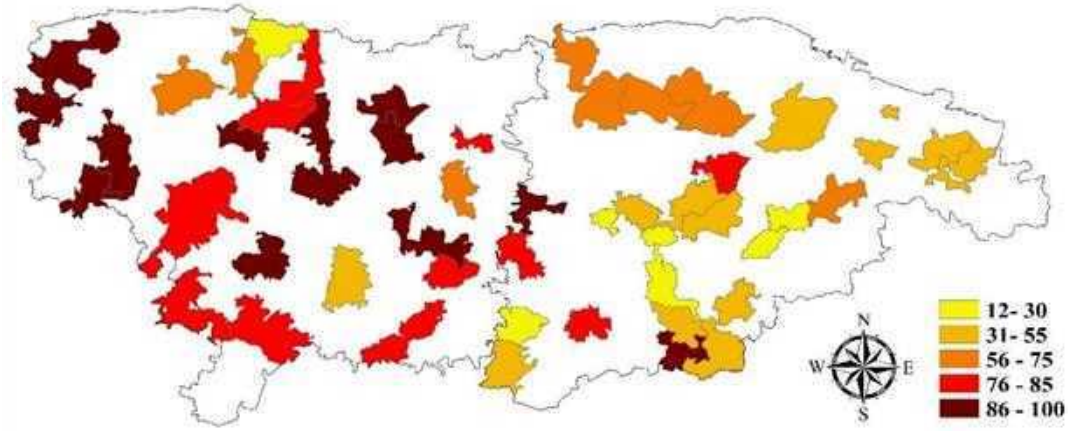
Figure 4.3: Chronology of food intake by district and gender (percent)

[2] Islam, M.S., Samreth, S., Islam, A.H.M. and Sato, M. 2022. Climate change, climatic extremes, and households' food consumption in Bangladesh: A longitudinal data analysis. Environmental Challenges 7 (2022) 100495, https://doi.org/10.1016/j.envc.2022.100495



Note: ≤33 percent, 66 percent, and 100 percent indicate the proportion of pre-flood food intake
Source: Field survey (2023)

Map 4.1: Households consumed one-third of pre-flood food intake by union (percent of respondents)



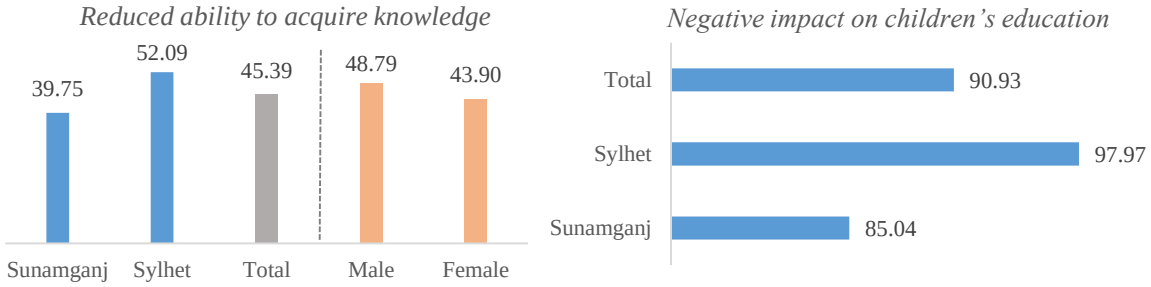
Source: Author's construction based on the survey data (2023)

According to the results disaggregated by the union, all responding households of Dakshin Bangshikunda, Dharmapasha, Madhyanagar, Maijgaon, and Rajanagar had one-third of pre-flood food intake, while 88 to 93 percent of the households in Laxmansree, Sachna Bazar, Joysree and Lamakazi unions had to consume that amount of food. Lower food consumption during floods was more prevalent among the households in Sunamganj district than their counterparts in Sylhet (Map 4.1).

4.2.2 Impact on education

The floods have been perceived to have impacted negatively on their children's education. Evidence suggests that natural disasters cause disruptions in school attendance due to damage to educational buildings and communication networks (Dewan, 2015; Ahsanuzzaman and Islam, 2020). It has perhaps been because of the perceived reduced ability of children to acquire knowledge due to high psychological stresses and reduction of nutritional status because of a significant decrease in the first three weeks. Overall, about 45 percent of parents reported that their children's ability to acquire knowledge has decreased. The study results reveal that more than half of the parents in Sylhet district mentioned that their children's education has been impacted negatively through a decreased ability to acquire knowledge, while about 40 percent of parents in Sunamganj reported the same for the children.

Figure 4.4: Percent of children with reduced ability to acquire knowledge (percent)



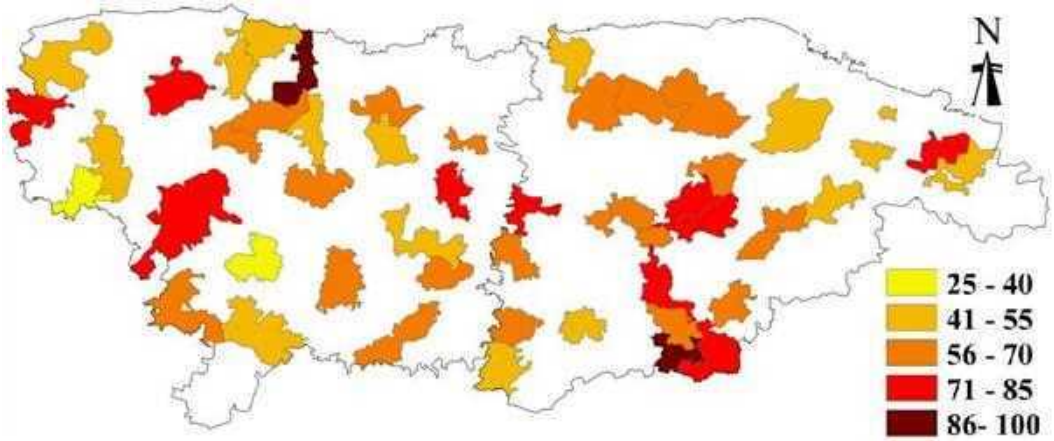
Source: Field survey (2023)

School absenteeism is a common characteristic of flood occurrence, which in obstructs children's education due to damages and inundation of road networks. Many children were deprived of education as the 2022 floods damaged more than 870 educational facilities, primarily government primary schools and they were closed in affected areas (Care, 2022). Chakraborty et al. (2024) found that 28.4 percent of schools and three-quarters of textbooks were damaged due to the 2022 floods which also refrained children from going to school. According to UNICEF (2022), more than 80 percent of primary and secondary schools out of some 3,000 primary schools in Sylhet and Sunamganj districts had been inundated which affected nearly 673,000 children. A total of 285 learning centers have been severely damaged negatively impacting the education of some 8,000 children. Approximately 7 percent of the learning centers had been completely destroyed and most of the other learning centers were partially damaged.

In the present study, high proportion of students (71-100 percent) remained absent from schools for a week or more following floods 2022 in several unions in both Sunamganj and Sylhet districts,

which include Maijgaon, Salukabad, Fenerbak, Lamakazi, Madhyanagar, Tahirpur, Moglabazar, Ghilachhara, Kandimpara and Bagha.

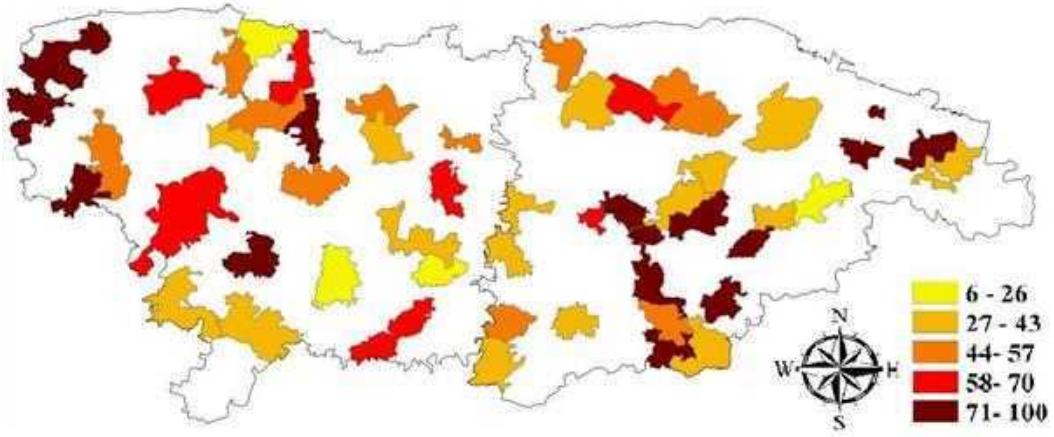
Map 4.2: Absent from school for a week or more because of floods



Source: Author's construction based on the survey data (2023)

The floods impacted negatively on children's education, which happened due to joint impact of decreased ability to learn and disruptions to attend school for a week or more because of inundation of road and/or school premises. An overwhelming majority of about 91 percent parents reported that floods caused negative consequences on their children's education. Sunamganj reports a lower proportion at 85 percent, while Sylhet starkly contrasts with a higher proportion at about 98 percent. The observed high prevalence of negative impact on children's education underscores the pressing need for targeted interventions.

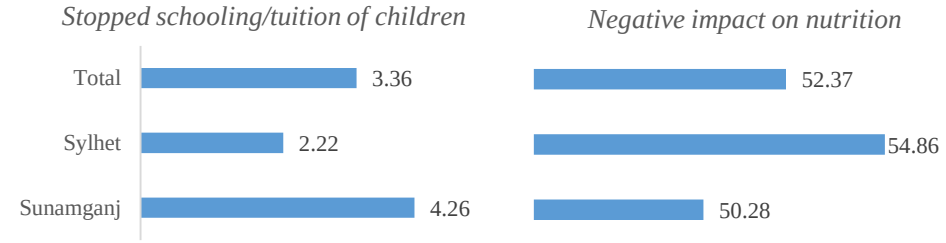
Map 4.3: Reduced ability to acquire knowledge (percent)



Source: Author's construction based on the survey data (2023)

Respondents in Kuchai, Maijgaon, Bagha, Bhadeshwar, Madhyanagar, Moglabazar, Purba Dighirpar, Laxmansree, Kanaighat, Dakshin Bangshikunda unions reported reduced ability to acquire knowledge the most after floods. Majority of unions where high reduction of ability to acquire knowledge was prevalent (71 to 100 percent) are located in Sylhet district. It implies that prolonged and devastating flood created considerably negative impact on the education of the children of the affected households.

Figure 4.5: Impact on children's education and nutrition (percent)



Source: Field survey (2023)

It has also been found that a small proportion of parents stopped sending their children to schools, with a higher proportion in Sunamganj after the floods. More than half of the parents believe that floods have impacted negatively on their children's nutritional status.

4.3 Damage and loss

Natural disasters incur considerable costs in terms of damage and loss. Loss of GDP at the national level and loss of welfare at the household level (through damage of assets, and loss of income and life) major cost consequences of natural disasters. Disasters damage physical assets, such as houses, household utensils, documents, dresses, valuable indigenous materials, and food grains (Bista, 2022).

The 2022 flash floods caused severe damage to crops, with 83,394ha damaged, and to livestock, with losses worth US$28.1 million (HCTT, 2022). Nearly 2 million people faced a food crisis during and after the floods (Care, 2022). Around 90 percent of the traditional Boro harvest was damaged, while stored rice at farmers' homes was damaged. Inundation of both private and market food storage primarily affected the availability of food stocks and agricultural produce (Chakraborty et al., 2024).

4.3.1 Tangible damage and loss

Tangible damage and loss can be broadly foregone household income and employment/livelihoods including due to destroyed rice and other crops and food staff, livestock death, or inactivity of businesses and job loss; damage and loss of assets, including homes (submerged or damaged houses), livestock, productive equipment, and household durables; damage to the transportation system marketplaces and additional costs emanating from rising food prices due to food shortages resulting from lost food stocks (Chakraborty et al., 2024).

Tangible damage and loss have been calculated for the following major sectors: (a) housing, (b) agriculture, (c) business, (d) transportation, and (e) other sectors. Damage has been defined as a deduction from the monetary value of stock of a unit of physical capital, finished goods, assets, and inventory of intermediate goods. Loss is conceived to be the deduction from the monetary value of the flow, such as income, and return of assets and wealth that include public and social

goods and services. Loss implies death in the case of livestock and fishery for which their market values were considered, while physical injury implies damage in the stock of health.[3]

Damage and loss of housing cover dwelling house/building (DH); household assets (AH) that include furniture, utensils, and food staff; machinery and equipment (MEH) that include electrical and electronics, machinery, and fuel; and others (OH) as follows:

$$H_i = \sum_{i=1}^{N} (DH_i + AH_i + MEH_i + OH_i) \quad (4.1)$$

For agriculture, damage and loss have been calculated as follows:

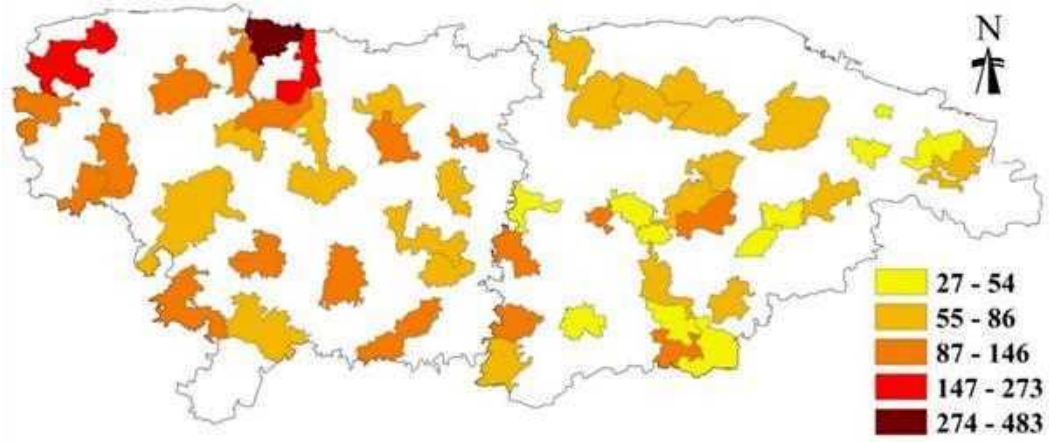
$$A_i = \sum_{i=1}^{N} (IE_i + C_i + F_i + L_i + OA_i) \quad (4.2)$$

where A, IE, C, F, L and OA imply agricultural- related infrastructure and equipment (cattle shed, crop storage, machinery and equipment, hatchery, etc.) crop, fishery, livestock, and others (cattle feed, seed, fertiliser, pesticides, etc.), respectively.

Damage and loss of business of the respondent households have been calculated by aggregating the damage of transport equipment related to business (TEB), machinery (MB), store, and grocery shop including equipment and inventories (SG) as follows:

$$B_i = \sum_{i=1}^{N} (TEB_i + MB_i + SG_i) \quad (4.3)$$

Map 4.4: Damage per household (Tk. '000')



Source: Author's construction based on the survey data (2023)

[3] However, DaLA methodology define losses as "These are the assets that are no longer produced and services that are no longer provided from the time the disaster occurs until full recovery and reconstruction is achieved". See, UNECLAC, *What is a DaLA? Damage and Loss Assessment*, available at: https://www.cepal.org/sites/default/files/infographic/files/dala_web_ingles.pdf; accessed on 16 February 2024.

The highest damage and household per household occurred in Dhanpur union (nearly Taka half a million) in Sunamganj district, which was followed by Salukabad, Dakshin Bangshikunda, Joysree, Daulatpur, Maijgaon, Pandargaon, Jagaddal, Tahirpur, Dharmapasha, Mogalgaon, and Chhatak unions. High damage has been observed at the unions in Sunamganj district.

Figure 4.6(a): Damage and loss by category

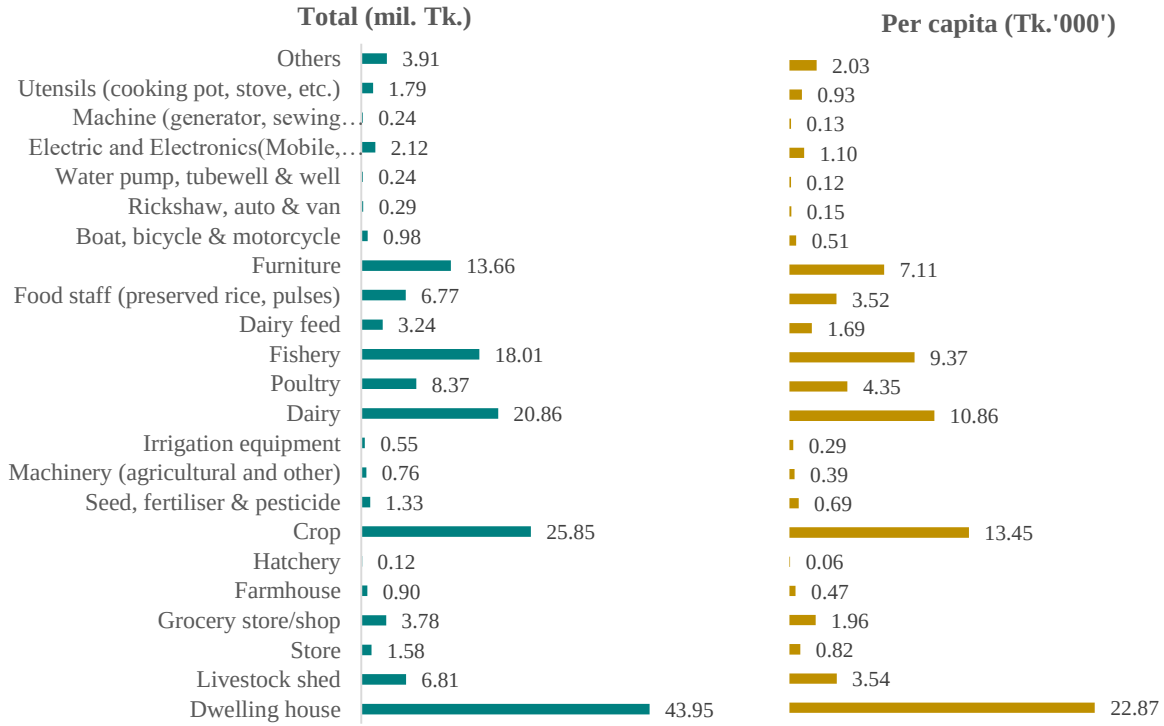
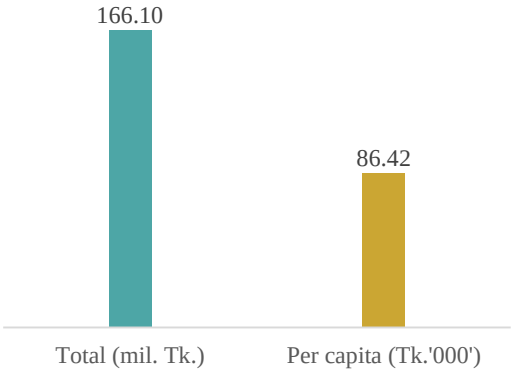


Figure 4.6(b): Aggregate damage and loss

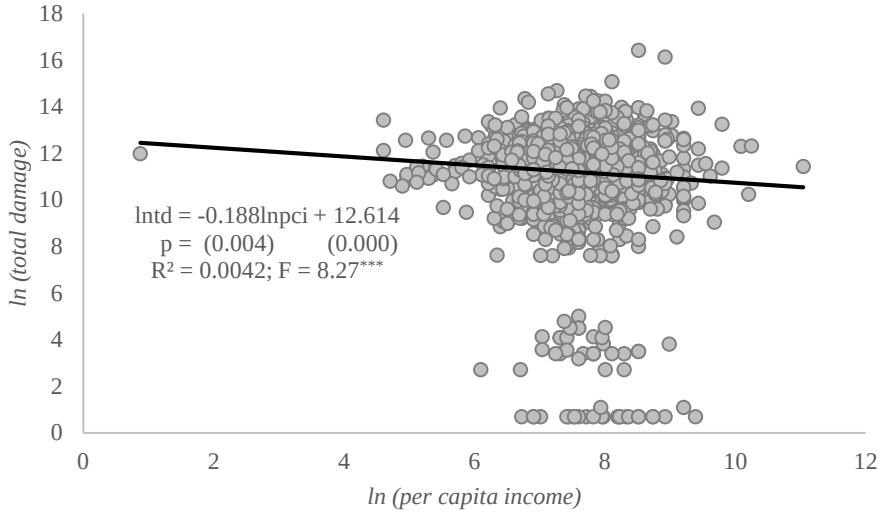


Source: Author's analysis based on field survey (2023)

The estimated monetary value of total damage and of floods 2022 was Tk.166 million for the responding households. The per household damage was estimated to be Tk.86,423. The highest damage occurred in the residential building or dwelling house, which was slightly higher than one-fourth of the damage. The other main damaged items were, furniture, grocery store, and livestock

shed. The main items of loss were wage income, crop, cattle, poultry, food ingredients (preserved rice, pulse, etc.), cattle feed, and fisheries (Figure 4.6).

Figure 4.7: Economic status of the households vs. damage of dwelling house



Note: Both per capita income and damage are expressed in Taka.
Source: Author's analysis based on survey data (2023)

Poverty and idiosyncratic flood risks are positively correlated and highly significant (Rayhan, 2010). Narloch and Bangalore (2018) found that the poor are disproportionally exposed to flooding in Vietnam. In the present study, a strong and negative correlation between level of income and damage to the dwelling house has been found from the survey data. The amount of damage is lower if the income level of the household is higher (Figure 4.7). In particular, lower-income households experienced a higher amount of damage than their comparatively high-income counterparts. It is perhaps mainly because comparatively high-income households constructed houses with quality materials, and undertook measures to protect their assets and business. These results support the literature on flood and poverty.

4.3.2 Intangible damage and loss

Disasters lead to intangible damage and loss of the affected population, which include damage of physical health (reduction from health stock), pain and suffering, and loss of mental balance. There are wide-ranging immediate health impacts of floods, which include drowning, injuries, hypothermia, diarrhoeal diseases, animal (snake) bites, pink eye, dermatitis, and vector-borne diseases, (e.g., dengue fever) while infected wounds, complications of injury, poisoning, and communicable diseases indirect medium-term effects of flooding. Chronic disease, disability, and malnutrition are the long-term effects of floods (Du et al., 2010; Ahern et al., 2004; Bich et al., 2011). The negative health impacts of floods are complex and extensive, which include both physical and mental health (Hajat et al., 2005).

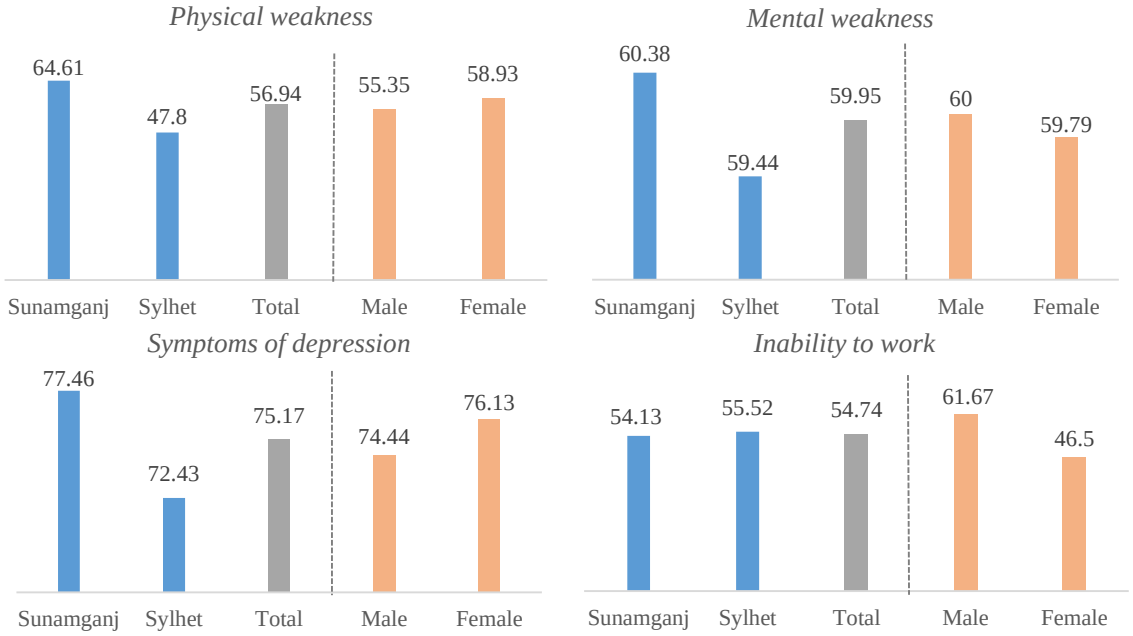
The greatest burden of disease due to flooding in developing countries is longer-term poor mental health consequences (Ahern et al., 2004). Du et al. (2010) argued that poor mental health is an intermediate effect of flooding. Increased incidence of common mental disorders including anxiety

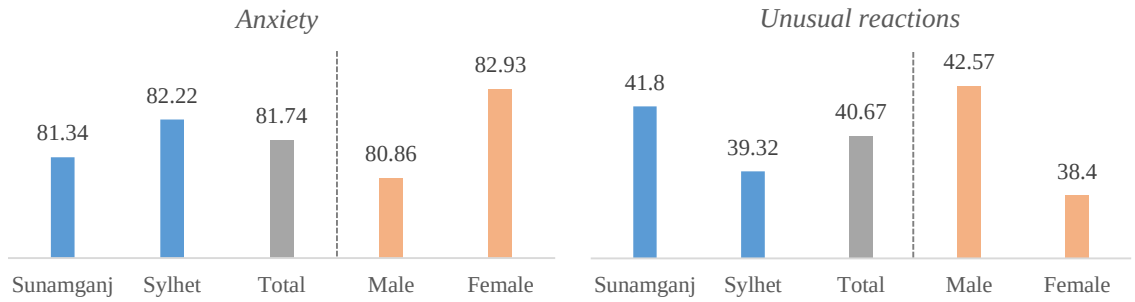
and depression for months and even years after the flood event, which is not often recognised (Hajat et al., 2005; Bich et al., 2011).

Disasters can create short- and long-term threats to the mental health of impacted individuals and communities. Rahman et al. (2023) explored the impacts of flash floods in 2022 on 393 women's mental health problems at Ajmiriganj (Habiganj district) and Dharmapasha (Sunamganj district) upazilas, which demonstrates that about 67, 65, and 37 percent of women experienced severe or extremely severe depression, anxiety and stress, respectively. In Sunamganj, 71 percent of areas were flooded, and approximately 50,000 people were evacuated to flood shelters who remained isolated from neighbours and relatives creating mental pressure on temporarily displaced people. Poor people were under considerable mental pressure due to a lack of safe drinking water, insufficient health facilities, food insecurity, and unemployment (HCTT, 2022).

The survey respondents reported a significant presence of physical and mental weaknesses as well as psychological pressure among their household members. More than half of the total respondents reported physical weakness due to floods (nearly 57 percent). About 59 percent of male and 55 percent of female respondents reported that they felt physical weakness during and right after the floods. It has been because of lower food intake and subsequent negative impact on nutrition. About two-thirds of the respondents in Sunamganj reported physical weakness (64.6 percent) less than half of the respondents reported the same in Sylhet (47.8 percent), which implies substantial regional variation due to prolonged floods in Sunamganj compared to Sylhet that contributed to variation in the pattern of food intake.

Figure 4.8: Physical and psychological impacts of floods (percent)

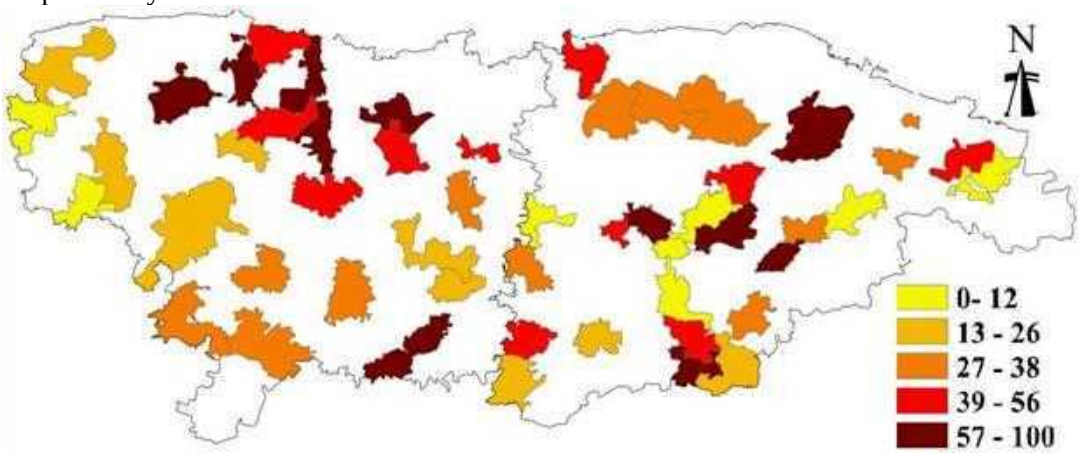




Source: Field survey (2023)

Households in Maijgaon, Laxmansree, Mannargaon, Bagha, Salukabad, Darbast, Amura, Badaghat, Tahirpur and Raniganj unions, and Sylhet city corporation as have been reported by the respondents. High physical weakness was prevalent almost equally at surveyed local government units in both the Sunamganj and Sylhet districts.

Map 4.5: Physical weakness



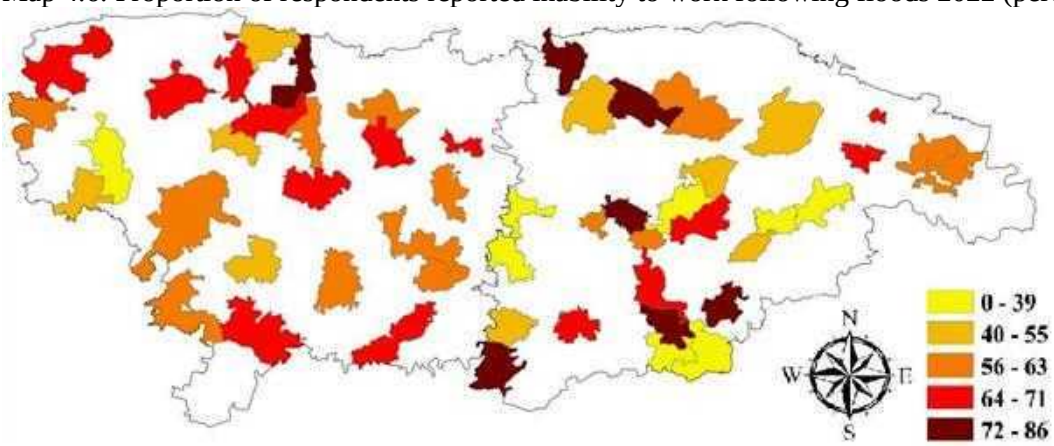
Source: Author's construction based on the survey data (2023)

The results demonstrate a considerable prevalence of mental weakness among flood-affected households. About 60 percent of respondents reported that they suffered from mental weakness, irrespective of gender and region. The psychosocial issues include the widespread presence of depression, anxiety, and inertia that underscores the psychological toll following the flood. Nearly 55 percent of respondents faced challenges to be involved in work because of inertia. Males report a considerably higher inability to work (61.7 percent) compared to their female counterparts (46.5 percent) while no significant regional difference has been observed. Symptoms of depression provide insights into the emotional impact of the flood event. Nearly three-quarters of the respondents reported symptoms of depression, such as persistent sadness and loss of interest in activities. Respondents in Sunamganj reported a higher prevalence of such a fragile mental state (77.5 percent) compared to their counterparts in Sylhet (72.43 percent). These regional differences could be influenced by varying degrees of flood severity and differing coping mechanisms. The observed prevalence of depression symptoms underscores the urgent need for mental health support and interventions in the aftermath of natural disasters.

The data on anxiety related to flooding in the event of heavy rainfall provides valuable insights into the emotional impact of weather-related concerns. A total of 81.7 percent of respondents reported experience anxiety about flooding in the face of heavy rainfall. The feeling of anxiety was found to be slightly higher among females (82.9 percent) than their male counterparts (80.7 percent). The high prevalence of anxiety underscores the psychological impact of environmental threats, emphasising the need for proactive measures to address mental health concerns associated with climate-related events. Tailoring community-based resilience programmes, improving early warning systems, and providing mental health support can contribute to alleviating anxiety and enhancing mental well-being.

Results on the experience of excessive stress in normal circumstances provide insights into the prevalence of heightened stress reactions within the surveyed population. Overall, 40.7 percent of respondents reported unusual reactions to excessive stress in their daily lives during and after floods with slight gender differences (about 43 percent of males and 38 percent of females) but insignificant regional disparity. The significant prevalence of unusual and stressful reactions due to devastating floods in Sylhet district underscores the importance of addressing mental health concerns in normal circumstances, as stress can significantly impact overall well-being. Promoting mental health awareness, and providing psychological support can contribute to mitigating the impact of excessive stress.

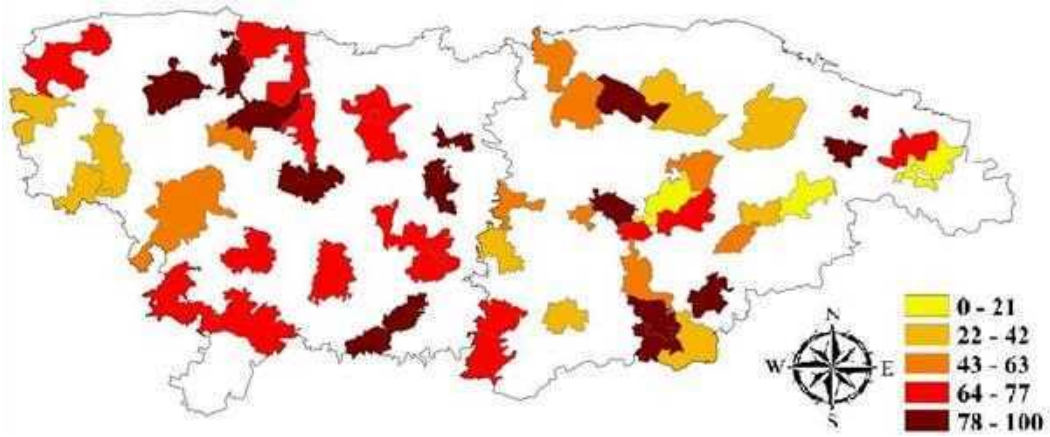
Map 4.6: Proportion of respondents reported inability to work following floods 2022 (percent)



Source: Author's construction based on the survey data (2023)

Respondents in Towakul, Fenchuganj, Sylhet, Islampur Purba, Sadipur, Bhadeshwar, Salukabad unions reported this impact of floods the most. Majority of unions where high work inertia was prevalent (64 to 86 percent) are located in Sthe ylhet district.

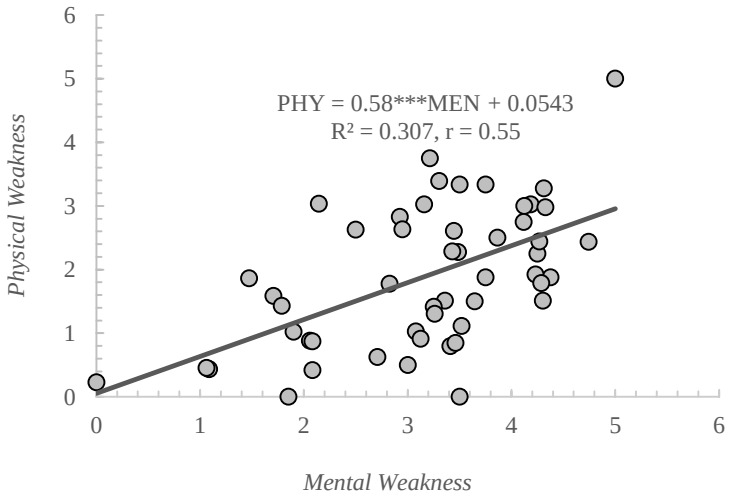
Map 4.7: Proportion of respondents reported mental weakness following floods 2022 (percent)



Source: Author's construction based on the survey data (2023)

Respondents in Towakul, Fenchuganj, Sylhet, Islampur Purba, Sadipur, Bhadeshwar, Salukabad unions reported this impact of floods the most. Majority of unions where high mental weakness was prevalent (64 to 100 percent) are located in the Sunamganj district. It implies that prolonged and devastating floods created a considerably negative impact on the mental health of the affected households. A positive and statistically significant relationship has been found between physical and mental weakness (Figure 4.9).

Figure 4.9: Relationship between physical and mental weakness



Note: Data are aggregated at union level.

