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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

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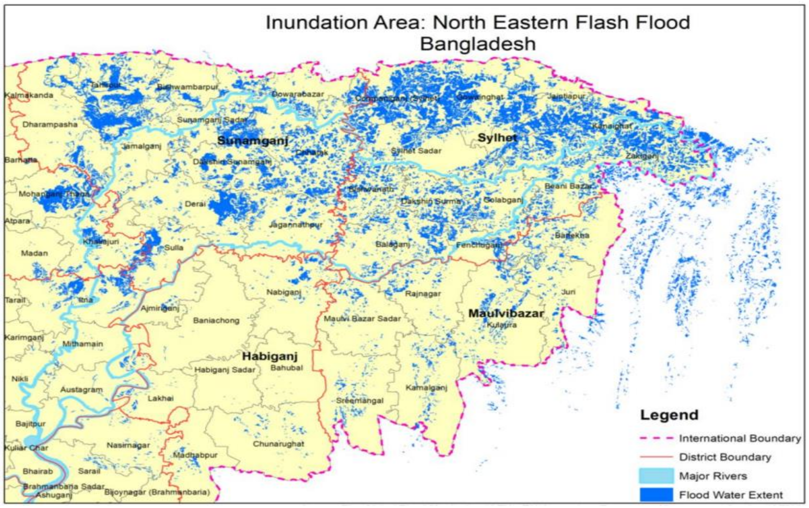
Chapter 1
Introduction

The frequency and magnitude of disasters are changing regularly. People around the world are experiencing more natural and human-induced disasters than ever before. Due to climate change and other causes, there is a change in the pattern and impact of disasters. With a mass population and limited resources, Bangladesh has been facing immense difficulties to manage both natural and human-induced disasters. According to INFORM Global Risk Index 2020, Bangladesh is in the 2^{nd} position to be at the highest risk of getting affected by natural hazards (United Nations Office for the Coordination of Humanitarian Affairs, 2020). According to the report, the exposure and vulnerability levels of Bangladesh to facing disasters are also very high. According to the World Bank, every year huge amount of loss is reported in the world due to natural disasters, which cost 520 billion US dollars, adding 26 million poor people each year. Due to heavy rain and the river system of the Brahmaputra-Ganges-Meghna basin Bangladesh has been experiencing severe flood hazards almost every year. The hydro-meteorological characteristics of the three basins are unique and their combined discharge is among the highest in the world, at $1.214*10^9$ cu m. Over millennia, people have naturally settled in flood plains and river basins. Evidence reviled that flood and poverty are inextricably linked. Flood can devastate the physical and social capital of societies and destroy whatever tiny amounts of savings poor households have.

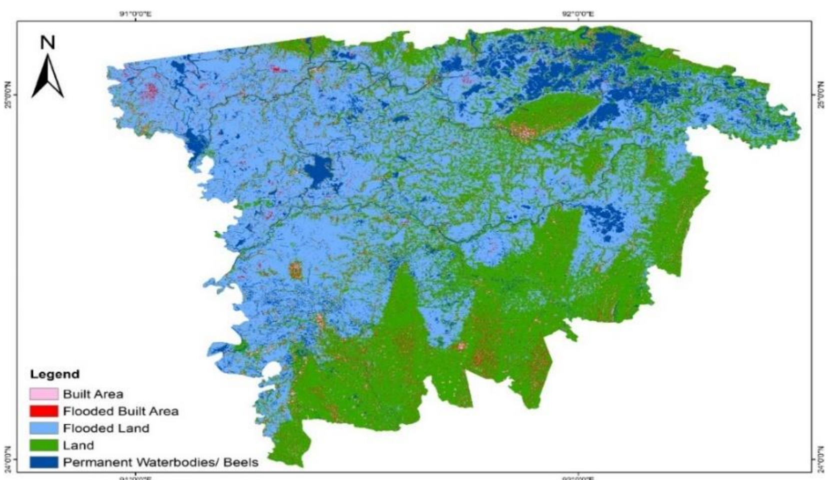
In May-June 2022, an early monsoon flood occurred in the north-eastern part of Bangladesh and affected several places in several districts in the northeast region of Bangladesh including Sylhet, Sunamganj, Habiganj, Netrokona, Maulvibazar, Kurigram, and Jamalpur especially Sylhet and Sunamganj**,** being the most affected (Map 1 and 2). 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 1003.6 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.

It is assumed that unprecedented rainfall happened in the upstream region causing flooding downstream. Flood mapping shown in Fig 1 and Fig 2 is a very initial estimate of flood extent. These maps can be substantially improved using the data of river cross-sections, water levels, and other relevant information. The destructiveness of flood and the dimension of damage and loss reported in the news media push the scientific community to conduct an in-depth investigation of the phenomena. 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) has been identified as a major area in disaster risk reduction process. Proper damage, loss and need assessment will also optimize the victims support strategies. Moreover, proper damage and loss assessment is related to the socio-economic and cultural vulnerabilities of the people at risk.

Map 1: Flood inundation extent map of the study area.



Map 2: Preliminary flood mapping of Sylhet region using Sentinel-1 SAR images



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.

The level of loss and damage 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 nexus between the damage and loss and resilience of the exposed community and elements at risk.

Though the Government of Bangladesh (GoB) and different Non-Governmental Organisations (NGOs) tried to support the affected population, the initiatives do not sustain due to a lack of capacity to withstand the natural shocks, which relates 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). 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 broad objective of this study is to map the flood hazard scenarios of various levels of rainfall in upstream and catchment areas and develop the relationship between vulnerabilities and resiliency within the framework of the damage-loss-need nexus caused by the flood hazards at the Sunamganj and Sylhet districts. Specific objectives of the study are to

a) Analyze 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) 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 towards Middle Income Country (MIC), and to attend the UN Sustainable Development Goals (SDGs) 1, 2, 5, 8, 10 and 13, and vision 2041 of Bangladesh.

Chapter 2
Research Approach and Methods

The investigations used the all-available observed data and relevant satellite images. Detailed questionnaire survey, Focus Group Discussion (FGDs) and Key Informant Interviews (KII) were conducted to collect both the 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 will be, "Is reducing vulnerabilities can improve the level of resilience of the flood affected communities?"

The study emphasided 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.

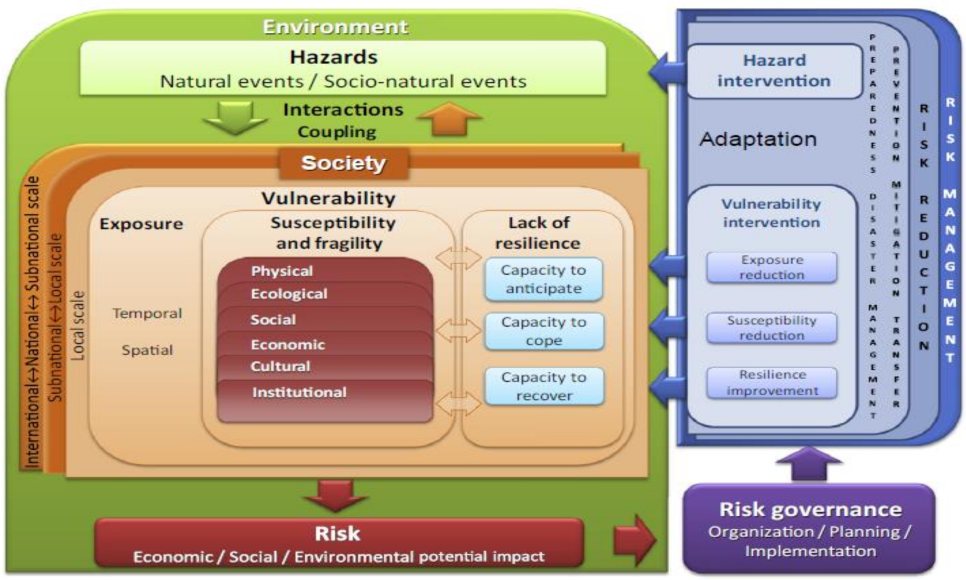


Figure 2.1: MOVE Framework

To *achieve the fourth objective,* this study analyzed the existing development interventions in the Sylhet region. For this purpose, the eighth five-year plan and the budgets of last 10 years were reviewed. From this analysis, a list of the development projects was sorted out and then the DPPs of the relevant projects 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 thorough analysis was conducted to find out the existing 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*, a scoping study was conducted on the existing national development plans and programmes, as well as the global development plans and programmes. 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 flood report 2022 by START Network, two of the major floods affected area were Sunamganj and Sylhet. Total 44,80,509 people were directly affected due to extreme level of flood in Sunamganj. On the other hand, total 29,63,756 people were affected by flood in Sylhet district. All the Upazilas of Sunamgani and Sylhet districts were covered under this study. The following table represents the sample size based on the population (Krejci & 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.

Size of Population	Sample Size (n) for Precision (e) of:			
	±3%	±5%	±7%	±10%
500	a	222	145	83
600	a	240	152	86
700	a	255	158	88
800	a	267	163	89
900	a	277	166	90
1,000	a	286	169	91
2,000	714	333	185	95
3,000	811	353	191	97
4,000	870	364	194	98
5,000	909	370	196	98
6,000	938	375	197	98
7,000	959	378	198	99
8,000	976	381	199	99
9,000	989	383	200	99
10,000	1,000	385	200	99
15,000	1,034	390	201	99
20,000	1,053	392	204	100
25,000	1,064	394	204	100
50,000	1,087	397	204	100
100,000	1,099	398	204	100
>100,000	1,111	400	204	100

a = Assumption of normal population is poor (Yamane, 1967). The entire population should be sampled.

Table 2: Sample size for ±3 percent, ±5 percent, ±7 percent and ±10 percent precision levels, where confidence level is 95 percent and P=0.5 (Krejcie & Morgan, 1970)

Sample Size of Each Upazila

Sunamganj:

Upazila	*Number of Households (BBS 2011)*	*Sample size (Households) (±10 percent Precision Levels)*
Bishwamvarpur	29,336	100
Chhatak	66,724	100
Dakshin Sunamganj	32,033	100
Derai	45,040	100
Dharmapasha	47,965	100
Doarabazar	42,693	100
Jagannathpur	42,866	100
Jamalganj	29,935	100
Shalla	20,299	100
Sunamganj Sadar	49,557	100
Tahirpur	37,931	100
Total	**440,332**	**1100**

Sylhet:

Upazila	*Number of Households (BBS 2011)*	*Sample size (Households) (±10 percent Precision Levels)*
Balaganj	54,246	100
Beanibazar	42,119	100
Bishwanath	37,993	100
Companiganj	28,756	100
Dakhin surma	43,004	100
Fenchuganj	18,859	100
Golapganj	50,465	100
Gowainghat	47,992	100
Jaintiapur	27,719	100
Kanaighat	46,147	100
Sylhet city corporation	97,991	100
Sylhet sadar	60,242	100
Zakiganj	40,548	100
Total	**596,081**	**1300**

The total sample size was **2400** households**.**

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

Districts	Number of FGDs	Participants
Sunamganj	11 (One FGD per Upazila)	Women, Men, PWD, Elderly people, Local leaders, NGO representatives, Teachers, etc. FGDs were organized with the support of Upazila Chairman/UNO. The participants were selected by the Upazila Chairman/UNO.

Sylhet	13 (One FGD per Upazila)	Women, Men, Persons with disabilities, Elderly people, Local leaders, NGO representatives, Teachers, etc. (Minimum 20-25 participants in every FGD). FGDs were organized 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

Chapter 3
Flood Hazard Assessment Modelling

1. Introduction

Floods have posed a constant threat to human civilization 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 (Cutter, 1996). 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 (T. H. 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 (R. 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 enormous number of rivers, like Bangladesh, it is commonly acknowledged that preventing or totally eliminating floods is unfeasible, 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 (A. Dewan et al., 2007; Hasan, 2006; A. S. Islam et al., 2010; M. M. 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.

2. Study Area

The study area comprises two districts in the north-east of Bangladesh, which are Sylhet and Sunamganj districts (Fig 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.

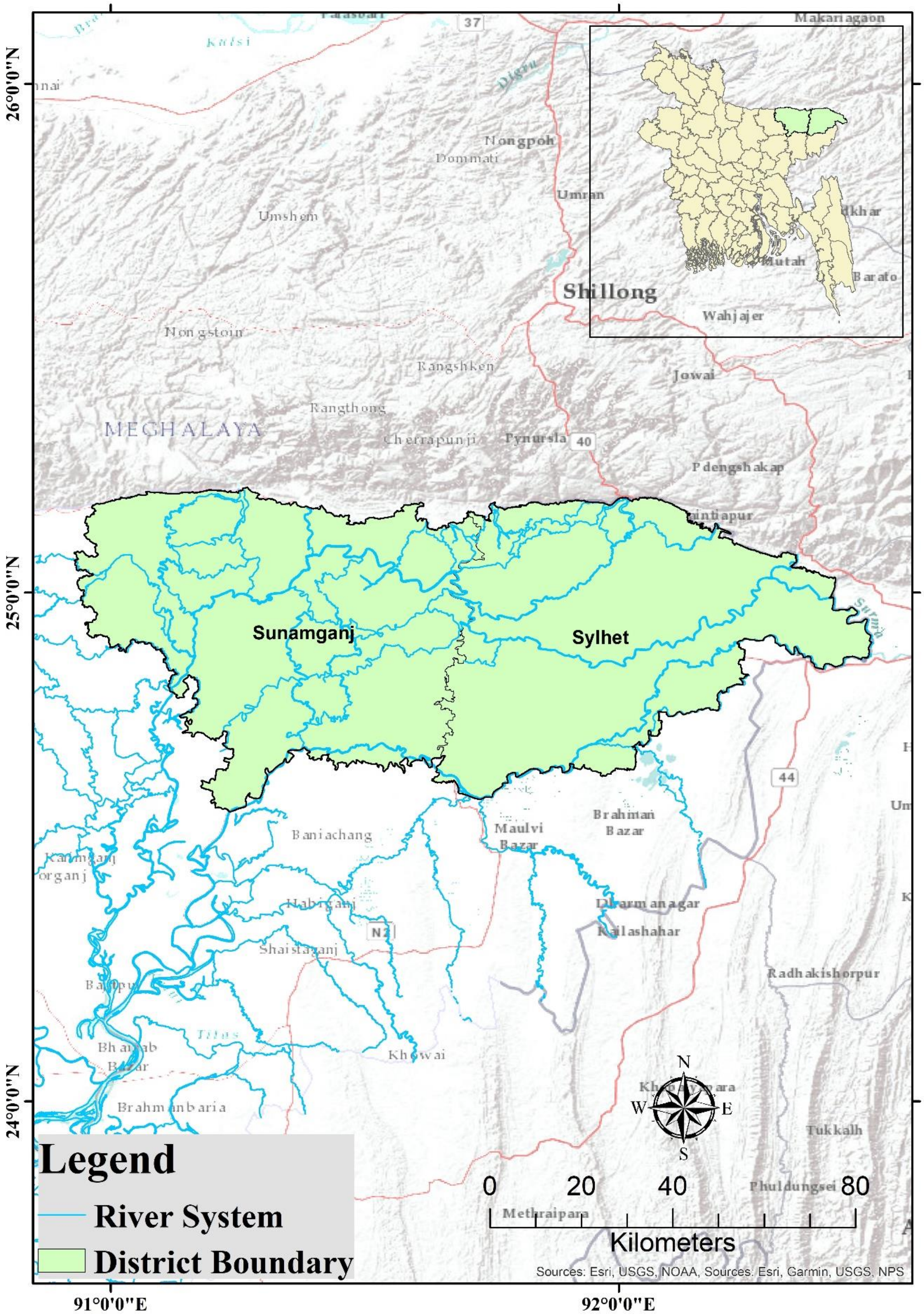


Fig 1: Location of the study area. The study area shows the district boundary and rivers system.

3. Materials and Methodology

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).

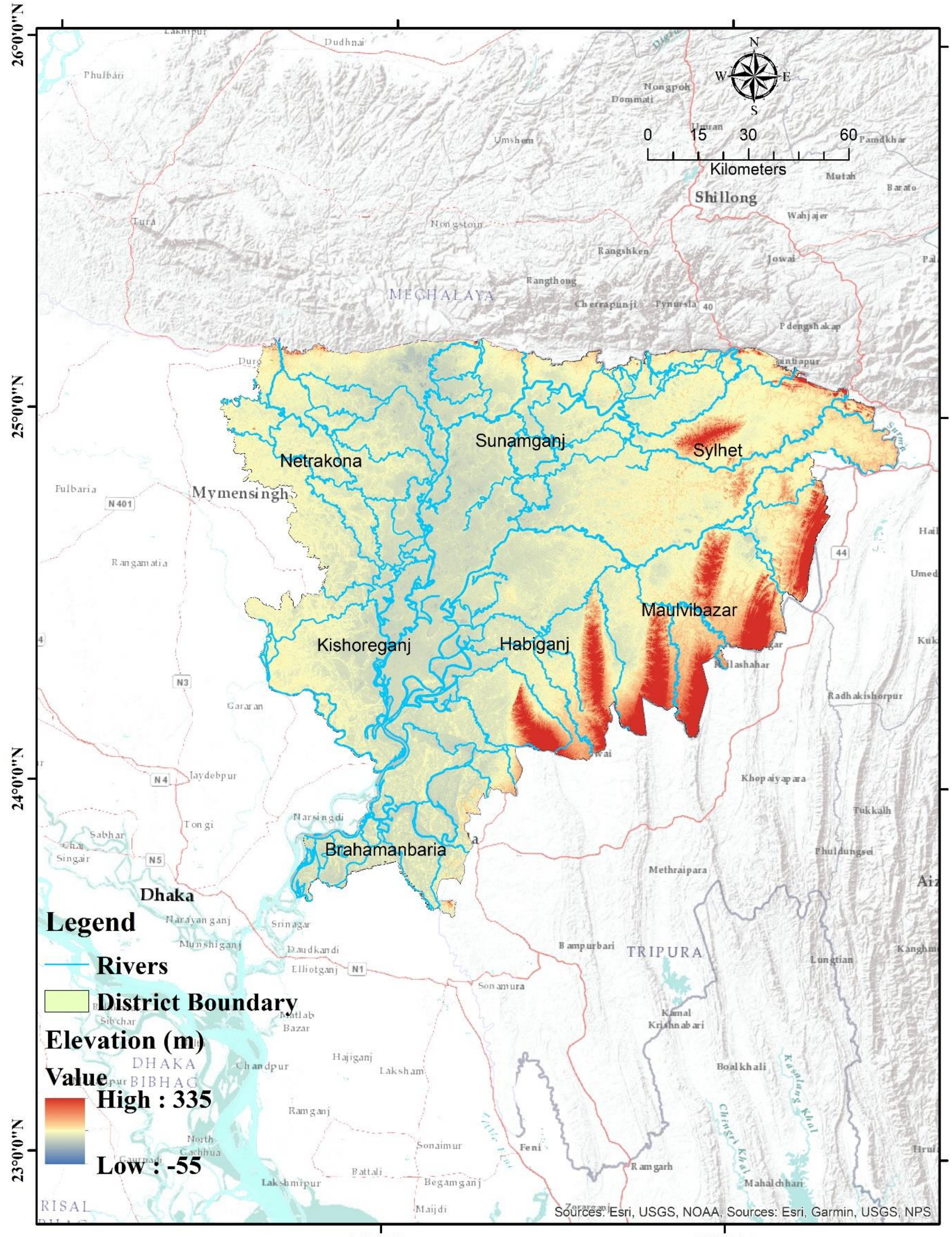


Fig 2. Topographic elevation of the study area prepared using Shuttle Radar Topography Mission (SRTM) data with 30 m resolution.

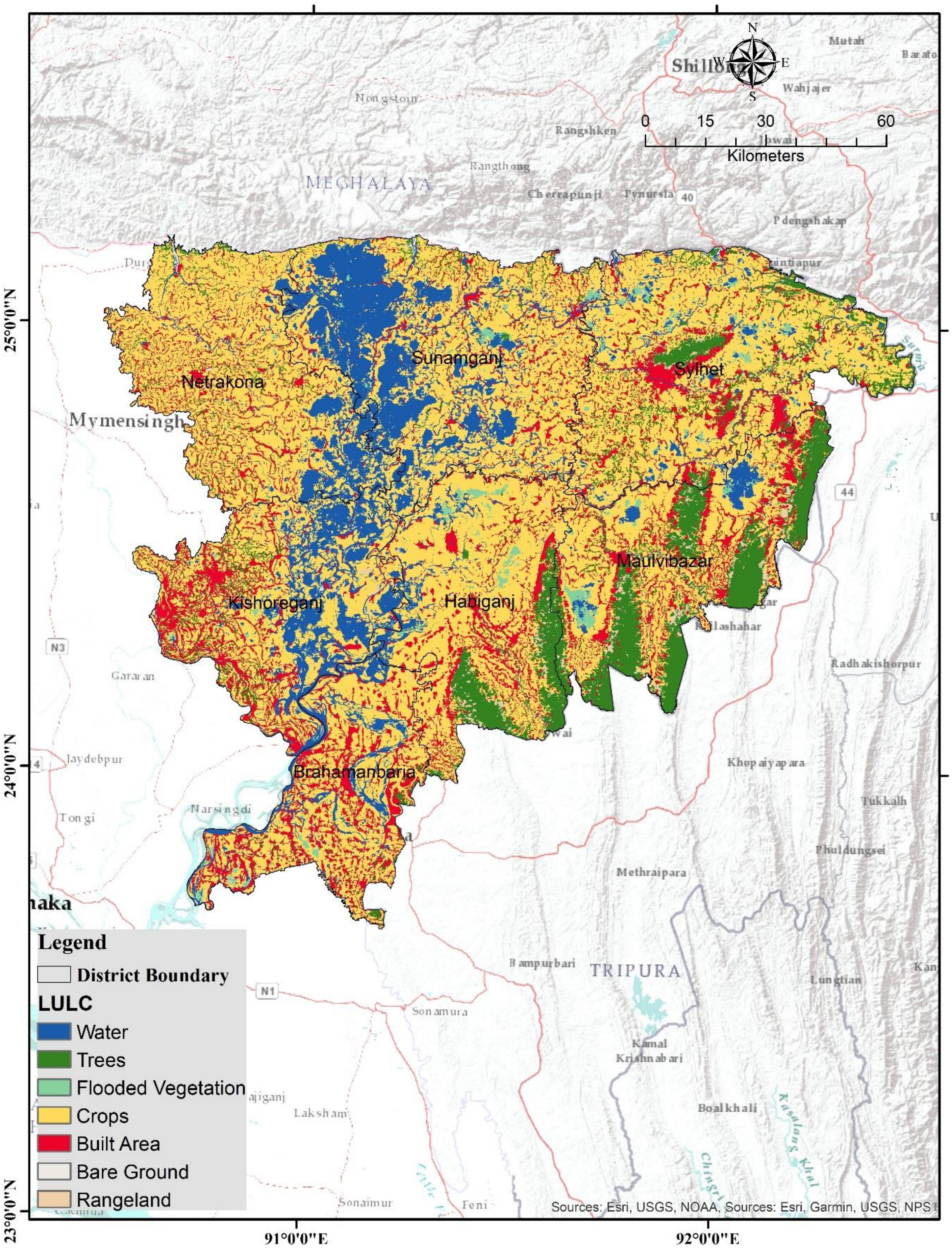


Fig 3. Land use and land cover map of the study area prepared using sentinel-2 satellite images with 10 m spatial resolution.

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.

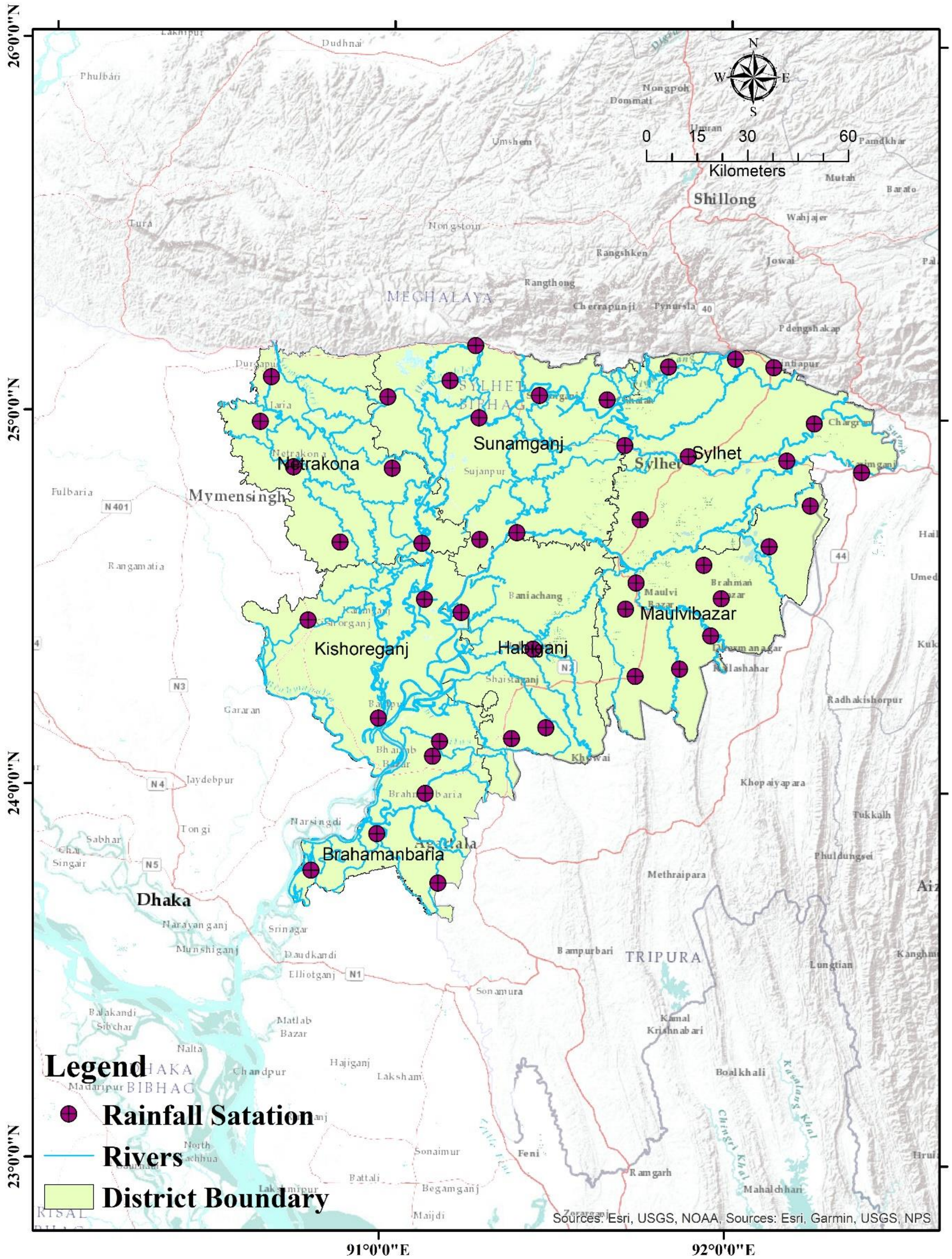


Fig 4. Rainfall station location and data of BWBD within the model domain used in flood modelling.

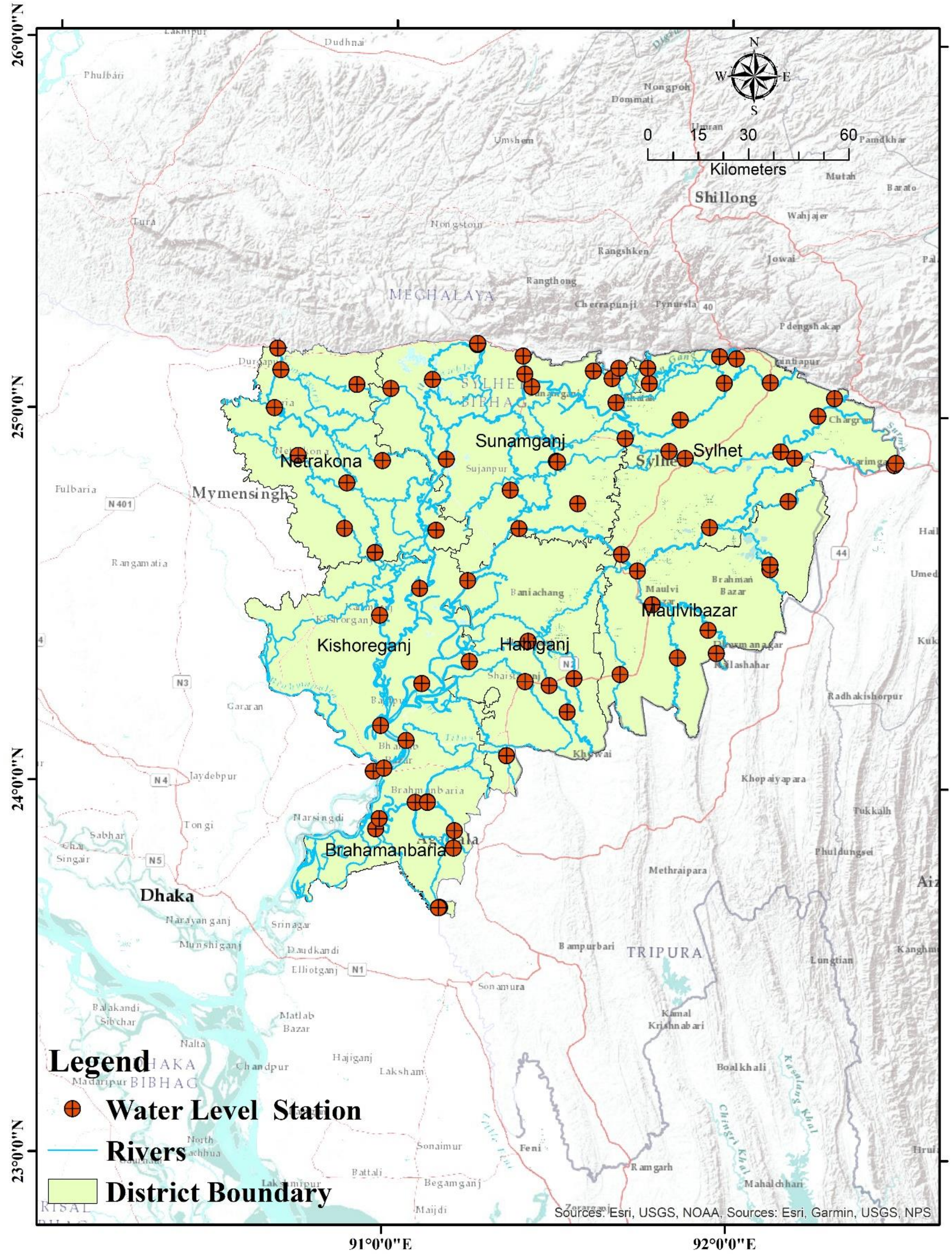


Fig 5. Surface water level station location and data of BWBD within the model domain used in flood modelling.