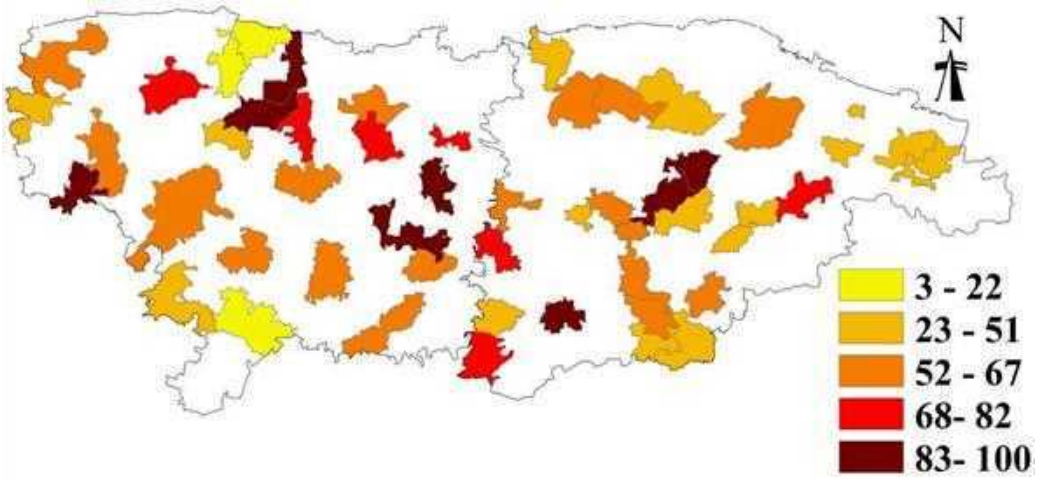
4.4 Relief, rehabilitation and social protection

4.4.1 Relief received by sources

The empirical results demonstrate the sources from which the flood-affected people received relief. About 60 percent of respondents received relief in the aftermath of the 2022 floods. The results reveal a slight gender difference, with 56.5 percent of males and 63.5 percent of females reporting the receipt of relief. Regionally, Sunamganj reports a higher proportion at 60.7 percent, while Sylhet registers a lower proportion at 58.5 percent. These regional variations may be influenced

by the severity of the flood impact, differing distribution mechanisms, and variations in the accessibility of relief resources in each area. The overall proportion implies that, while not distributed universally, a notable portion of the surveyed population did receive relief after the 2022 floods. However, in a Survey conducted in Sunamganj, Chakraborty et al. (2022) found that 89.7 percent of respondents felt socially insecure due to lack of sufficient relief activities during the 2022 floods.

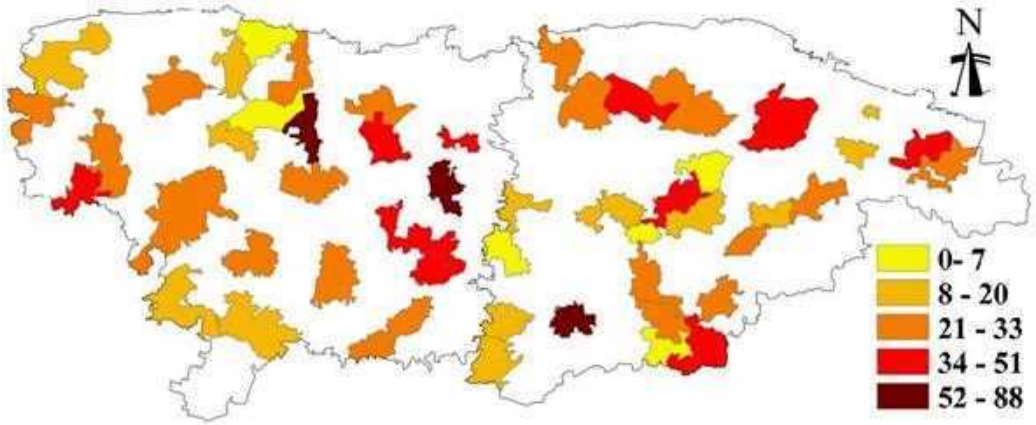
Map 4.8: Received relief after floods 2022



Source: Author's construction based on the survey data (2023)

An overwhelming majority of respondents in Kandimpara, Osmanpur, Chiknagul, Birgaon, Dakshin Khurma, Salukabad, Dharmapasha, Gourarang, Laxmansree and Chhatak unions reported that they received relief after floods (more than 80 percent). The lowest recipient respondents were located in Islampur Purba, Kajalshah, Habibpur, Badaghat and Dhanpur unions. The lower proportion of respondents in the Sylhet district received relief than their counterparts in Sunamganj.

Map 4.9: Relief from the government



Source: Author's construction based on the survey data (2023)

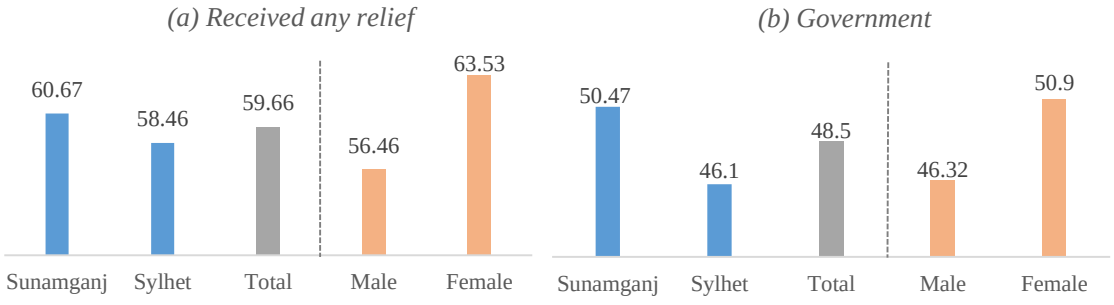
Among the respondents who received any relief, around half of them received from the government (49 percent). It suggests a substantial outreach in assisting to individuals affected by

the flood. Sunamganj reports a higher proportion at 50.47 percent compared to Sylhet (46 percent). These regional variations may be influenced by factors such as the duration and severity of the flood impact, distribution mechanisms, and accessibility. About 51 percent of females and 46 percent of males reported that they received relief.

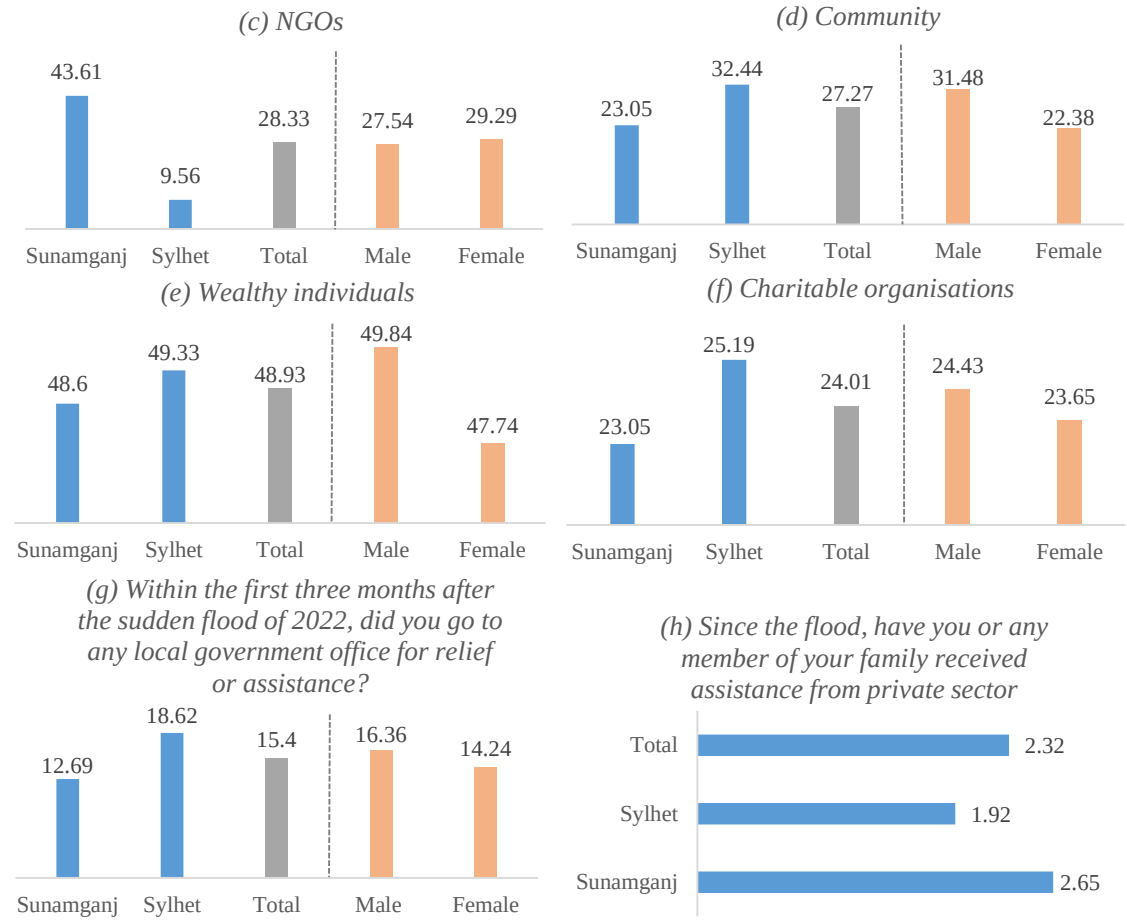
A notable portion of the respondents also received relief from NGOs after the 2022 floods (28 percent). While a marginal gender disparity is observed in outreaching relief by NGOs, a notable discrepancy was observed between Sunamganj and Sylhet (43.6 and 9.6 percent, respectively). It highlights the contribution of the NGOs during and after floods, particularly in Sunamganj. The findings also highlight the complementary role of NGOs alongside government initiatives after disasters. The local community also extended considerable support through relief operations. Overall, a quarter of the respondents who received relief also received relief from the community (27 percent). A total of 31.5 percent of the males and 22.4 percent of females received support from their communities, which indicates considerable gender-based differences against females. Sunamganj records a modest 23 percent, while Sylhet stands out with a higher proportion at 32.4 percent. This divergent community support stems from community dynamics, local initiatives, or varying capacities to extend assistance.

The survey result elucidates the distribution of relief received from wealthy individuals following the 2022 floods. About 49.8 percent of males and 47.7 percent of females reported the receipt of relief from wealthy individuals. Households in Sunamganj reported a proportion of 48.6 percent, while Sylhet is marginally higher at 49.3 percent. These minimal regional variations imply a uniform reliance on support from wealthy individuals across both surveyed regions even though the incidence of poverty and flood vulnerability is much higher in Sunamganj than in Sylhet.[4] Overall, nearly 49 percent of the surveyed households received relief from wealthy individuals. This suggests a noteworthy contribution from affluent members of the community in supporting flood victims in Sunamganj and Sylhet. These findings underscore the significance of community cohesion and social capital, where individuals of higher economic standing actively participate in providing relief. The minimal gender and regional differences suggest a relatively equitable distribution of assistance from wealthy individuals (Figure 4.10).

Figure 4.10: Sources of relief during floods 2022 (percent)



[4] According to BBS (2018), the proportion of population living under upper poverty line was 26 and 13 per cent in Sunamganj and Sylhet districts, respectively in 2016.



Source: Field survey (2023)

Beside government, NGOs, community and wealthy individuals, a considerable portion of respondents also received relief from charitable organisations (about a quarter of the respondents who received any relief). Significant regional and gender difference was not observed in their relief operation in the flood-affected areas. This suggests a notable contribution from philanthropic entities in supporting those affected by the flood, contributing to the overall sustenance and recovery efforts of the flood victims.

The study examines the frequency of individuals seeking relief or assistance from local government offices within the first three months following the sudden flood of 2022. The results indicate that 15.4 percent of respondents visited local government offices for relief or assistance during the specified period. While no significant gender gap has been found, respondents Sunamganj and Sylhet reported variations in seeking assistance (12.7 and 18.6 percent, respectively) (Figure 4.10). These findings suggest a moderate level of engagement of the flood victims with local government offices for relief or assistance. The data highlights the significance of local government offices as key points of contact for individuals seeking support in the aftermath of the flood.

The study assesses the extent of assistance received by individuals or their family members in the aftermath of the flood. The results reveal a very low level of respondents who received assistance

from the private sector since the flood (2.32 percent). It reveals that the private sector was hardly involved in relief operations in the Sylhet region.

4.4.2 Types of relief

Traditionally, food, clothes, medicine, water purifiers (alum or others), and housing materials are distributed during disasters like floods. The survey aimed to understand the type of relief the flood-affected people received. Floods significantly reduce the availability, access, affordability and utilisation of food especially by vulnerable and low-income households, thereby raising concerns over food security. Since inundation makes it difficult to cook at home due to a lack of fuelwood, stove, safe water, and cooking materials, cooked food significantly reduces the predicaments of the affected households. Cooked food also eases food intake at flood shelters where scope of cooking is rather limited. Figure 4.9 illustrates the type of relief in the 2022 floods. About 12 percent of respondents received cooked food with no significant regional and gender disparity. It suggests a notable contribution from relief efforts focused on providing prepared meals. An overwhelming majority of the respondents received dry food during floods (about 95 percent) without notable gender and regional disparity. This suggests a considerable reliance on relief efforts providing non-perishable, dry food items, contributing to sustenance, and addressing food insecurity in Sunamganj and Sylhet. The minimal gender and regional differences suggest an effective and equitable distribution of dry food, reflecting the success of relief strategies in meeting the essential needs of the surveyed households.

Besides food, the distribution of clothing is one of the most important activities of relief operations during floods. However, a negligible proportion of respondents (about 4 percent) have been found to receive clothing with slight regional and gender-based differences. It suggests a modest contribution from relief efforts focusing on providing clothing items, contributing to the overall well-being and recovery of individuals in Sunamganj and Sylhet.

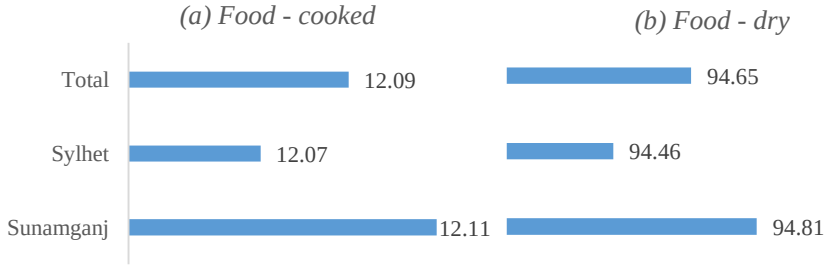
Distribution of medicine contributes significantly to the overall health recovery in response to outbreaks of various waterborne and communicable diseases during floods. The survey results demonstrate that more than half of the respondents (53.6 percent) received medicine after the 2022 floods. Slightly greater proportion of females received medicine compared to their male counterparts (56 and 51.4 percent, respectively). The distribution of medicine was higher in Sunamganj than in Sylhet (58 and 49 percent, respectively), which was mainly due to the prolonged period of inundation in Sunamganj. Availability of oral saline is important in countering dehydration due to diarrhoea, which frequently outbreaks during floods. The results indicate that overall 68.7 percent respondents received saline, while 76.57 percent of respondents in Sunamganj and 59.16 percent in Sylhet received saline during the 2022 floods. The higher proportion in Sunamganj could be indicative of a higher prevalence of diarrhoea and a more extensive healthcare response in Sunamganj compared to Sylhet. Distribution of medicine and oral saline is related to SDG 3: Ensure healthy lives and promote well-being for all at all ages, target 3.3 - combat hepatitis, waterborne diseases, and other communicable diseases; target 3.7 - ensure universal access to sexual and reproductive healthcare services; and **target 3.4 - promote mental health and well-being.**

The importance of shelter-focused relief to the overall recovery and well-being of the affected population cannot be overstated as many households are exposed to damage of their houses. About 7.6 percent of the surveyed respondents received shelter after the 2022 floods. However, regional disparity has been found in the distribution of shelter materials—Sunamganj reports a significantly higher proportion at 11.16 percent, while Sylhet is substantially lower at 3.26 percent. These findings emphasise the need for nuanced strategies in providing shelter support, considering distinct regional challenges.

The candle was an important relief item during the floods as the price of candles became around 10 times and nearly unavailable at that time. The survey results indicate that overall 52.5 percent of the respondents received candles during the 2022 floods. Survey result exhibits substantial variations in the distribution of candles between districts. In Sunamganj, a significant majority of 73 percent reported receiving candles, while the proportion is notably lower at 28 percent in Sylhet.

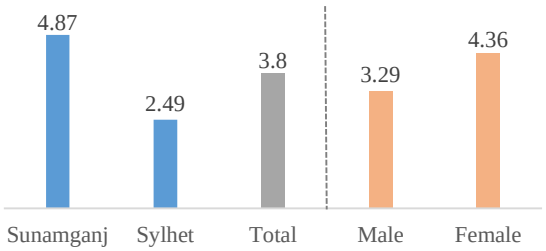
Supply of safe drinking water is essential during floods among affected populations. Nearly 2 million people faced a freshwater crisis during the flash floods in Sunamganj district during the flash floods of 2022. As high as 80 percent of tube wells and other freshwater sources were submerged while drinking water sources became contaminated in many localities caused a lack of drinking water for one to two weeks (Chakraborty et al., 2024).[5] In the present study, a notable proportion of respondents did not receive safe drinking water during that period. The results reveal overall 52 percent of the respondents received water during the 2022 floods with both gender-based and regional variations. Respondents of Sunamganj reported a majority of 72.6 percent receiving water, while in Sylhet, the proportion is considerably low at 27 percent. This underscores the vital role of the distribution of safe water in addressing one of the fundamental needs during floods when access to drinking water is at stake, which is related to access to safely managed water under **SDG 6**. On the other hand, alum is commonly used for water purification during natural disasters, especially during floods. The results indicate that overall 7.4 percent of respondents received alum, while 9.12 percent of respondents in Sunamganj and 5.4 percent in Sylhet received saline during the floods. The higher proportion in Sunamganj suggests a more significant impact or targeted distribution of alum in addressing specific needs related to water purification.

Figure 4.11: Types of relief received by affected households during floods 2022 (percent)

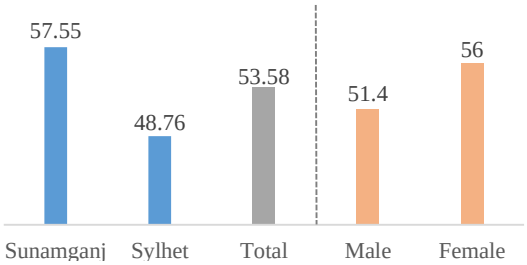


[5] Chakraborty, D., Mondal, K.P., Jubaer, A., Islam, S.T., and Talukder, B. 2024. Health impacts of rapid-onset event: 2022 flash flood in Bangladesh. In: T. Letcher (ed.), *Living with Climate Change*, 1st Edition, Elsevier, pp. 199-212, https://doi.org/10.1016/B978-0-443-18515-1.00004-6

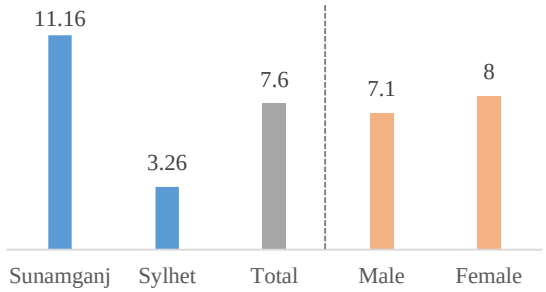
(c) Clothing



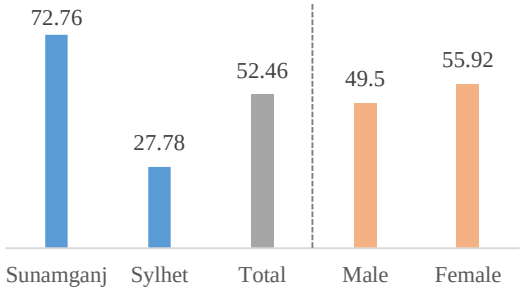
(d) Medicine



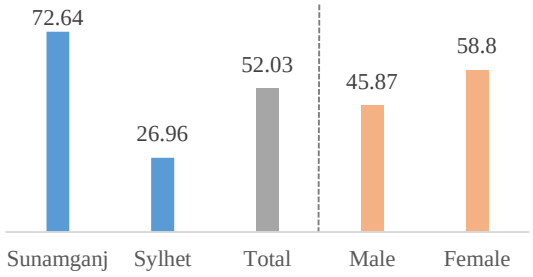
(e) Shelter materials



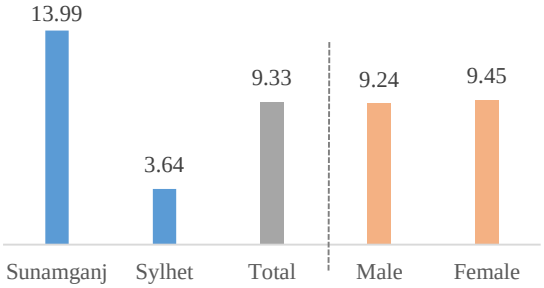
(f) Candle



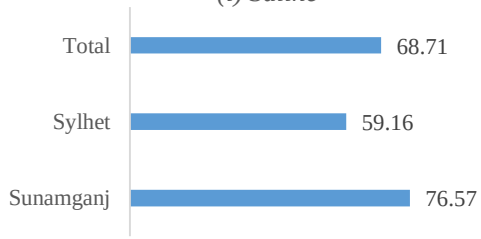
(g) Water



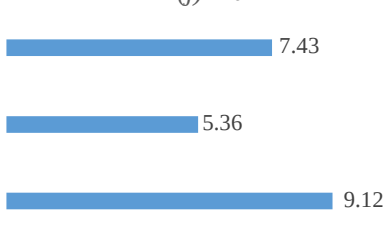
(h) Baby food



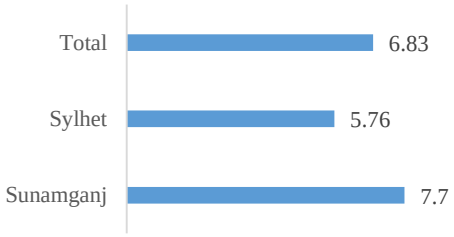
(i) Saline



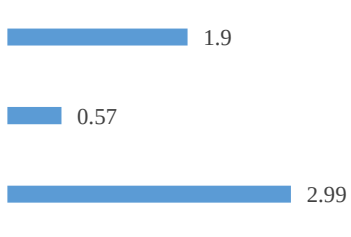
(j) Alum

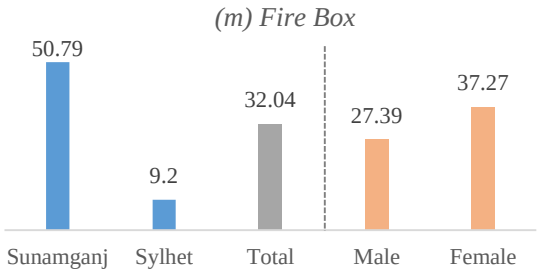


(k) Cash



(l) Sanitary napkin





Source: Field survey

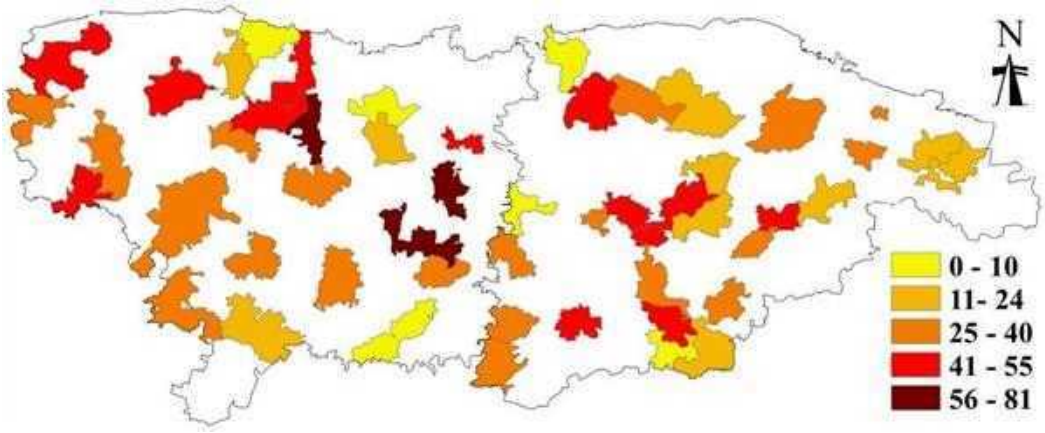
Access to baby food reduces the risks of undernutrition of infants during prolonged floods. The survey results indicate that overall 9.3 percent of the respondents received baby food. Regionally, a higher proportion of households in Sunamganj received baby food compared to their counterparts in Sylhet (14 and 3.64 percent, respectively). It could be attributed to increased efforts or resources allocated to address the specific needs of infants in the flood relief initiatives.

The availability of firebox is important during floods for cooking and lighting. The results reveal that about one-third of the respondents received fireboxes during the 2022 floods (32 percent). Regionally, Sunamganj reports a substantial majority of 51 percent, while in Sylhet, the proportion is notably low at 9 percent in receiving firebox.

A small proportion of flood-affected households also have received cash support during and after floods. The survey results reveal overall 6.83 percent of respondents, and 7.7 percent in Sunamganj and 5.76 percent in Sylhet received cash support. Cash support is a flexible form of aid that allows individuals to address their specific needs and priorities in prolonged floods. The higher proportion in Sunamganj suggests a more significant impact or targeted distribution of cash support, possibly reflecting the recognition of diverse and immediate needs among the surveyed population in that region. This could include aspects such as purchasing essential items, repairing homes, and meeting other urgent requirements.

Supply of sanitary napkins is essential for managing personal hygiene during floods. The results indicate that overall 1.9 percent of respondents received it, which is meagre. About 3 percent of individuals in Sunamganj while only 0.6 percent in Sylhet received it during the 2022 floods. This suggests a relatively low level of distribution of sanitary napkins, which has a detrimental impact on reproductive health of women and adolescent girls. It is related to target 5.6: Ensure universal access to sexual and reproductive health and reproductive rights under SDG **5**, achieve gender equality, and empower all women and girls.

Map 4.11: Quality of relief



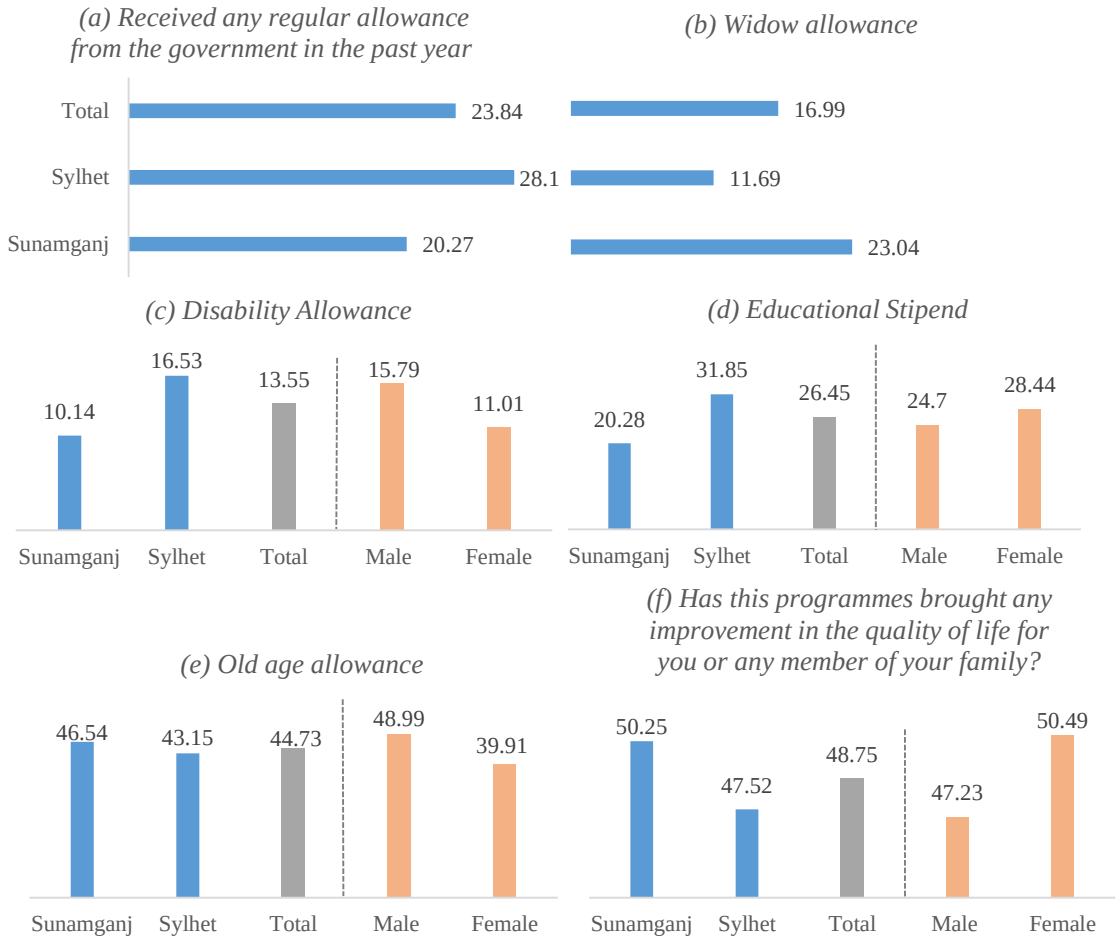
Source: Author's construction based on the survey data (2023)

Even though a considerable proportion of flood-affected households received relief from the government and other sources, the quality of relief determined recipients' satisfaction matters to support the coping capacity of the victims. The survey results demonstrate that half or more respondents of only unions out of 51 surveyed local government units were satisfied with the quality of relief, which include Dakshin Khurma, Laxmansree, Birgaon, Dharmapasha, Osmanpur Dakshin Bangshikunda, Fenchuganj, Tahirpur, Gourarang and Kuchai.

4.4.3 Social protection

Social protection programmes play an important role among disaster-affected and climate-vulnerable populations to promote adaptation and respond effectively to shocks. Educational stipends are essential in supporting access to education, particularly for individuals facing financial challenges. The findings reveal that more than a quarter of the respondents benefit from educational stipends (26.45 percent) with slightly higher rate for Sylhet than Sunamganj (32 and 20 percent, respectively). The result provides insights into the distribution of other social protection schemes, which include disability, widow and old age allowances (received by 13.6, 17 and 44.7 percent of responding households, respectively). While a greater proportion of responding households of Sylhet received disability allowance, a higher proportion of respondents of Sunamganj received widow and old age allowances. Overall, 17.5 percent of the surveyed individuals reported receiving regular allowances or benefits from the government before the flood of 2022, while about a quarter of the respondents received any social protection benefit in the past years (about 24 percent). A higher proportion of respondents of Sunamganj received any social protection compared to Sylhet (23 and 12.8 percent, respectively). The findings also suggest that the overwhelming majority of the surveyed households (as high as 76 percent) were not receiving any social protection allowances or benefits from the government in the past, with minor variations observed between the two districts. It implies that despite most of the surveyed households falling under a lower poverty line, they are not covered by any allowance under social protection. It increases their vulnerability during floods.

Figure 4.12: Disbursement of social protection programmes among the affected households and impact (percent)



Source: Field survey (2023)

The survey result indicates that no respondents were included in Vulnerable Group Feeding (VGF), Vulnerable Women Benefit (VWB), Employment Generation Programme for the Poorest (EGPP), Test Relief (TR), and Rural Employment and Road Maintenance Programme (RERM). Only one recipient was found (in Sylhet) for Open Market Sale (OMS), and Food for Work/Work for Money (FFW/WFM) out of the respondents receiving benefits (469).

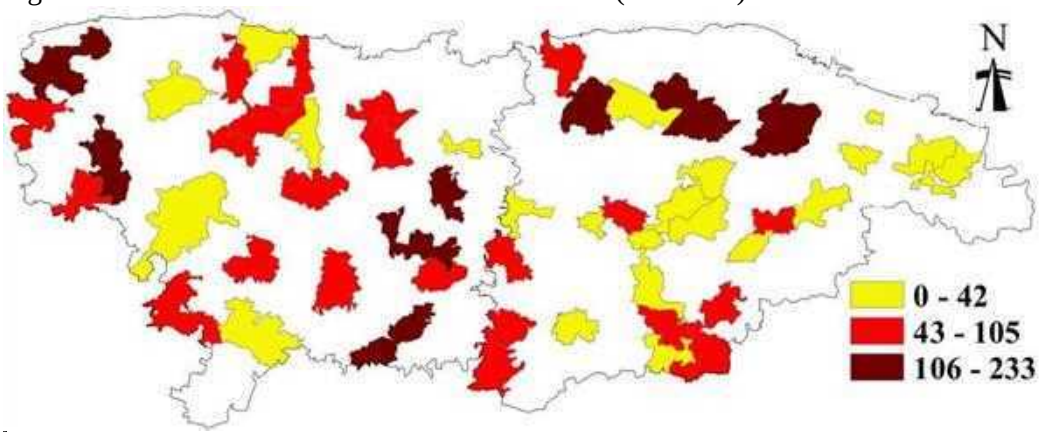
The success of social protection programme depends on improvements in the quality of life of the recipients or their family members. The results indicate that about half of the 48.75 percent of respondents believe that the programmes has brought about positive changes in their quality of life without significant gender and regional variations. It implies that social protection can make a difference through lessening and mitigating the impacts of disasters and climate change on poor and vulnerable populations, especially through promoting their resilience.

4.5 Resorting to flood shelters: Quality of supply and living condition

The survey also aimed to assess the quality of supply, facilities, and living conditions at flood shelters, especially considering women and girls, persons with disability (PWD), and the elderly population. The result reveals insights into the inadequacy of cooked food experienced by individuals during their stay at flood shelters, considering both gender and regional perspectives

as cooking facilities are hardly available at shelters. Overall, 41.27 percent of individuals reported facing challenges related to the inadequacy of processed (cooked) food during their shelter stay. Both Sunamganj and Sylhet exhibit the same proportion of individuals facing challenges related to the inadequacy of processed food (about 41 percent). This highlights a significant portion of shelter occupants grappling with difficulties in accessing sufficient cooked meals as the cooking facility is rather limited at the shelters.

Figure 4.12: Time to reach flood shelter from home (in minute)



Source: Author's construction based on the survey data (2023)

The longer time required to reach flood shelters discourages flood victims from moving to shelters that is likely to increase vulnerability, especially during prolonged floods. The survey results reveal that households in Dakshin Ranikhai, Darbast, Dakshin Khurma, Lengura, Dakshin Bangshikunda, Joysree, Birgaon, Raniganj, Mannargaon, and Madhyanagar unions required long time, which range from 1 hour 40 minutes to nearly four hours to reach the nearest flood shelters. Respondents in Sunamganj were the biggest victims of long traveling time to flood shelters.

The disruption of water supply and sanitation systems is a major public health-related issue in the developing world during floods (Ahern et al., 2004). The survey respondents reported a shortage of safe drinking water during their stay at flood shelters. Overall, about 70 percent of individuals reported facing a shortage of safe drinking water during their shelter stay. There was a significant regional disparity as about 82 percent of respondents in Sunamganj while nearly 47 percent in Sylhet experienced a shortage of safe water. This indicates a significant portion of shelter occupants encountering challenges related to access to clean and safe drinking water, emphasising the critical need for proper water supply management in shelter planning. These regional variations may be influenced by factors such as water infrastructure, water quality, or the impact of the flood, emphasising the need for interventions to ensure the safe water supply at flood shelters, which is related to SDG 6.

The flood victims experienced food crisis during their stay at flood shelters. Overall, more than two-thirds respondents reported facing a food crisis during their shelter stay (70 percent) without gender disparity, while regional difference was significant as 79.4 percent respondents in Sunamganj and 53 percent in Sylhet reported experience of food crisis. This indicates a substantial portion of shelter occupants encountering challenges related to food availability, emphasising the critical need for adequate food provisions in shelter planning and management. The regional

variations may be influenced by the severity and duration of the flood, access to food resources, and the inefficiency of local relief operations.

The inadequacy of safe sanitation facilities at flood shelters was a major challenge, which is related to SDG 6 (National Priority Target, NPT 18). According to MoDMR (2023), floods disproportionately affect vulnerable groups like women and girls, children, and persons with disabilities (PWD) with greater severity, complexity, and uniqueness compared to other groups. Infrastructural damage due to the 2022 floods considerably hindered the right to privacy and security of women and girls including lack of access to sanitary latrines and maintaining menstrual hygiene; and difficult in daily commuting because of damaged roads. Flood shelters were also overcrowded and lacked gender-sensitive and disability-inclusive design.