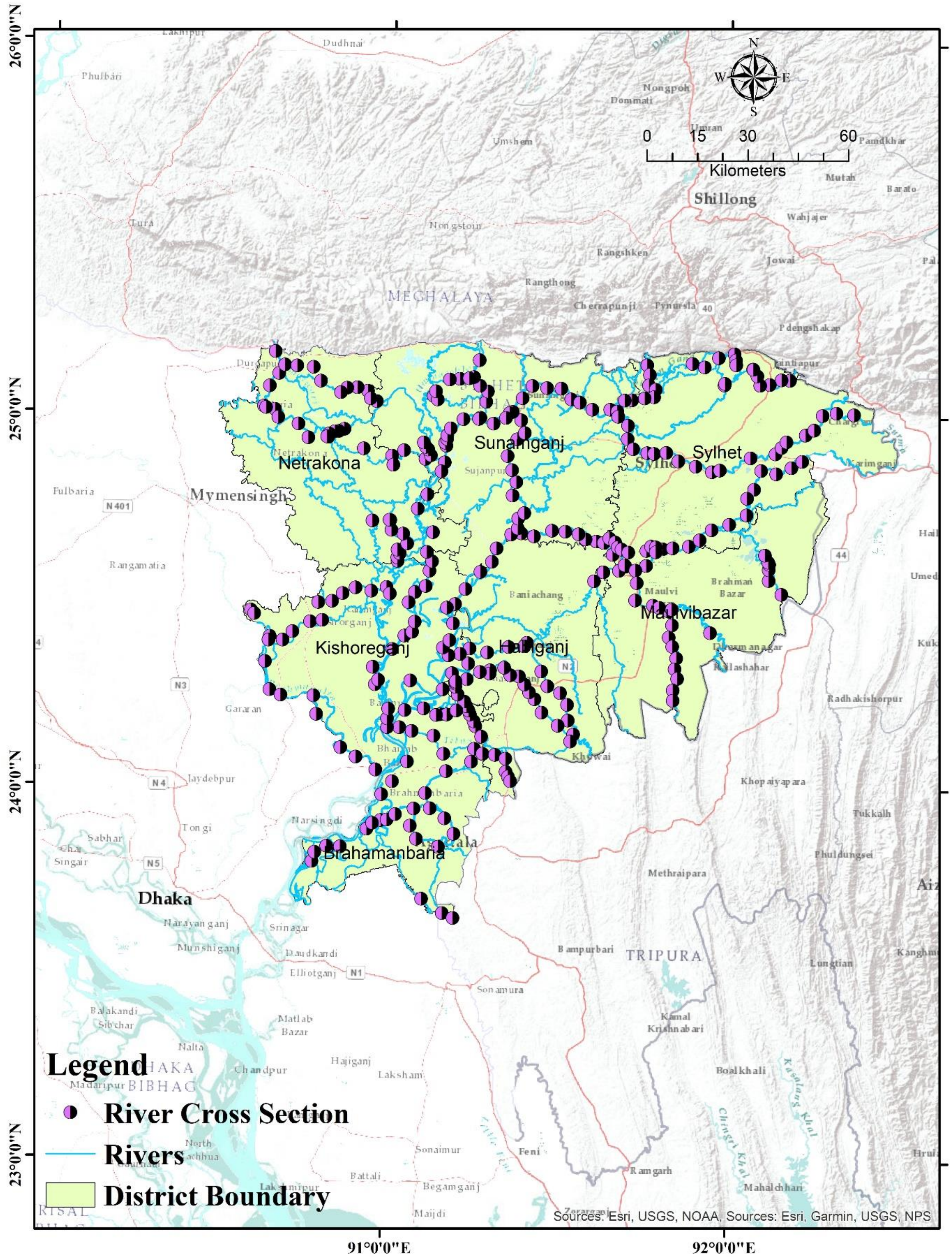


Fig 6. River cross section station location and data of BWBD within the model domain used in flood modelling.

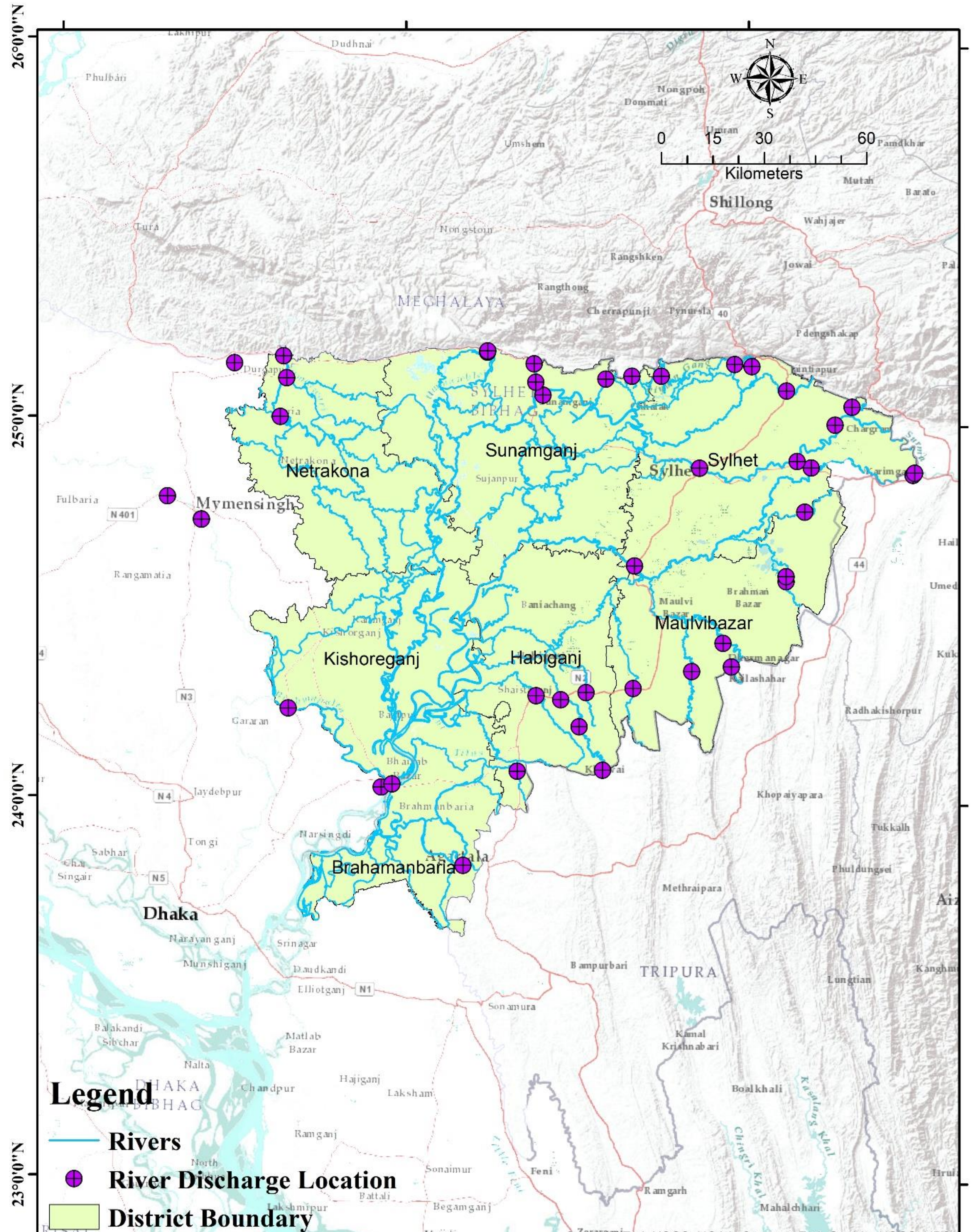


Fig 7: River discharge station location and data of BWBD within the model domain used in flood modelling.

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:

$$\frac{\delta h}{\delta t} + \frac{\delta(hu_x)}{\delta x} + \frac{\delta(hv_y)}{\delta y} = \gamma \tag{3}$$

The momentum equations:

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

and

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

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.

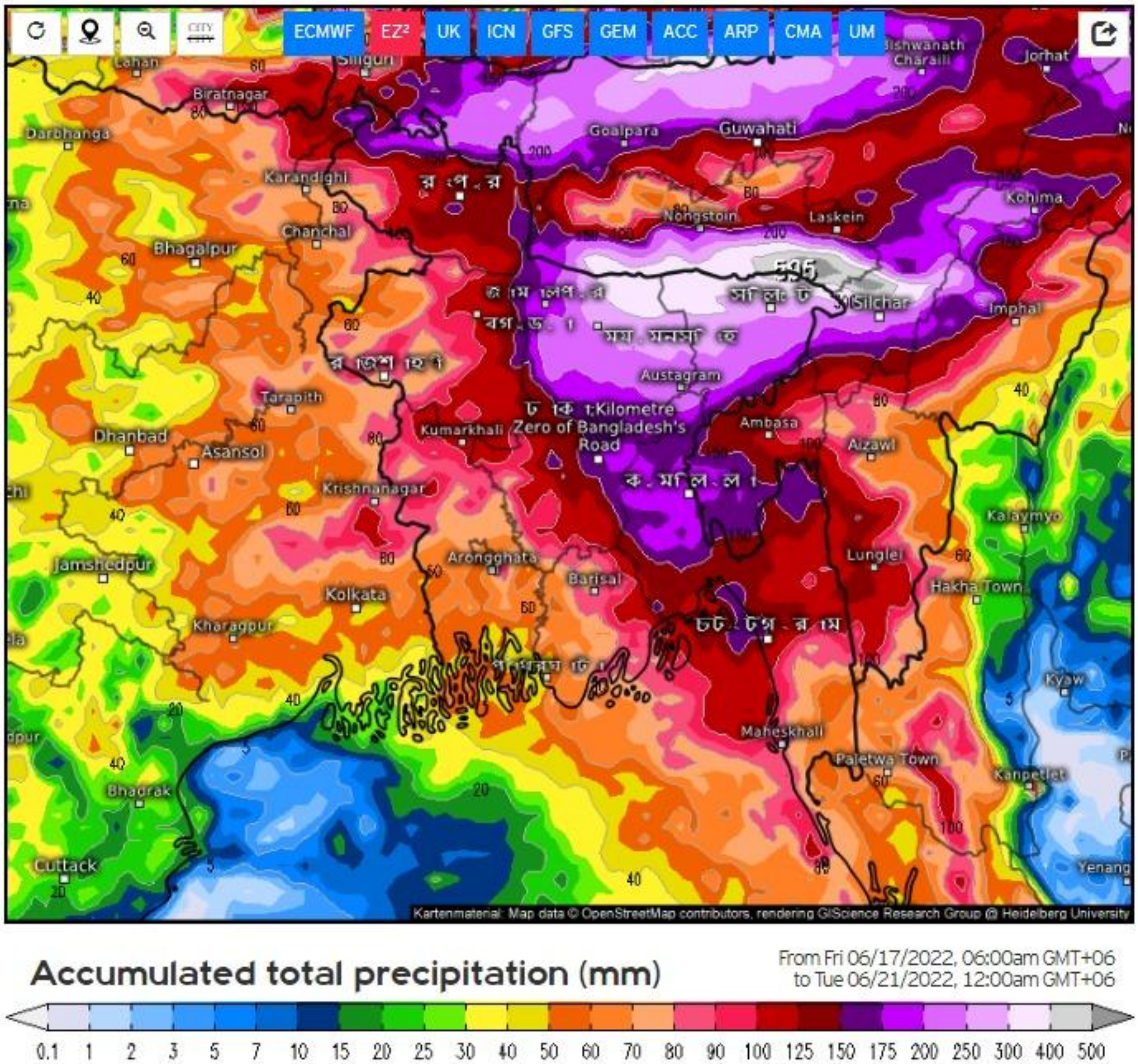


Fig 8: Three days forecast of accumulated total precipitation (mm) based on European Centre for Medium-Range Weather Forecast (ECMWF)

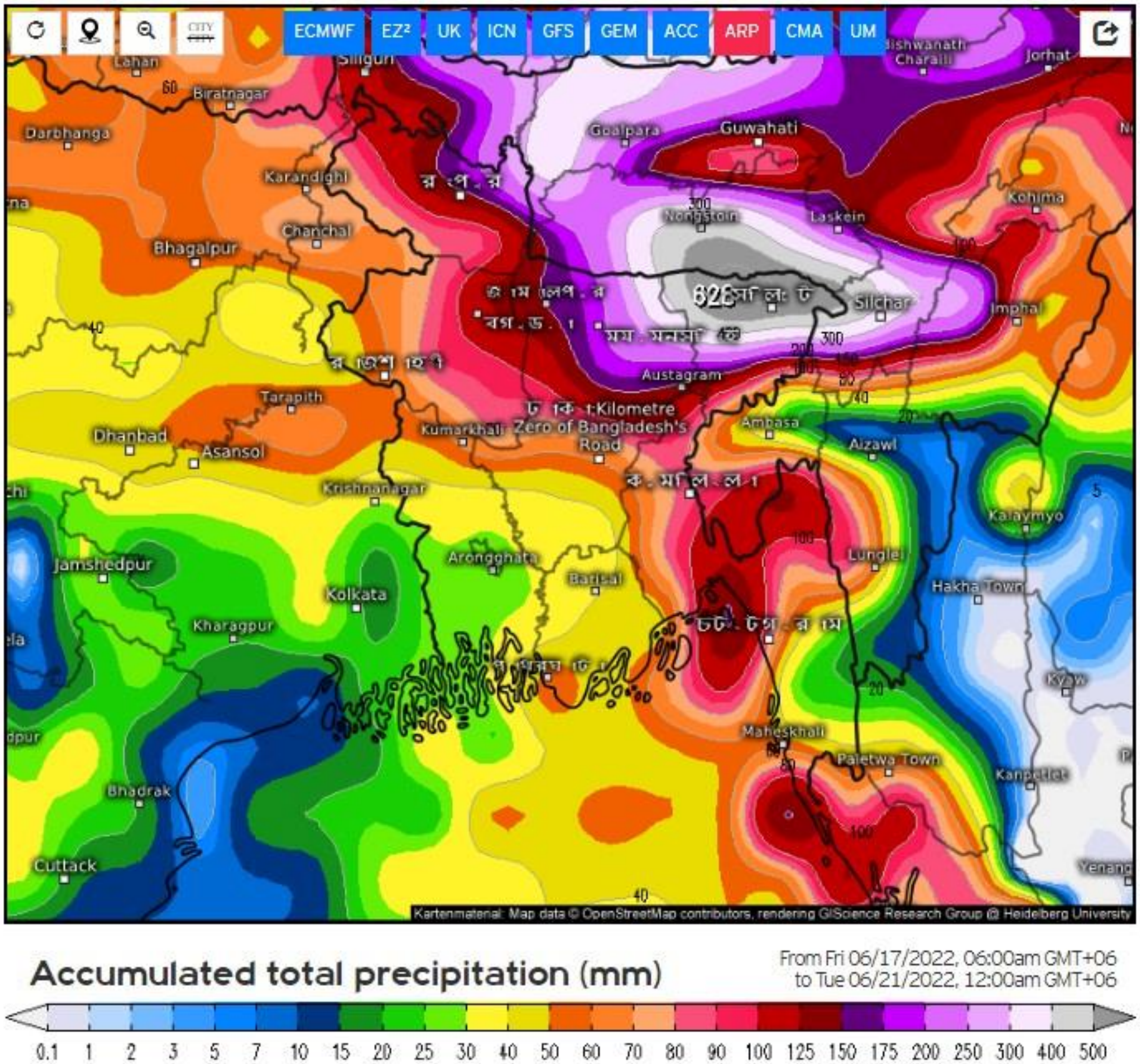


Fig 9: Five days forecast of accumulated total precipitation (mm)

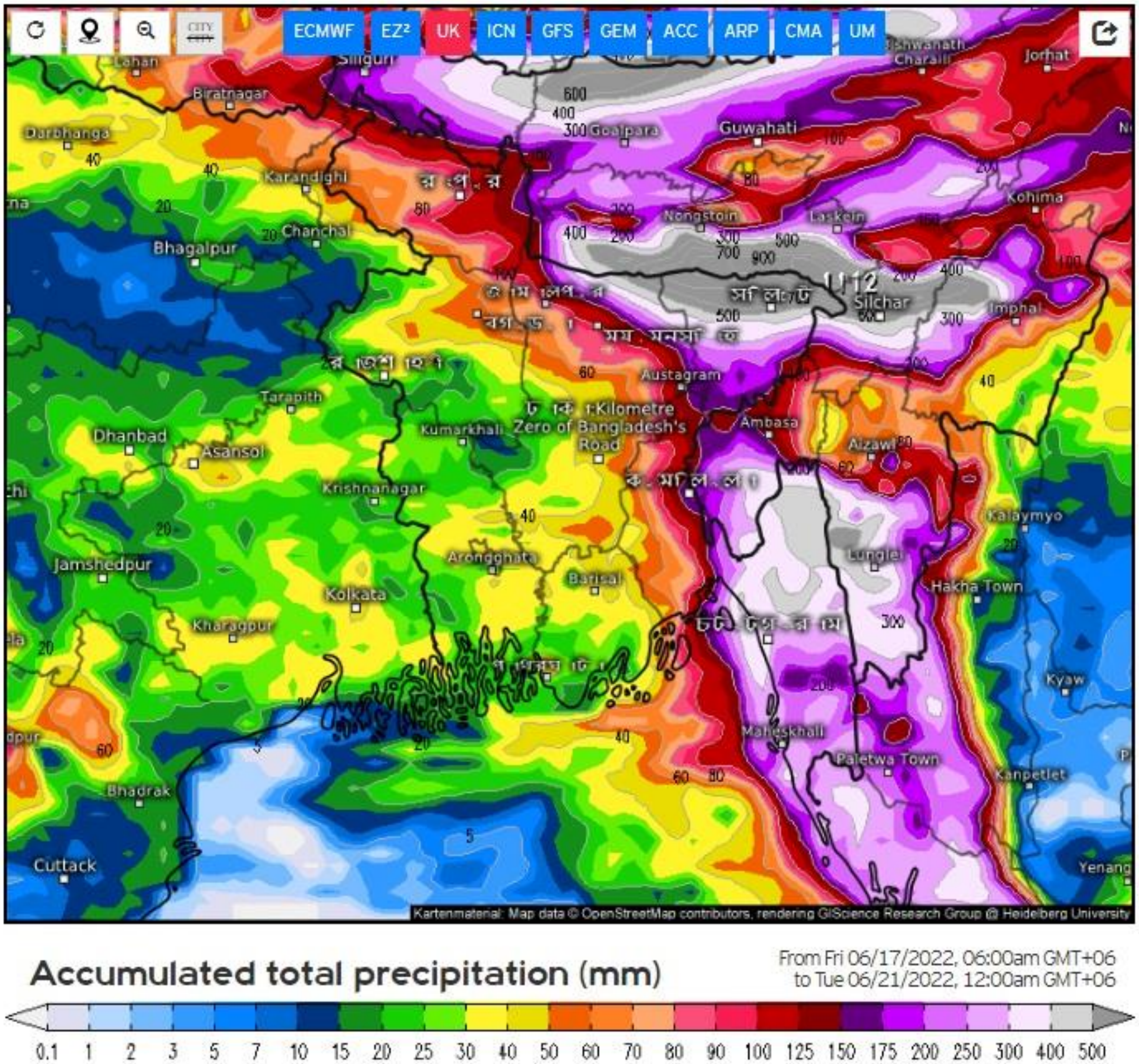


Fig 10: Seven days forecast of accumulated total precipitation (mm)

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.

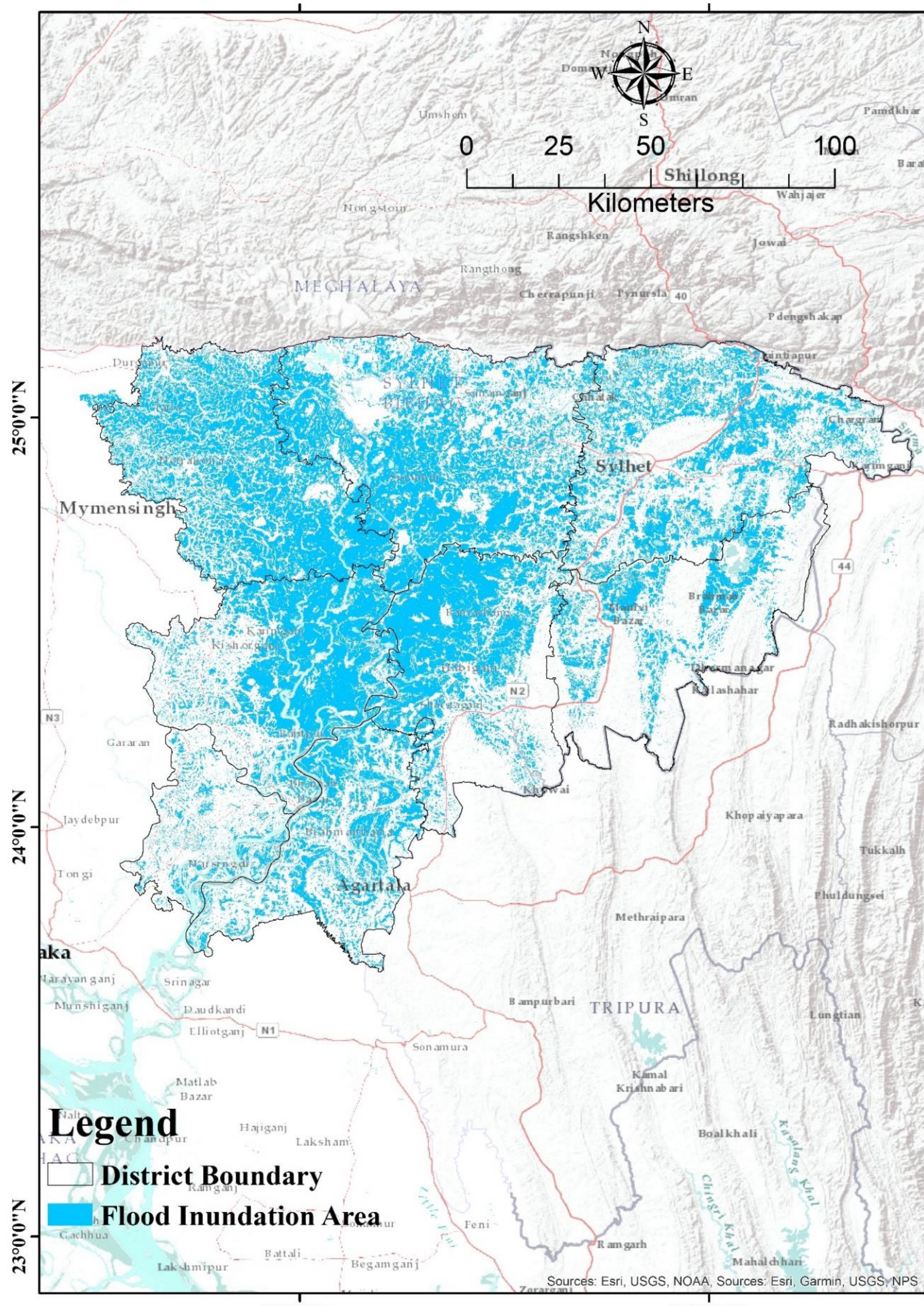


Fig 11: Flood inundation mapping using Sentinel-1 satellite images for north east of Bangladesh.

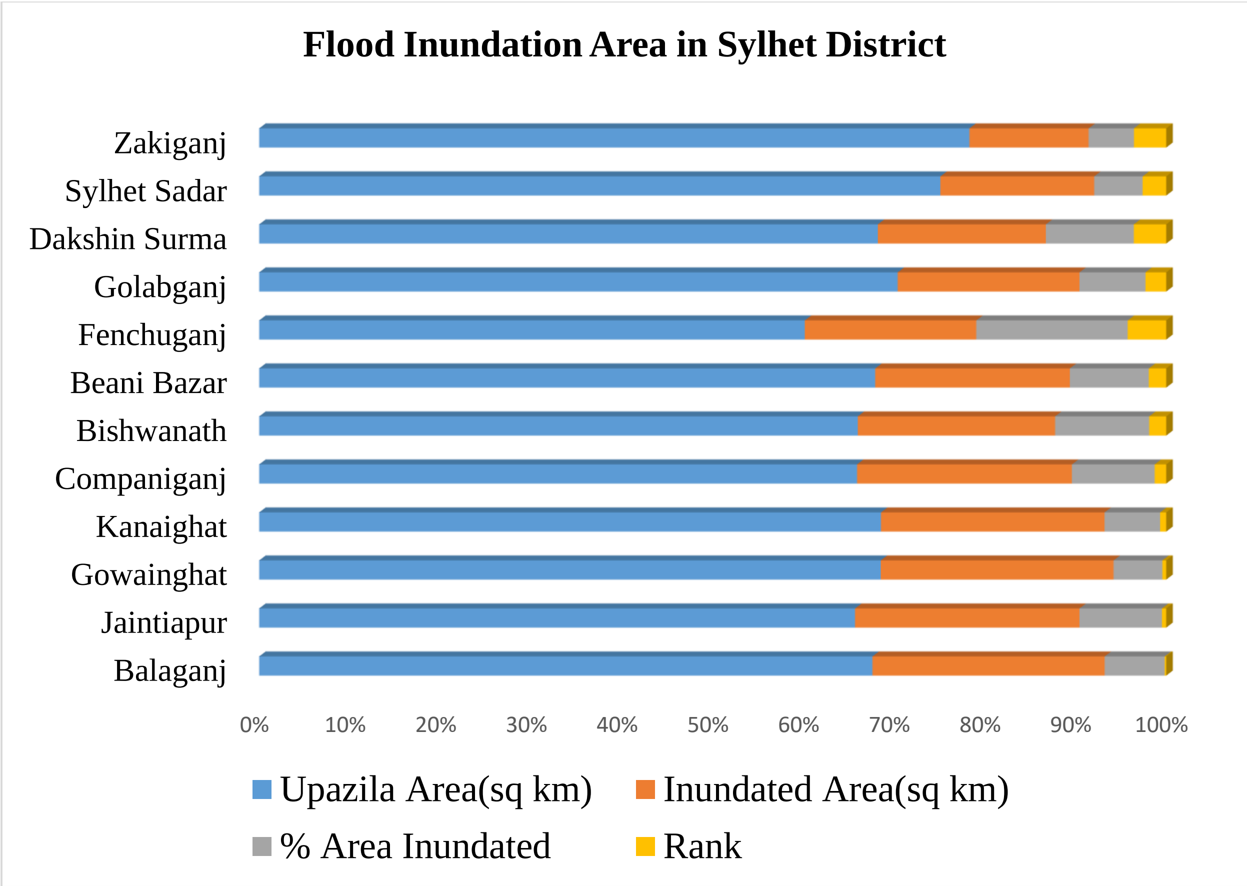


Fig 12. Flood inundation area derived from Sentinal-1 satellite images at different upazila of Sylhet district

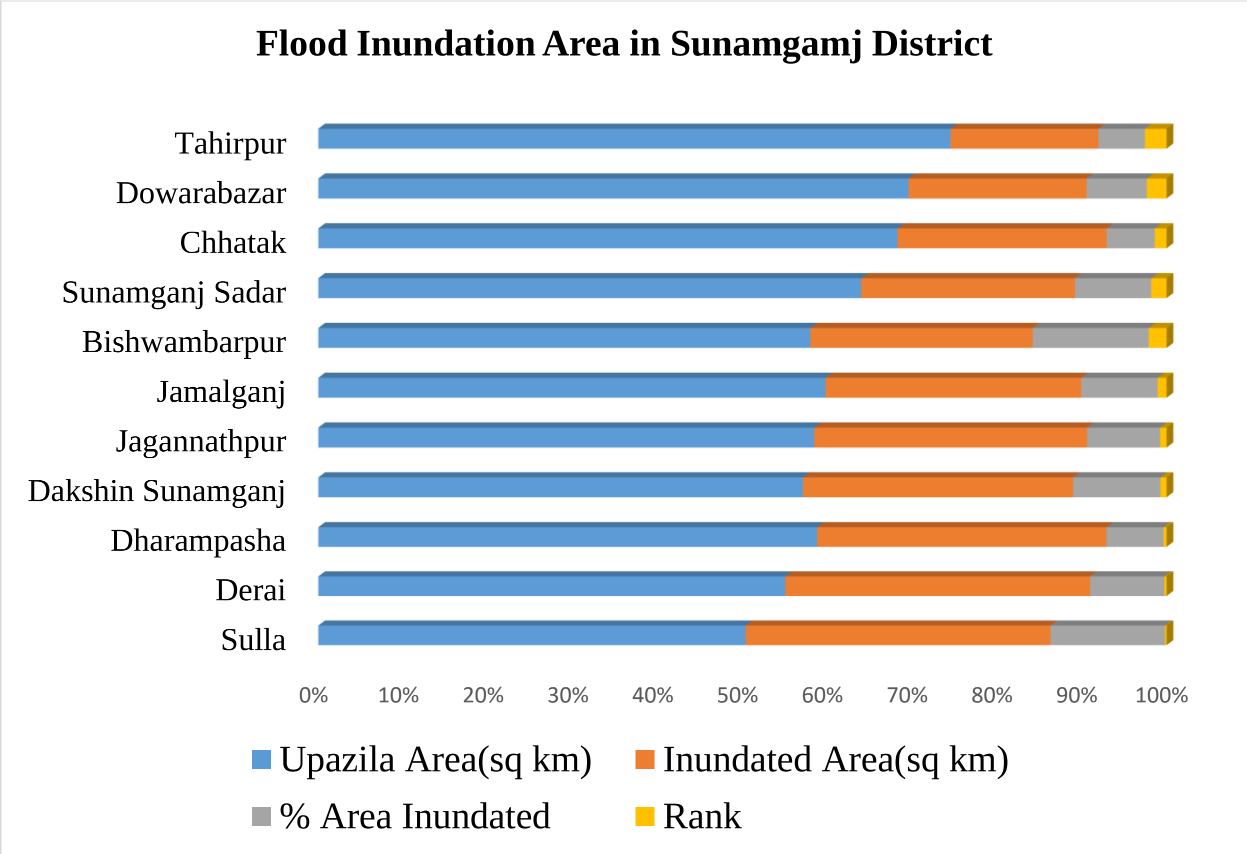


Fig 13: Flood inundation area derived from Sentinal-1 satellite images at different upazila of Sunamganj district

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.