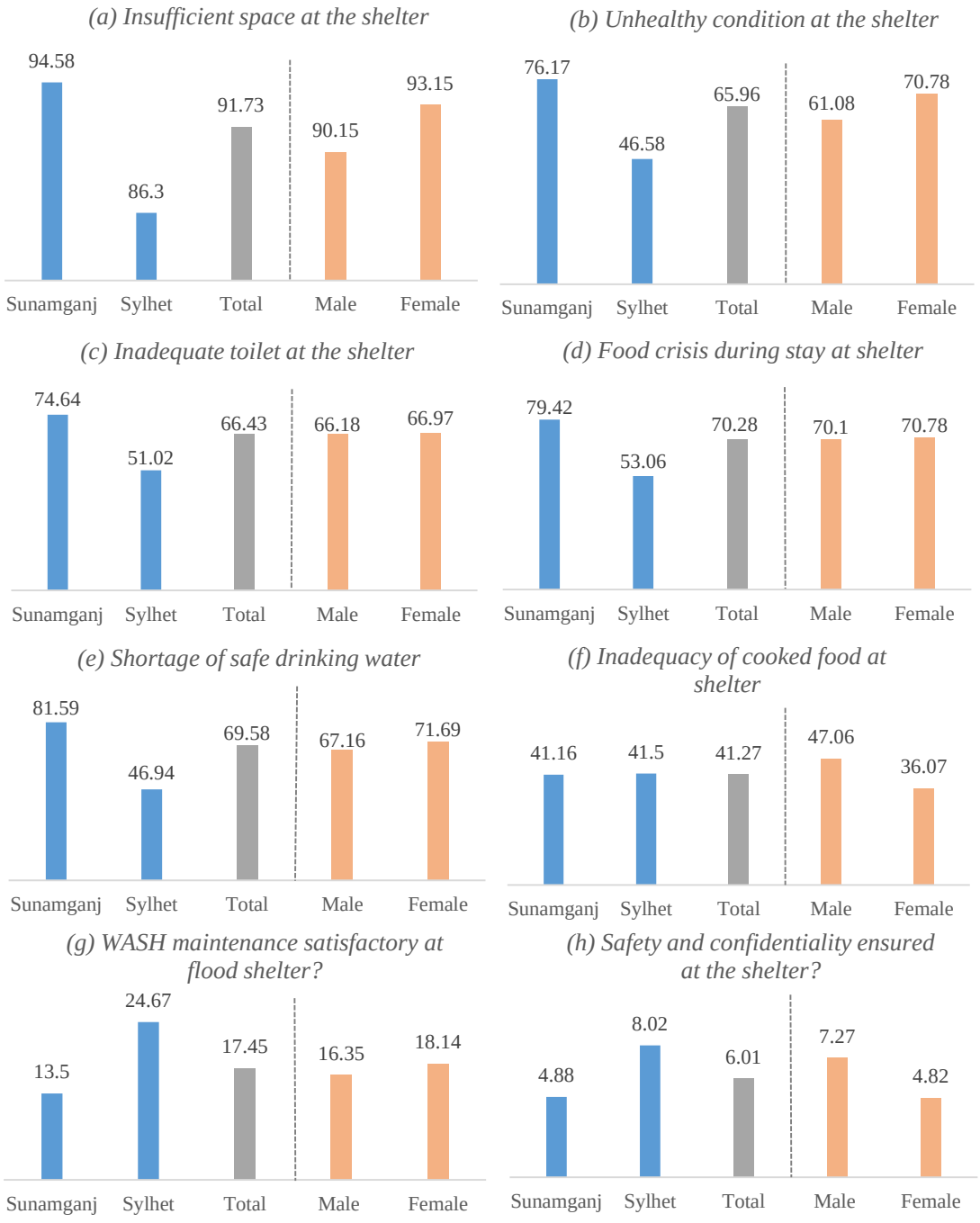
In the present study, about two-thirds of respondents (with an equal proportion of males and females) reported facing challenges related to inadequate safe sanitation during their shelter stay (66.4 percent). The regional difference was significant as 79.4 percent of respondents in Sunamganj and 53 percent in Sylhet reported deficiency of safe sanitation at flood shelter. These regional variations may be influenced by factors such as the availability and capacity of sanitation facilities, emphasising the need for context-specific interventions. The results indicate a significant proportion of shelter occupants grappling with insufficient sanitation infrastructure, emphasising the critical need for proper sanitation facilities in shelter planning and management in line with the NPT 18.

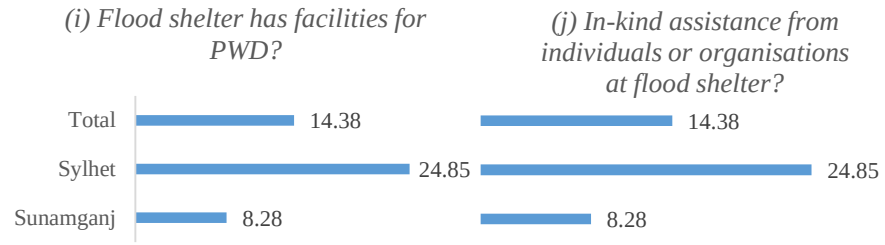
Unhealthy living conditions at flood shelters affect physical and mental health of the occupants. The survey results provide important insights into the prevalence of challenges related to unhealthy conditions at flood shelters. Overall, about two-thirds of respondents reported facing issues associated with unhealthy conditions during their shelter stay (66 percent). Females were especially sufferers due to unhealthy conditions as a higher proportion of them reported this problem compared to their male counterparts (71 and 61 percent, respectively). This gender disparity suggests potential variations in health vulnerabilities or hygiene needs between male and female shelter occupants, emphasising the need for gender-sensitive health interventions in shelter management This highlights a substantial portion of shelter occupants grappling with health-related challenges, emphasising the critical importance of maintaining sanitary and conducive environments in shelter facilities. Regional disparities reveal that in Sunamganj, a higher proportion (76 percent) experienced challenges due to unhealthy conditions, while in Sylhet, the proportion is comparatively low at 47 percent. These regional variations may be influenced by factors such as shelter infrastructure, access to sanitation facilities, and overall disaster response capacities, highlighting the importance of tailored sanitation and hygiene strategies based on regional contexts.

Another challenge at shelters was related to insufficient space, which made the stay of the respondents difficult during floods in 2022. An overwhelming majority of 92 percent of respondents faced issues with insufficient space during their stay at the shelters. Females (93 percent) reported a slightly higher proportion of challenges related to insufficient space compared to males (90.15 percent). This gender disparity suggests potential variations in space utilisation or requirements between male and female shelter occupants. Regional disparities reveal that in Sunamganj, a higher proportion (95 percent) experienced challenges due to insufficient space

while the proportion is comparatively low in Sylhet (86 percent). These emphasising the importance of tailoring shelter management strategies, improved shelter planning and resource allocation.

Figure 4.13: Quality of supply and living condition at flood shelter (percent)





Source: Field survey (2023)

Cleanliness, availability of clean water, sanitation facilities, and hygiene (WASH) are important indicators of flood shelter management and quality of living at the shelter. Overall, about 17.5 percent of respondents were happy with the cleanliness, availability of clean water, and hygiene maintenance of sanitation facilities during their stay at the flood shelter, which indicates that an overwhelming majority of the respondents (82.5 percent) were unhappy with the quality of WASH services at flood shelters with insignificant gender difference. About three-quarters of the respondents in Sylhet and 86.5 percent in Sunamganj were unhappy on the WASH services. It implies that there is a need for substantial improvement in the standard of WASH services at flood shelters.

Safety and confidentiality of specific groups, including children, teenagers, women, pregnant women, and PWD is important for decent living at flood shelters. The elderly, PWD, children, and women are more vulnerable to floods compared to others (Hajat et al., 2004). These are essential elements to ensure human dignity, which are embodied as the cornerstone of the SDGs. Overall, about 94 percent of the respondents had dissatisfaction with the special safety and confidentiality measures of these specific groups during their stay at shelters. This indicates a modest effort to address the unique needs and vulnerabilities of children, teenagers, women, pregnant women, and PWD. About 95 percent of women and respondents from Sunamganj were dissatisfied with safety and confidentiality at shelters, while the dissatisfaction of males and respondents from Sylhet was slightly low. The findings highlight the importance of ensuring specialised safety measures for vulnerable groups in flood shelters. The variations in reporting indicate the need for continuous efforts to improve and standardised practices, ensuring that all individuals, irrespective of gender or region, receive adequate safety and confidentiality support during their stay at shelters in floods.

The availability of facilities to accommodate PWD, such as stairs with handrails and handicapped-friendly sanitation facilities in flood shelters is an important indicator to consider of inclusiveness of the flood shelter. Overall, about 85.6 percent of respondents reported that the flood shelters did not have facilities to accommodate PWD. According to the about 92 respondents in Sunamganj, physical facilities for PWD were unavailable while three-quarters of the respondents in Sylhet reported the same. These findings underscore the importance of ensuring inclusive infrastructure in flood shelters, particularly for PWD.

The survey result provides insights into the receipt of in-kind assistance by individuals or their family members when they sought refuge in flood shelters. Overall, 14.4 percent of individuals reported receiving in-kind assistance during their stay at flood shelters. This suggests that a modest portion of shelter occupants benefited from support in the form of goods or services provided by individuals or organisations. Sunamganj had a lower proportion of individuals receiving in-kind assistance compared to Sylhet (8.28 and 24.85 percent, respectively). The regional variation

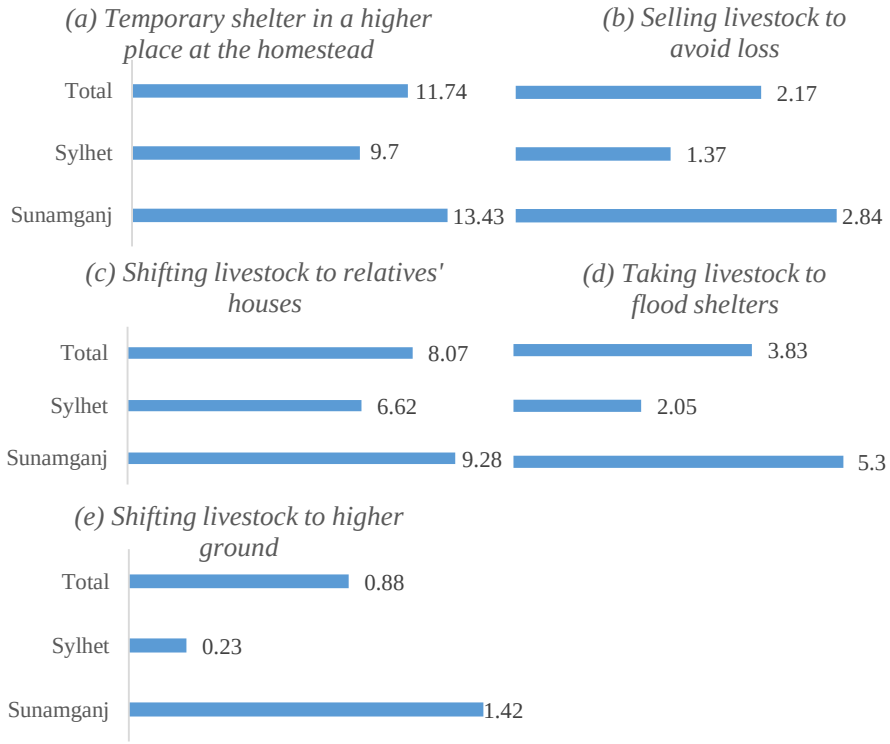
suggests potential differences in the availability of support networks and social capital that spurred during such a devastating flood.

4.6 Response, coping and capacity building

4.6.1 Autonomous response and coping

The survey tries to understand the state of autonomous response and coping strategies during floods. The result presents the practice of arranging temporary shelter in a higher place at the homestead during flood events. The data indicates that 11.7 percent of respondents reported the practice of arranging temporary shelter at a higher place within their homestead as a strategy during floods, which is more prevalent in Sunamganj than Sylhet (13.4 and 9.7 percent, respectively), which is mainly because floods are more common in Sunamganj and victims in this district are practice adaptive measures.

Figure 4.14: Autonomous response during flood (percent)



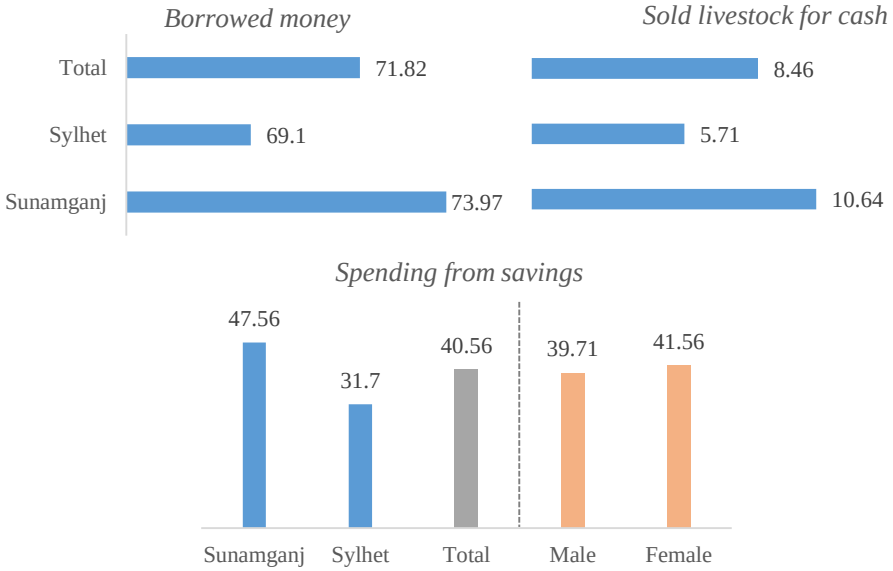
Source: Field survey (2023)

Selling livestock to avoid loss during flood events is another mode of autonomous response. However, a small proportion of the respondents chose to sell their animals to minimise the economic impact of the flood on their livelihoods (2 percent). A portion of the flood victims (8 percent) relocated their livestock to relatives' houses to safeguard livestock during flood events. A small proportion of respondents (3.8 percent) reported the practice of shifting livestock to higher ground during flood events (about 0.9 percent) and taking livestock to flood shelters. It implies that since most of the responding households are poor, they opt for alternative coping strategies instead of selling their livestock which is an important means of their livelihoods.

4.6.2 Coping strategy

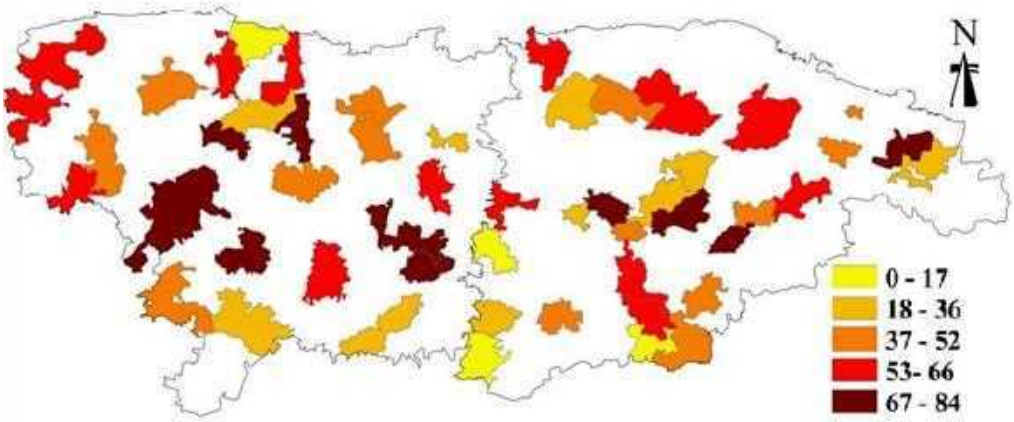
Coping capacity is one of the important dimensions of resilience to natural and climate disasters. According to Birkmann et al. (2014), a lower capacity to cope implies lower resilience of the households affected by disasters. The study intends to examine the level of coping capacity of the households in the floods 2022. About three-quarters of the respondents reported that they had to borrow money to cope with the shocks posed by devastating floods. The result did not demonstrate significant gender difference. Sunamganj reveals a higher proportion at about 74 percent, while Sylhet registers a slightly lower proportion at 69 percent. In addition, a lower proportion of respondents in Sylhet had to sell livestock and spend from savings to cope with floods. It implies that the surveyed households resorted to selling livestock for cash to mitigate economic challenges and the need for immediate financial resources during floods.

Figure 4.15: Borrowing, selling, and spending from savings as a coping strategy (percent)



Source: Field survey (2023)

Map 4.13: Borrowed money

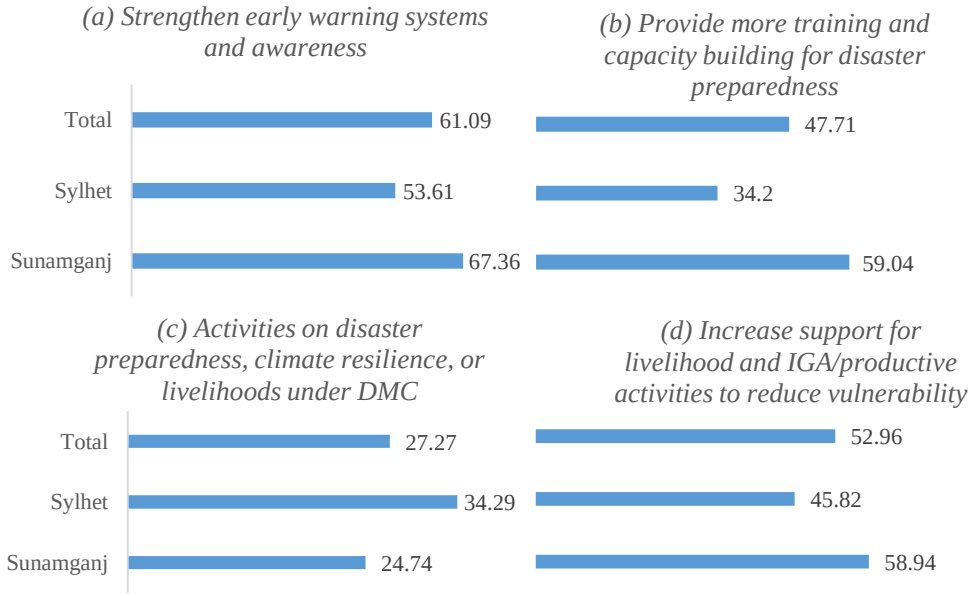


Source: Author's construction based on the survey data (2023)

4.6.3 Avenues of capacity building

Community-based capacity building fosters resilience against disasters (Rumpa et al., 2023).[6] The survey intended to understand the avenues of capacity-building measures as perceived by the flood-affected people in cooperation with the local Disaster Management Committee (DMC). The study explores respondents' consideration of long-term plans or measures to mitigate the risk of flooding in the aftermath of the 2022 flood. The results indicate that about a quarter (25.23 percent) of respondents expressed intentions to implement long-term plans or measures to reduce the risk of flooding. The result emphasises the importance of fostering community engagement and awareness in developing effective and region-specific strategies for sustainable flood risk reduction. Variations were observed between Sunamganj in the proportion of respondents contemplating long-term measures (27.2 and 22.9 percent, respectively). These findings suggest a notable but moderate inclination among respondents to address the adverse impacts of flooding by adopting sustained and proactive strategies.

Figure 4.16: Avenues of capacity building (percent)



Source: Field survey (2023)

The results shed light on the involvement of the communities in activities related to disaster preparedness, climate resilience, or livelihood improvement under the DMC. More than a quarter of respondents are engaged with the activities under the DMC (27.3 percent), which is more prevalent in Sylhet than Sunamganj (34.3 and 24.7 percent, respectively). This result suggests a notable level of participation among respondents in disaster management and resilience activities. The higher proportion in Sylhet may indicate a more proactive engagement in such endeavors, influenced by local initiatives and community awareness.

[6] Rumpa, N.T., Real, H.R.K., and Razi, M.A. 2023. Disaster risk reduction in Bangladesh: A comparison of three major floods for assessing progress towards resilience. *International Journal of Disaster Risk Reduction* 97 (2023) 104047, https://doi.org/10.1016/j.ijdrr.2023.104047

Increasing institutional support for livelihood and income-generating activities can reduce vulnerability during floods. The results demonstrate that more than half of respondents advocated for increased support in livelihood initiatives to reduce vulnerability (53 percent) with a greater proportion in Sunamganj than Sylhet (59 and 45.8 percent, respectively). This result underscores the need for intensified support in livelihood activities for enhanced resilience and reduced vulnerability to flood. The regional variations may stem from distinct community needs, economic landscapes, and the severity of flood impacts.

People in both Sunamganj and Sylhet are concerned about improving early warning systems and awareness. Overall, 61 percent of respondents express this shared interest with a greater proportion in Sunamganj than Sylhet (67.4 and 53.6 percent, respectively). This suggests a community-wide acknowledgment of the importance of strong early warning systems. The differences between the regions is influenced by a higher frequency of flash floods in Sunamganj than Sylhet.

Training and capacity-building programmes play important role in disaster preparedness of vulnerable communities. The result reveals a strong opinion among respondents in favour of the need for initiating more training and capacity-building programs for disaster preparedness by local government institutions (LGIs) and NGOs (according to a total of 47.7 percent of respondents) with a greater proportion in Sunamganj than Sylhet (59 and 34.2 percent, respectively) (Figure 4.16). This underscores a considerable awareness of the importance of preparedness and the desire for enhanced skills and knowledge to cope with future disasters.

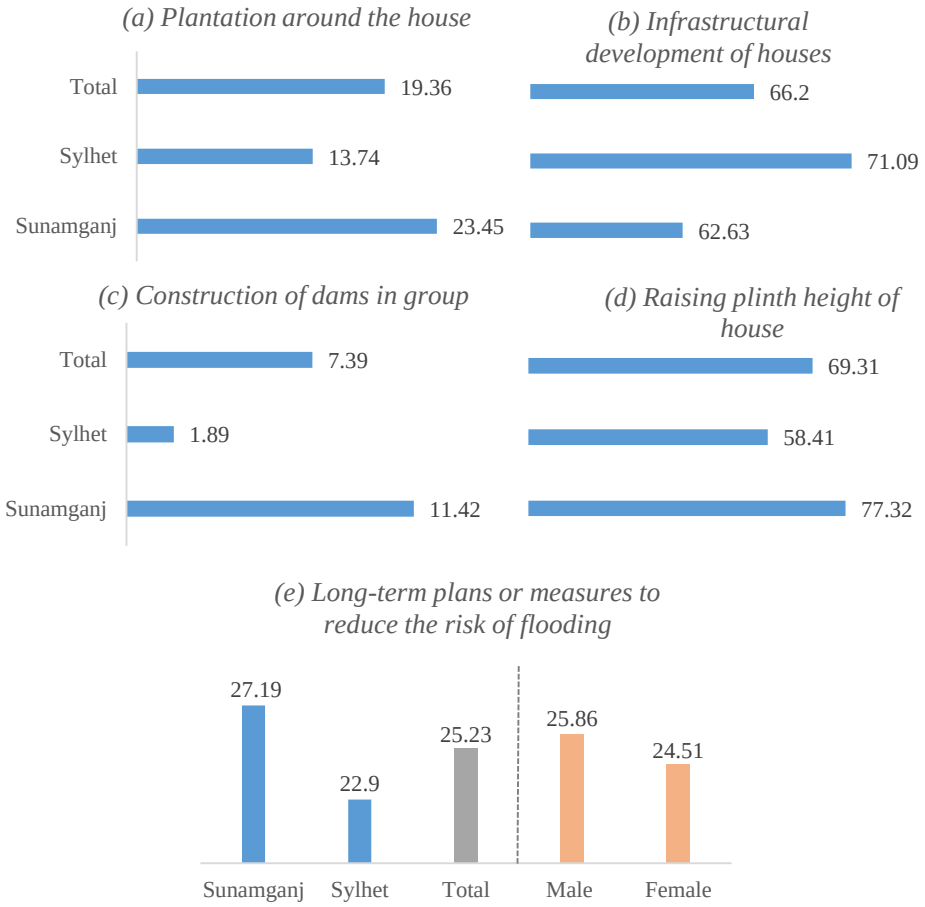
4.6.4 Adaptation

The survey results provide important insights into various measures to promote adaption and resilience among flood-affected households. It highlights the consideration of plantation around houses as a long-term measure to reduce the risk of flooding following the 2022 flood. The results reveal that about one-fifth of respondents are contemplating the plantation around their houses for flood risk mitigation (19.4 percent) with a greater proportion in Sunamganj than Sylhet (23.45 and 13.74 percent, respectively). This result suggests a noteworthy interest among respondents in adopting plantation measures around their houses to address potential future flood risks. It is mainly because of greater awareness and physical space among the surveyed households in Sylhet regarding the benefits of tree plantation.

The result reveals insights into the inclination towards long-term infrastructural development in terms of improvement of dwelling houses and construction of dams as a strategy to mitigate the risk of flooding after 2022 floods. The findings suggest that about two-thirds of respondents are considering enhancing their home infrastructure to combat future flood risks (66.2 percent) with a greater proportion in Sylhet than Sunamganj (71 and 62.6 percent, respectively). The results also provide insights into the consideration of raising the plinth height of houses as a flood mitigation measure after the 2022 flood. The results indicate that more than two-thirds of respondents are contemplating raising the plinth height of their houses (69.3 percent) with a greater proportion in Sunamganj than Sylhet (77.3 and 58.4 percent, respectively). These findings underscore a significant interest among respondents in adopting structural measures to enhance their resilience to flooding. The higher proportion in Sunamganj suggests a greater awareness and urgency in that district, influenced by the local topography, and recurrence and severity of floods.

The survey results indicate the growing realisation among flood victims on the consideration of constructing dams in groups as a flood mitigation measure after the 2022 flood. The results reveal that 7.39 percent of respondents are contemplating the construction of dams in groups. Sunamganj and Sylhet exhibit variations in the proportion of individuals considering this specific flood mitigation strategy (11.4 and 1. 9 percent, respectively) (Figure 4.14). The results suggest a notable interest among respondents in exploring collective efforts through the construction of dams. The higher proportion in Sunamganj may indicate a more significant recognition of the potential benefits of group-based flood control measures, influenced by the local geography, community dynamics, and past flood experiences.

Figure 4.17: Awareness of and need for increasing adaptation and resilience (percent)



Source: Field survey (2023)

4.7 Vulnerability and resilience of the flood-affected households

4.7.1 Assessing vulnerability

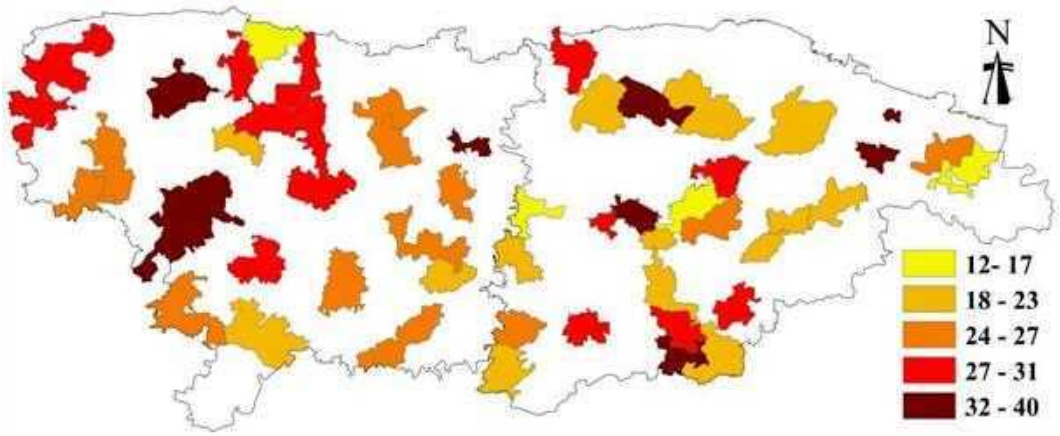
Determining vulnerability and their capacity to anticipate, cope with, fight, and recover from the impact of floods is a major challenge (Hajat et al., 2004). The present study followed MOVE framework, based on which the aggregate vulnerability index has been decomposed into physical, economic, social and institutional sub-indices. The estimation results reveal that the territory of

five local government units in Sylhet and three unions in Sunamganj are suffering from the highest level of physical vulnerability, which were Maijgaon, Tahirpur, Fenerbak, Chhatak, Towakul, Sylhet and Kanaighat (Map 4.13). Although both households in Sylhet and Sunamganj were highly physically vulnerable, physical vulnerability has been found more prevalent in Sylhet despite having less incidence of poverty compared to Sunamganj.

Indicators of physical vulnerability sub-index

a. Food intake in 1st week of flood compared to pre-flood food consumption
b. Impact of floods on nutrition
c. Ability to acquire knowledge
d. Physical weakness
e. Mental weakness
f. Missed from school due to the flood for more than 7 days
g. Absence from school due to damaged road/road inundation
h. How long (hours) did it take to reach the nearest flood shelter center from your house?

Map 4.14: Physical vulnerability sub-index



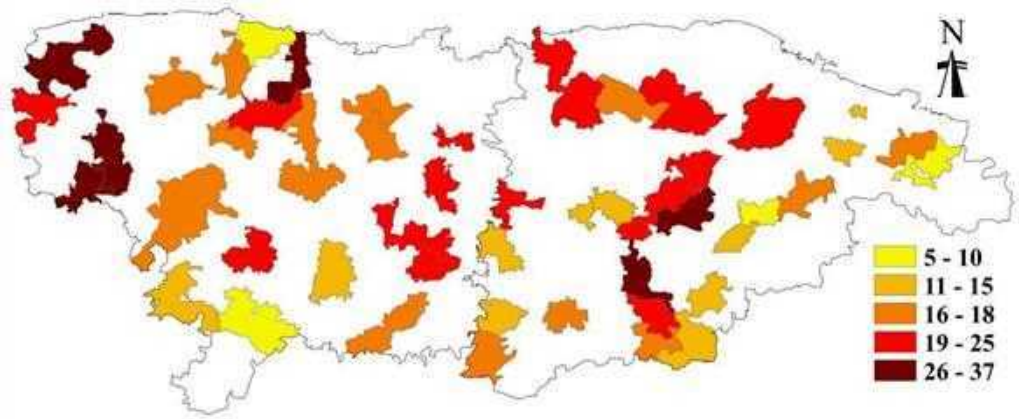
Source: Author's construction based on the survey data (2023)

The result of economic vulnerability sub-index implies that high economic vulnerability is prevalent among the surveyed households in both Sunamganj and Sylhet districts nearly equally (Map 4.14). The worst economic vulnerability has been observed in Salukabad, Dakshin Bangshikunda, Moglabazar, Bagha, Dharmapasha, Joysree, Birgaon, Rajanagar, Fenchuganj and Kandimpara.

Indicators of economic vulnerability sub-index

a. Did you receive any relief after the 2022 floods?
b. Per capita damage
c. Inverse (per capita income)
d. Borrow money
e. Spending from savings

Map 4.15: Economic vulnerability sub-index



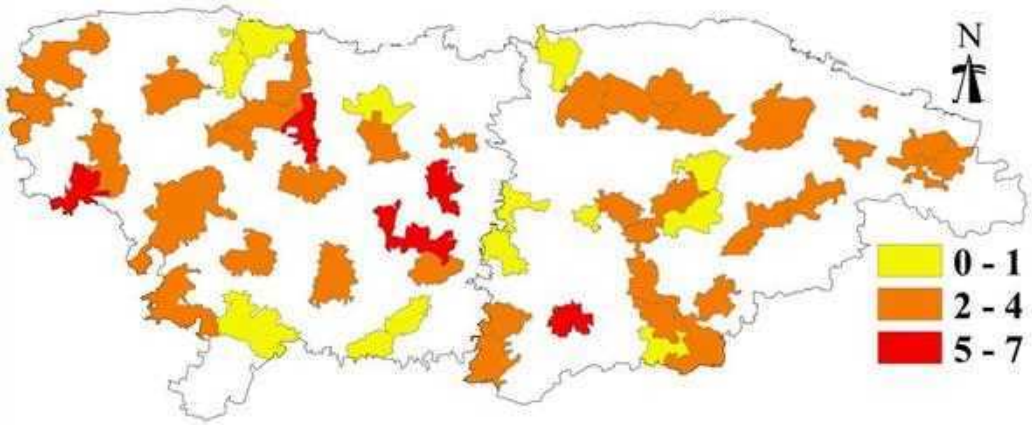
Source: Author's construction based on the survey data (2023)

Moderate to high institutional vulnerability has been observed among majority of the surveyed households in both Sunamganj and Sylhet districts almost equally (Map 4.15). The highest institutional vulnerability (with score 4 and above) has been observed in Laxmansree, Dakshin Khurma, Osmanpur, Birgaon, Dharmapasha, Kandimpara, Chhatak and Tahirpur.

Indicators of institutional vulnerability sub-index

a. Received relief from government
b. Quality of the assistance programmes

Map 4.15: Institutional vulnerability sub-index



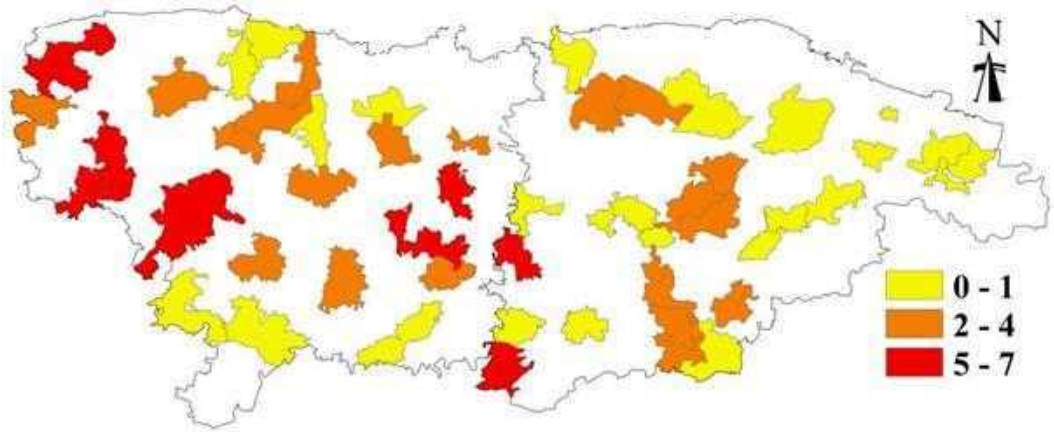
Source: Author's construction based on the survey data (2023)

Moderate to high social vulnerability has been observed predominantly observed among the surveyed households in Sunamganj compared to their counterparts in Sylhet district (Map 4.16). The worst social vulnerability (with score 4 and above) has been found in Dharmapasha, Joysree, Birgaon, Dakshin Bangshikunda, Daulatpur, Dakshin Khurma, Fenerbak, Sadipur and Jagaddal unions.

Indicators of social vulnerability sub-index

a. Received relief from NGOs
b. Received relief from the community
c. Received relief from charitable organisations
d. Harvesting crops earlier with the help of community people

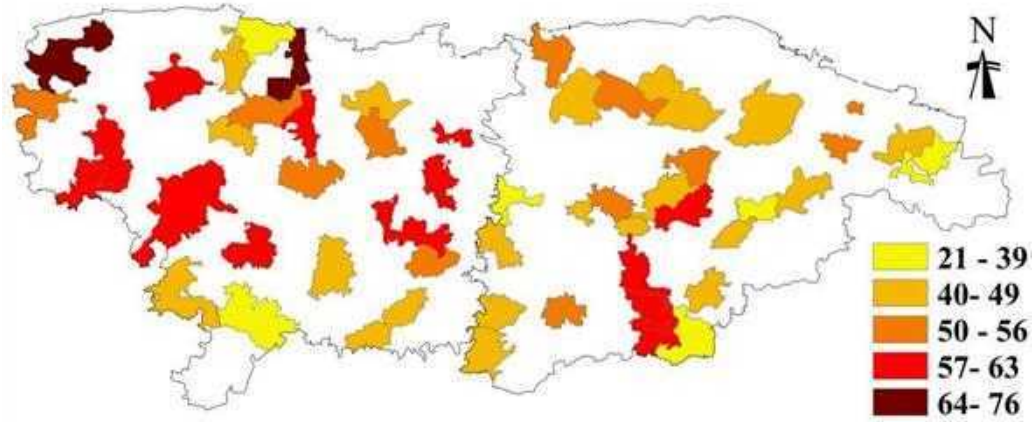
Map 4.16: Social vulnerability sub-index



Source: Author's construction based on the survey data (2023)

The estimated aggregate vulnerability index reveals that surveyed households located in Salukabad, Dakshin Bangshikunda, Dharmapasha, Joysree, Birgaon, Tahirpur, Rajanagar, Chhatak, Fenerbak and Dakshin Khurma unions had been highly vulnerable. The lowest vulnerable households were located in Lamakazi, Ghilachhara, Alinagar, Habibpur, Dhanpur and Kajalshah unions. Highly vulnerable households are located in the union of Sunamganj district.

Map 4.17: Vulnerability index



Source: Author's construction based on the survey data (2023)

The present study intended to examine the determents of damage and loss due to floods 2022 using the following empirical equation:

$$DLOSS_i = \alpha_0 + \alpha_1 PCI_i + \alpha_2 SCHOOL_i + \alpha_3 CAUTION_i + \alpha_4 PLAN_i + \alpha_5 WARNING_i + \alpha_6 NOMEAS_i + \varepsilon_i \qquad (4.4)$$

where

DLOSS = log of per capita damage and loss
PCI = log of per capita income
SCHOOL = Maximum years of schooling of a household member
CAUTION = Whether the household taken precautions before floods 2002 (1= yes and 0 = no)
PLAN = Whether the household had long-term plans to protect their residence, business and other assets (1= yes and 0 = no)
WARNING = Whether the household received early warning from official sources (1= yes and 0 = no)
NOMEAS = No measures taken by the household (1= No measures taken, and 0 = if any measure taken)
ε = error term
i = 1, 2, …, 1922

The variable DLOSS takes the following form:

$$DLOSS_i = \begin{cases} DLOSS_i^* & if \;\; DLOSS_i^* > 0 \\ 0 & otherwise \end{cases}$$

Three empirical equations have been estimated to examine the variables explaining damage and loss. It has been found that lower per capita income was associated with higher per capita damage of the dwelling house of the respondents. It means that residents of poor households are more vulnerable to floods-induced damages than their non-poor counterparts. Less damage and loss of dwelling houses, businesss and other assets were related to higher years of education, which implies a positive role of education in reducing damage and loss. The households that took precautions before floods could lessen damage and loss, which has been found separately in the equations of the dwelling house, business, and other assets, and total damage and loss. The role of long-term plans was found to be positive in reducing damage and loss of business and other assets, while early warning was associated with lower overall damage and loss. Finally, the households that did not take any measures were found to be ended up with a higher magnitude of per capita damage and loss (Table 4.1).