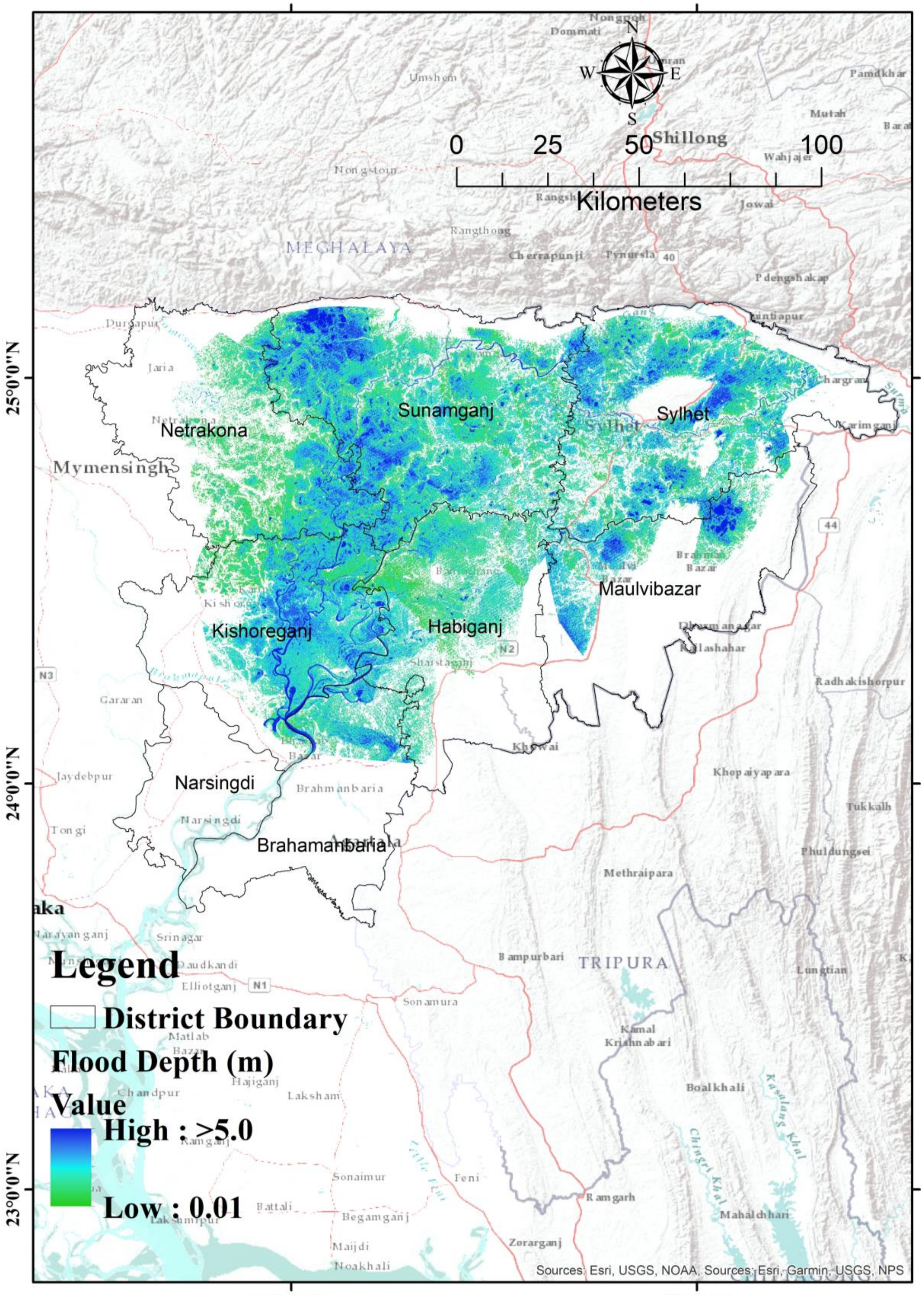


Fig 14: Preliminary result of simulated flood depth from hydrodynamic modelling

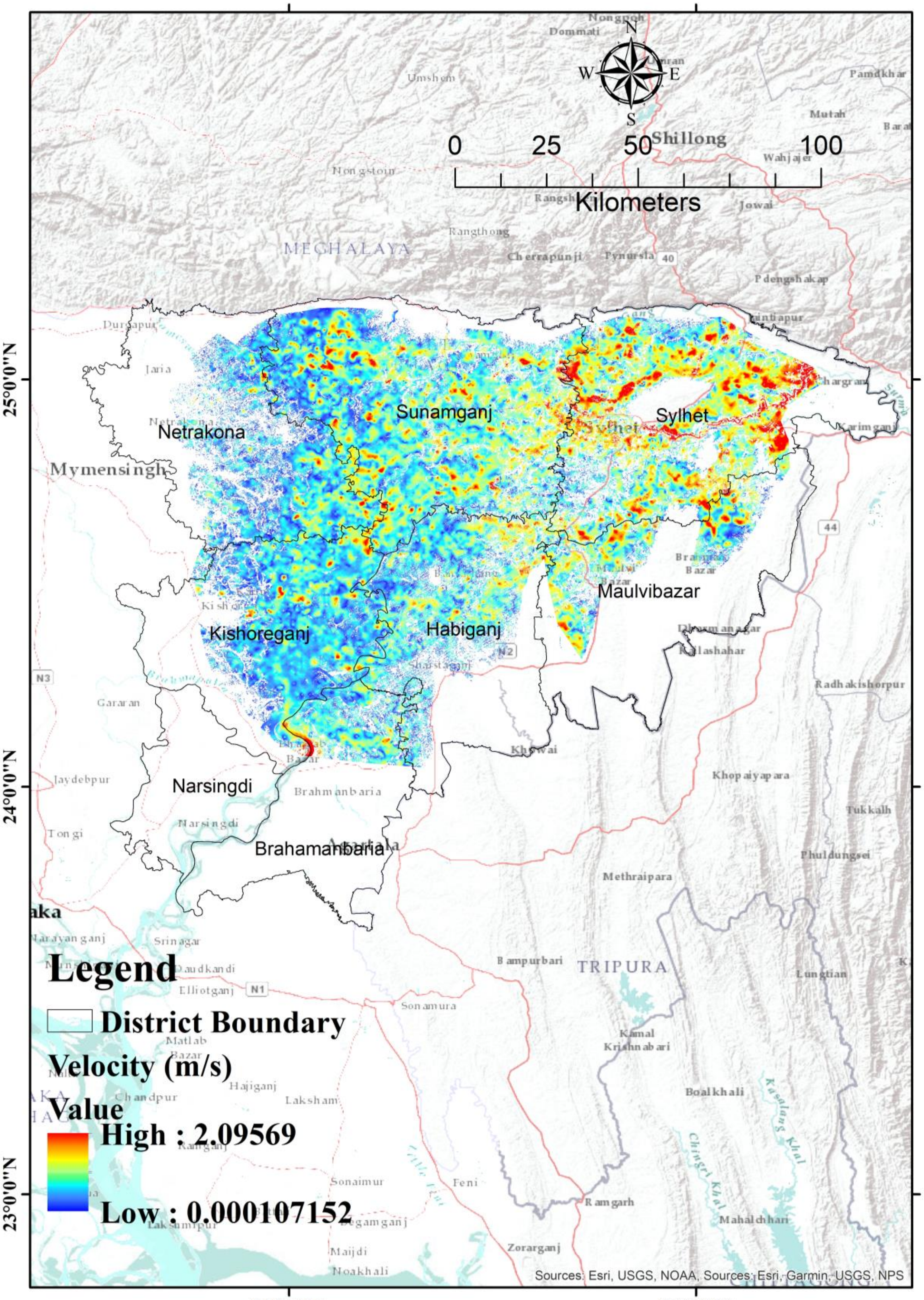


Fig 15. Preliminary result of simulated flood velocity from hydrodynamic modelling

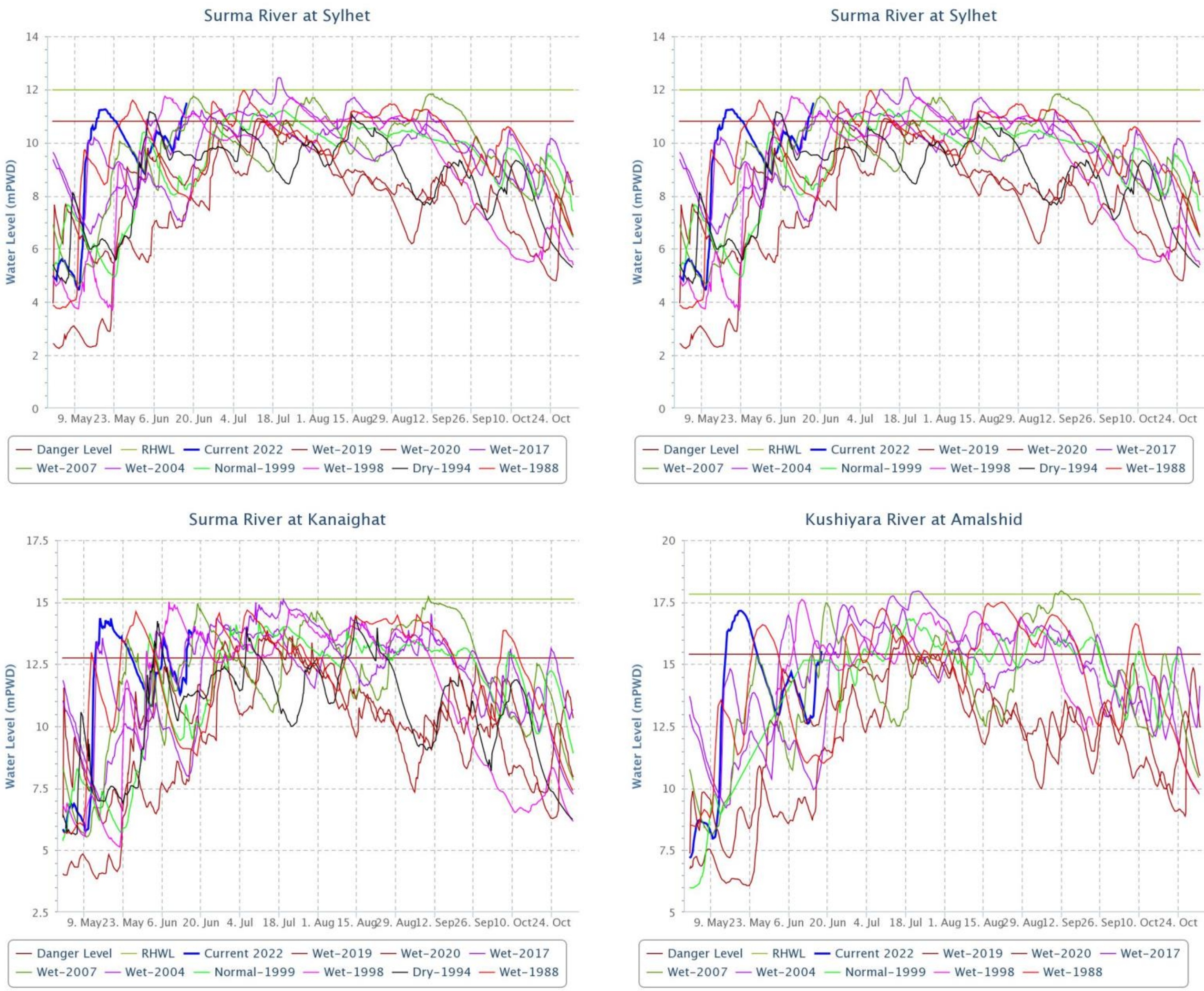


Fig 16: Monsoon flood hydrograph of Surma and Kushiyara rivers at different locations for different flood events (Source: FFWC).

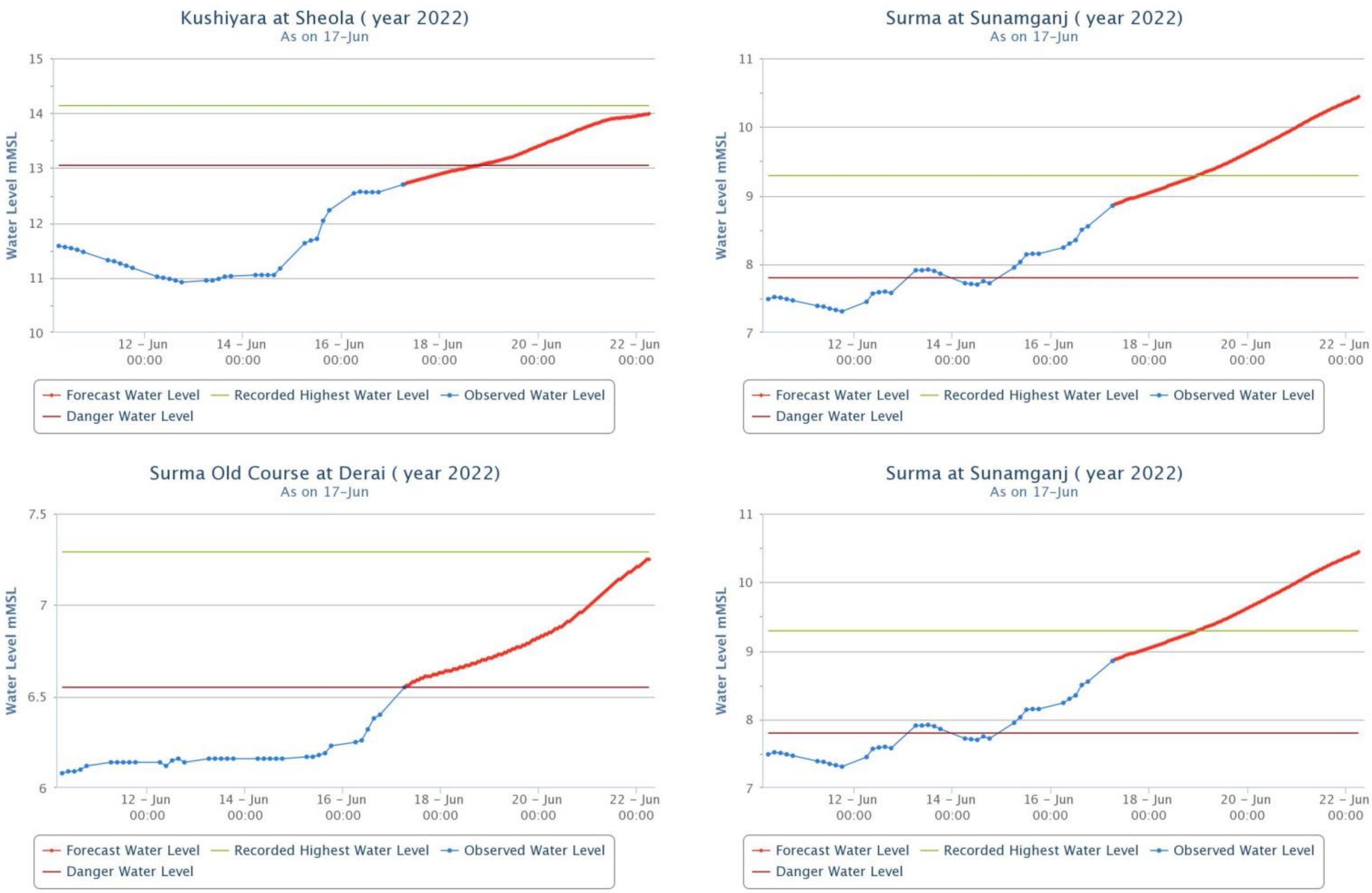


Fig 17: days deterministic flooding forecasting in Surma and Kushiyara river in Sylhet and Sunamganj districts in Bangladesh (Source: FFWC)

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.

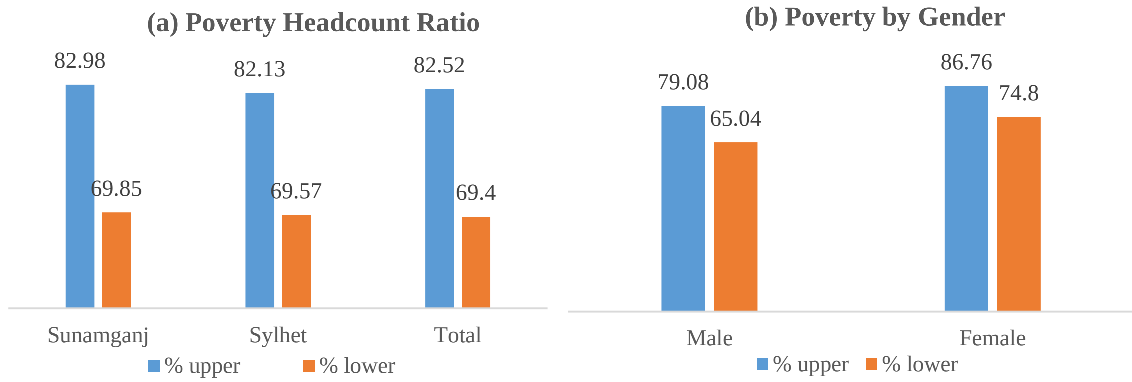
Chapter 4
Vulnerability, Impacts and Resilience: Evidence from Household Survey

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

Poverty and damage

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. These figure illustrates the proportion of households falling within each poverty threshold. It has been found that Sunamganj reports slightly higher poverty headcount ratios than Sylhet. When measured by the proportion of surveyed households under the upper poverty line, Sunamganj records 82.98 percent, while Sylhet reports a marginally lower proportion at 82.13 percent. For the lower poverty line, Sunamganj stands at 69.85 percent, whereas Sylhet registers 69.57 percent. These regional variations could be influenced by diverse economic conditions, resource accessibility, or other contextual factors shaping poverty levels. Considering the overall perspective, the combined poverty headcount ratios reveal that 82.52 percent of households are under the upper poverty line, and 69.40 percent fall below the lower poverty line. This consolidated view emphasizes the substantial prevalence of poverty within the surveyed communities.

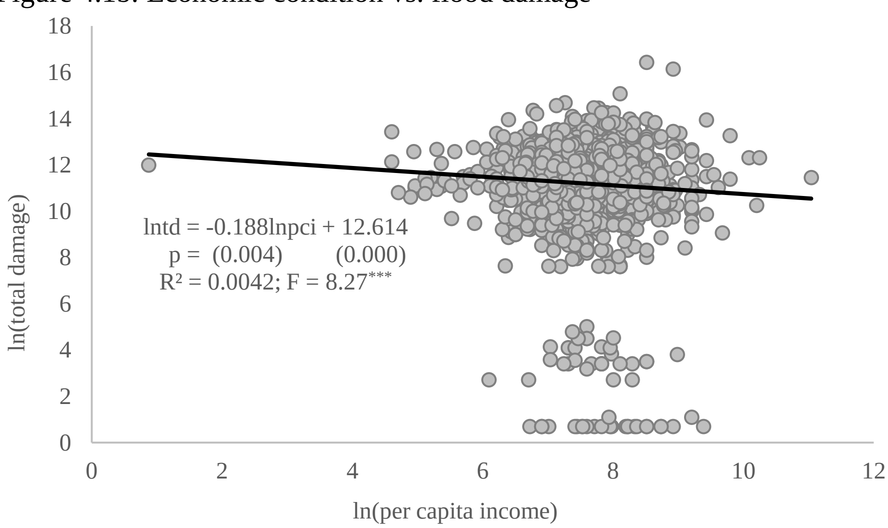
Figure 4.1a: Population of surveyed households living under poverty line (percent)



Source: Field survey (2023)

In scrutinising gender-based disparities, it is evident that a higher proportion of females, both in Sunamganj and Sylhet, find themselves under both upper and lower poverty lines in comparison to males. Specifically, 86.76 percent of females are under the upper poverty line, contrasting with 79.08 percent of males. Similarly, 74.80 percent of females fall below the lower poverty line, as opposed to 65.04 percent of males. This gender-specific divergence accentuates the increased vulnerability of females to poverty within the surveyed population.