Table 4.1: Determinants of damage and loss per capita (Tobit model)

	ln (Damage of dwelling house)	ln (Damage and loss of business and other assets)	ln (Total damage and loss)
PCI	-0.202***	0.081	0.057
	(0.073)	(0.057)	(0.049)
SCHOOL	-0.128***	-0.034***	-0.044
	(0.016)	(0.012)	(0.010)
CAUTION	-0.286**	-0.311***	-0.362***
	(0.119)	(0.092)	(0.079)
PLAN	-0.189	-0.271*	-0.105
	(0.213)	(0.165)	(0.141)
WARNING	0.054	-0.271	-0.308*
	(0.276)	(0.213)	(0.183)
NOMEAS	-0.008	1.267***	0.855***
	(0.139)	(0.107)	(0.092)
Constant	9.355***	8.037***	8.886***

	(0.554)	(0.819)	(0.703)
Diagnostic Tests			
F	85.84***	156.38***	121.91***
Pseudo R^2	0.0093	0.0185	0.0157

Note: ***, ** and * indicate that the corresponding coefficients and test statistic are statistically significant at 1, 5 and 10 percent levels, respectively.

One of the most awful result of the present study is that an overwhelming majority of the households had to nearly starve in the first week of flood as evident from one-third of food intake on the first week of flood. The following equation has been estimated to examine the determinants of decline in food intake:

$$LFOOD_i = \alpha_0 + \alpha_1 BORROW_i + \alpha_2 DLOSS_i + \varepsilon_i \quad (4.5)$$

where

LFOOD = one-third of pre-flood food intake on the first week of flood (1= yes and 0 = no)
BORROW = the respondent borrowed money to survive during floods (1= yes and 0 = no)

The empirical estimates reveal that the households that could not borrow money to survive during floods had to reduce food consumption. The households that incurred low total damage and loss (because of comparatively less worth of inventory, assets and business) had to undergo less food intake (Table 4.2).

Table 4.2: Determinants of one-third of food intake on the first week of flood (Probit model)

	Coefficient	Standard Error
BORROW	-0.394**	0.184
DLOSS	-0.250***	0.061
Constant	5.034***	0.887
Diagnostic Tests		
LR $\chi^2(3) = 19.14$***		
Pseudo $R^2 = 0.0605$		

Note: *** and ** indicate that the corresponding coefficients and test statistic are statistically significant at 1 and 5 percent levels, respectively.

Social vulnerability has been found to be associated with greater physical and economic vulnerability (Table 4.3). It implies that the households that received relief from non-government sources like NGOs and charitable organisations and had resorted to community support to harvest crops early due to lack affordability to hire workers were socially vulnerable. These households were also found to be physically and economically vulnerable.

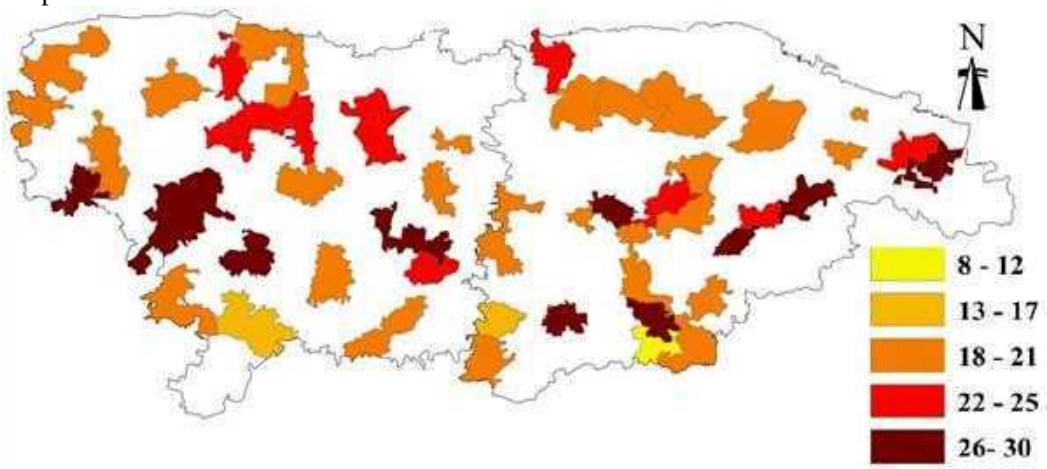
Table 4.3: Physical and economic vs. social vulnerability (dependent: physical vulnerability sub-index)

	Physical vulnerability	Economic vulnerability
	Coefficient (Robust Standard Error)	
Social vulnerability sub-index	0.122*** (0.038)	0.515* (0.291)
Constant	6.501*** (0.034)	4.347*** (0.435)
Diagnostic Tests		
R^2	0.01	0.001

F(3,1920)	10.34**	3.13*

Note: *** and * indicate that the corresponding coefficients and test statistic are statistically significant at 1 and 10 percent levels, respectively.

Map 4.18: Resilience index



Source: Author's construction based on the survey data (2023)

Households in Kuchai, Dharmapasha, Joykalash, Maijgaon, Kajalshah, Osmanpur, Mogalgaon, Jagaddal, Patali and Gourarang unions have been found to be highly resilient. Lowest vulnerable households were located in Sachna Bazar, Sadipur, Salukabad, Sylhet, Tahirpur, Towakul and Umarpur unions. Highly resilient households are located in the union of Sylhet district. However, four unions in Sunamganj have also been found to be highly resilient.

4.7.2 Assessing resilience

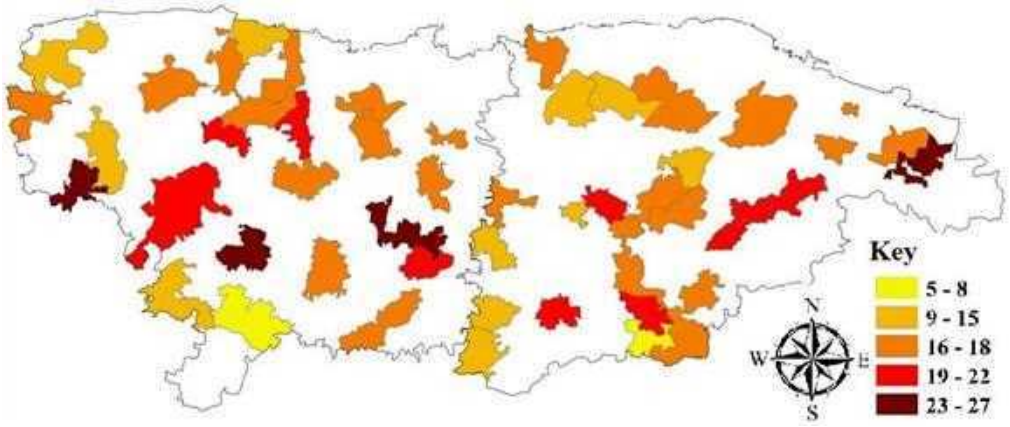
The present study followed the MOVE framework, based on which the aggregate resilience index has been decomposed into the capacity to cope, anticipate, and recover sub-indices. To understand the coping capacity of the survey households by the union, a sub-index has been developed as a part of assessing the resilience of the flood victim households. The results reveal that households in Kuchai, Dharmapasha, Mogalgaon, Jagaddal, Kajalshah, Patali, Maijgaon, Kandimpara, Lengura and Bagha unions had the highest coping capacity as per the value of the sub-index, which are mostly located in Sunamganj district. The least coping capacity has been found in Ghilachhara, Dakshin Ranikhai, Daulatpur, Dhanpur, Chiknagul, Moglabazar and Alinagar unions, which are mostly located in Sylhet district. Thus, even though respondents in Sylhet district could anticipate the flood occurrence, they had lower coping capacity than their counterparts in Sunamganj.

Indicators of capacity to cope sub-index

a. Did you receive any relief after the 2022 floods?
b. Did you receive any training on disaster preparedness before the 2022 floods?
c. Did you take any precautions to reduce the risk of disasters at the household level before the 2022 floods?
d. Was your house protected by any embankment before the 2022 floods?
e. Did you or your family members receive any training on how to evacuate to a shelter after receiving early warning?
f. Inverse of damage

g. Per capita income
h. Harvesting crops earlier with the help of community people
i. Borrowed money to meet financial requirement
j. Spending from savings
k. Any measures taken to cope with floods
l. Taking livestock to flood shelters
m. Shifting livestock to relatives' houses

Map 4.19: Coping capacity sub-index by union



Source: Author's construction based on the survey data

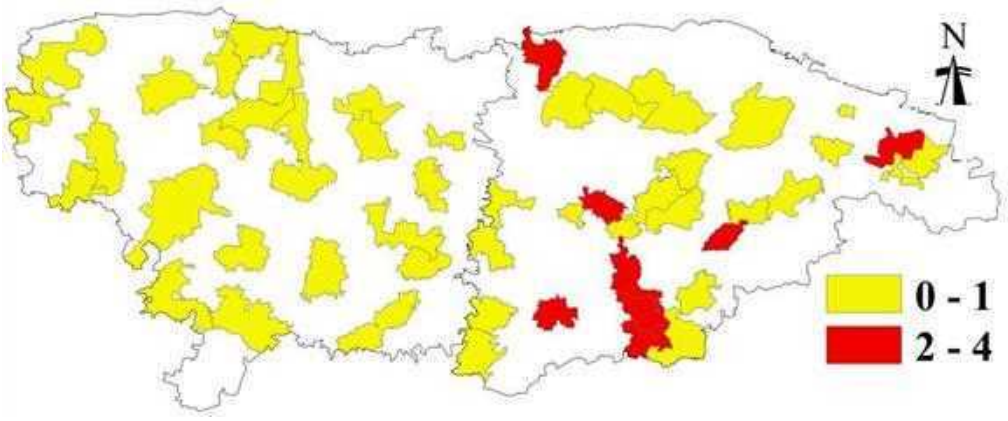
The coping capacity of the household largely depends on how and to what extent they could foresee the possibility of occurrence of floods and likely damage based on prior official information, and subsequently they plan or take actions to face the disaster based on their anticipation. The study constructs a sub-index to understand the capacity of the flood-affected households to anticipate the floods of 2022 and their devastating consequences.

Indicators of capacity to anticipate sub-index

a. Before the flood of 2022, did you or any member of your family receive any kind of flood-related warnings?
b. Before the 2022 flood, did you adopt any long-term plans/measures to reduce the risk of flooding?

The results indicate that households in Amura, Purba Dighirpar, Fenchuganj, Islampur Purba, Maijgaon, Moglabazar, and Osmanpur union, and Sylhet city corporation could successfully anticipate the occurrence of floods, which are located in Sylhet district. However, respondents of key interviewees revealed that even though they received early warning of floods, they could not imagine such a massive and rapid inundation that would hardly allow them to adopt measures as per their plans.

Map 4.20: Capacity to anticipate sub-index by union



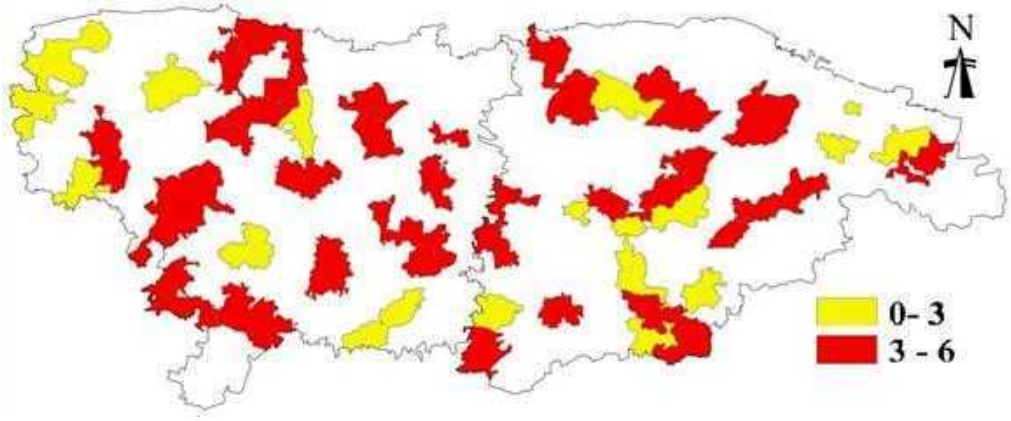
Source: Author's construction based on the survey data

The third dimension of residence is the capacity to recover from the adverse consequences of floods which include tangible and intangible damage and loss. The sub-index of capacity to recover demonstrate that surveyed households in Charkhai, Atgaon, Pandargaon, Osmanpur, Habibpur, Fenchuganj, Joykalash, Mannargaon, Kandimpara and Amura had the highest capacity to recover from the negative impacts pf floods. Households in Bhadeshwar, Dharmapasha, Moglabazar, Laxmansree, Bagha, Kuchai, Madhyanagar and Maijgaon demonstrate the lowest capacity to recover from the devastating impacts of floods.

Indicators of capacity to recover sub-index

a. Ability to acquire knowledge
b. Did you receive any assistance from the government to rebuild houses after the 2022 flood?
c. Do you have any long-term plans or measures to reduce the risk of flooding after the 2022 flood?

Map 4.21: Capacity to recover sub-index by union



Source: Author's construction based on the survey data (2023)

The present study intended to examine the determents of damage and loss due to floods 2022 using the following empirical equation:

$$COPE_i = \alpha_0 + \alpha_1 PCI_i + \alpha_2 SCHOOL_i + \alpha_3 CAUTION_i + \alpha_4 RELIEF_i + \alpha_5 SAVING_i + \alpha_6 BORROW_i + \varepsilon_i \quad (4.6)$$

where

COPE = Capacity to cope sub-index
RELIEF = Whether the household received any relief after floods 2022 (1= yes and 0 = no)
SAVING = Whether the household spent from savings to cover expenses during floods 2022 (1= yes and 0 = no)

Other variables and notations of Equation (3) are defined before. The variable COPE takes the following form:

$$COPE_i = \begin{cases} COPE_i^* & if \ \ COPE_i^* > 0 \\ 0 & otherwise \end{cases}$$

The results reveal that all estimated coefficients are positive and significant at a one percent level. It implies that income, years of schooling, precautions taken, spending from savings and borrowing to cover expenses during floods had a strong and positive role in enhancing the coping capacity of the flood victims.

Table 4.4: Determinants of capacity to cope (Tobit model)

	Coefficient	Robust Standard Error
PCI	0.984***	0.170
SCHOOL	0.040***	0.014
CAUTION	1.384***	0.216
RELIEF	0.719***	0.102
SAVING	1.241***	0.100
BORROW	0.906***	0.115
Constant	-5.958***	1.285
Diagnostic Tests		
F(6,1369) = 58.20***		
Pseudo R^2 = 0.0829		

Note: *** indicates that the corresponding coefficient and test statistic are statistically significant at 1 percent level.

To assess the capacity to recover from the menace of floods in 2022, the following empirical model has been estimated:

$$RECOVER_i = \alpha_0 + \alpha_1 CAUTION_i + \alpha_2 PLAN_i + \alpha_3 ASSISTANCE_i + \varepsilon_i \quad (4.7)$$

where

RECOVER = The capacity to recover sub-index
ASSISTANCE = Whether the household had any assistance from the government to rebuild houses after the 2022 floods (1= yes and 0 = no)

Other variables and notations of Equation (4) are defined before. The variable COPE takes the following form:

$$RECOVER_i = \begin{cases} RECOVER_i^* & if \ \ RECOVER_i^* > 0 \\ 0 & otherwise \end{cases}$$

The results reveal that all estimated coefficients are positive and significant. It implies that taking precautions before floods, having plans to counter negative impacts, and receiving assistance from the government to rebuild houses had a robust and positive role in strengthening the capacity to recover the flood-affected households.

Table 4.5: Determinants of capacity to recover (Tobit model)

	Coefficient	Robust Standard Error
CAUTION	0.025*	0.013
PLAN	1.019***	0.017
ASSISTANCE	1.067***	0.050
Constant	0.114***	0.008
Diagnostic Tests		
F(3,1894) = 230.42***		
Pseudo R^2 = 0.6614		

Note: *** and * indicate that the corresponding coefficients and test statistic are statistically significant at 1 and 10 percent levels, respectively.

Finally, the capacity to anticipate is associated with greater capacity to cope and recover (Table 4.6). It implies that the households that received early warning from official sources and adopted long-term plans or measures before the onset of floods had greater capacity to cope with and recover from the floods in the Sylhet region.

Table 4.6: Capacity to cope and recover vs. capacity to anticipate

	Capacity to cope	Capacity to recover
	Coefficient (Robust Standard Error)	
Capacity to anticipate sub-index	0.318** (0.129)	0.225*** (0.032)
Constant	3.234*** (0.074)	6.365*** (0.014)
Diagnostic Tests		
R^2	0.013	0.03
F(3,1920)	6.08**	48.22***

Note: ***, ** and ** indicate that the corresponding coefficients and test statistic are statistically significant at 1 and 5 percent levels, respectively.

4.8 Concluding remarks

The above results suggest that is a need for formulating a comprehensive design of adaptive and shock-responsive social protection (ASRSP) improving upon the existing relief operation, food and cash transfer, and traditional recovery support equipped with better information system, pre-disaster and long-term planning, and improved and adequate infrastructure and services. Risk-informed and well-coordinated emergency management for preparedness, short-term response, and recovery would support the development of such an ASRSP system, which would be backed up by the principles of social justice to address the needs of PWD, vulnerable women and adolescents, children, and elderly, and religious and ethnic minorities. The ASRSP system should aim at alleviating vulnerability and bolstering community resilience towards achieving the SDGs and transforming into a developed country by 2041.

Chapter 5
Flood Resilience Mapping

1. Introduction:

Bangladesh is one of the world's most flood-vulnerable nations since it is located in the delta of the Ganges, Brahmaputra, and Meghna rivers and frequently experiences catastrophic flooding. The districts of Sunamganj and Sylhet, which are both in the northeastern section of the country, are among those that have been severely impacted by these inundations. The socioeconomic fabric of these districts is severely impacted by the frequent floods, which hurt livelihoods, infrastructure, agriculture, and general societal well-being.

The idea of flood resilience has become increasingly important due to the growing hazards posed by climate change and the increasing frequency of extreme weather events. The ability of communities and systems to anticipate, prepare for, respond to, and recover from the negative effects of floods is referred to as flood resilience. A thorough assessment of flood resilience is being carried out in the districts of Sunamganj and Sylhet, in recognition of the pressing need to strengthen resilience in flood-prone areas.

The purpose of this assessment is to provide a comprehensive overview of the target districts' existing level of flood resilience by highlighting their strengths, weaknesses, and areas for improvement. Through the use of a multidimensional technique, the evaluation will take into account several variables, including socioeconomic dynamics, environmental sustainability, early warning systems, infrastructure resilience, and community readiness. It will also consider the perspectives of nearby communities, integrating indigenous knowledge and community-based resilience-building techniques.

To improve flood resilience and, eventually, lessen the impact of floods on the lives and livelihoods of the communities in Sylhet and Sunamganj, stakeholders are working together to produce evidence-based plans and recommendations. The results of this evaluation will provide important information to support sustainable development strategies, improve disaster preparedness, and help communities overcome the difficulties presented by frequent flooding. By doing this, it will be possible to develop an environment that is more adaptable and robust, protecting the people living in these vulnerable regions.

2. Materials & Methodology

To estimate flood resilience in the northeastern part of Bangladesh (Sylhet and Sunamgaj), the relevant data was collected from multiple data sets from different organizations. The main purpose of the study is to assess shock-responsive social protection. Social protection measures are taken to increase the resilience of the community in the event of extreme climate events. There are different methodologies to estimate resilience qualitatively, quantitatively, and semi-quantitatively, depending on the purpose and objectives of the studies. The goal of the study is to estimate the resilience for the assessment of adaptive social protection measures for flood events

that usually occur in the Sylhet and Sunamganj districts of Bangladesh. In this study, flood resilience is estimated by combining the major resilience components: social, economic, and physical/infrastructure resilience. Each resilience component was assessed based on the different indicators (Table 1).

Table 5.1: Resilience component and indicators(variables) used to estimate flood resilience

Resilience Component	Indicators
Social	
	Education facility
	Age/% population above 60 years of age
	Age/% population below 5 years of age
	Population density
	Female population size
	Health access
Economic	
	Household income/Income in USD
	Wealth Index
	likelihood of being below $2.50 per day
Physical /Infrastructure	
	Built Up
	Accessibility of roads/Evacuation routes
	Building density/Housing
	Settlement

2.1 Social Resilience Component

Social resilience is one of the most important components of shock-responsive, adaptive social protection. For estimating social resilience, suitable indicators (variables) were selected based on the literature, expert opinions, and availability of the geospatial data for the current study area. In this study, six different indicators were chosen. The first one is education facilities, which indicates the educational institutions (from primary level to university level) coverage per unit area of the study region. The educational facility data was collected from the Local Government Engineering Department (LGED), Bangladesh. The spatial coverage of the educational facilities was shown using the kernel density function (Fig. 5.1). The higher value of the kernel density indicates more coverage of the educational facilities, and a lower kernel density indicates low coverage of the educational facilities. The second indicator for social resilience was age/population above 60 years of age. This data was collected from the census data of Bangladesh from the Bangladesh Bureau of Statistics (BBS) for 2023. People ages 60 and older may have less resilience to natural disasters (e.g., floods). The spatial coverage of the data was at the Upazilla level (Fig. 19). Another important indicator is that children under 5 years old are more vulnerable to flooding or other disasters.

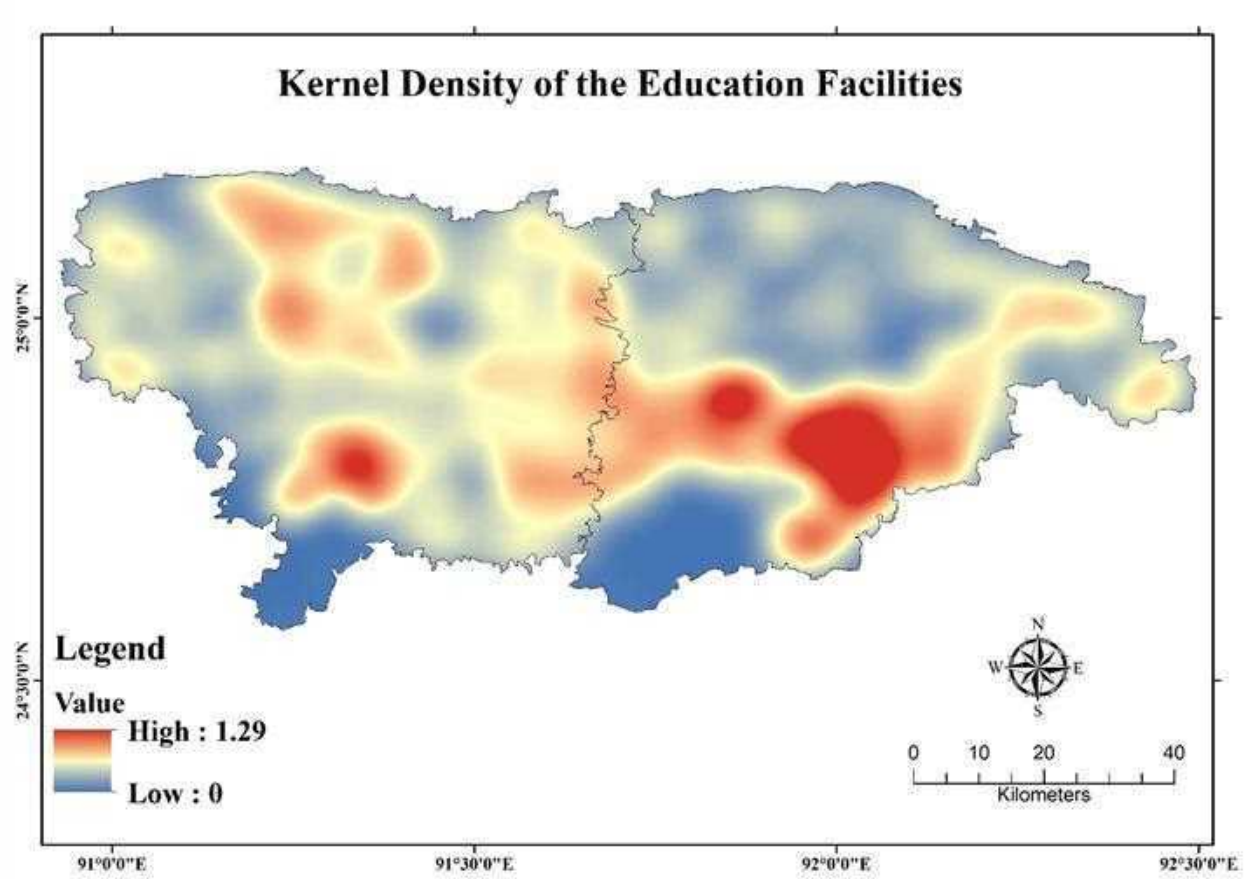


Fig. 5.1 Spatial distribution of the Kernel density of the education facilities in the Sylhet and Sunamganj districts in Bangladesh

This data was also collected from the recent census data for BBS (Fig. 20). The grided population density data of the study area was also used as an indicator collected from the same census data (Fig. 21). Females are more vulnerable to disasters, and it is also included in this study to emphasize gender issues in adaptive social protection measures. The children and female population size (Fig 22) and children below 5 years used in this study were upazila-level data from the recent census database of BBS. Access to health facilities during the disaster is one of the most important indicators, which is included in this study to assess the social resilience of the community.

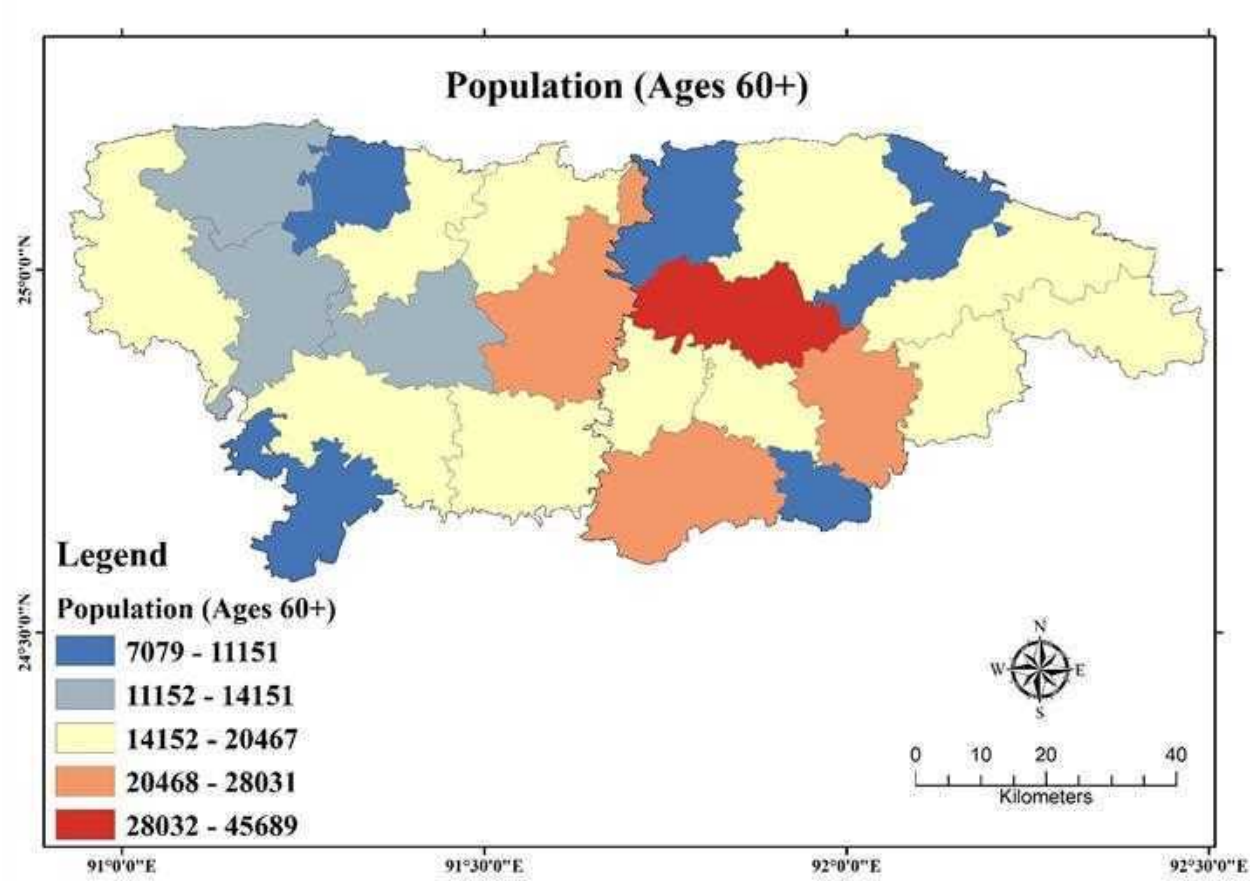


Fig 1: The spatial distribution of the population with ages above 60 years at the upazila level in the Sylhet and Sunamganj districts in Bangladesh.

Access to health facilities indicates coverage of the facilities (from a community clinic to a medical college hospital). This database was also collected from the LGED. The spatial distribution of access to health facilities was shown using the kernel density of access to health facilities (Fig 23).

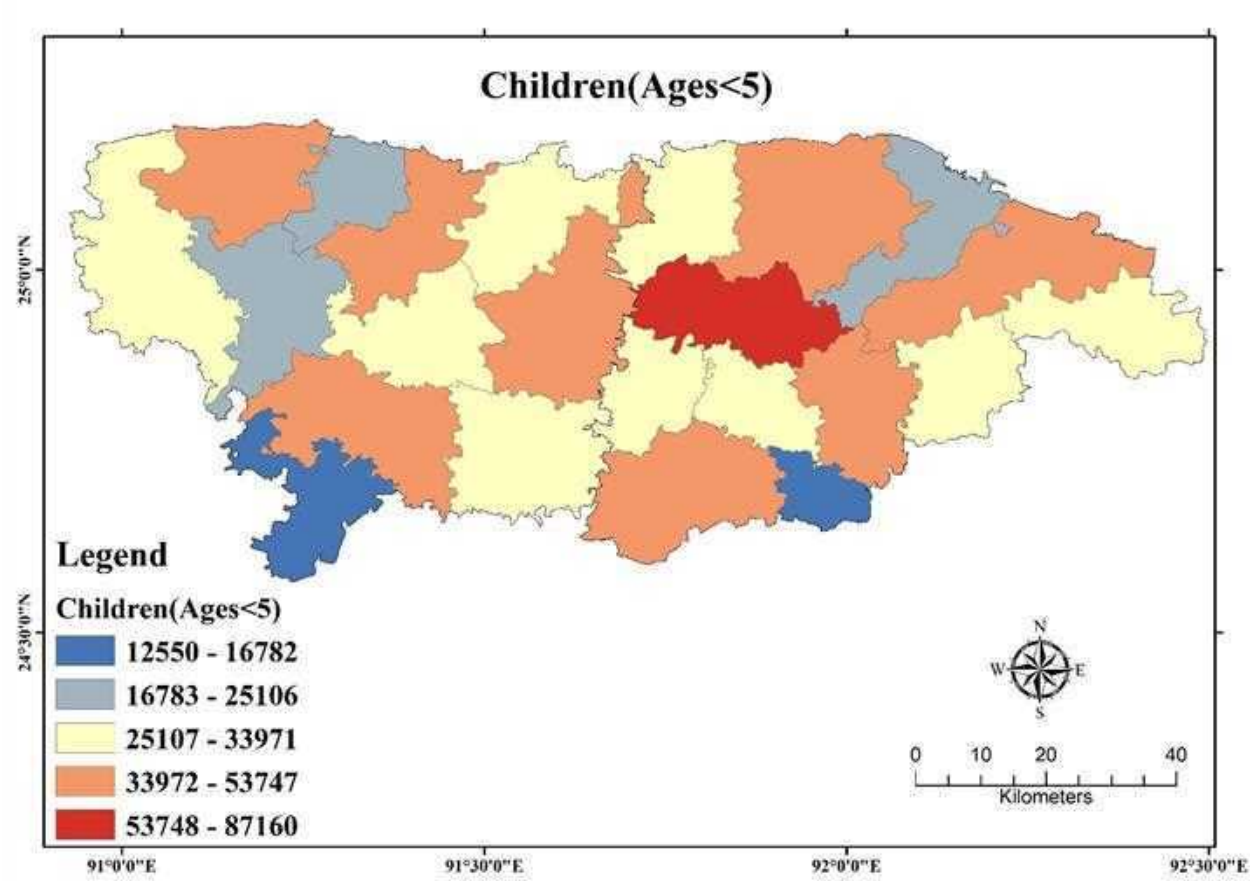


Fig 2: The spatial distribution of the children with ages below 5 years at the upazila level in the Sylhet and Sunamganj districts in Bangladesh.

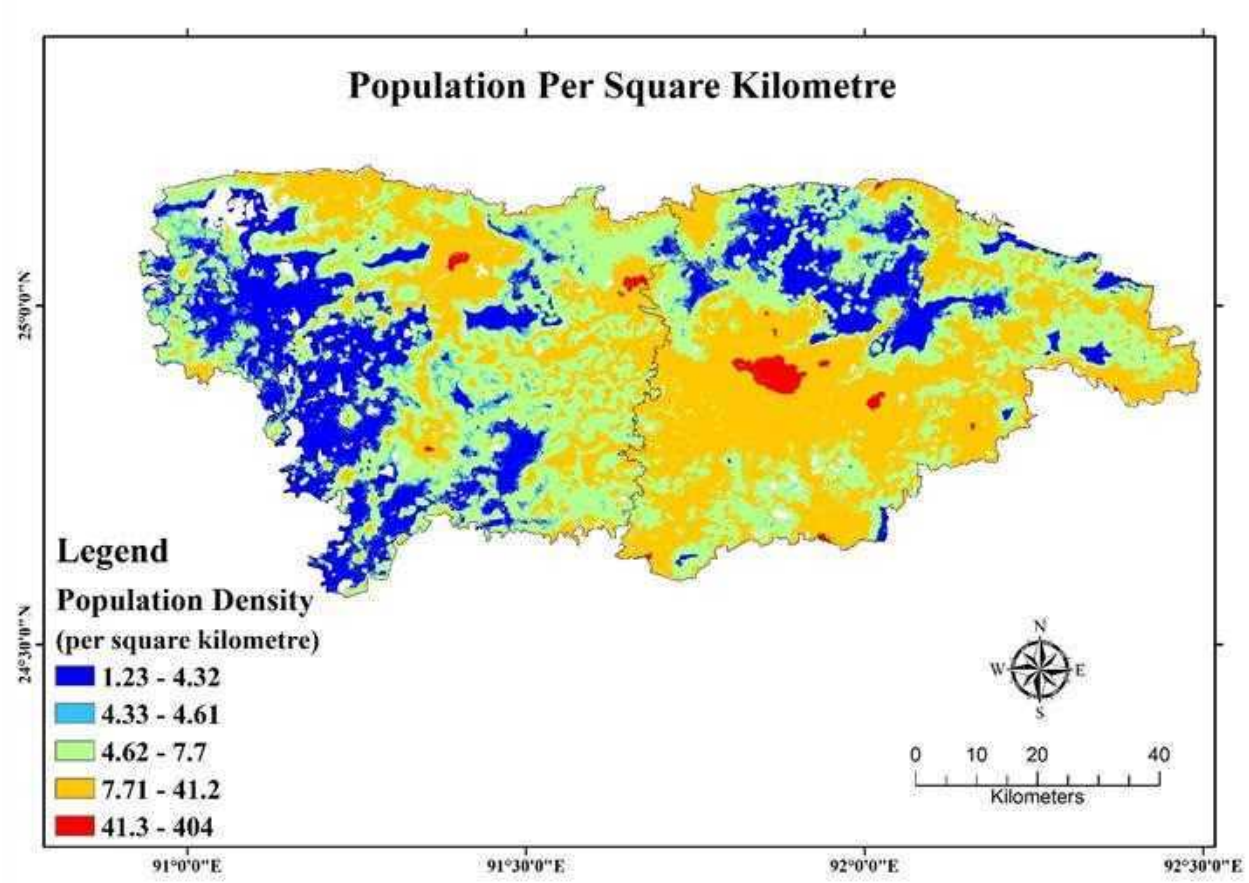


Fig 3: Population density (people per square kilometre) in the Sylhet and Sunamganj district of Bangladesh.

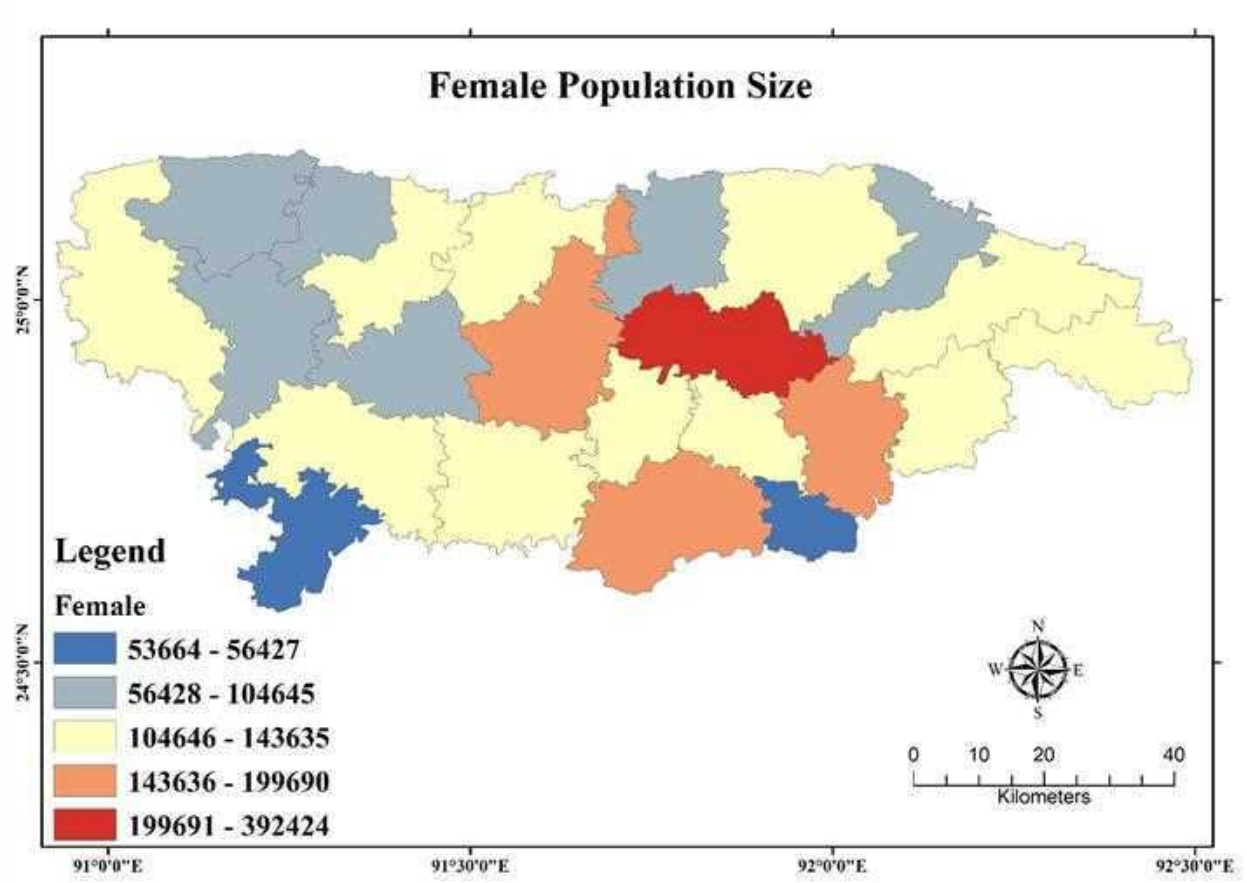


Fig 4: The spatial distribution of the female population size at the upazila level in the Sylhet and Sunamganj districts in Bangladesh.

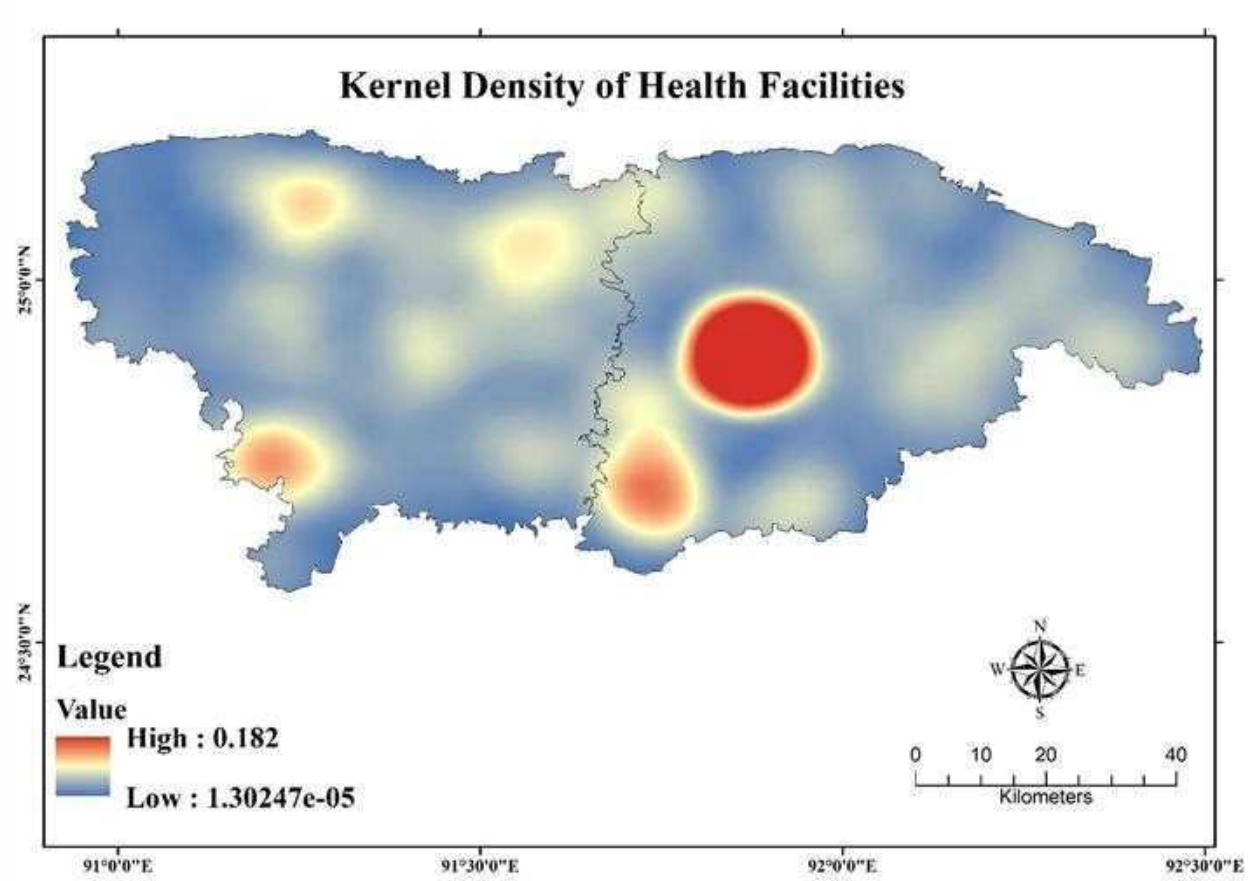


Fig 5: Spatial distribution of the Kernel density of the education facilities in the Sylhet and Sunamganj districts in Bangladesh.

2.2 Economic Resilience Component

The economic resilience of the community to flood events was assessed using three indicators: income in USD, the Demographic and Health Surveys (DHS) wealth index, and the probability of income falling below 2.5 dollars per day. All of the indicators were collected from the previously published article (Steele JE et al., 2017). The details of the data collection, processing, and analysis were described by Steele JE et al. (2017). The higher values of income and DHS wealth index indicate the greater economic resilience of the community. On the other hand, the higher value of the likelihood of income being below 2.5 $ per day indicates the less resilience of the household or community to natural disasters. The spatial distribution of income in USD is shown in Fig. 24, and the spatial distribution of the DHS wealth index is shown in Fig. 25. The spatial distribution pattern depicting the likelihood of income falling below $2.5 is illustrated in Figure 26.

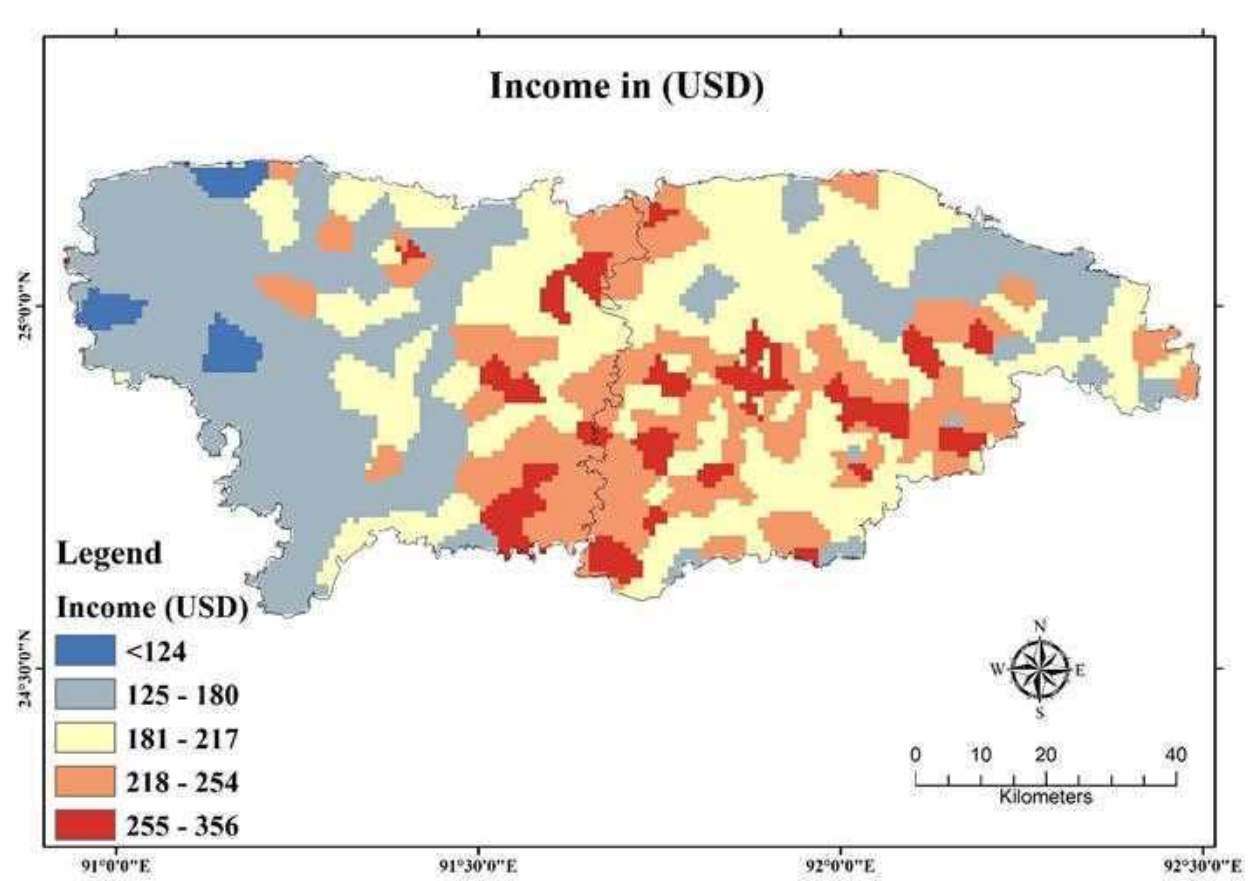


Fig 6: Spatial distribution of income in USD in the Sylhet and Sunamganj districts in Bangladesh

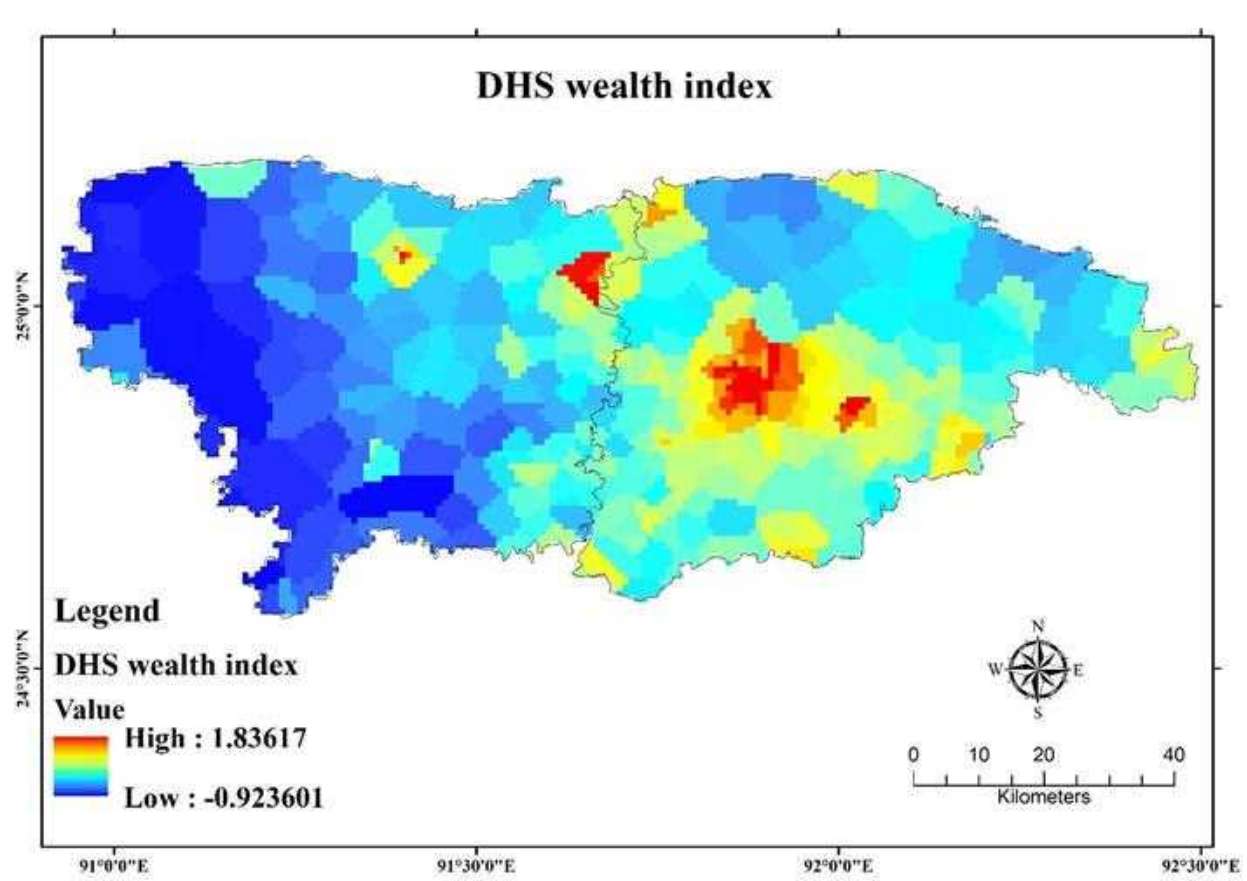


Fig 7: Spatial distribution of DHS wealth index in the Sylhet and Sunamganj districts in Bangladesh

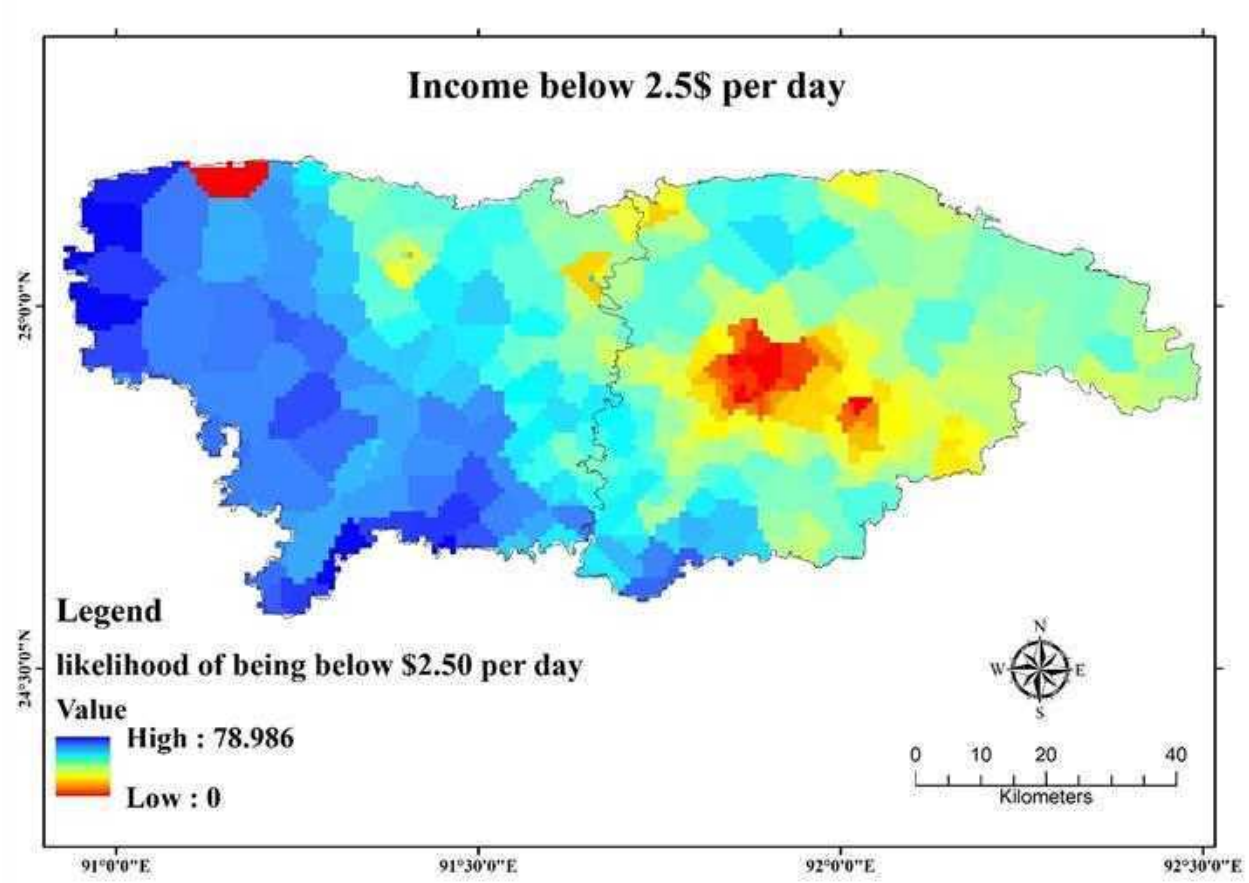


Fig 8: Spatial distribution of the likelihood of being below $ 2.5 per day in the Sylhet and Sunamganj districts in Bangladesh.

2.3 Physical/Infrastructre Resilience Component

The physical or infrastructure resilience indicates how the infrastructure in the physical environment is resilient to flood events. To estimate physical or infrastructure resilience, four different indicators were chosen. The initial indicator was the built-up area, acquired from satellite images (Sentinel-2) with a spatial resolution of 10 meters. The built infrastructure is more resilient to flooding than the non-built infrastructure. The spatial distribution of the built-area kernel density is shown in Fig. 27. This figure indicates the spatial distribution of the built area per unit area in the study area. The second important indicator is the accessibility of roads or evacuation routes. The road network data was collected from LGED. The evacuation routes help create resistance during flood events. The spatial distribution of evacution routes per unit area is shown in Fig. 28 using kernel density. The building data was also used in estimating infrastructure resilience. The geospatial building location data was collected from the Google Earth building information data, and finally, the building density distribution was calculated using kernel density (Fig. 29). Lastly, the settlement data collected from LGED was also used in estimating infrastructure resilience. The settlement density was also calculated using the kernel density to estimate the distribution of settlements per unit area of the study area (Fig. 30).

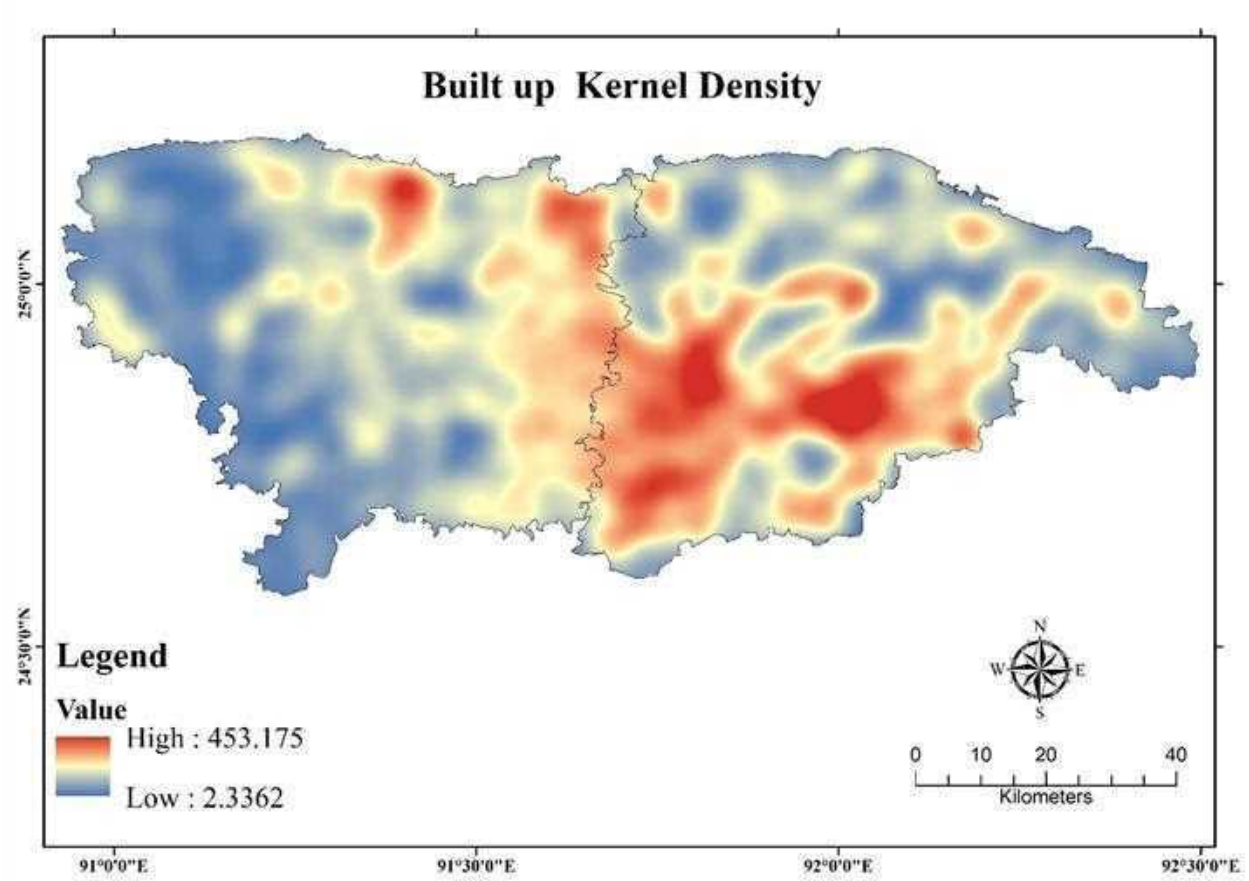


Fig 9: Spatial distribution of the built-up area Kernel density in the Sylhet and Sunamganj district in Bangladesh

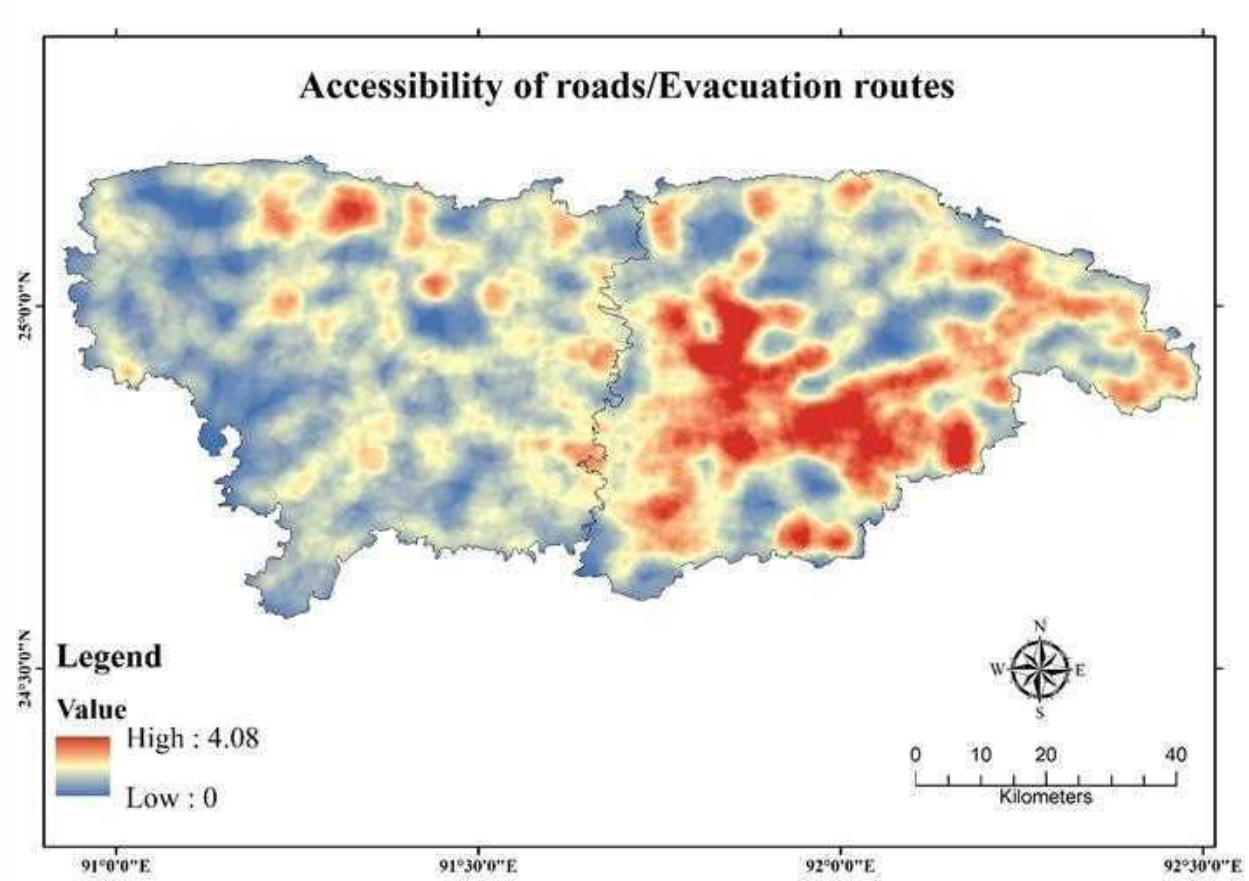


Fig 10: Spatial distribution of the accessibility of roads or evacuation routes kernel density in the Sylhet and Sunamganj district in Bangladesh

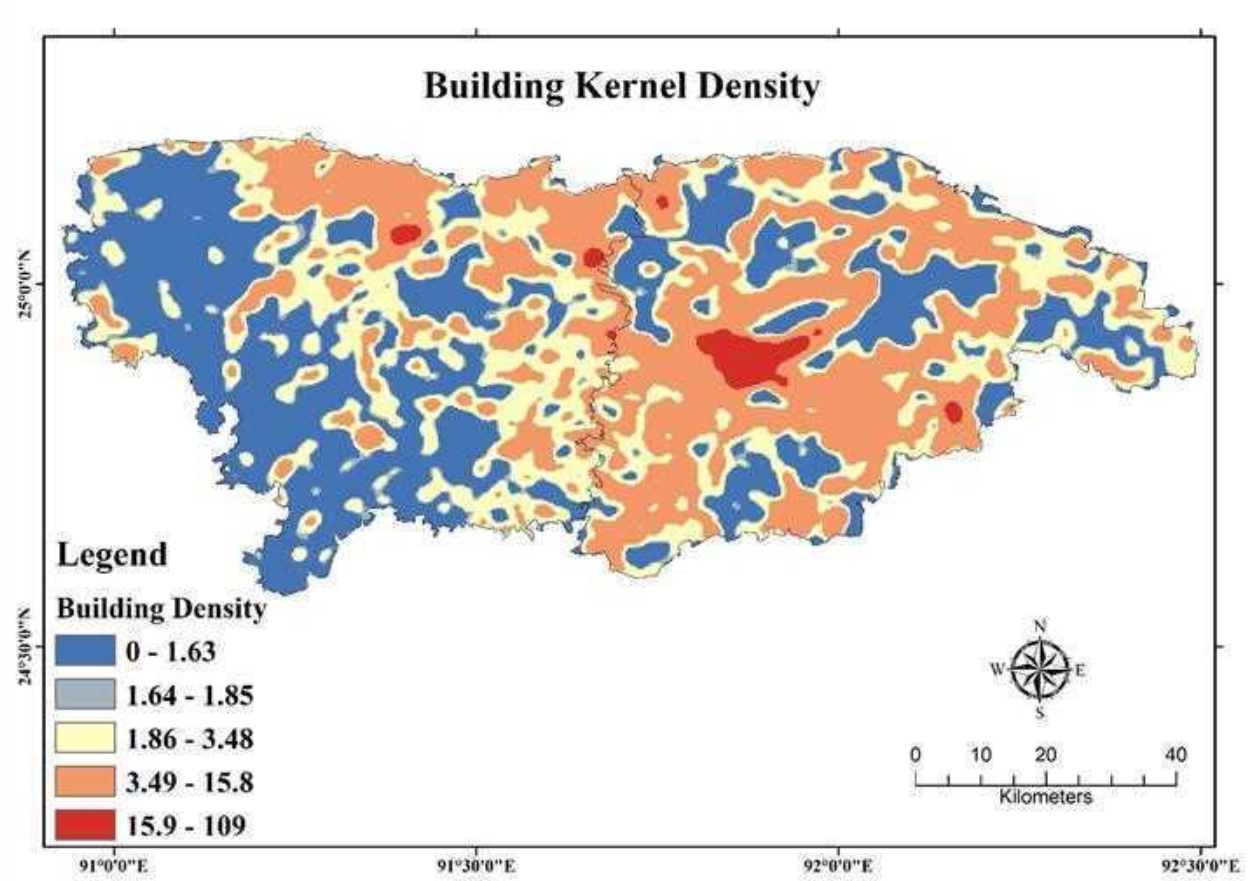


Fig 11: Spatial distribution of the building kernel density in the Sylhet and Sunamganj district in Bangladesh

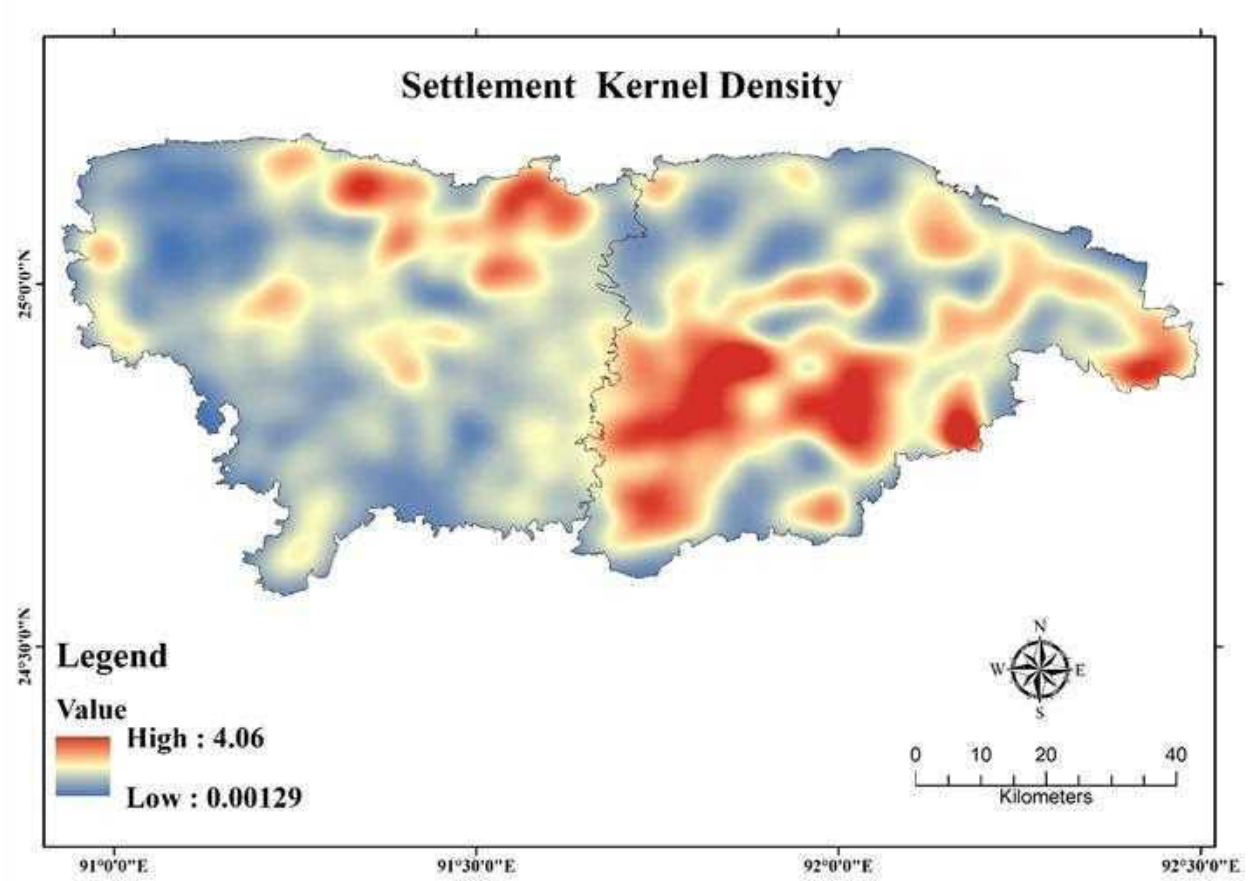


Fig 12: Spatial distribution of the settlement kernel density in the Sylhet and Sunamganj district in Bangladesh

2.4 Fuzzy Logic for Estimating Resilience Index

Fuzzy logic has a wide range of applications in geospatial data analysis. In this study, we used a fuzzy-based geospatial technique to combine different indicators of resilience to estimate the final resilience index. At first, the raster geospatial data of all the indicators was converted into fuzzy membership functions based on the relationship between each indicator with the final reliability score. Fuzzy large membership was used for the indicators, where there is a direct potential relation, and fuzzy small membership was used for the indicators, where there is an indirect relation between the indicators and the resilience score. Finally, indicators of social, economic, and physical/infrastructure resilience were combined using the OR function in the fuzzy overlay to estimate social, economic, physical, and infrastructure resilience, respectively. Since the OR function maximizes each indicator in the final output, it was chosen to overlay the operation of each membership function to combine the indicators. The reason for the choice of the OR function is described (Prodhan et al., 2017) in detail. Finally, social, economic, and physical/infrastructure resilience were combined to estimate the total resilience or flood resilience. These three resiliences were combined using the Gamma overlay function. The power of gamma was chosen as 0.9. The reason for choosing the Gamma function is described (B. Prodhan et al 2017) details in.

3. Results and Discussions:

3.1 Social Resilience

The resulting social resilience map derived from the overlay operation is depicted in Figure 31. The result shows that the central part of the Sylhet district and the eastern part of the Sunamganj district have high resilience. On the other hand, the northern part of the Sylhet and the western part of the Sunamgaj are less socially resilient. The maximum resilience score obtained from the results is 0.97, which is located in the Sylhet metropolitan area. The results also show that the Sylhet region is more resilient than the Sunamganj district.