Figure 4.1b: Economic condition vs. flood damage



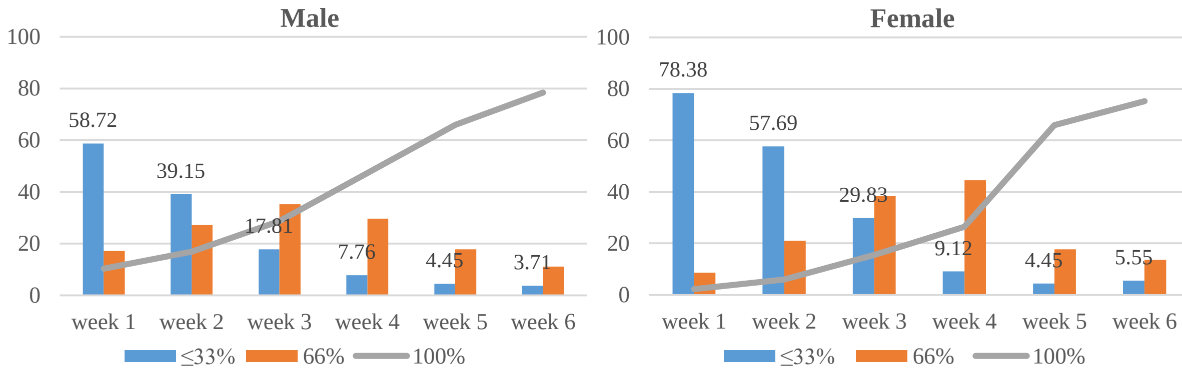
Source: Author’s analysis based on survey data (2023)

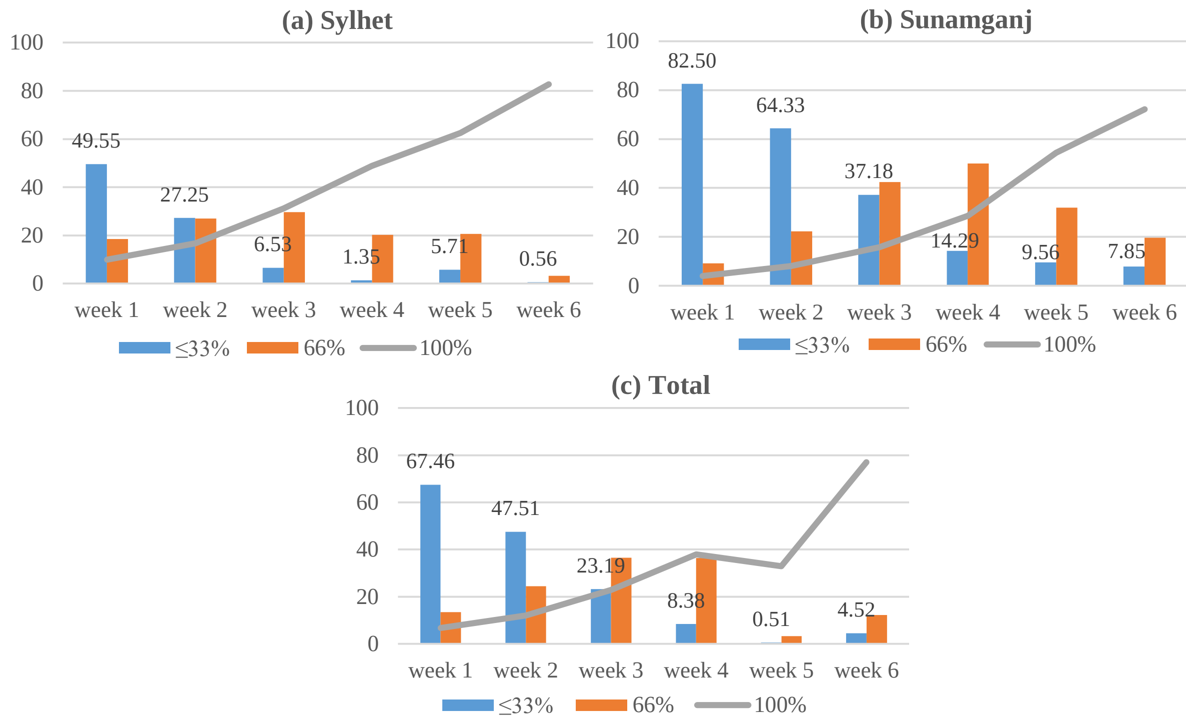
The survey data reveals that there is strong and negative correlation between level of income and damage. It has been found that the amount of damage is lower if the income level of the household is higher (Figure 1b). Especially, lower-income households experienced higher amount of damage than their 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.

Food intake during floods

It has been found that the onset of flood caused substantial reduction of 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 household in Sunamganj compared to their Sylhet counterparts. The onset of the floods brings about a significant decline in food intake for the surveyed households. In this crucial first week, more than two-thirds of the individual report consuming only up to one-third of their pre-flood food intake. This immediate drop reflects the acute impact of the flood on access to sustenance, signaling an urgent need for assistance and intervention. 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 reports consuming only up to one-third of their pre-flood food intake. This positive change could indicate adaptive measures, community support, or external interventions starting to make a positive impact. Despite ongoing challenges, the fourth week reveals a nuanced picture. The patterns suggest fluctuations in food intake proportions, with males showing a preference for higher intake than women. This diversity in dietary patterns within the surveyed population highlights the need for tailored interventions that consider gender-specific needs during the prolonged flood. In the fifth and sixth week 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 meal. 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 4.2: Chronology of food intake by gender and district (percent)





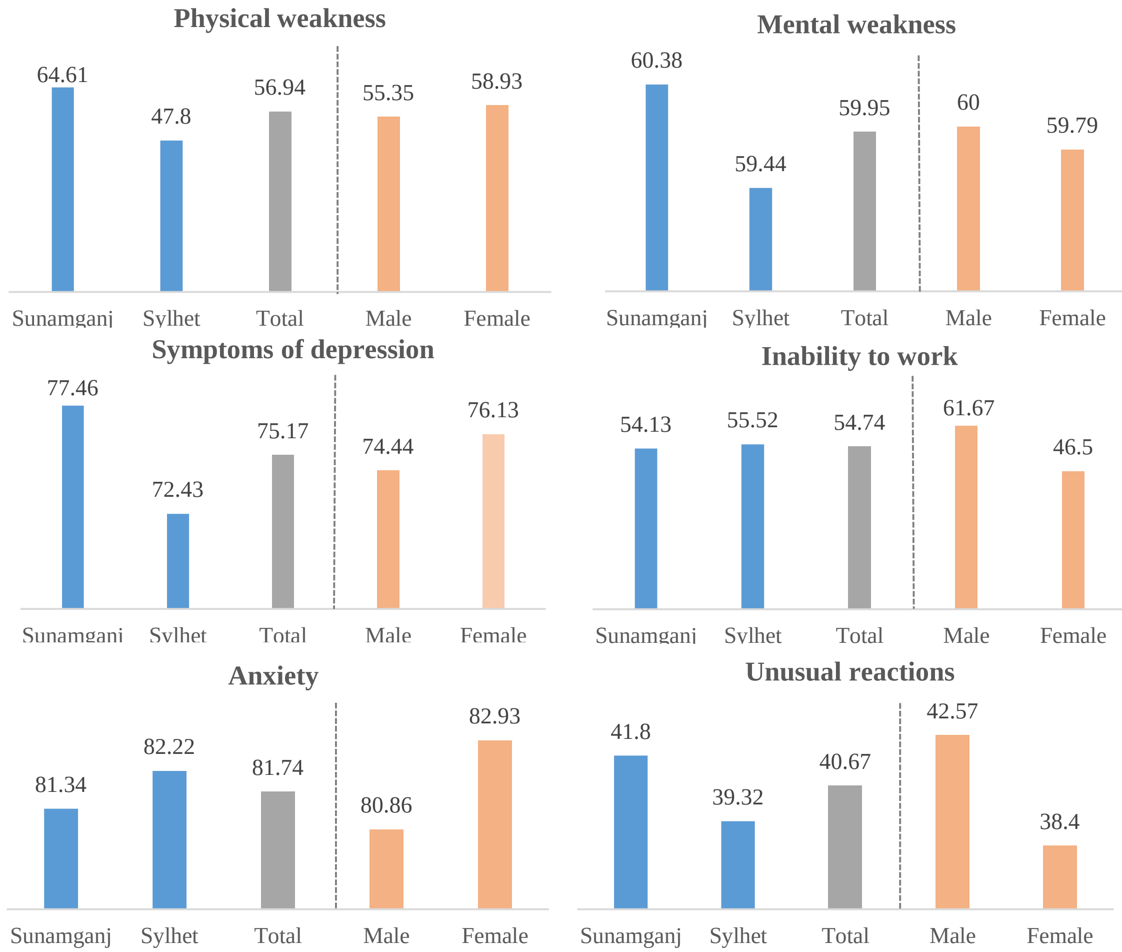
Note: ≤33 percent, 66 percent and 100 percent indicate proportion of pre-flood food intake
Source: Field survey (2023)

Physical and psychological impacts

The survey respondents reported significant presence of physical and mental weaknesses as well as psychological pressure among their household members. The presented data delves into the prevalence of physical weakness, dissected by gender and region in Sunamganj and Sylhet. Notably, females exhibit a slightly higher proportion of reported physical weakness at 58.93 percent, compared to males at 55.35 percent. This gender disparity prompts a critical examination of underlying factors contributing to health differences between male and female respondents.

Regionally, the results unveil distinct patterns, with Sunamganj reporting a substantially higher prevalence of physical weakness at 64.61 percent, contrasting with Sylhet's lower proportion of 47.80 percent. This regional variation raises questions about potential disparities in health conditions or reporting practices, emphasising the need for targeted investigations into the unique factors influencing health outcomes in these regions. Aggregating the data for the entire surveyed population yields an overall proportion of 56.94 percent, providing a comprehensive snapshot of the prevalence of physical weakness among respondents. The observed trends underscore the importance of nuanced, gender-sensitive, and region-specific mental health interventions to address the diverse health challenges.

Figure 4.3: Physical and psychological impacts of floods (percent)



Source: Field survey (2023)

The provided data offers insights into the perception of mental weakness, dissected by gender and region in Sunamganj and Sylhet. Notably, there is a marginal gender difference, with males reporting 60 percent, slightly higher than females at 59.79 percent. The slight difference between males and females, with males reporting a slightly higher proportion, suggests a delicate interplay of factors influencing how each gender perceives mental weakness. Regionally, Sunamganj reports 60.38 percent, while Sylhet reports 59.44 percent, contributing to an overall total of 59.95 percent.

The provided data on the inability to work, categorised by gender and region in Sunamganj and Sylhet. The overall total of 54.74 percent indicates a substantial portion of the surveyed population facing challenges in workforce participation. Regionally, Sylhet reports a slightly higher inability to work at 55.52 percent compared to Sunamganj at 54.13 percent. Breaking down the data by gender unveils a significant gender disparity. Males report a considerably higher inability to work at 61.67 percent, while females report a lower proportion at 46.50 percent. This gender contrast prompts a closer examination into the specific challenges faced by males in workforce participation compared to females. Several factors could contribute to these disparities. Traditional gender roles and expectations, coupled with the types of occupations commonly held by each gender, may influence these reported proportions. The regional differences could be indicative of varying socio-economic conditions or disparities in the impact of local events like floods.

Results on experienced symptoms of depression, categorised by gender and region in Sunamganj and Sylhet, provides insights into the emotional impact of the flood event. The overall total of 75.17 percent indicates a substantial proportion of the surveyed population reporting symptoms of depression, such as persistent sadness and loss of interest in activities. Analyzing the data by gender reveals a relatively close proportion, with males at 74.44 percent and females slightly higher at 76.13 percent. While the difference is marginal, it suggests a comparable emotional impact on both genders, emphasizing the universality of the psychological toll following the flood. Regionally, Sunamganj reports a higher proportion at 77.46 percent, while Sylhet is slightly lower at 72.43 percent. These regional differences could be influenced by varying degrees of flood severity, differing coping mechanisms, or distinct socio-economic conditions in each area. The observed prevalence of depression symptoms underscores the urgent need for mental health support and interventions in the aftermath of natural disasters. Understanding these variations in gender and region is crucial for tailoring mental health initiatives effectively.

The data on anxiety related to flooding in the event of heavy rainfall, categorised by gender and region in Sunamganj and Sylhet, provides valuable insights into the emotional impact of weather-related concerns. The overall total of 81.74 percent indicates a significant proportion of the surveyed population experiencing anxiety about flooding in the face of heavy rainfall. Analyzing the data by gender reveals a relatively close proportion, with males at 80.7 percent and females slightly higher at 82.9 percent. This marginal difference suggests a comparable level of anxiety between genders, highlighting the shared emotional response to the threat of flooding. Regionally, Sunamganj reports a slightly lower proportion at 81.34 percent, while Sylhet is slightly higher at 82 percent. These regional variations could be influenced by factors such as historical flood experiences, geographical vulnerability, or differing levels of awareness and preparedness.

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 programs, improving early warning systems, and providing mental health support can contribute to alleviating anxiety and enhancing overall well-being in both Sunamganj and Sylhet.

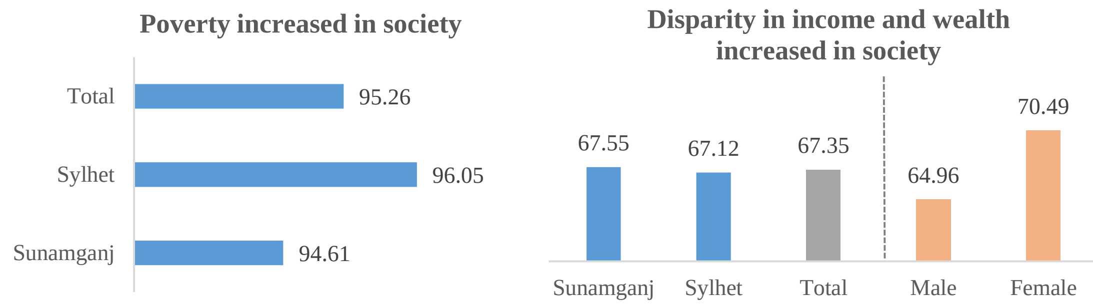
Results on the experience of excessive stress in normal circumstances, categorised by gender and region in Sunamganj and Sylhet, provides insights into the prevalence of heightened stress reactions within the surveyed population. The overall total of 40.67 percent indicates a significant portion of individuals reporting unusual reactions to excessive stress in their daily lives. Results by gender reveals a slight gender difference, with males at 42.57 percent and females at 38.40 percent. While the disparity is modest, it suggests a somewhat higher prevalence of unusual stress reactions among males compared to females. Regionally, Sunamganj reports a slightly higher proportion at 41.80 percent, while Sylhet is slightly lower at 39.32 percent. These regional variations may be influenced by diverse socio-economic conditions, cultural factors, or varying stressors prevalent in each area.

The observed prevalence of unusual stress reactions emphasises the importance of addressing mental health concerns in normal circumstances, as stress can significantly impact overall well-being. Promoting mental health awareness, and providing accessible support resources can contribute to mitigating the impact of excessive stress.

Perceived change in poverty and inequality in the society

The results illustrate the perceived increase in poverty within the surveyed society or community, categorised by gender and region in Sunamganj and Sylhet. The consistent proportion of 95.26 percent across both genders and the total population suggests a widespread acknowledgment of rising poverty levels. Considering the results by gender reveals a marginal difference, with males at 95.26 percent and females at 95.37 percent. This minor gender disparity indicates a comparable perception of increased poverty among both males and females within the surveyed population. Regionally, Sunamganj reports a slightly lower proportion at 94.61 percent, while Sylhet registers a slightly higher proportion at 96 percent. These regional variations could be influenced by distinct socio-economic conditions, economic activities, or the impact of external events, contributing to the nuanced perception of poverty increase.