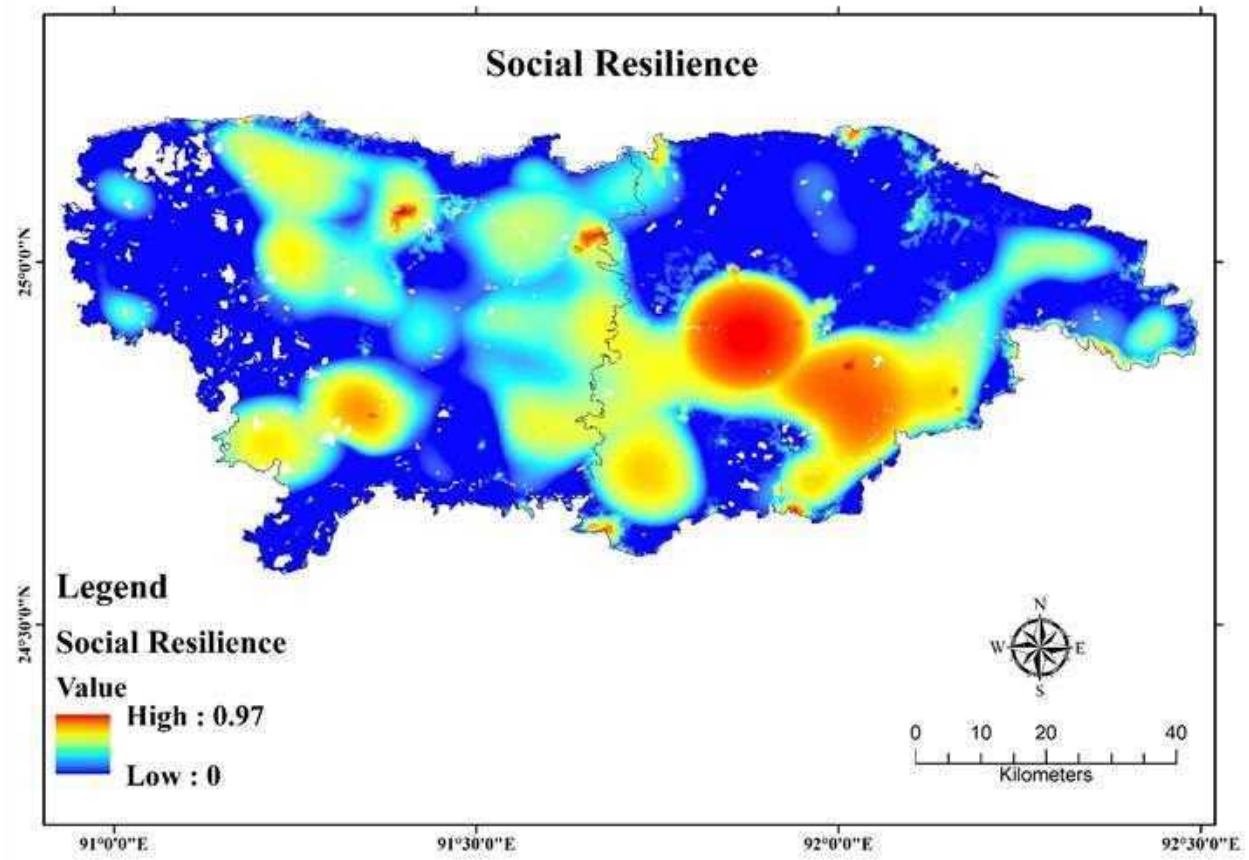


Fig 13: The spatial distribution of the estimated social resilience in the Sylhet and Sunamganj district in Bangladesh

3.2 Economic Resilience

The output of the economic resilience map obtained from the overlay operation is shown in Fig. 32. The results show that the majority of the Sylhet district and the eastern part of the Sunamganj district have high resilience. On the other hand, the western part of the Sunamgaj is less economically resilient. The maximum resilience score obtained from the results is 1, which is located in the largest area of Sylhet district. The results also show that the Sylhet region is more economically resilient than the Sunamganj district.

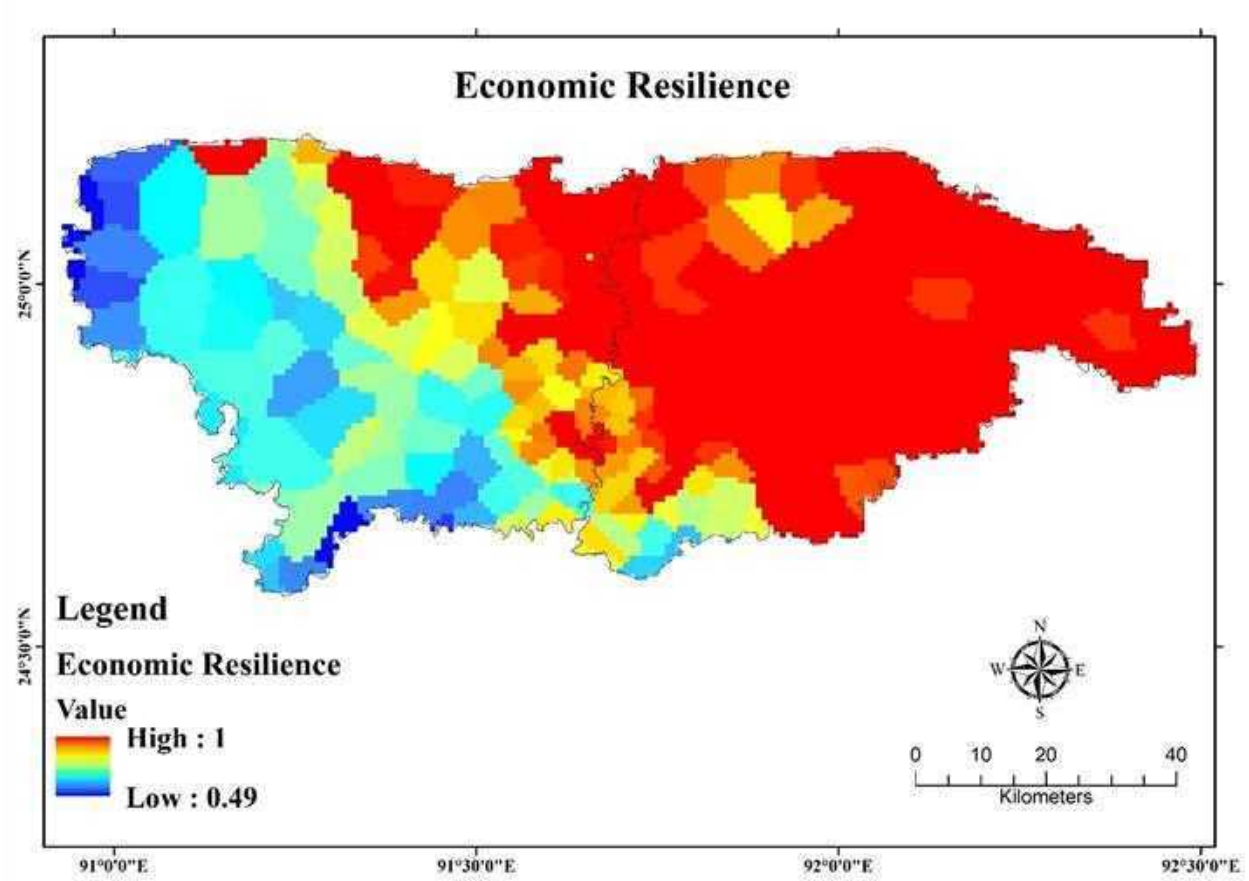


Fig 14: The spatial distribution of the estimated economic resilience in the Sylhet and Sunamganj district in Bangladesh

3.3 Physical/Infrastructure Resilience

The output of the physical/infrastructure resilience map obtained from the overlay operation is shown in Fig. 33. The results show that the majority of the Sylhet district and the eastern part of the Sunamganj district have high resilience. On the other hand, the western part of the Sunamgaj is less resilient. The maximum resilience score obtained from the results is 0.94, which is located in the central part of Sylhet district. The results also show that the Sylhet region is more resilient than the Sunamganj district.

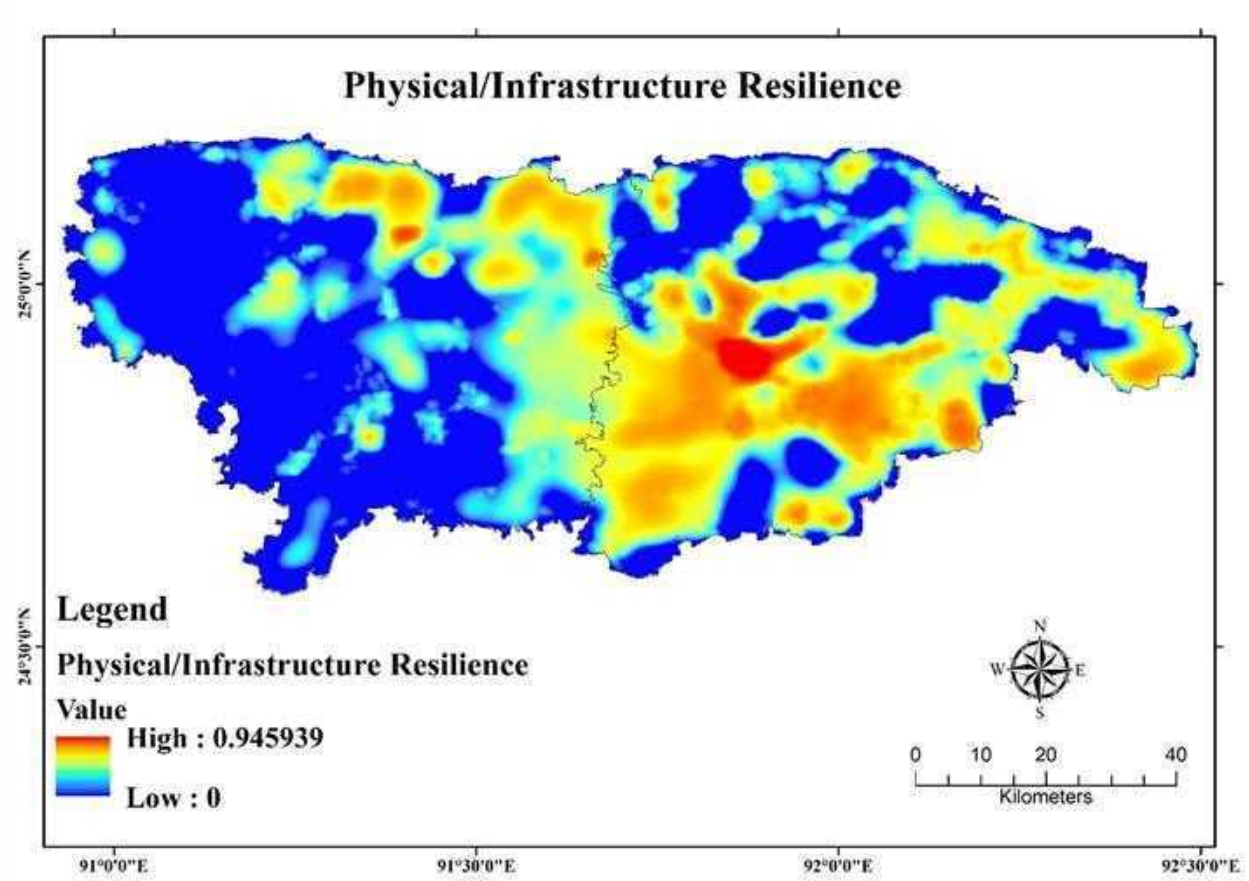


Fig 15: The spatial distribution of the estimated physical/infrastructure resilience in the Sylhet and Sunamganj district in Bangladesh

3.4 Flood Resilience Assessment

The output of the flood resilience map obtained from the combination of social, economic, and physical or infrastructure resilience is shown in Fig. 34. The results show that the central part of the Sylhet district and the eastern part of the Sunamganj district have high resilience. On the other hand, the northern part of the Sylhet district and the western part of the Sunamgaj are less resilient. The maximum resilience score obtained from the results is 1, which is located in the central part of Sylhet district. The results also show that the Sylhet region is more flood-resilient than the Sunamganj district.

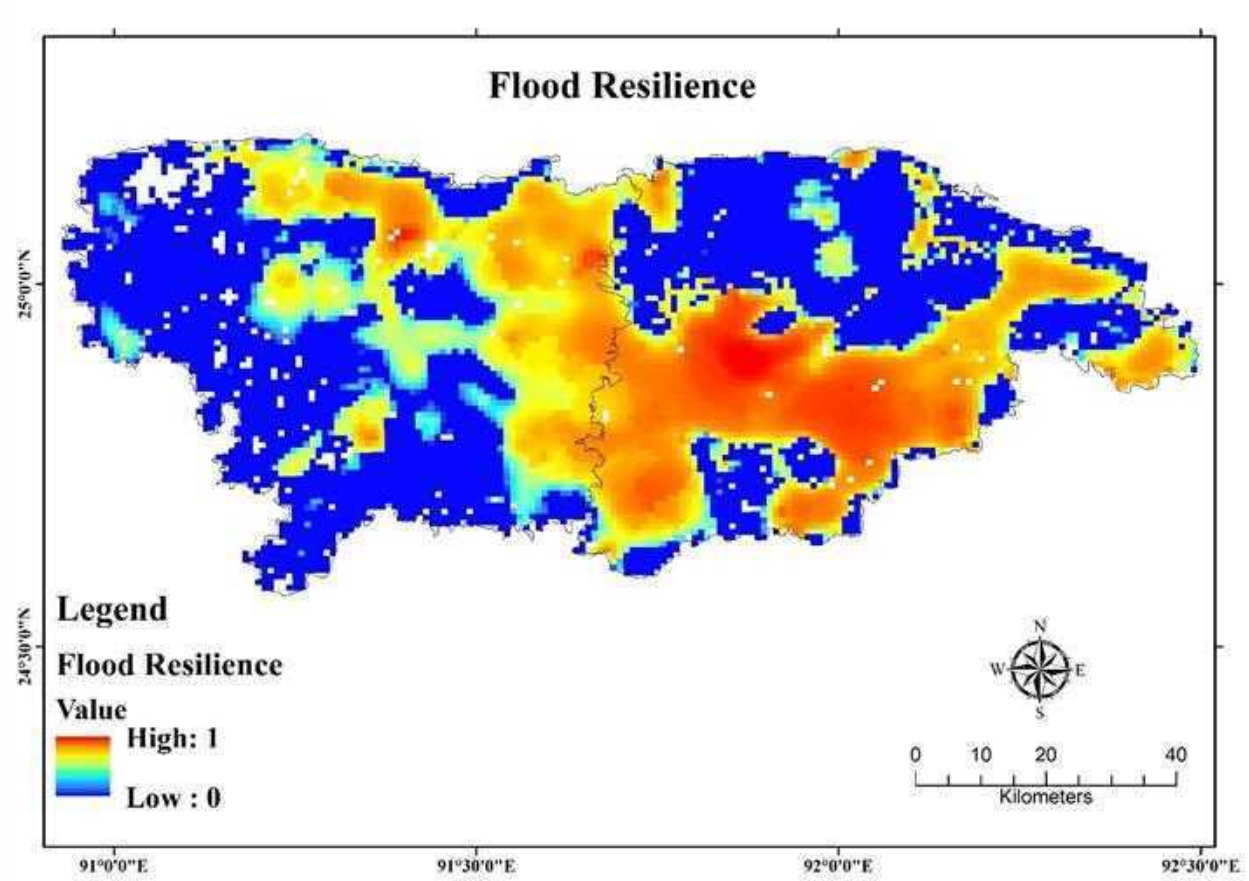


Fig 16: The spatial distribution of the estimated flood resilience in the Sylhet and Sunamganj district in Bangladesh

Flood Resilience and SRSP

The relation between flood resilience and shock-responsive adaptive social protection is shown in the conceptual diagram (Fig. 35). For adaptive social protection, there are four building blocks: data and information, finance, institutional arrangements and partnerships, and programs. Using the physical modeling of the hazards' intensity, magnitude, frequency, and socioeconomic data, the resilience could be calculated for any spatial scale, and then based on the resilience of the individual or community, a specific program could be implemented to increase the resilience as a measure of social protection. The resilience map could give guidelines for where and what kind of program should be taken for any specific area of the community. Thus, resilience mapping could provide decision-support tools for shock-responsive adaptive social protection.

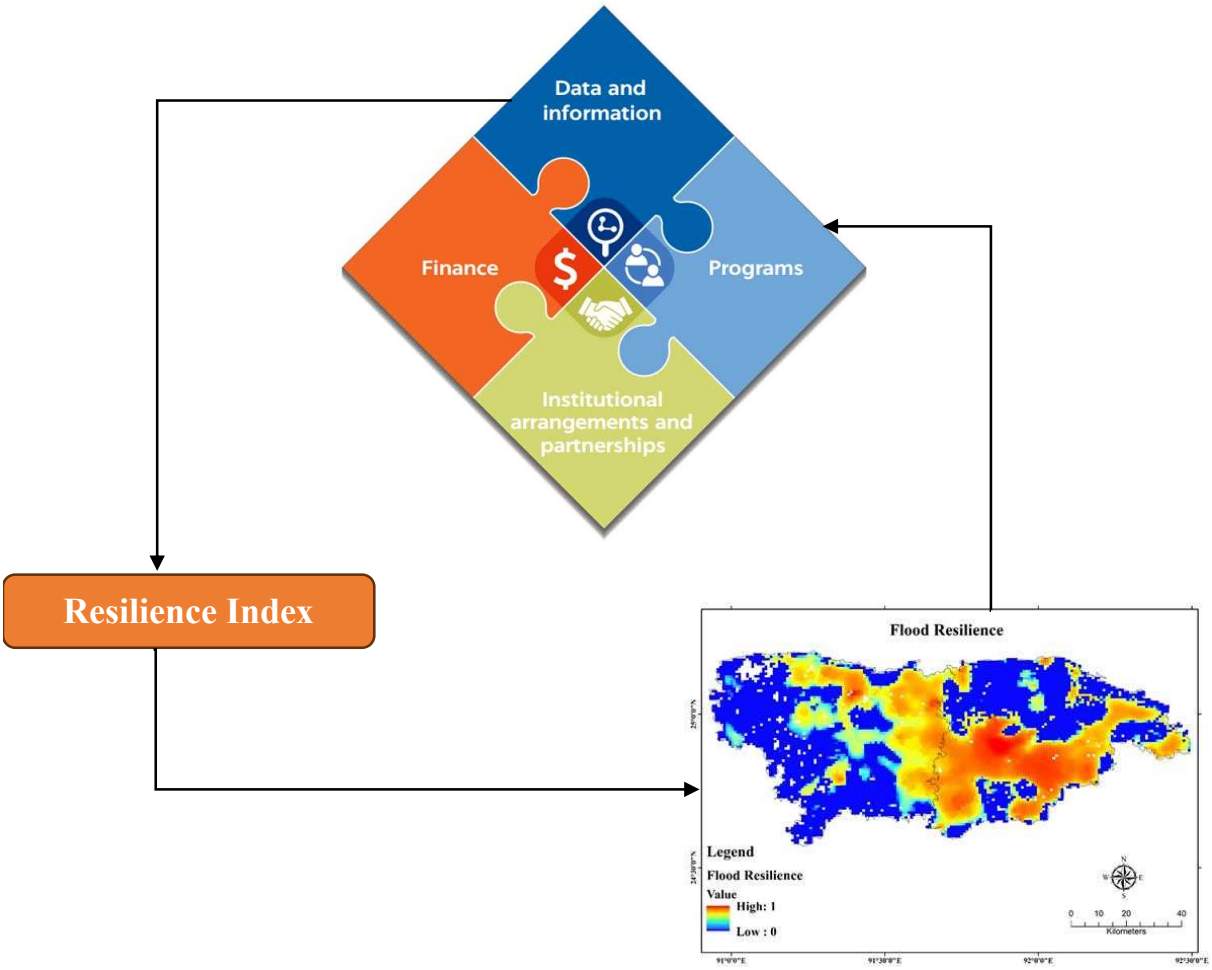


Fig 17: Conceptual framework of flood resilience with the building block of adaptive social protection.

Conclusion

The social, economic, and physical resilience maps of the Sylhet district reveal that the central and eastern parts of the district have high resilience, while the northern and western parts are less resilient. The Sylhet region is more resilient than the Sunamganj district, with a maximum resilience score of 0.97 in the Sylhet metropolitan area. The economic resilience map shows that the majority of the district and eastern part of the Sunamganj district have high resilience, while the western part is less resilient. The physical/infrastructure resilience map shows that the majority of the district and eastern parts have high resilience, while the northern and western parts are less resilient. The flood resilience map could be used for shock-responsive adaptive social protection planning and policymaking. This map could also give a guideline for the implementation of social security or social protection programs in the Sylhet and Sunamganj districts.

Chapter 6
Towards a Shock-Responsive Adaptive Social Protection System in Bangladesh

Heavy monsoon rains and water from upstream in northeast India led to rapid inundation in large parts of the Sylhet division in Bangladesh since May 2022 that left millions of people extremely vulnerable. Local people could not make much preparations for shifting to flood shelters and other safe places because of no forecast for such a rapid inundation in Sylhet and nearby districts due to massive water flow from upstream that created an unprecedented flash flood. It caused a non-trivial magnitude of damage and loss of dwelling houses, business and economic activities, education, health, and social life of the population of the region. According to the Flood Forecasting and Warning Centre (FFWC) of Bangladesh Water Development Board (BWDB), around 94 percent of Sunamganj and over 84 percent of Sylhet districts were submerged by this flood. An estimated 481,827 people were temporarily displaced and took shelter to 1,606 shelter centers, while 83,394 hectares of cropland were inundated by the flash flood. The floods caused significant damage to the stock of agricultural output, foodstuff, livestock, hospitals and educational institutions, water and sanitation facilities, road network and other public infrastructure. Also, the flood had greater and differential impact on vulnerable groups including the poor, households living in remote areas, women, adolescent girls, children, and persons with disability (PWD). An estimated 135,770 houses were damaged fully or partially in Sylhet, Sunamganj, Moulvibazar, Habiganj and Netrakona districts.[1] The flood victims also lost their income, part of their savings to meet expenses during floods, and many essential household items including utensils. The survey results reveal that flood victims suffered from non-trivial physical and psychological impacts that included temporary inability to work, physical weakness, inability to learn, various diseases, and considerable mental stresses among adults, adolescents, and children.

The flash flood has caused widespread displacement and destruction of infrastructure and property in affected districts. The internally displaced population (IDP), including PWD, immediately needed food assistance, safe drinking water, medicine, and cash support to meet their most basic needs, part of which was provided by government agencies, NGOs, charitable organisations, and persons, and CBOs. However, many households living in remote parts that were difficult to communicate were out of reach of relief support. Rapid recovery and rehabilitation supports were also imperative but the coverage was low as evident from the survey.

6.1 Policy Landscape

The 8th Five Year Plan (8FYP) 2020-2025, Bangladesh Delta Plan 2100 (BDP2100) and the Perspective Plan 2041 (PP2041) present detailed strategies for flood risk management, fresh water management, and strategies for haor and flash flood areas. In haor areas, where pre-monsoon flash floods from neighboring hilly regions are common, efforts are needed to protect agriculture and vulnerable communities. Existing Flood Control, Drainage & Irrigation (FCDI) projects have

[1] Global Shelter Cluster, "Bangladesh Flash Flood 2022: 2022-12 Factsheet", available at: https://sheltercluster.org/bangladesh-flash-flood-2022/factsheets/2022-12, accessed on 25 February 2024

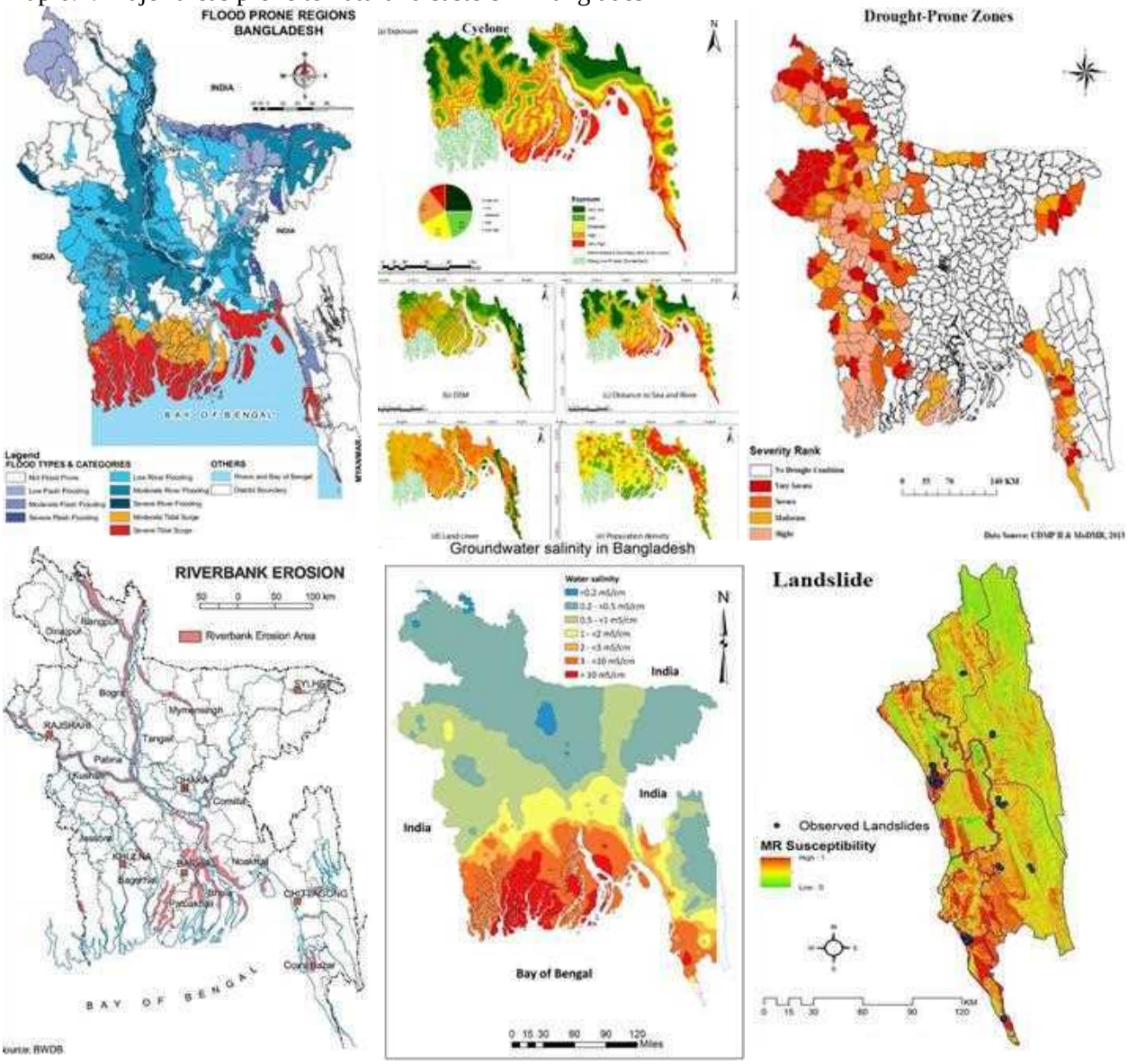
already reduced damages from flash floods in certain river systems. It is crucial to maintain these projects and develop integrated water control structures to address future climatic scenarios outlined in the Bangladesh Delta Plan 2100, such as increased rainfall intensity and peak river discharges. Furthermore, enhancing the conveyance capacity of rivers prone to flash flooding through strategic maintenance dredging and re-excavation is necessary. To prevent post-harvest crop spoilage in haor and flash flood areas, it is important to encourage private and public initiatives and investments in intensive agriculture, specifically focusing on areas where higher returns on investment can be achieved through activities like homestead gardening and intensive livestock production. Promoting mechanisation in the haor and flash flood area is crucial for expediting land preparation, planting, weeding, harvesting, processing, drying, and other agricultural activities. The proposed raised platforms, constructed using dredged spoil, can be effectively utilised to enhance the cultivation of homestead vegetables, pulses, spices, and fruits. As a result, this will contribute to improved nutrition and increased household income. The 8FYP has underscored the importance of creation of alternative livelihood for the people of Haor region.

Mainstreaming climate change and disaster risk management has received attention. The government has taken active steps to integrate climate change and disaster risk management into national planning. Various policies and institutional initiatives have been established to address climate change-related risks. The government is committed to promoting a whole-of-government approach to tackle these challenges. The Local Government Division (LGD) has also mainstreamed climate change into the planning process of 72 Union Parishads (UPs) that are most vulnerable to climate change. This division has supported 300,000 people in building their adaptive capacity against salinity, cyclones, flash floods, and coastal floods. To address new risks, including earthquakes and urban disasters, the Standing Order on Disaster (SOD) has been revised. The government is also developing an ex-ante Disaster Impact Assessment (DIA) tool to integrate knowledge and information on potential disasters into the process of risk-informed planning.

Improving water and sanitation services in challenging climate hotspots is a priority of the 8FYP, which include chars, haors, hilly areas, and coastal regions, which face significant challenges in providing adequate water, sanitation, and hygiene (WASH) services, especially during floods. It has pledged to improve the quality of life of the people of the haors as in 6 haor districts affected by flash floods, both food and income support were given to affected households.

The National Social Security Strategy (NSSS) of Bangladesh 2015 recognised the growth of the social protection agenda in Bangladesh has been driven by both demand and the need to respond to crisis events and democratic aspirations. The country initiated social security programnmes on food security through programs like the Vulnerable Group Development (VGD) and Rural Maintenance Programme (RMP). These programs aimed to address the needs of specific segments of the poor who were not covered by existing programs, such as char-dwellers and vulnerable communities like the Monga belt, Haors, and coastal communities.

Map 6.1: Major areas prone to natural disasters in Bangladesh



Source: Author's compilation

Figure 6.1: Chronology of major natural and climate-induced disasters in Bangladesh

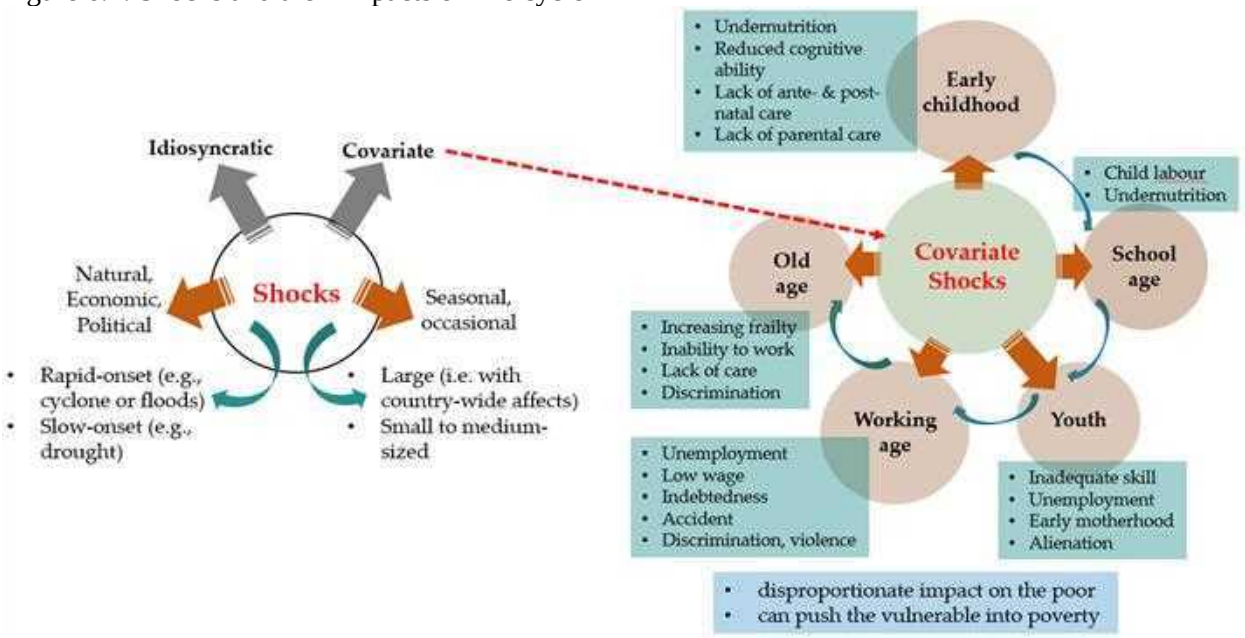
Food security and rural employment programmes have been the main focus in terms of beneficiary participation and funding. With the country's rapid GDP growth and strong agricultural performance in the past decade, the incidence of hunger and food poverty has significantly decreased. There is also evidence of a tightening labor market in agriculture, as reflected in increasing agricultural real wages. However, there are still pockets of poverty, such as char areas, haor regions, coastal belts, and hill districts, that are unable to benefit from the country's economic progress. Therefore, it is important to carefully review the present social security system to ensure its adequacy in meeting the social security needs of the population in Bangladesh in the 21st century.

Climate change presents additional risks to an already disaster-prone region. Communities most susceptible to these risks include coastal populations, those living in low-lying *haor* areas, and urban settlements in vulnerable environments. In terms of beneficiary participation and funding, there is a strong emphasis on food security and rural employment programs. With significant GDP growth and positive agricultural performance in the past decade, the prevalence of hunger and food poverty has significantly decreased. Additionally, there is evidence of a tightening labor market in agriculture, indicated by rising wages in the sector. Given this evolving economic landscape, the nature of poverty and the associated risk profile are also changing. There are still pockets of poverty in areas such as char, haor, coastal belt, and hill districts that are unable to benefit from the country's economic progress. As a result, it is essential to carefully assess the adequacy of the existing social security system to meet the needs of the country (GED, 2015).

6.2 Shock-responsive adaptive social protection

Shock-responsive social protection is centered around addressing covariate shocks that impact a significant portion of the population simultaneously. It involves modifying existing social protection programmes and systems to effectively handle changes in circumstances and needs following large-scale shocks. This can be done in two ways: proactively, by establishing shock-responsive systems, plans, and partnerships ahead of time to enhance preparedness for emergency response; or reactively, by providing assistance to households after the shock has taken place. By doing so, social protection can work alongside and bolster other emergency response measures (European Commission, 2019).

Figure 6.2: Shocks and their impacts on life cycle

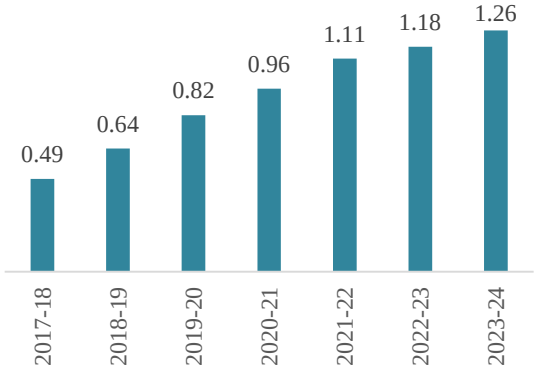


Source: Author

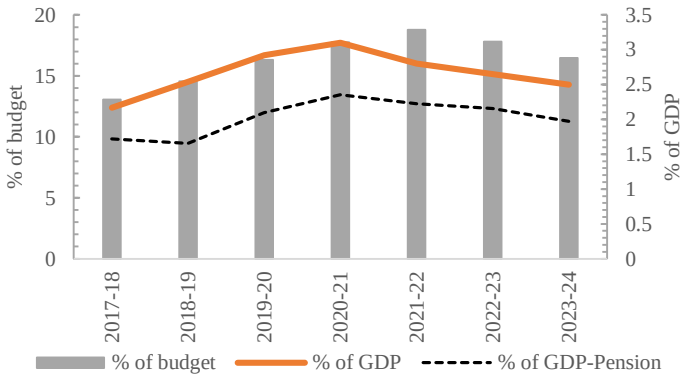
Covariate shocks, stemming from disasters, create considerable impacts on the life cycle of the affected population. It effects all stages of the life cycle of the individuals, starting from early childhood to school age, then youth, working age and finally at the old age. If disasters hamper nutrition in early childhood, then it affects the learning ability of the children creating a lifetime impact. At other stages of life, covariate shocks lead to unemployment, early motherhood, school dropout, increasing vulnerability to poverty, low wages, indebtedness, and finally increasing fragility at the old age. Therefore, a shock-responsive adaptive social protection (SRASP) should aim to give protection from and reverse the negative impacts of disaster- and climate-induced shocks in the life cycle of the vulnerable population.

Figure 6.2: Trend of allocation in social protection

(a) Trend of budget (trillion Tk.)

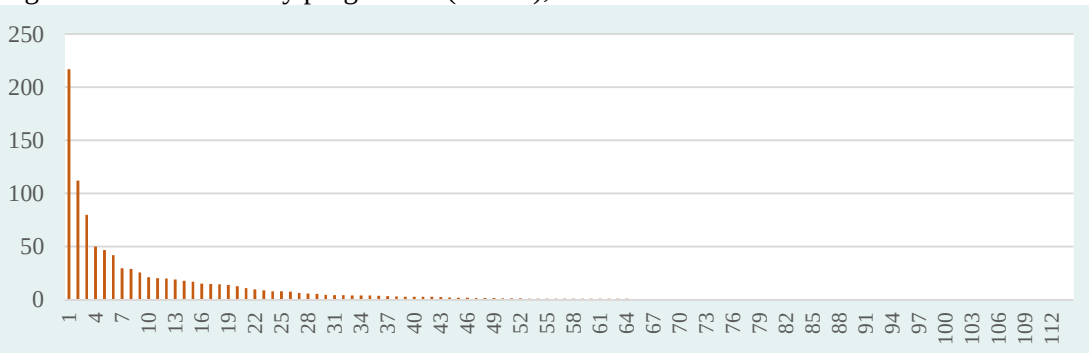


(b) Share in budget and GDP (percent)



Note: Data till FY2022-23 indicate revised budget, data for FY2023-24 indicate provisional budget and GDP
Source: Author's analysis based on Finance Division's data (various years)

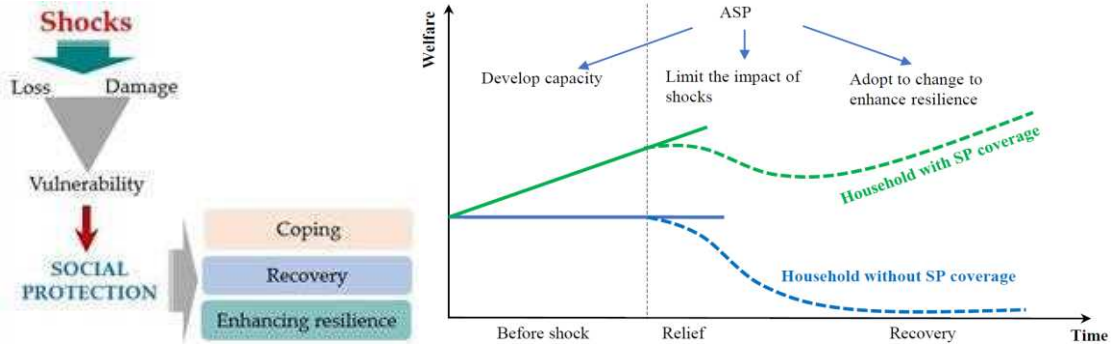
Figure 6.3: Allocation by programme (Tk. bn), FY 2023-24



Source: Author's analysis based on Finance Division's data (2023)

The GoB has been spending a considerable amount of resources on social protection in Bangladesh. In fiscal year 2023-24, the allocation is 16.5 percent of the national budget in 115 schemes and 2.5 percent of the Gross Domestic Product (GDP). The share of social protection spending was the highest in the fiscal year 2020-21 in GDP (3.1 percent) and in 2021-22 in national budget (18.78 percent of the budget). A large number of small schemes are listed in social protection (52 schemes less than Tk.1 billion). However, such a high total allocation is consistent with the government's commitment towards implementing the NSSS 2015, which emphasises on life cycle approach to social protection.

Figure 6.4: Role of ASP during the phases of shocks



Shocks, especially emanating from natural disasters and climate change create at least three impacts: vulnerability, loss, and damage. However, social protection helps develop coping capacity, supports early recovery, and enhances the resilience of the affected population. Households without social protection incur permanent depletion of welfare. With capacity development, limiting the impact of shocks, and enhancing climate resilience, adaptive social protection helps recover affected populations regain the increasing level of welfare.

The government has been allocating a considerable amount of resources on social protection focusing on the impacts of natural disasters and climate change, with special attention on climate hotspots. In the fiscal year 2023-24, the allocation for disaster- and climate-related social protection programmes was Tk.200 billion, which was 15.9 percent of the social protection budget. The programmes that are focused on flash flood haor areas include Relief Goods, Disaster Grant; Relief Works (flood, drought, cyclone, and others); Special assistance for the development of people in chars, haors, and backward areas; Infrastructure and livelihood Improvement in Haor

and Coastal Area; and Flood Management and Livelihood Improvement Project in Char/Haor Area.

Indeed, social protection includes policies and programmes to provide support and assistance to individuals and households facing various risks and vulnerabilities. It extends support through, among others, allowance, workfare, child and maternal support, access to essential services, and social insurance. These aim at reducing poverty and inequality, mitigating social and economic risks and vulnerabilities, building resilience, and developing human capital through education, training, and skill development.

Figure 6.5: The role of the social protection system throughout the shock cycle

Source: Adapted from UNICEF (2019)

Table 6.1: Allocation for and beneficiary of disasters and climate change-related projects

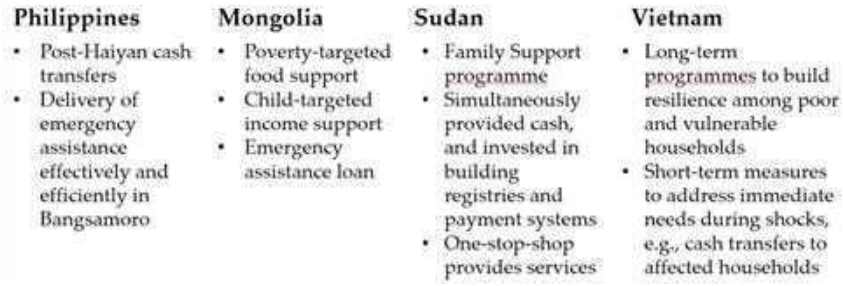
Description	Implementing Ministries/ Divisions	Beneficiaries (Persons in lac)			Budget (Taka in crore)		
		Budget 2022-23	Revised 2022-23	Budget 2023-24	Budget 2022-23	Revised 2022-23	Budget 2023-24
Vulnerable Group Feeding (VGF)	MoDMR	180	257.14	180	991.07	1,542.19	1,089.79
Gratuitous Relief (Food)	MoDMR	33	33	33	589.92	621.85	648.68
Food For Work (FFW))	MoDMR	9.8	9.8	9.8	876.27	989.73	991.97
Work For Money (WFM)	MoDMR	18.2	18.2	18.2	1,500.00	1,500.00	1,500.00
Test Relief (TR) (Cash)	MoDMR	3.69	3.69	3.69	1,450.00	1,450.00	1,450.00
EGPP	MoDMR	5.18	5.97	5.18	1,830.00	2,107.62	1,780.00
Relief Goods	**MoDMR**	**82.9**	**82.9**	**80**	**190.00**	**190.00**	**180.00**
Disaster Grant	**MoDMR**	**-**	**-**	**-**	**100.00**	**20.00**	**40.00**
Relief Works (flood, drought, cyclone and others)	**MoDMR**	**4.8**	**4.8**	**4.8**	**81.00**	**81.00**	**80.20**
PM's rehabilitation assistance to the people of river erosion-affected areas	Finance Division	-	-	-	100.00	100.00	100.00
Agricultural Rehabilitation	Agriculture	56.35	56.35	60.97	500.00	500.00	600.00
Special assistance for development of people in chars, haors and backward areas	**Finance Division**	**0.25**	**0.3**	**0.3**	**50.00**	**50.00**	**50.00**
Fund for Climate Change	MoEF	3.52	3.52	3.52	100.00	100.00	100.00
Skills Development and Earthquake Risk Management Fund	MoDMR	-	-	-	100.00	100.00	100.00
Funds to deal with economic and natural shocks*	Finance Division	18.5	22	22	5,000.00	2,000.00	8,000.00
Ashroyan-2 Project	PMO	1.51	1.63	1.5	1,190.00	1,190.00	1,530.03
Increasing the adaptability of coastal communities, especially women, to tackle salinity caused by climate change	MOWCA	0.43	0.43	0.43	87.06	64.53	66.00
Rural/Grameen Infrastructure Development16	LGD	-	-	-	314.53	471.28	385.16
Construction of the Multiple Disaster Shelters	LGD	500	430	470	628.40	400.00	418.71
Rural employment and road maintenance	LGD	0.57	0.48	0.49	551.92	413.45	409.18
Infrastructure and livelihood Improvement in Haor and Costal Area	**LGD**	**0.01**	**0.01**	**0.01**	**70.55**	**30.96**	**16.86**
Gucchagram (Climate Victims Rehabilitation) Project	MoEFCC	0.02	0.02	0.02	94.00	30.00	59.35
Flood Management and Livelihood Improvement Project in Char/Haor Area	**Water Resources**	**0.13**	**0.13**	**0.13**	**86.23**	**84.52**	**44.07**

Description	Implementing Ministries/ Divisions	Beneficiaries (Persons in lac)			Budget (Taka in crore)		
		Budget 2022-23	Revised 2022-23	Budget 2023-24	Budget 2022-23	Revised 2022-23	Budget 2023-24
Construction of Flood Shelter in the Flood and River Erosion Prone Area	MoDMR	1.8	1.8	1.8	290.00	290.00	250.00
Char development and settlement project-bridging	Water Resources	0.78	0.78	0.78	65.48	104.81	117.58
Total					**16,836.43**	**14,431.94**	**20,007.58**
Social security					**113,576**	**117,634**	**126,090**
Disaster/climate-related social security % of social security budget					14.82	12.27	15.87

* This fund has been created for the day-labourers, farmers, laborers, domestic workers, and victims affected by natural calamities, such as floods, untimely floods, storms, hailstorms, cyclones, etc.

Source: Finance Division (2023)

Figure 6.6: Shock-responsive social protection: Global practice



Source: Author's compilation

National documents have emphasised social security for disaster-prone and climate-vulnerable areas. NSSS 2015 focused on life-cycle-based social security, focus on disasters, climate change, and co-variate shocks. SOD 2019 highlighted immediate disaster management, relief operation response, recovery, and administrative roles and responsibilities. National Plan for Disaster Management (NPDM) 2021-2025 highlighted on disaster management, relief, response, recovery, assessment, institutional collaboration, and partnership. The 8FYP emphasised on disasters & climate change and received special attention, and social protection in the context of NSSS, disasters, and climate change. PP2041 mentioned social security as a part of long-term development. Disaster Management and Climate Change Adaptation (CCA) are key to addressing developmental challenges. National Adaptation Plan of Bangladesh (2023-2050) presented a long-term plan for facilitating climate change adaptation and outlined a detailed plan for individual and community-based adaptation.

6.3 Shock-Responsive Adaptive Social Protection System based on SDGs:

6.3.1 Common SDGs Policy Focused

Integration with Sustainable Development Goals (SDGs): Align the development of a shock-responsive adaptive social protection system in Bangladesh with the objectives outlined in the SDGs, particularly those related to poverty alleviation (Goal 1), zero hunger (Goal 2), decent work and economic growth (Goal 8), reduced inequalities (Goal 10), and climate action (Goal 13).

Strengthening Resilience: Enhance the resilience of vulnerable populations by integrating shock-responsive measures into existing social protection systems. This may involve implementing early warning systems, improving disaster preparedness and response mechanisms, and promoting livelihood diversification to withstand climate-induced shocks.

Targeted Assistance: Tailor social protection programs to address the specific needs of different demographic groups, such as women, children, the elderly, and persons with disabilities, who are disproportionately affected by climate-induced disasters. Ensure that the most vulnerable communities receive adequate support during times of crisis.

Enhancing Data and Monitoring: Improve data collection, analysis, and monitoring systems to accurately assess the impact of climate-induced shocks on vulnerable populations and track progress toward achieving the SDGs. Utilize advanced technologies, such as remote sensing and geographic information systems (GIS), to enhance data accuracy and accessibility.

Strengthening Institutional Capacities: Build the capacity of government agencies, non-governmental organizations (NGOs), and other stakeholders involved in the implementation of social protection programs to effectively respond to climate-induced disasters. Foster collaboration and coordination among relevant institutions to ensure a coherent and efficient response.

Empowering Communities: Empower local communities to actively participate in the design, implementation, and monitoring of shock-responsive adaptive social protection programs. Promote community-based approaches that leverage local knowledge and resources to build resilience and enhance adaptive capacity.

Mainstreaming Climate Adaptation: Mainstream climate adaptation considerations into national development policies and strategies to promote sustainable and inclusive growth. Ensure that social protection interventions are aligned with climate adaptation goals and contribute to building climate resilience at both the community and national levels.

Strengthening Policy Coherence: Promote policy coherence across sectors, including social protection, disaster risk reduction, agriculture, and environmental conservation, to address the underlying drivers of vulnerability and build long-term resilience. Ensure that policies are coherent, complementary, and mutually reinforcing to maximize their impact on sustainable development and poverty reduction.

6.3.2 Mapping of Strategic SDG-Focused Programs: Initiating Organisations, Importance, Rationale, and Implementation

Program	Initiating Organization	Why	How
Community-Based Climate Resilience Centers	Ministry of Disaster Management and Relief (MoDMR), in collaboration with local NGOs such as BRAC and CARE Bangladesh	To empower vulnerable communities with access to climate-resilient infrastructure, disaster preparedness training, and livelihood support.	Establishment of CBRCs in disaster-prone areas, offering training workshops, providing resources for disaster preparedness, and supporting community-led initiatives for sustainable livelihoods.
Climate-Smart Agricultural Extension Services	Ministry of Agriculture, in collaboration with international organizations like FAO and local agricultural NGOs such as Bangladesh Agricultural Development Corporation (BADC)	To promote climate-smart agricultural practices among farmers, enhancing food security and resilience to climate change.	Provision of training to farmers on climate-smart agricultural techniques, including drought-resistant crops, efficient irrigation methods, and agroforestry.
Green Jobs Creation and Skills Development Program	Ministry of Labor and Employment, in partnership with international organizations like ILO and local NGOs such as the Bangladesh Employers' Federation (BEF)	To address unemployment and poverty while promoting environmental sustainability through the creation of green jobs and skills development training.	Identification of green job opportunities, provision of skills training to unemployed youth and marginalized groups, and promotion of green business practices.

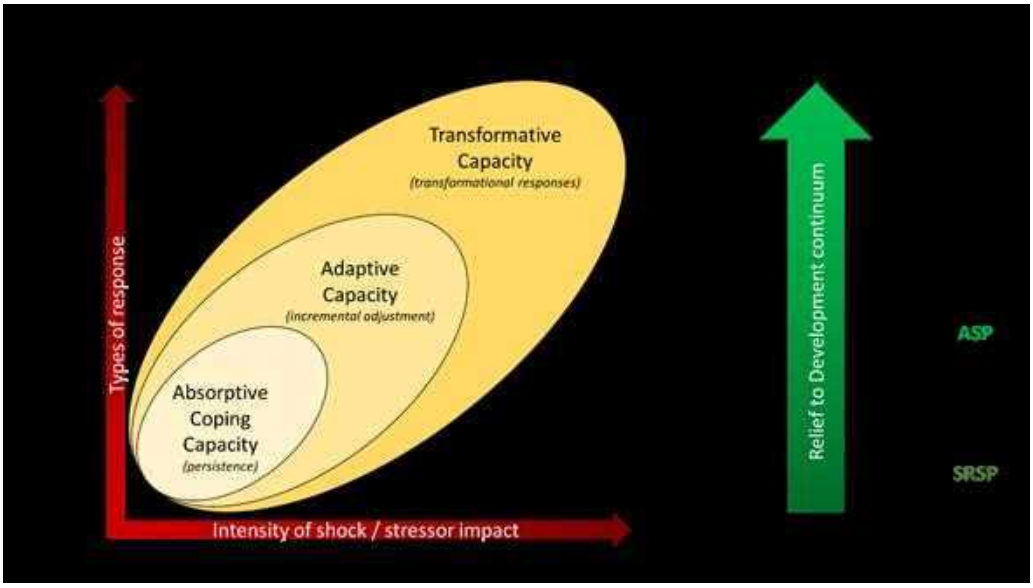
Program	Initiating Organization	Why	How
Integrated Water Resource Management (IWRM) Initiative	Ministry of Water Resources, with support from international organizations such as UNDP and local NGOs like WaterAid Bangladesh	To improve water governance, ensure equitable access to water resources, and mitigate water-related risks such as floods and droughts.	Development and implementation of IWRM plans, involving stakeholder consultations, capacity building, and adoption of integrated approaches to water management.
Education for Sustainable Development (ESD) Program	Ministry of Education, in partnership with UNESCO and local educational NGOs such as BRAC Education Program	To integrate sustainability principles into the education system, fostering knowledge, skills, values, and attitudes necessary for building a sustainable future.	Collaboration to develop ESD curriculum materials, train teachers, integrate sustainability themes into school curricula, and engage students, parents, and communities in environmental conservation and sustainable development initiatives.

6.4 Towards Shock Responsive Adaptive Social Protection in Bangladesh

Adaptive Social Protection (ASP) helps develop the resilience of poor and vulnerable households by investing in their capacity to prepare for, cope with, and adapt to shocks, to prevent them from falling into poverty. In the short run, Shock-Responsive Social Protection (SRSP) helps absorb climate-induced shocks while ASP promotes climate resilience through an inclusive social protection system. Idiosyncratic and covariate shocks generated by climatic events impact adversely on various stages of the life cycle of the affected communities, viz. early childhood, school age, youth, working age, and old age. Adverse shocks of climatic events have non-trivial impacts on the poor and vulnerable people that substantially reduce their welfare in the absence of effective adaptive and shock-responsive social protection.

At the global level, Vietnam, the Philippines, Mongolia, and Sudan practice SRSP and ASPs. However, their scale of operation is mostly limited to climate-vulnerable regions and directly affected groups, without large-scale national coverage. In Bangladesh, social protection policies and programs include support and assistance to individuals and households facing various risks and vulnerabilities. The country is exposed to increased incidences of large and frequent climatic events, such as cyclones, floods, droughts, and salinity. Two of its largest programmes, viz. (a) Agricultural subsidy (Tk.21.7 bn) and (b) Funds to deal with economic and natural shocks (Tk.8 bn) are included in ASP and SRSP even though benefits could be much higher if they are designed optimally. Important national documents, such as the 8FYP (2020-2025), PP2041, NPDM (2021-2025) NSSS 2015 suggest incorporating disasters and climate change in social protection that lay the foundation for ASP and SRSP in the country. The NSSS 2026 will have the climate to develop social protection programmes.

Figure 6.7: Adaptive and shock-responsive social protection in the context of resilience and the development continuum



Source: Cornelius (2018), Béné et al. (2018)

The proposed framework of shock-responsive adaptive social protection in Bangladesh has seven steps that include identifying shocks; assessing vulnerability, damage, and loss; designing and modifying social protection programs; financing and implementing interventions; monitoring and evaluation; scaling; and coordination and collaboration across stakeholders.

Step 1: Conduct a national baseline to identify shocks

Shocks emanate from natural disasters, climate-induced events, fire hazards and accidents, and economic downturns. These shocks affect the well-being of individuals and communities. The effects include income erosion, displacement, increased incidence of poverty, damage to houses and assets, crop loss, psychological damage, nutritional deficiency, and depleted general and reproductive health stock. As the survey results reveal, shocks disproportionately affect the elderly, children and adolescent girls, and PWD disproportionately.

Cyclone Amphan

- 2.4+ million people were moved to 14,636 shelters in 19 coastal districts
- Apprx. 2.6 million people were affected
- 205,368 houses were damaged and 55,767 houses were destroyed
- 26 people lost lives
- 40,894 latrines, 18,235 water points, 32,037 hectares of crops and vegetables, and 18,707 hectares of fish cultivation area were damaged

A comprehensive range of idiosyncratic and collateral shocks needs to be identified that emanate from climatic events and impact the life cycle of vulnerable households, especially those who live in climate hot-spots. The baseline of shocks and associated vulnerable households can be generated through conducting a nation-wide survey and mapping. Thereafter, the existing social protection schemes need to be modified in line with the temporary and life-cycle impacts, and assessed vulnerability, damage and loss.

Step 2: Assess vulnerability, damage and loss

The shock cycle persists because of the lack of necessary modification of social protection schemes. The major drawbacks of the current social protection programmes are limited assessment of damage and loss, inadequate understanding and timely monitoring of risks and vulnerability, lack of robust scientific modeling and forecasting of major disasters for social protection schemes, and lack of rapid needs assessment to address shocks immediately through social protection.

For developing SRASP, there is a need for a comprehensive assessment of vulnerability, damage, and loss in disaster-prone areas and climate hotspots of the country. The assessment would entail:

- Nature, extent, depth and severity
- Vulnerability, damage and loss
- Households, occupations
- Physical and mental health, nutrition
- Gender, ethnicity
- Education and health services

In doing so, is important to identify who is most at risk and what are their specific needs. Assessing vulnerability, damage and loss could be conducted through developing a common baseline all over Bangladesh in line with the climate hotspot identified in the BDP2100, and constructing a resilience index for Bangladesh.

Step 3: Design and Modify Social Protection Programmes

For SRASP transformation, there is a need for intervention in the major streams of programmes for redesigning and modification. The streams are:

- Transfers – cash and kind
- Healthcare and nutritional support
- Workfare
- Insurance
- Index-based SP scheme

There is a need for addressing the identified vulnerabilities from step 1 and 2. The major cross-cutting issues to be considered are gender, age, disability, ethnicity, income, occupation, spatial characteristics, nature-dependence, recurrence of exposure of the disasters and climatic events. The core agencies and organisations will include the Ministry of Disaster Management and Relief at the centre, which would be accompanied by, among others, the General Economics Division (GED) of the Planning Commission, Cabinet Division, Prime Minister's Office, Finance Division and Ministry of Social Welfare. The other agencies would involve the Ministry of Environment, Forest and Climate Change; Ministry of Health and Family Welfare; Ministry of Labour Employment; Local Government Division; and development partners. Academia and think tanks can be important partners would be involved in the design, monitoring, research, reporting, and developing technical instruments for implementation of the programmes.

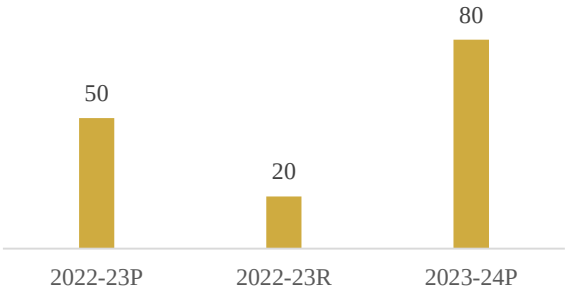
Figure 6.8: Core Agencies and Partners

Source: Author's compilation

Step 4: Finance and Implement Interventions

After new designing and modification of the existing programmes with the necessary inclusion of disaster and climate dimensions, the main challenge will be to finance for implementation of the schemes. It is important to recognise that lower-income households suffer from higher damage and loss as evidenced from the survey results. In addition, there is evidences of gender-based differences, especially against women, in terms of food intake, WASH, management of personal hygiene, etc. during devastating floods in Sylhet division. The elderly population and PWD also find it difficult to access flood shelter and stay comfortably. There are issues related to personal safety and privacy, especially for women and girls. Therefore, the SRASP will need to finance and implement considering manifold aspects of the disaster-affected and climate-vulnerable population going beyond the traditional approach of intervention through transfer and creating simple infrastructure. Additional funding and manpower will be required for specialised and targeted intervention to effectively benefit the affected segments of society.

Figure 6.9: Allocation for "Funds to deal with economic and natural shocks" (Tk. bn)



Source: Based on Finance Division data

Among the social security schemes, "Funds to deal with economic and natural shocks" has received the second largest allocation, which is tailored to support the day-labourers, farmers, general workers, domestic workers, and victims affected by natural disasters including regular and flash floods, cyclones, and other climatic events. To reach the benefit of this programme to intended groups, proper financing and implementation mechanism are required to avoid significant under-implementation (Figure 6.9). Therefore, it is necessary for SRASP to determine the necessary budget for each scheme, secure funding, and coordinate with development partners to ensure adequate resources as technical aspects are involved in effectively implementing the schemes.

Thus, it must be ensured that the SRASP to deliver the intended support to the target group, provide access to necessary services, and monitors the effectiveness of the interventions through regular and random spot visits. At the same time, the principles of resource allocation for SRASP should be determined to reach the programmes to the target group complying with equity, equality and social justice to ensure the overarching national priority target of the SGDs, i.e., "leave no one behind". In doing so, resource gap analysis as well as cost-effectiveness and value-for-money analysis need to be conducted.

Step 5: Monitor and Evaluate

To understand the effective implementation of the programmes and need for new programmes, data need to be collected at regular intervals by academia and think tanks. Third party monitoring is essential to ensure effective targeting and implementation. It will help measure outcomes and make adjustments in the schemes as necessary keeping in mind the drawbacks. In doing so, a comprehensive disaster atlas needs to be developed for entire Bangladesh to complement the two important national documents, BDP2100 and Bangladesh Disaster-Related Statistics 2021. In addition, few important maps need to be prepared based on the baseline survey all over the country to effectively monitor and evaluate the programme implementation at the micro, meso, and macro levels:

- Inundation map
- Exposure map
- Damage and loss map
- Index-based shock-vulnerability and resilience map vs. poverty map
- Scenario analysis – simulation of future disasters and shocks

The following tools can be utilised in assessing effectiveness of SRASP:

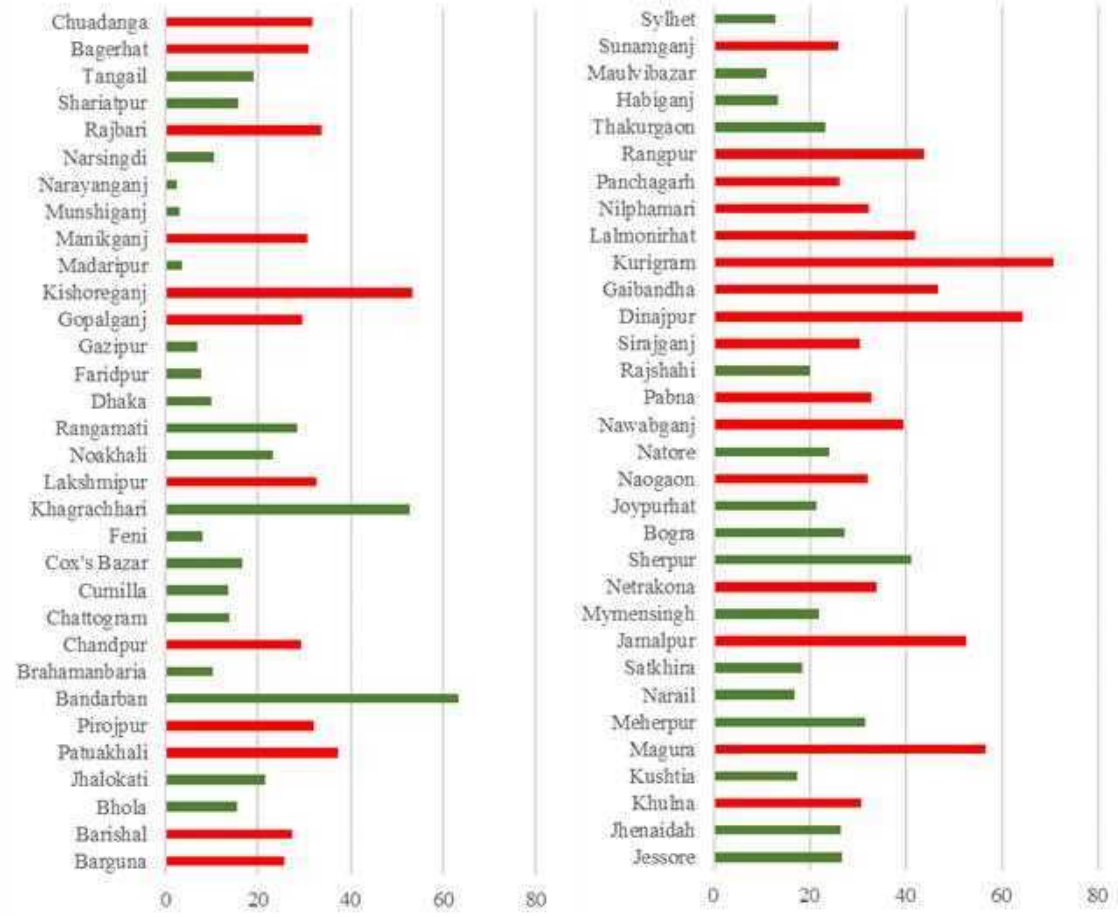
- World Bank's Software Platform for Automated Economic Analysis (ADePT)
- Benefit incidence analysis
- Performance audit
- Ethnographic study – understand life-cycle impacts

These exercises will help draw policy lessons for further improvement of the impact and efficiency of the interventions.

Step 6: Adapt and Scale up

It is important for devising strategy to expand coverage of SRASP. For example, nearly half of the districts of Bangladesh are poverty-stricken, which are also disaster-prone and climate-vulnerable (see, red bar of Figure 6.10). However, some existing schemes are working fairly well to cover the poorest population of these districts to reduce vulnerabilities due to disasters and climate change. These programmes are being implemented only in rural areas while urban poor populations are also equally sufferer in those districts. Therefore, scaling up the existing programmes, e.g., urban extension EGPP in disaster-prone regions would be an interim solution before introducing a new programme for the same target group. It will require an increased amount of support. At the same time, new measures need to be introduced to address emerging needs of the affected population.

Figure 6.10: Major disaster-prone and climate-vulnerable districts



Note: Districts with red bar indicate disasters-prone district with higher incidence of poverty than national average
Source: Based on BBS (2018)

Step 7: Coordinate and Collaborate

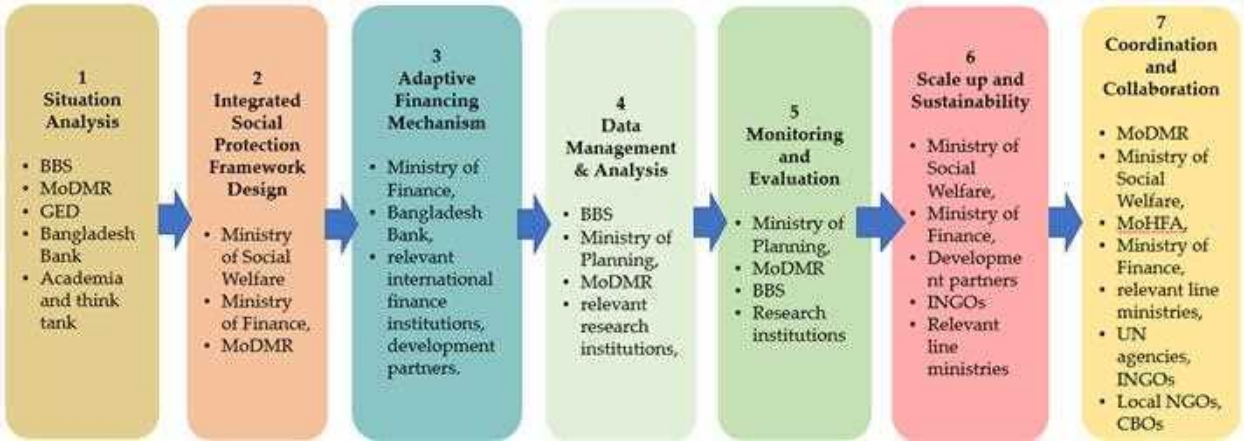
Coordination and collaboration among stakeholders will be the final and most important part of an effective SRASP strategy as the lack of effective cooperation and collaboration among relevant agencies is often cited as the principal drawback of the social protection programmes in

Bangladesh. The list of relevant institutions and agencies has been furnished in Figure 6.11. However, the main group of organisations are:

- Government agencies
- NGOs
- Development partners
- Private sector
- Academia
- Other relevant organisations

Some programmes will be completely new, and will require piloting, and randomized control trial (RCT) in most disaster-prone areas (e.g., coastal zone). Effective and meaningful coordination and collaboration will help design, mobilise resource and technical support, implement, monitor evaluate the programmes for scaling up after piloting some experimental schemes. It will help ensure a cohesive and efficient response to the shocks, and early recovery and rehabilitation.

Figure 6.11: Coordination of Agencies in Establishing SRSP



Keeping in mind the developmental trajectory of Bangladesh, viz. becoming an upper middle-income country by 2031 and Medium- to long-term developmental approach to ASP. Projection in the Medium Term Budgetary Framework (MTBF) will be required to understand resource requirements, strategic objectives, and tangible outcomes along with poverty and gender impacts.

To secure external funding and technical assistance, the country strategies of the development partners need to be assessed. Currently, the 'climate' component is available in the Overseas Development Assistance (ODA) of IMF, World Bank and ADB, which can be utilised for designing and implementing the SRASP. Finally, the Loss & Damage Fund can be a long term and viable source of funding for the SRASP.

The Government of Bangladesh implements social protection programmes as one of its core strategies for addressing risks and vulnerabilities, reducing poverty and inequality, and socio-economic development for disadvantaged and backward communities. Climate change will be a major driver of strategy and resource use in social protection in the country in the backdrop of increased frequency of disasters leading to non-trivial damage and loss, and vulnerability.

Therefore, the focus of the proposed SRASP should be on effective short-term response and long-term recovery and resilience.

Annex

Annex 1: Damage, loss and needs

Table A1: Estimates of damage by broad category

Sector		Sunamganj (Tk. Mn.)	Sylhet (Tk. Mn.)
Infrastructure	Transport & Communications	3,831.1	4,000.3
	WASH	2,087.9	553.3
	Water resources management	705.9	1,788.4
	Energy	35.8	30.4
Productive	Agriculture, livestock & fisheries	1,574.1	1,728.6
	Commerce and industry	-	10.9
Social	Housing	2,977.5	2,155.9
	Education	195.3	82.5
	Health	16.2	19.4
	Culture and heritage	44.4	46.5
Cross-cutting	Environment	5,,99.2	455.9
Total		12,067.4	10,872.0

Table A2: No. of tube-wells and sanitation facilities damaged

	Deep		Shallow		Sanitation	
	Fully	Partially	Fully	Partially	Fully	Partially
Sylhet	532	7,232	1,742	12,674	46,750	100,949
Sunamganj	3,408	26,208	4,076	18,149	33,368	48,207
% of all flood-affected districts	79.40	88.37	78.13	84.82	82.25	86.45

Table A3: Damage, loss, and needs in the agriculture and livestock sector

		Sylhet	Sunamganj
Damage (Tk lac)	Agricultural machinery	2,862	4,502
	Inputs	6,747	21,980
	Livestock	304	1,033
	Seedbeds	91	119
Total Damage (Tk lac)		10,004	27,634
Land Damage (Ha)		27,317	7,379
Yield (MT/Ha)		5.3	4.9
Loss of Production (MT)		144,780	93,767
Total loss (Tk lac)		39,091	25,317
Total damage and loss	(Tk lac)	49,095	52,951
	($ million)	47.3	51.0
Recovery & reconstruction needs	(Tk lac)	16,729	21,412
	($ million)	16.1	20.6

Table A4: Loss in agriculture sector

	Crop area damaged (Ha)	MT/Ha	Total rice production (MT)	Total rice production lost (MT)	% of production lost	Value of loss (Tk lac)
Sylhet	27,317	5.3	250,496	144,780	57.8	39,091
Sunamganj	19,136	4.9	819,988	93,767	11.4	25,317

Table A5: Damage, loss, and needs

	Damage		Loss		Total damage and loss		Recovery & reconstruction needs	
	(Tk lac)	(US$ mil.)	(Tk lac)	(US$ mil.)	(Tk lac)	(US$ mil.)	(Tk lac)	(US$ mil.)
Sylhet	95,083	91.6	55,873	53.8	150,956	145.4	138,258	133.2
Sunamganj	165,640	159.6	56,107	54.0	221,747	213.6	240,218	231.4

Source: MoDMR. 2023. *Post Disaster Needs Assessment Bangladesh: Floods 2022*, Dhaka: Government of Bangladesh

Annex 2: Case stories

Case 1: Survivors on the Bridge: A Flood's Tale

In the heart of Union Noarai, the residents of Barkahon found themselves confronting a challenge unlike any they had encountered before. Nestled amid the serene yet treacherous Surma River in the year 2022, this community faced the overwhelming force of a flood that turned the once tranquil river into a formidable test of resilience. The Surma River, usually a source of both life and potential peril, had breached its banks, unleashing a torrent that swiftly engulfed homes and landmarks, compelling people to seek refuge from its destructive path.

As the floodwaters rose with alarming speed, leaving devastation in their wake, the inhabitants of Barkahon found themselves in a dire predicament. Despite the urgency of the situation, a glaring absence became apparent – there was not a single shelter center in the area. In their hour of greatest need, when homes were lost, and safety became a scarce commodity, the community struggled to find a haven from the relentless force of nature.

Jubi Begum, a strong mother, and her neighbours decided to stay alive, and the Surma Bridge became their safe haven. This concrete span, which was never meant to hold people, became an alternative home for those who had to leave their homes. Every day was a fight on the bridge. They made it through without toilets, clean water, or the simple comforts of home. Women, like Jubi begum, Rupjan, Anowra, Jahanara had to go through extra hardships and had to wear their damp cloths throughout those days as there was no place to clean them. When the men had to choose between staying to protect their homes and going home to be with their families, they often chose to stay and keep watch alone against the endless waves.

Figure 1: Surma Bridge

A community leader named Mr. Borhan talked about a shelter house that was out of reach because it was already full of people looking for safety. The people of the uzanpara asked for help many times, but not many people responded. Non-governmental organisations sometimes sent help, like a matchbox, dry food which wasn't enough to meet the needs of the people who had to leave their homes.

This is not just a case about how to stay alive; it's also a call to action. People from Uzanpara were on the bridge went through terrible things that most people can't even imagine. No one came forward to help them or to hear their sufferings.

Case 2: Birthing Hope in the Deluge: A Pregnant Mother's Struggle Amidst the Floodwaters

“This is my child; my mother-in-law named her Banna.” A 28-year-old woman, Rajia, rushed to her house to bring her child and started telling her courageous story.

In the Fatehpur Union, where the entire area is flooded, there are people fighting to survive on their own. Among them is **Rajia**, who endures excruciating pain in trying to save not only her own life but also the life of the unborn child. Rajia, a strong woman nearing the end of her pregnancy.

Chaos and fear erupted as the floodwaters continued to advance into Fatehpur. Families quickly fled and sought safety in flood shelters. Nevertheless, Rajia’s condition complicated an already dangerous position. Like many others, her house was flooded, making it difficult to navigate the dangerous currents. As time went on, Rajia and her husband navigated waist-deep waters in search of cover and safety. There were several obstacles during the expedition, including fast-moving currents, hidden debris, and a persistent worry of getting hurt. Rajia gripped her swelling tummy, and their fight intensified with the child's imminent arrival.