Figure 4.4: Perceived change in poverty and inequality (percent)



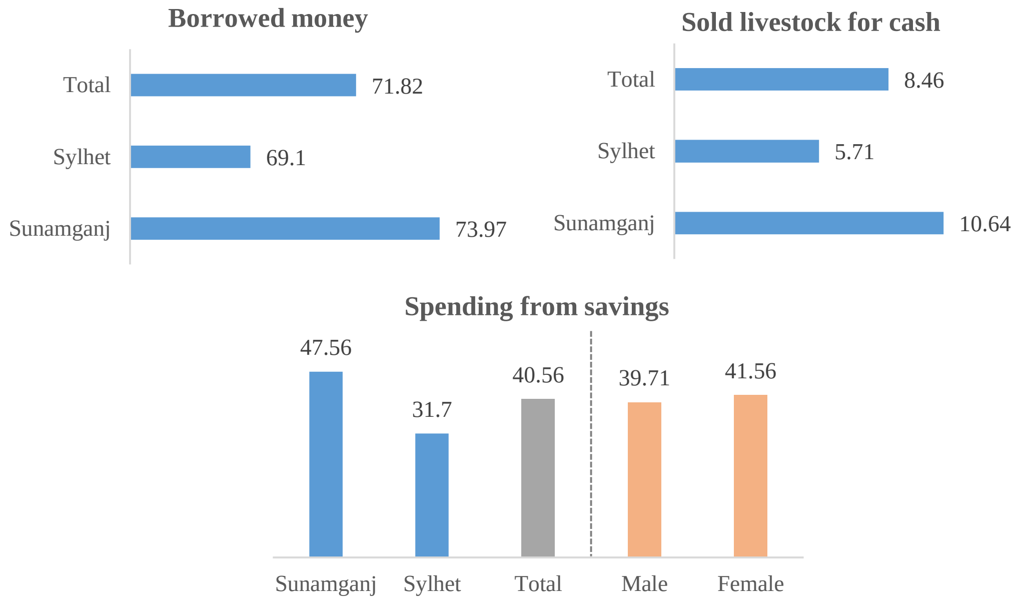
Source: Field survey (2023)

The result depicts 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. Analysing the data by gender shows a notable gender difference, with males at 64.96 percent and females at 70.49 percent. This gender disparity indicates a greater perception of increased income and wealth disparity among females compared to males within the surveyed population. Regionally, Sunamganj reports a slightly higher proportion at 67.55 percent, while Sylhet registers a slightly lower proportion at 67.12 percent. These regional variations may be influenced by distinct economic structures, disparities in economic opportunities, or differing impacts of external events contributing to the nuanced perception of growing income and wealth inequality.

Coping strategy

The figure presents the results on the incidence of borrowing money within the surveyed community, categorised by gender and region in Sunamganj and Sylhet. The overall about one-fourth respondents reported that they had to borrow money to cope up with the shocks posed by devastating floods. Breaking down the data by gender shows a minor difference, with 72.06 percent of males and 71.51 percent of females reporting borrowing money. This marginal gender disparity suggests a relatively similar likelihood of borrowing among both males and females within the surveyed community. Regionally, Sunamganj reports a higher proportion at 73.97 percent, while Sylhet registers a slightly lower proportion at 69.10 percent. These regional variations may stem from differing economic conditions, levels of financial literacy, or cultural influences affecting borrowing behaviors.

Table 4.5: Borrowing, selling and spending from savings as coping strategy (percent)



Source: Field survey (2023)

The figure presents data on the sale of livestock for cash within the surveyed community, categorised by gender and region in Sunamganj and Sylhet. The overall proportion of 8.46 percent indicates that a portion of the surveyed population has resorted to selling livestock to generate cash.

Analysing the data by gender reveals a slight gender difference, with 9.36 percent of males and 7.49 percent of females reporting the sale of livestock for cash. This modest gender disparity suggests a relatively comparable impact on both male and female individuals within the surveyed community. Regionally, Sunamganj, a poorer district than Sylhet, reports a higher proportion at 10.64 percent, while Sylhet registers a lower proportion at 5.71 percent. These regional variations may be influenced by distinct economic conditions, cultural practices, or differing levels of reliance on livestock as a source of income in each area. The overall proportion signifies that, while not a predominant practice, there is a noteworthy subset of the surveyed population resorting to selling livestock for cash, potentially indicating economic challenges or the need for immediate financial resources.

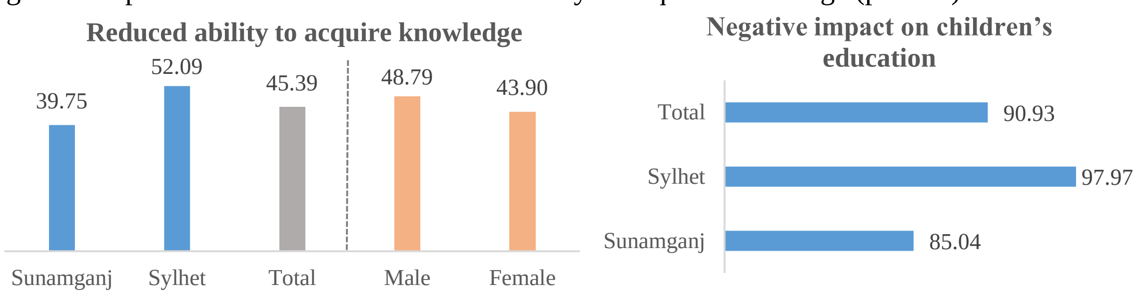
The result provides insights into the spending behavior from savings within the surveyed society or community, classified by gender and region in Sunamganj and Sylhet. The overall proportion of 40.56 percent indicates that a substantial portion of the surveyed households spent from their savings. Result by gender reveals a modest difference, with males at 39.71 percent and females at 41.56 percent. This slight gender disparity suggests a comparable propensity for spending from savings among both males and females within the surveyed community.

Regionally, Sunamganj reports a higher proportion at 47.56 percent, while Sylhet registers a lower proportion at 31.7 percent. These regional variations may be influenced by diverse economic conditions, levels of financial literacy, or cultural attitudes towards spending and saving. The observed prevalence of spending from savings underscores the financial behaviors within the surveyed community. The higher proportion in Sunamganj may indicate a greater reliance on savings for daily expenditures, whereas the lower proportion in Sylhet could suggest varying financial practices or economic conditions.

Impact on education

The figure illustrates the perceived ability of children to acquire knowledge, reported by a proportion of respondents in the regions of Sunamganj and Sylhet, with an overall total. In Sunamganj, 39.75 percent of respondents believe children possess this ability, whereas in Sylhet, the reported proportion is higher at 52.09 percent. The overall average for the surveyed population is 45.39 percent.

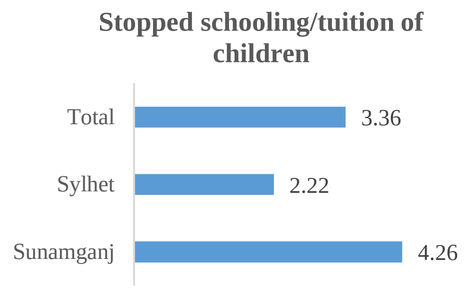
Figure 4.6: percent of children with reduced ability to acquire knowledge (percent)

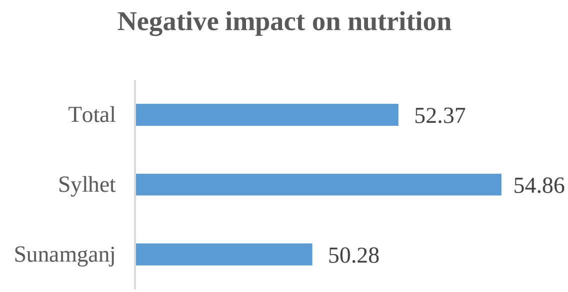


Source: Field survey (2023)

The figure shows the impact on children's education, delineated by gender and region in Sunamganj and Sylhet. The overall picture, with a total of 90.93 percent, indicates a significant prevalence of negative consequences affecting children's educational experiences. Examining the data by gender reveals a marginal difference, with males at 90.99 percent and females at 90.85 percent. This minor gender disparity suggests a comparable level of adverse impact on education for both males and females within the surveyed population. Regionally, Sunamganj reports a lower proportion at 85 percent, while Sylhet starkly contrasts with a higher proportion at 97.97 percent. This regional variation highlights significant differences in the challenges faced by children in accessing quality education, potentially influenced by diverse socio-economic factors or the severity of external events. The observed high prevalence of negative impact on children's education underscores the pressing need for targeted interventions. Addressing regional disparities may involve enhancing educational infrastructure, improving access to resources, and implementing community-based initiatives

Figure 4.7: 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 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.

Relief received by sources

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 15.40 percent of respondents visited local government offices for relief or assistance during the specified period. When disaggregated by gender, males and females reported proportions of 16.36 percent and 14.24 percent, respectively. Regionally, Sunamganj (12.69 percent) and Sylhet (18.62 percent) show variations in the proportion of individuals seeking assistance. These findings suggest a moderate level of engagement with local government offices for relief or assistance, with a slightly higher proportion in Sylhet compared to Sunamganj. 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 non-governmental assistance received by individuals or their family members in the aftermath of the flood, differentiating between genders and regions (Sunamganj and Sylhet). The data reveals that 2.32 percent of respondents have received non-governmental assistance since the flood. Breaking down the results by gender, both males and females report similar proportions at 2.32 percent. Regionally, Sunamganj and Sylhet show slight variations, with 2.65 percent and 1.92 percent, respectively. These proportions indicate a relatively low level of reported non-governmental assistance among the surveyed population. The minimal gender and regional differences may suggest a uniform distribution of such assistance across the surveyed areas.

The survey aimed to understand the sources from which the flood-affected people received relief. The results demonstrated in Figure 7 reveal the receipt of relief after the 2022 floods within the surveyed community, categorised by gender and district. The overall proportion of 8.46 percent indicates that a segment of the surveyed respondents received relief in the aftermath of the 2022 floods. The results reveal a slight gender difference, with 9.36 percent of males and 7.49 percent of females reporting the receipt of relief. This modest gender disparity suggests a relatively comparable impact on both male and female individuals within the surveyed community.

Regionally, Sunamganj reports a higher proportion at 10.64 percent, while Sylhet registers a lower proportion at 5.71 percent. These regional variations may be influenced by the severity of the flood impact, differing distribution mechanisms, or variations in the accessibility of relief resources in each area. The overall proportion implies that, while not universally distributed, a notable portion of the surveyed population did receive relief after the 2022 floods.

The figure summarises the distribution of relief received after the 2022 floods, categorised by gender and region (Sunamganj and Sylhet). The proportions represent the proportion of individuals who received relief from the government within the surveyed population. Analysing the data by gender reveals a slight disparity, with 50.9 percent of females and 46.32 percent of males reporting that they received relief. This marginal difference suggests a relatively equitable distribution of government relief among both genders within the surveyed population.

Turning attention to the regional breakdown, Sunamganj reports a higher proportion at 50.47 percent compared to Sylhet, which stands at 46 percent. These regional variations may be influenced by factors such as the severity of the flood impact, distribution mechanisms, or accessibility to relief resources. In the broader context, the overall proportion indicates that 48.5 percent of the surveyed population received relief from the government after the 2022 floods. This suggests a substantial outreach in providing assistance to individuals affected by the flood, contributing to the overall recovery efforts in the surveyed regions.

The figure summarises the distribution of relief received from NGOs after the 2022 floods, categorised by gender and region (Sunamganj and Sylhet). The proportions represent the proportion of individuals who received relief from NGOs within the surveyed population. Examining the data by gender, a marginal disparity is observed, with 29.29 percent of females and 27.54 percent of males reporting the receipt of relief from NGOs. This slight difference suggests a relatively balanced distribution of NGO assistance among both genders within the surveyed population.

Shifting focus to the regional breakdown, a notable discrepancy emerges between Sunamganj and Sylhet. Sunamganj reports a significantly higher proportion at 43.61 percent, while Sylhet stands at a lower 9.56 percent. These pronounced regional variations may stem from differences in NGO presence, accessibility, or varying levels of collaboration with local communities. The overall proportion indicates that 28.33 percent of the surveyed population received relief from NGOs after the 2022 floods. This underscores the significant role played by NGOs in contributing to the post-flood recovery efforts, particularly in Sunamganj where a substantial proportion of the population received NGO assistance. These findings highlight the complementary role of NGOs alongside government initiatives in post-disaster scenarios. The regional disparities underscore the importance of understanding local dynamics and optimising NGO outreach strategies for more effective disaster response and recovery.

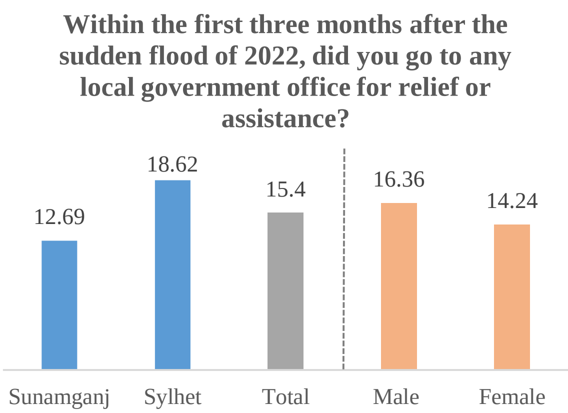
The figure of post-2022 flood relief distribution, spotlighting the role of community support and delving into gender and regional dynamics. Proportions represent the portion of individuals benefitting from community-driven aid within the surveyed population. When examining gender distinctions, a notable trend surfaces. A total of 31.48 percent of the males report receiving support from their communities, eclipsing the 22.38 percent reported by females. This gender-specific variance prompts a closer examination of the factors shaping community-based assistance and its potential uneven impact.

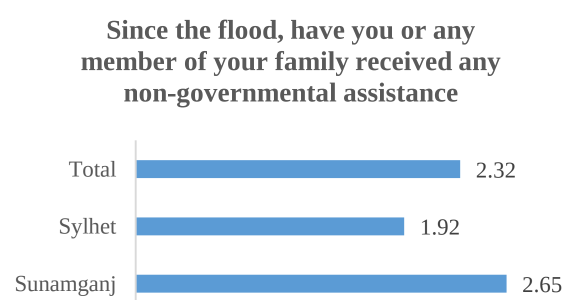
Sunamganj and Sylhet demonstrate divergent reliance on community support. Sunamganj records a modest 23.05 percent, while Sylhet stands out with a higher proportion at 32.44 percent. These regional fluctuations could stem from unique community dynamics, local initiatives, or varying capacities to extend assistance. In the broader landscape, the overall proportion reveals that 27.27 percent of the surveyed population received relief from the community post-flood. This highlights the substantial role played by local communities in fostering resilience and solidarity during the recovery phase.