“As I counted down the days until my baby's delivery, I was already anxious and afraid. It was made worse in every way possible by this deluge. I had trouble moving at all. We went to the flood shelter with completely empty hands after I could barely manage to tie a piece of fabric around my tummy to provide support when the flood came. My mother made a lot of clothes for my child, but I was unable to transport anything to the shelter in time. Despite the fact that we were in the shelter, my suffering persisted. A room had more than forty individuals in it, and about fifty people were using the same bathroom. I was devoid of drinking water for a full day. However, I later had some meals. The locals joined together and shared what few resources they had, even if the temporary shelters did not provide much comfort. Despite her physical exhaustion, Rajia took comfort in her community's companionship. Upon learning of her impending birth, the village's ladies came together to support and encourage her.

Since there was no indication that the floodwaters would go down, the villagers, trying to restore some sort of order, gave Rajia a corner of the improvised shelter. An elderly midwife with years of experience stepped out as a powerful figure. The people in the neighborhood combined their scant resources to construct a birthing room, giving Rajia some privacy at this personal but difficult time.

“Many nights come and go, but that night I will always remember. The rain drummed down on the makeshift roof the night I gave birth. With hands worn with age, the midwife helped me through the excruciating pangs of childbirth, and my husband, caught between excitement and fear, clutched my hand, providing reassuring support.” Amidst the devastation caused by nature's wrath, a new life born in that temporary sanctuary. The baby's cries resounded throughout the shelter, demonstrating how life can overcome hardship. The locals, exhausted and drenched,

rejoiced over the birth, viewing it as a sign of hope and a reminder that life goes on even in the most difficult circumstances.

"We are grateful to God for his assistance. My child is in good health. However, I had no clothes for my kid. In the shelter area, a few women offered their clothes to cover my daughter and me. Even though I was having a lot of trouble getting to the flood shelter at that time, my husband handled it by managing a boat. It's also a big challenge to give birth to a child without holding anything in my hands after visiting the shelter. The dampness that clung to the air hurt me as I found myself balancing on a small pad on top of chilly concrete flooring. However, all of my pain disappeared when I met my kid, Rajia said. "I struggled to feed my child after giving birth because the shelter had privacy issues. Maintaining hygiene is treated as a luxury. But amidst all this, my child survived. Since my child was born during a flood in a very difficult time, my mother-in-law named her "Banna." Again, she had prevailed in the fight at the moment, I called her "Joyi."

While she was telling this, her heart grew full of resilience and gratitude. The community would bear the tale of a mother's unflinching courage in the face of a flood's unrelenting torrent, Fatehpur would rebuild, and the waters would recede.

Case 3: Echoes of Neglect: The Picture of Pretend Help

The small village of Noagao (known as Hindupara), which is on the calm Jadukata River, in Bishwamvarpur Upazila, was the scene of neglect, resistance, and shocking revelations. Even though the area was beautiful, the people who lived there were hard to find, where the houses hide behind the long path from the road, people were left with hopes hanging in thin air. But that hand never came. A terrible flood in 2022 destroyed their homes, threw people off their feet, and put their lives in danger. After such a disaster, there seemed to be no response from the government. People who lived in Noagao, particularly those who lived on the edges, felt like they were ignored and abandoned. It looked like the Jadukata River ate their cries for help.

Archona Begum, who is a house-wife, shared that some neighbors did receive help from the government to mend their broken homes after the 2022 flood. They were Sobita das, Rita rani talukdar, Rita, Sima brahman. They were the winner. But for many, that support was just a distant dream.

On a day during the 2022 flood, amidst the despair, there appeared to be a glimmer of hope. An organization, carrying the banner of aid, sailed through the Jadukata river. The community's eyes sparkled with a fleeting sense of relief. But that sparkle was short-lived. It became clear that the visit was not about giving real help. It was a show, a performance for the camera. They offered aid to just one individual, leaving many to watch with empty hands and heavy hearts. The moment the camera captured the scene, the spectacle concluded abruptly, and the organization departed as swiftly as they had arrived.

Figure 2: Jadukata River near village Noagao

Sumita Das, stated that "We thought they came to help but all they wanted were pictures." The act was a mockery of their pain. The community couldn't believe that those who came to help would only use their suffering as a backdrop for their own story. The people of Noagaon were left with a lesson that was hard to digest. They learned that in this world of show, genuine help is rare.

Case 4: Tragedy Amidst Relief Mismanagement

The catastrophic inundation unleashed by the Sunamganj flood of 2022 didn't merely submerge homes; it laid bare the entrenched inequalities within aid distribution, intensifying the suffering of the most marginalized in society. **Salek Mia**, a revered UP Member of the Gourarong Union, provided crucial insights into aid allocation during this tumultuous period. Despite concerted efforts to provide essentials like dry goods, medicine, and rice, the stark reality of uneven assistance distribution became painfully clear.

Multiple NGOs, including prestigious entities like Islamic Relief, BRAC, CNRS, and Uttaran, channeled financial support to select households, leaving others bereft of essential aid. This glaring disparity ignited tensions among villagers, with relief access restricted based on organizational affiliations, resulting in heated confrontations. Tragically, one altercation led to the death of an elderly woman amid the chaos, underscoring the human toll of such disparities.

Moreover, Salek Mia highlighted the uneven allocation of additional resources, such as funds for animal care and shelter insulation materials, exclusively provided by specific groups. Only those affiliated with these organizations could access these vital resources, exacerbating the suffering of those already reeling from the flood's aftermath. This systemic injustice perpetuated hardship and underscored the urgent need for reform in aid distribution processes.

The ordeal served as a poignant reminder of the imperative to prioritize equitable access to resources and support for all members of the community during crises, fostering a more inclusive and resilient society. It underscored the urgency of ensuring that aid reaches those in dire need, regardless of organizational affiliations, to mitigate the disproportionate impact of natural disasters on vulnerable populations.

Case 5: Whispers of the Unheard: The Untold Tales of Women

The problems that women and girls endure are intensified when they are in the grip of a relentless flood, frequently resounding beyond the rising waves. They are forced into overcrowded shelters where privacy is nonexistent due to displacement, which compromises their dignity and puts them at risk for safety issues. Women bear the major responsibility of providing for their families, and they struggle to do so in an environment where resources are limited. Girls also face interrupted schooling and increased hazards; in the midst of this instability, their susceptibility to exploitation and early marriage increases. In addition to submerging homes, the floodwaters worsen social injustices, highlighting the critical need for gender-sensitive relief operations and legislation to address the unique difficulties faced by women and girls in the wake of natural disasters.

Amidst the deluge-ravaged village, **Muntuza**, a 36-year-old woman, was thrown into a terrifying struggle against the unrelenting waves. Her family was forced to flee their home as the swelling water caused the once-familiar streets to turn into dangerous currents. Holding a tiny rucksack with a few items inside, Muntuza walks through waist-deep water, her steps stuttering on the invisible wreckage below.

Muntuza had numerous difficulties in the crowded shelter, which were made worse by the fact that she was a woman. She had little personal liberty due to the lack of private spaces, which made even simple tasks like getting dressed difficult. Women like Muntuza were particularly vulnerable to security concerns because of the communal aspect of the shelter, which resulted in ongoing anxiety and alertness. As a mother, Muntuza struggled to keep her kids safe in the tumultuous surroundings, maneuver through congested areas, and strike a balance between their emotional demands and the group's distress. Her suffering was compounded by the lack of hygienic facilities, which made her prioritize her family's needs with her meager finances. Muntuza also mentioned that, similar to many other women in the shelter, she found it difficult to express her unique needs and concerns, underscoring the importance of having gender-sensitive support networks during times of crisis. Though designed to offer sanctuary, the shelter unintentionally brought attention to the particular challenges faced by women in the wake of the disaster.

"Many people in the shelter had to live together and share the toilet," Muntuza said. “In one of the flood shelter's rooms, men and women lodged together. Women are incapable of even caring for their personal hygiene, let alone having any privacy. There was a lengthy line when I tried to use the bathroom because it was frequently used by a lot of people. Following that, the state of the bathroom was even worse and less hygienic. During our menstrual cycle, we were without any sanitary pads or clothes. Many of the women were deprived, though some received the sanitary pad as a relief product. There was nowhere for us to dry, clean, and wash the clothes. I personally wore my clothing for as long as I could since I was unable to wash and dry it or change it.” Sahara, a thirty-year-old lady, was unable to reach the flood refuge. She and her six-month-old toddler had to remain with her in home.

"I have to stay with my child all alone in my house," stated Sahara. “There was no food and no light source. I was unable to even use the bathroom. I spent three days straight in the water. There was nothing else for it but to defecate in the water. After some days, I used polythene to defecate and threw this away. I used to wear the same petticoat (a piece of cloth worn under the saree) during my periods.”

"I stayed in the iron boat during the flood," Sheuili said. I used to go to my house to defecate quite late at night, and then I would go back to the boat. However, I had to do it on the boat on certain days.

While many women in the shelter also endure physical and psychological abuse, and some even suffer molestation while receiving relief products, these stories are rarely spoken about or told. Many individuals blackmailed them to acquire aid and assistance by offering them many insulting things. The perpetrators who attempted to take advantage of the women's vulnerabilities were those associated with the relief systems.

"I don't know how people can be this cruel," said a woman who asked to have her identity kept secret. “Some animals took advantage of their power to mistreat me during the flood, when we needed the humanity the most. I was at a loss for what to do and how to resist. "There were both men and women in the room of the flood shelter," said another woman. “Some of the men were making us feel uncomfortable and acted inappropriately toward us.”

The story of women's misery emerged in the quiet aftermath of the flood, hidden beneath the surface of common struggles. The widespread shame and stigma associated with physical and sexual abuse kept survivors silent, suppressed by cultural norms that valued privacy above all else. The perpetrators' frequent positions of influence and the power dynamics at work created a culture of silence and terror. Difficulties with personal cleanliness, compounded by social stigmas and scarce resources, added to the underlying struggles. The terrible reality that women faced was further obscured by the normalization of violence, victim-blaming, and a lack of knowledge about available support services. The silent struggles that women fought in the wake of the flood, in spite of their apparent resilience in the face of outside obstacles, highlighted the critical need for cultural changes, educational programs, and support networks in order to expose these obscured narratives and open the door to recovery and empowerment.

Case 6: Challenges faced in flood shelter

The catastrophic flood that ravaged the Sylhet division in 2022 left a devastating trail of destruction, forcing residents to seek refuge in overcrowded flood shelters as their homes lay submerged under the relentless waters. However, the conditions within these shelters proved to be a breeding ground for further misery, significantly impacting the already fragile health and well-being of the affected population of Satgaon, Sunamganj.

During a poignant focus group discussion held at Satgaon Bazar, Sunamganj, individuals came forward to share their harrowing experiences, shedding light on the dire challenges they confronted within the confines of the designated flood shelter, Satgaon High School. Among them, **Seikh Khalilur Rahman,** a seasoned 50-year-old, painted a grim picture of the shelter's appalling

conditions, dominated by an overpowering stench emanating from the accumulation of human and animal waste.

Rahman vividly described how the shelter, operating beyond its capacity, resorted to housing domestic animals on its ground floor, resulting in a distressing buildup of dung and feces. The absence of a proper sewage system exacerbated the problem, fostering the gradual accumulation of waste and perpetuating a pervasive foul odor that permeated the air.

Moreover, Rahman highlighted the alarming formation of a half-meter mass of dirt within the vicinity, serving as a breeding ground for mosquitoes and escalating the risk of mosquito-borne diseases and skin ailments among shelter occupants. His account was corroborated by Mohosin Reja, a 35-year-old Office Assistant at Satgaon High School, who underscored the severe challenges posed by the unsanitary conditions within the shelter.

The unspeakable ordeal endured by residents forced the school to remain closed for an extended period, subjecting nearby residents to the noxious odor emanating from the shelter. Eventually, desperate measures were taken to mitigate the adverse effects of the accumulated waste, with the shelter being cleansed using bleaching powder.

The shared experiences of the residents underscored the urgent need for enhanced sanitation infrastructure and improved management within flood shelters to safeguard the health and well-being of the affected communities. In the wake of such calamitous events, it becomes imperative to prioritize the implementation of measures that offer respite and dignity to those grappling with the aftermath of natural disasters, ensuring that such tragedies do not exact an even greater toll on the most vulnerable members of society.

Case 7: A Tale of Tragedy and Transformation

The Sunamganj Flood of 2022 inflicted profound and irreversible changes on the lives and livelihoods of its residents, reshaping their existence in ways that defied comprehension. Amidst the torrent of narratives recounting loss and upheaval, the story of **Mr. Sharif** stands out as a stark testament to the devastation wrought by the floodwaters.

Before the deluge, Mr. Sharif led a modest life in the serene confines of his hometown, Atgaon, where he eked out a living through his humble grocery shop and the modest acreage of land he cultivated. However, the merciless onslaught of the flood in March 2022 brought unprecedented destruction to his doorstep. The rising waters surged with terrifying force, engulfing his shop under a foot of water, rendering it unrecognizable amidst the chaos. His once-sturdy home fared no better, succumbing to severe damage from the relentless flow, while every cherished possession was mercilessly swept away by the flood's unyielding currents.

Amidst the unfathomable chaos and devastation, Mr. Sharif endured yet another devastating blow as his children succumbed to illness, deprived of the most basic necessities like proper treatment and sanitation. Despite his frantic attempts to save them, both children tragically lost their lives, leaving Mr. Sharif engulfed in an abyss of grief and inconsolable despair in the aftermath of such profound loss.

With his world torn asunder and his aspirations reduced to rubble, Mr. Sharif was compelled to seek solace in Chatak, Sunamganj, where he now toils as a day laborer alongside his wife. Their once-stable and secure existence has been irreversibly upended, replaced by a perpetual struggle to make ends meet and an unbearable burden of memories of their lost children. While the scars of financial ruin may eventually fade with time and perseverance, the emotional chasm left by the untimely departure of their beloved offspring remains an open wound, a perpetual reminder of the immeasurable toll exacted by the cataclysmic events of the 2022 Sunamganj Flood.

Case 8: Kuddus Ali's Struggle in the Aftermath of the Sunamganj Flood

In the aftermath of the devastating Sunamganj Flood of 2022, **Kuddus Ali** emerged as a poignant symbol of resilience amidst unimaginable adversity. During a survey conducted in Gourarang, Sunamganj, Kuddus Ali approached with a palpable urgency, driven by a desperate need to share his harrowing tale. His life, marked by instability and uncertainty, lacked the anchor of a stable occupation, with Kuddus sporadically engaging in tasks such as assisting at grocery shops and manual labor.

Living in an old tin-roofed house, Kuddus Ali's existence was irrevocably altered when the merciless force of a flash flood swept away his humble abode, leaving him and his family displaced and destitute. The gravity of his predicament was further compounded by the presence of his elderly and infirm mother, whom he found himself unable to evacuate amidst the chaos of the emergency. Despite their desperate attempts to escape the rising waters, leaving her behind emerged as their only agonizing option.

In the wake of the receding floodwaters, Kuddus Ali returned to the remnants of his former life, only to be met with a devastating reality: his home, his possessions, and most heartbreakingly, his beloved mother, were all lost to the merciless currents. Today, Kuddus Ali grapples with the harsh realities of poverty as he endeavors to navigate the uncertain path of survival. Unable to rebuild his once cherished dwelling, he now finds shelter in a makeshift abode fashioned from thatch materials, with basic sanitation facilities serving as a meager semblance of normalcy.

As Kuddus Ali recounts the agonizing ordeal he endured, it becomes painfully apparent that the loss of his mother and the destruction of his property have left an indelible mark on his psyche, plunging him into the depths of despair. The road ahead appears fraught with challenges, with the specter of poverty looming ominously over his uncertain future, serving as a haunting reminder of the enduring impact of the Sunamganj Flood. Yet, amidst the overwhelming darkness, Kuddus Ali's unwavering resolve and resilience stand as a testament to the human spirit's capacity to endure, offering a glimmer of hope amidst the despair.

Case 9: Bravery in the Flood: A Mother's Struggle and Dedication for Her Disabled Daughter

The Sachna union in the Jamalganj upazila suffered significant damage in the Sunamganj district, turning the whole region into a swamp. A flood has especially devastating impacts on poor areas like Sachna, where infrastructure is frequently lacking and resources are few. These vulnerable communities find themselves on the front lines of nature's wrath as rivers burst their banks and severe rains fall. Houses, which are frequently made of thin materials, are quickly submerged by rising waves, uprooting people and leaving them homeless. Already unstable livelihoods are quickly destroyed, which exacerbates the poverty cycle. The difficulties these settlements confront after a flood are exacerbated by a lack of effective disaster preparedness measures and restricted access to basic amenities, underscoring the critical need for focused aid and sustained resilience-building initiatives.

A devoted mother named **Sabia Begum** started struggling greatly during the flood with her 12-year-old daughter in this area. Sabia Begum felt her heart sink when the village heard the orders to evacuate. The wheelchair her daughter was using could not fit down the small pathway leading to the temporary shelter. And she herself is unable to take her to the shelter either. She was overcome with panic as she considered her options: risk her daughter's safety and undertake the treacherous voyage to the refuge, or stay in their home, which was now surrounded by rising water.

As time went on and the water level rose, Sabia made the decision to stay in their house out of an unwavering love for her kid. The mother made a very selfless decision to confront the floodwaters rather than subject her disabled child to the unpredictability of the voyage; it was a decision that involved great sacrifice.

Sabia said, “I had no other options. There was a shelter in the fifth-story building of the Liberation War office complex in Sachna Bazar. It was impossible for my daughter to go there, so I had to stay with my disabled child in my home.”

“The hours became a tight watch. The river was a frightening presence, lapping at the boundaries of my house while the unrelenting rain pounded on the roof. I was praying that the floods would spare us. I took refuge on the tallest point while holding my daughter in my arms. When dawn arrived, the water in my house was still there. I was without food in my house for three days. Though occasionally I was able to consume chira, muri, etc.”

The people living in the nearby shelter started to notice Sabia's and her daughter's absence more and more. As worried rumors began to circulate, a group of locals decided to go on a rescue mission equipped with homemade boats and unyielding resolve. But work was slow due to the severe floodwaters.

“My little refuge, in the meantime, became an island in the rising water. Sensing my concern, my daughter held on to me while I uttered comforting words in a whisper, a quiet lullaby in the middle of the storm.” Sabia said. The image of the mother battling nature's wrath to protect her child from harm was one of both extreme strength and fragility.

Sachna held its collective breath while the rescue team struggled against the currents. When the improvised boats finally arrived at Sabia's house, the people saw a moving display of motherly

bravery. With tears streaming down her cheeks, Sabia gave her daughter up to the rescuers, having faith that they would get her to safety.

Despite their relentlessness, the floodwaters were unable to erase the tenacity and solidarity that characterized Sachna. Sabia, tired but alive, was reunited with her daughter when she was delivered safely to the refuge.

Their tale became a timeless testament to the unwavering love of a mother and the resilience of a community in the face of hardship. After the flood, the village of Sachna was transformed into a community where compassion and selflessness prevailed over the laws of nature. The village was struck by Sabia's decision to stay, risking her life for her crippled kid, as evidence of the resilience of love in the face of unbelievable hardship.

Case 10: The Long-term Economic Impact of the 2022 flood and Challenges faced due to the absence of an appropriate Flood Shelter.

Mrs. Aspia Akhter is a resident of the ward number 4 of Balijuri union parishad, within the Tahirpur Upazila of Sunamganj District. She lives there with her family, which consists of 4 members; herself, her husband and her two sons. She does not own her residence, but lives in a tin-shade house owned by her brother-in-law. The house sustained damages worth 15000 taka due to the flood. The adjacent farm-yard also sustained considerable damages in the flood.

Her husband, who is a driver, is currently the sole breadwinner of the family. According to her, her husband was unable to work for at least 2 months following the flood of 2022. Her household has a monthly income of 18,000 taka, which according to her, is not enough for the family. The eldest son of Aspia is a student of Class-1 in the Anwarpur Madrasha, is physically disabled. As such, a great deal of the household income is allotted to the treatment, education and specialized food that is required by her son. Aspias son has been receiving disability allowances for a few years, which slightly helps to reduce the financial burden on her family.

Mrs Aspia used to be involved in the rearing of domestic animals like hen, duck, sheep etc. However, she was unfortunately unable to continue following the devastating flood that occurred in the month of June, in the year of 2022. This was because the animals drowned in the flood water. The rapid escalation and lack of early warning, prevented Mrs. Aspia from relocating the valuable domestic animals.

The loss of income from the domestic animals, has had a devastating impact on her financial security. She had faced an agricultural related economic loss of 119600 taka in total; consisting of loss of domestic animals worth 15000-taka, loss of hen and ducks' worth 100000 taka and finally food of domestic animals worth 4600 taka.

Besides suffering from economic loss in the agricultural center, Mrs Aspia Akhter also faced economic loss of 12000 taka in non-agricultural sectors. The losses consist of; food items like rice, lentils worth 2000-taka, furniture worth 3000 taka and motorcycle damaged worth 7000 taka. She suffered a great deal of loss due to the flood.

Mrs Aspia and her family were only able to have a single meal a day during the first week of the flood. She said that her family was able to return to their normal rate of nutritional intake, around

1 and a half month after the flood. Furthermore, Mrs. Aspia had also suffered from fever during the flood. She was unable to be treated by a doctor and instead bought medicines worth 3000 taka from a pharmacy.

The lack of early warning, combined with the rapid onset nature of the flood contributed to Mrs Aspia akhters lack of adequate preparation and her delayed evacuation. She evacuated after her house was submerged by flood water. According to her the flood water reach 1.5 meter approximately. During the flood, Mrs aspia and her family took shelter in the Tahirpur bazar for 7 days. She and her family used a boat to evacuate since the roads were submerged. According to Mrs. Aspia, she and her neighbors saught shelter in the Tahirpur Bazaar as it was located at a land of highter elevation.

Mrs. Aspia reported that she had faced a number of challenged during her temporary stay in the Tahirpur Bazar. Notably there was inadequate space due to over crowdedness, absence of sufficient toilet facilities and lack of cooking facilities. Besides, since the Tahirpur Bazaar was not a proper, organized flood shelter it also had no accommodations required by disabled people. For example, there were no handrails, ramps or disability friendly sanitation facilities at all. As a result, Mrs. Aspias physically disabled eldest son faced many obstacles during the flood. Besides her sons were also unable to attend school for more than a month because the roads were damaged by the flood water and the school infrastructure sustained damages due to the flood.

The financial strain on Mrs. Aspia Akhter has been exponentially exacerbated due to the flood. Mrs. Aspia Akhter feels that she has not been able to recover from the impacts of the flood. For this reason, she recommended the expansion of programs that support income generation and production-based activities in order to reduce vulnerability.

Case 11: The importance of the role of a Community Leader in times of Disaster.

Mr. Md. Abdur Rauf is a resident of the Tuker Bajar area, in the Sunamganj Sadar upazila of Sunamganj district. He is also a member of the ward commission. He said, “Since Tuker Bajar is situated in the bank of the Surma river, Flood is the most common hazard in the area. Besides flood, there is also risk of river erosion, lightening etc. He further elaborated that, “The 2022 flood was much more devastating compared to all recent floods, even including the 1970 and 2004 flood. Almost the entire area of Tuker Bajar was submerged during the flood, including higher elevated roads that usually remain above water during normal floods.”

Mr. Md. Abdur Rauf mentioned that residential houses and domestic animals were damaged and lost due to the flood. In addition, household furniture, appliances and gas stoves were also damaged by flood water. Moreover, crops, seeds and seedlings were also ruined by the flood water. Furthermore, the shops located in the Tuker bajar area also suffered huge losses. Notably, 500 sacks of cement were damaged according to Mr. Md. Abdur Rauf.Mr. Md. Abdur Rauf also said that there was no electricity in the area for 10 days, which effected all production and economic

activities dependent on electricity. Besides, a large amount of waste materials became dispersed in the flood water and were spread out across the entire area as the flood water flowed. This resulted in diarrhea among children and elderly people, along with serious odor pollution.

Mr. Md. Abdur Rauf took shelter in the "Haji Abdus Sattar and Moriam Secondary School and Flood Shelter Center" along with other residents of the area. He was able to bring his domestic animals to the flood shelter, along with him. According to him, around 200-400 domestic animals, consisting mostly of cows and sheep were given shelter in the ground floor of the afore mentioned flood shelter, while men and women took shelter in the first and second. Since a large number of people resided in a limited area, the capacity of the shelter was exceeded, and he had to face some challenges. The challenges were due to insufficient sanitation facilities and absence of electric supply.

He mentioned that the affected community received dry foods like puffed rice, flattened rice, molasses' etc. as aid from both the state and civilians from Dhaka, Rajshahi, Comilla, Chottogram and other areas of the country. Mr. Md. Abdur Rauf stated that the aid that was provided was drastically insufficient. He believes that the comparatively large distance between tuker bajar and the main road may be the reason behind insufficient access to disaster relief and aid. Mr. Md. Abdur Rauf, noted that community members that had the ability and resources to cook in their homes, shared food with the most vulnerable affected members of the community.

Besides, Mr. Md. Abdur Rauf was also able to organize 10-15 financially strong community members to raise around 2 lakh takas, to provide aid to the most vulnerable people. According to him, they were able to provide salt, spice, lentil, onion, candle, matchstick etc. to almost 200 families. This was a huge momentary relief to the families. Lastly Mr. Md. Abdur Rauf recommended river dredging, construction of strong embankments, the distribution of adequate financial support and the execution of flood forecasting and warning systems as potential flood mitigation and recovery activities.

Case 12: Obstacles in the path toward Post-flood Disaster Recovery

Mr. Kamrujjaman resides with his wife near the Derai road, West Chandipur of Derai Upazila, Sunamganj District. To Mr. Kamrujjaman, flood is one of major natural hazards of Sunamganj district. The floods of 2014, 2022 are two devastating floods faced by him in his recent memory. But he is confident that the 2022 Flood of Sunamganj was the more damaging of the two floods.

Mr. Kamrujjaman is not engaged in any economic activity and does not have a reliable source of income. He depends on his adult children for money. However, he had plans to start a business, for which he bought cows and other farm animals. The 2022 flood prevented his plans from becoming reality, as he was forced to resell the domestic animals and borrow money to repair his house. Not only his house but also his cowshed sustained a great degree of damage due to the flood. Luckily, his cows had been relocated in advance. After the flood water receded, he had to spend 50000 takas in order to fix his damaged house.

Since, Mr. Kamrujjamans house was submerged in flood water he and his wife had to seek temporary shelter in Chandipur Islamia Madrasha, where the water level was chest height. The

Shelter was overcrowded since more than 350 people took shelter there. As a result, he and his wife faced challenges related to hygiene, sanitation, sleep and food intake.

He and his wife were unable to eat proper meals for two days and had only one meal in total, during these 2 days, since their gas stove was submerged and due to lack of dry foods. During the first week of the flood, his food intake decreased to 33% of his normal food intake rate. They were finally able to use a gas stove to cook after 3 days and it took 3 weeks for foot intake rate to become 66% of normal intake rate. It took around 5-6 weeks for his food intake to recover and return to pre-flood rates.Mr. kamrujjaman had suffered from fever and a minor cold during the flood. He shared that he felt psychologically vulnerable and anxious due to his bad health and the stress caused by the disaster.

Although he had received some relief from the government, Mr. Kamrujjaman states that it was not satisfactory at all. He had received flattened rice, puffed rice, molasses, milk, cooking oil etc as relief from UNO chairman and members. He had also received aid from the teachers and religious scholars of the Chandipur Islamia Madrasha and Bangladesh Military, besides receiving financial support from wealthy people, both domestic and foreign.

Mr. Kamrujjaman mentioned the importance of financial support for a disaster affected community. He believes that he and others like him would have been greatly benefitted if they had been provided tin, bamboo and other materials to rebuilt their damaged residences. He also recognized the necessity of river dredging to reduce flood risk. According to Mr. Kamrujjamn, he has still been unable to return to his normal pre-flood way of life because of his vulnerable economic condition, which was further exacerbated by the flood of 2022.

Case 13: Building Strength: A Farmer's Journey to Become a Fisherman

Harun, a contented farmer, resided in the quiet Derai Upazilla village of Dhapkai,tucked away between gently flowing water and undulating hills. He spent his days tending to the fertile land that had been passed down through the years. The peace was broken when the fields that had long been the village's lifeblood were submerged by the unexpected flood. When Harun realized that his profession would never be the same, he took an unforeseen trip to switch occupations.

With the floodwaters receding and a devastated landscape emerging, Harun looked out over his once-flourishing crops that were now just muddy patches. It became apparent that his family might not be able to survive on traditional farming. It was a time of great transition, when flexibility and resilience needed to work together.

"I was thinking about what changes I could make so that I could run my family," Harun stated. "I can't allow my wife, kids, and mother to suffer from this flood. After this terrible flood, all of my fertile land was rendered useless. I lost all control as I was unable to feed my family twice a day.

In the midst of this hardship, Harun found a glimmer of hope. Although the familiar territory was claimed by the floodwaters, they also revealed new possibilities. Motivated by the collective hardship of the community, Harun chose to adopt aquaculture, converting the flooded fields into fish farms. Though greeted with suspicion at first, the notion gained traction as other people realized they could make a good living in the middle of the altered terrain.

The change wasn't without difficulties. Harun had to navigate the learning curve of an unfamiliar occupation, deal with the complexities of fish farming, get the required supplies, and persuade people to support him in this endeavor. Nevertheless, his tenacity from his farming days served him well as he negotiated the uncharted waters of aquaculture.

"The beginning was really challenging. I must admit that I knew very little about this line of work. Second, I lacked enough money to purchase the tools I would have needed for my new occupation. All I had was the courage and the desire to provide my family with a happy existence. To keep everything under control and organize things, I worked days and nights. Throughout my journey, I received support and encouragement from certain people, but I also encountered some who demotivated me. "Harun Mia, think twice before you take the risk," a few of them added. "If you were unsuccessful, don't come to us for help, Harun stated.

Previously reliant only on agriculture, the tiny village has evolved into a center for innovative pisciculture. Harun eventually rose to prominence in the area as a pioneer, demonstrating how tenacity and flexibility could revitalize a community devastated by flooding. The aquaculture project represented hope and rejuvenation in addition to offering sustainable means of subsistence.

A villager remarked, "Harun Bhai gave us new hope. My family won't have to go hungry because of the curse of the flood. Now, despite being new to this field, I am picking things up gradually. Making a change is preferable to doing nothing and seeing your family suffer."

In the village, the seasons brought with them changes in employment. The fields that had produced golden harvests in the past were now shimmering with water, symbolizing the tenacity of a people who refused to let the destruction caused by a flood define them. Harun's transition from farmer to fisherman embodied the village's ethos of adaptability, showing that robust, opportunity-filled new beginnings may arise after change.

Case 14: Survivor to Social Volunteer: Priyanka's Inspirational Journey"

Figure 3: Priyanka-while describing her story

"Are you guys searching for something? May I help you?" That's how we got to know Priyanka and saw how strong a girl can become after overcoming a terrible flood.

Alipur is a small village in the Sunamganj district of Bishwamvarpur Upazilla in Fatehpur union. Northeastern Bangladesh's Sunamganj is particularly susceptible to flash floods because of its low-lying topography inside the Surma Valley. Due to its complex network of rivers, which includes the Surma, Kushiyara, and Jadukata, the area is prone to sudden rises in water levels during the monsoon season. Natural drainage systems are hampered by siltation, land use changes, and deforestation, which increase the danger. Heavy monsoon rains, deficiency of reliable early warning systems increase susceptibility to the effects of flash floods on the area.

The Sunamganj flood of 2022 was a terrifying event that left a path of destruction in its wake. The low-lying plains of Sunamganj were submerged due to the swift erosive surge of the Surma River and its tributaries caused by the intense monsoon rains. The first and most noticeable effect was the forced relocation of thousands of citizens, who had to take up temporary shelters. Tragically, lives were lost and injuries were reported as a result of the floods, which took several communities by surprise. The once-vibrant agricultural environment was severely damaged, with livelihoods destroyed and crops drowned. Rescue and relief efforts were hampered as vital infrastructure, including roads and bridges, collapsed due to the power of the floodwaters. The flooded schools caused disruptions in instruction, making the problems already faced by the impacted community worse.

The region faced a protracted and difficult recovery process, and businesses suffered severe losses. Following the floods, the area struggled with the fallout, with an increase in waterborne illnesses, visible environmental destruction, and a harsh test of the people's resilience in Sunamganj.

As impacted communities battled to have access to clean water, sanitary facilities, and healthcare, the humanitarian crisis worsened. Damaged infrastructure complicated emergency response efforts and complicated the logistical supply of supplies and medical support. The region's fragile ecosystem was impacted by soil erosion and biodiversity loss as a result of the devastating environmental effects of the floods. The devastating Sunamganj flood of 2022, which is still remembered by many, highlighted the critical necessity for extensive disaster planning.

Priyanka, a twenty-year-old college student with bigger aspirations, resided in the rural heartland of Sunamganj, where life thrived in sync with the seasons and the ebb and flow of the rivers. When unprecedented floods engulfed the area and transformed it into an infinite body of water, the peace of her village was upended.

Despite her determination and fortitude, Priyanka was swept up in the chaos caused by the rising floodwaters. The river that had once provided her town with vitality had turned into a destructive force. Since her college was in a nearby town, getting to her classes proved difficult because the water ate up the regular routes. Unfazed, she constructed a crude boat out of leftover parts to cross the flooded fields and get to the town where her dreams were waiting for her.

With the rising waters that threatened Sunamganj, Priyanka's everyday routine turned into a daily fight to survive in the initial days of the flood. She got up before the sun came up and swam through knee-deep water to the remaining patches of dry land where her homemade boat was waiting. She had to make the treacherous trek over flooded fields and improvised waterways every day, fighting the currents with a resolute paddle fashioned out of a broken plank.

“It was really difficult to get to my college. I had to cross a river at first, and it was a pretty unpleasant trip. I had to stack books to shield them from the constant risk of water. I came upon

hidden roadblocks in the form of fallen tree limbs, rubble, and sometimes the debris of my neighbors' houses. Since the construction of the Fatehpur Bridge, my struggles have decreased somewhat. Even though the colleges were closed for a few days during the flood, I had to get the college as soon as it started, even if there was still water in my village. Consequently, I struggled greatly to attend college. But after all that, I have missed many classes also." – Priyanka stated.

Figure 4: The Fatehpur Bridge that has eased Priyanka's life

Like other families in the village, Priyanka's family had financial difficulties. Houses were flooded, and essentials were transformed into luxuries. By balancing her studies with household duties like recovering treasures and ensuring that everyone had a dry place to sleep, Priyanka developed into a pillar of strength for her family. She achieved this by maintaining a balance between her home and college responsibilities. Due to her father's illness, she was forced to do tuition, which she did in order to cover her educational expenses. Suddenly, the place where she goes for her tuition found a UNICEF program circular. She applied for it without giving it much thought, and out of five applicants, she was chosen.

Figure 5: The Anandadhara Primary School (UNICEF program) where Priyanka works

"Through this UNICEF program, I am not only learning how to support myself, but I am also able to assist many people, especially women and children, with whom I come into contact on a regular basis. I have just been here for eight months; therefore, my monthly income is BDT 6600 tk, but after a year, I will receive BDT 8000 tk. I want to help children who are facing the terrible effects of floods with their studies because I had a difficult time getting an education during that period. Additionally, since my father is helpless on his own and I have to take care of my younger brother, there is the utmost peace of mind in supporting and taking care of my family."

As a third-year student, Priyanka is a story of inspiration who has faced immense trouble in the time of the flood. Her spirit remained intact, and her desire for education remained unabated in spite of the difficulties. The physical environment may have changed due to the flooding, but Priyanka's unwavering determination and dedication to her goals have endured as a tribute to the human spirit's tenacity in the face of nature's harsh obstacles.

Case 15: Ripples of Hope: A Tale of Honufa Begum's Triumph

A story of strength and community spirit takes place in the heart of Balijuri Union, in Ward No. 9 of Taherpur Upazila. The life of the community people who lived there turned upside down by the 2022 Sunamganj Flood that destroyed their land, damage their crops and so on. In the middle of all the chaos, the government's help was barely audible. They only sent dry foods like chira, muri, and rice to the people who were suffering.

Here comes **World Vision**, a source of hope for many but also a source of debate because it only helps certain people (Only the member of their committee). The organization's work was both good and bad. In the form of school materials and food, children got general aid. However, there was bias in the spread of major aid like money, animals, and other resources. Few people, mostly those in the close group of the local bodies, found favor. It is heard from locals that the organization provide a cow or equivalent 50k tk particularly to their members in the form of donation.

The locals complained, which brought attention to the unfair way that Government flood aid was being given. Mr. Afzal who is a farmer, complained about how the chairman's friends and family were favoured over the needs of many people. In this background of chosen kindness, a story of determination came to light.

It was **Honufa Begum**, a widowed tailor. Honufa's situation touched many people because her daughter's schooling was in danger. Together, the locals fought for her and told World Vision about her situation. After many requests, their voices were finally heard above the noise of disinterest, and a 'Sanitary Latrine' was given to Honufa as a sign of help. People in the heartlands of Balijuri felt a sense of hope after this small but important win.

Figure 6: Interviewing with Honufa Begum

"Ripples of Hope: A Tale of Honufa Begum's Triumph" is more than just a case about hardship. It shows how strong togetherness can be and how people can never give up when they stand together against unfairness and how people always hope for a better tomorrow.

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