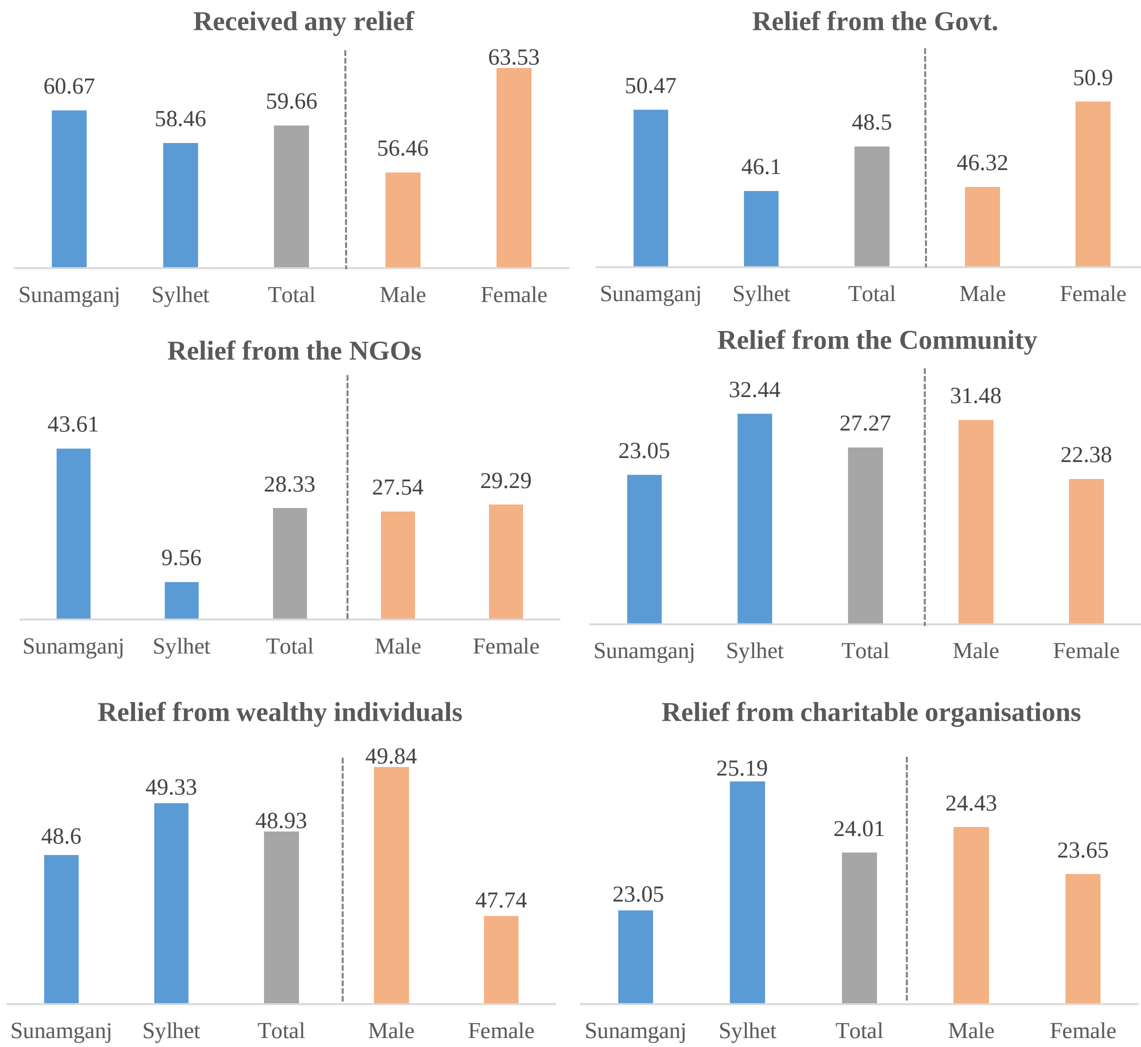
The survey result elucidates the distribution of relief received from wealthy individuals following the 2022 floods, categorised by gender and region (Sunamganj and Sylhet). The figure denotes the proportion of individuals who received assistance from affluent members within the surveyed population. Examining the data by gender reveals a subtle difference, with 49.84 percent of males and 47.74 percent of females reporting the receipt of relief from wealthy individuals. This marginal gender disparity suggests a relatively balanced distribution of assistance from affluent sources among both genders within the surveyed population. Turning to the regional breakdown, Sunamganj and Sylhet showcase comparable figures. Sunamganj reports a proportion of 48.60 percent, while Sylhet is marginally higher at 49.33 percent. These minimal regional variations imply a uniform reliance on support from wealthy individuals across both surveyed regions.

In the broader context, the overall proportion indicates that 48.93 percent of the surveyed population received relief from wealthy individuals after the 2022 floods. This suggests a noteworthy contribution from affluent members of the community in supporting those affected by the flood, contributing to the overall recovery efforts in Sunamganj and Sylhet. These findings underscore the significance of community cohesion, 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 4.8: Sources of relief during floods 2022 (percent)







Source: Field survey (2023)

The figure delineates the distribution of relief received from charitable organisations following the 2022 floods, categorised by gender and region (Sunamganj and Sylhet). The proportions signify proportion of individuals who received assistance from charitable sources within the surveyed population. Analysing the data by gender, a marginal difference is observed, with 24.43 percent of males and 23.65 percent of females reporting the receipt of relief from charitable organisations. This minimal gender disparity suggests a relatively balanced distribution of assistance from charitable sources among both genders within the surveyed population. Shifting focus to the regional breakdown, Sunamganj and Sylhet exhibit subtle variations. Sunamganj reports a proportion of 23.05 percent, while Sylhet is marginally higher at 25.19 percent. These regional differences imply a nuanced reliance on support from charitable organiszations across both surveyed regions.

In the broader context, the overall proportion indicates that 24.01 percent of the surveyed population received relief from charitable organizations after the 2022 floods. This suggests a significant contribution from philanthropic entities in supporting those affected by the flood, contributing to the overall recovery efforts in Sunamganj and Sylhet. These findings highlight the crucial role played by charitable organisations in post-disaster recovery. The minimal gender and regional differences suggest a relatively equitable distribution of assistance from these organizations.

Types of relief received

Traditionally, food, clothes, medicine, water purifier (alum or others) and housing materials are distributed during disasters like flood. The survey aimed to understand the type of relief the flood-affected people received. Figure 9 illustrates the distribution of received cooked food after the 2022 floods, categorized by gender and region (Sunamganj and Sylhet). The proportions represent proportion of individuals who received cooked food within the surveyed population.

Analysing the data by gender, a marginal difference is observed, with 11.39 percent of males and 12.55 percent of females reporting the receipt of cooked food. This minimal gender disparity suggests a relatively balanced distribution of cooked food among both genders within the surveyed population. Turning to the regional breakdown, Sunamganj and Sylhet exhibit subtle variations. Sunamganj reports a proportion of 12.11 percent, while Sylhet is nearly identical at 12.07 percent. These regional differences imply a uniform reliance on receiving cooked food across both surveyed regions.

In the broader context, the overall proportion indicates that 12.09 percent of the surveyed population received cooked food after the 2022 floods. This suggests a notable contribution from relief efforts focused on providing prepared meals, contributing to the overall sustenance and recovery of individuals in Sunamganj and Sylhet. These findings underscore the importance of catering to immediate nutritional needs in post-disaster scenarios. The minimal gender and regional differences suggest a relatively consistent distribution of cooked food, reflecting the effectiveness of relief efforts in addressing the essential needs of the surveyed population.

The figure delineates the distribution of received dry food after the 2022 floods. Analysing the data by gender, there is a minimal difference, with 94.23 percent of males and 95.09 percent of females reporting the receipt of dry food from the respondents who received relief. This marginal gender disparity suggests a nearly uniform distribution of dry food among both genders within the surveyed population. Sunamganj and Sylhet exhibit subtle variations. Sunamganj reports a proportion of 94.81 percent, while Sylhet is slightly lower at 94.46 percent. These regional differences imply a consistent reliance on receiving dry food across both surveyed regions. The overall proportion indicates that 94.65 percent of the surveyed population received dry food after the 2022 floods. This suggests a significant reliance on relief efforts providing non-perishable, dry food items, contributing to the overall sustenance and recovery of individuals in Sunamganj and Sylhet. These findings underscore the critical role of dry food in post-disaster sustenance. 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 population.

The figure illustrates the distribution of received clothing after the 2022 floods. Analysing the data by gender, a slight difference is observed, with 3.29 percent of males and 4.36 percent of females reporting the receipt of clothing. This minimal gender disparity suggests a relatively balanced distribution of clothing among both genders within the surveyed population. Turning to the regional breakdown, Sunamganj and Sylhet exhibit notable variations. Sunamganj reports a higher proportion at 4.87 percent, while Sylhet is lower at 2.49 percent. These regional differences imply divergent reliance on clothing support across both surveyed regions. In the broader context, the overall proportion indicates that 3.80 percent of the surveyed population received clothing after the 2022 floods. This 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.

These findings underscore the importance of addressing not only immediate sustenance needs but also factors contributing to overall comfort and well-being in post-disaster scenarios. The gender and regional differences highlight the need for nuanced strategies in providing clothing support, considering the diverse needs and preferences of individuals in both Sunamganj and Sylhet.

The results indicate that 56 percent of females received medicine after the 2022 floods, surpassing the 51.40 percent reported by males. This gender difference suggests a slightly higher prevalence of medicine distribution among females within the surveyed population. When examining regional disparities, Sunamganj and Sylhet display contrasting patterns. In Sunamganj, 57.55 percent reported receiving medicine, while in Sylhet, the proportion is slightly lower at 48.76 percent. These regional variations suggest diverse levels of access to medicinal relief across the surveyed regions.

In the broader context, the overall proportion indicates that 53.58 percent of the surveyed population received medicine after the 2022 floods. This emphasizes the significant role of medical relief efforts in contributing to the overall health recovery of individuals in both Sunamganj and Sylhet. These findings underscore the importance of tailored medical interventions post-disaster, considering both gender-specific health needs and regional disparities.

The findings reveal that 8 percent of females received shelter after the 2022 floods, slightly exceeding the 7.1 percent reported by males. This marginal gender difference suggests a relatively equitable distribution of shelter among both genders within the surveyed population. However, regional disparities are more pronounced. Sunamganj reports a significantly higher proportion at 11.16 percent, while Sylhet is substantially lower at 3.26 percent. These regional variations highlight differing levels of access to shelter support across the surveyed regions.

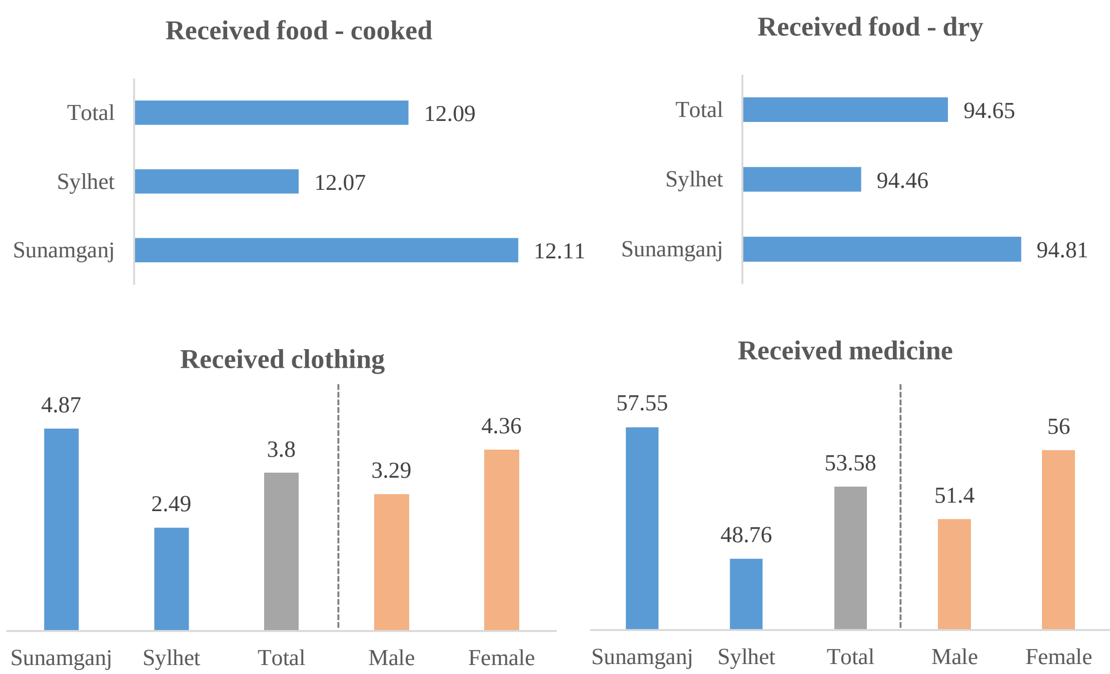
The overall proportion indicates that 7.6 percent of the surveyed population received shelter after the 2022 floods. This underscores the importance of shelter-focused relief efforts in contributing to the overall recovery and well-being of individuals in both Sunamganj and Sylhet. These findings emphasise the need for nuanced strategies in providing shelter support, considering both gender-specific needs and distinct regional challenges.

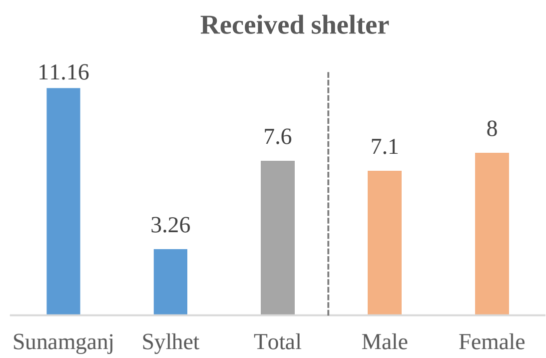
Candle was an important relief item during the floods as the price of candle became around 10 times and nearly unavailable at that time. The data indicates that 55.92 percent of females received candles after the 2022 floods, which is higher than the 49.5 percent reported by males. This suggests a slightly higher prevalence of candle distribution among females within the surveyed population. Examining regional differences, Sunamganj and Sylhet exhibit substantial variations.

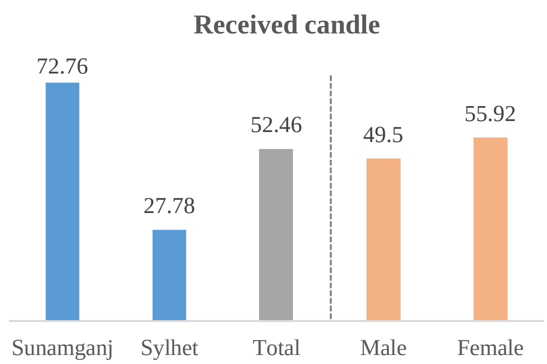
In Sunamganj, a significant majority of 72.76 percent reported receiving candles, while in Sylhet, the proportion is notably lower at 27.78 percent. These regional disparities highlight divergent levels of access to candle relief across the surveyed regions. The overall proportion indicates that 52.46 percent of the surveyed population received candles during the 2022 floods. This underscores the significant role of candle distribution in addressing lighting needs, particularly in Sunamganj where a substantial percent of the population received candles.

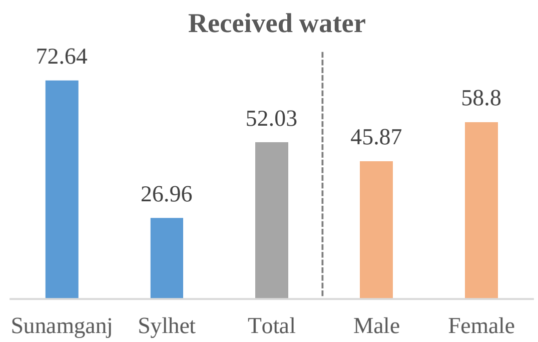
Supply of safe drinking water is essential during floods among affected population. However, a notable proportion of respondents did not receive safe drinking water during that period. The data reveals that 58.8 percent of females received safe drinking water after the 2022 floods, significantly higher than the 45.87 percent reported by males. Regional disparities are substantial, with Sunamganj reporting a majority of 72.64 percent receiving water, while in Sylhet, the proportion is considerably lower at 26.96 percent. These regional variations underscore differing levels of access to water relief across the surveyed regions. The overall proportion indicates that 52.03 percent of the surveyed population received water after the 2022 floods. This underscores the vital role of water distribution in addressing one of the fundamental needs in post-disaster scenarios, with Sunamganj experiencing a more significant impact in this regard.

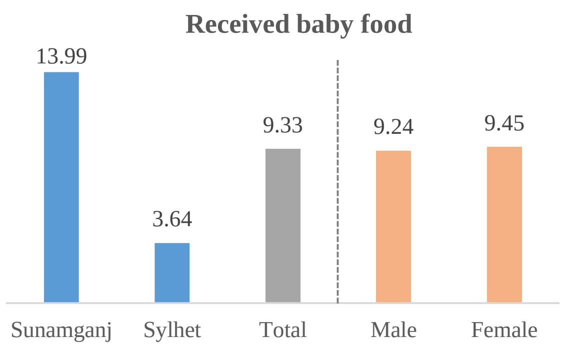
Figure 4.9: Types of relief during floods 2022 (percent)

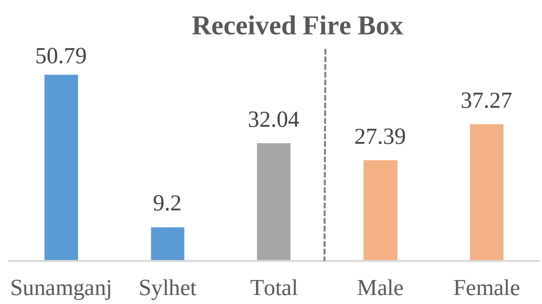


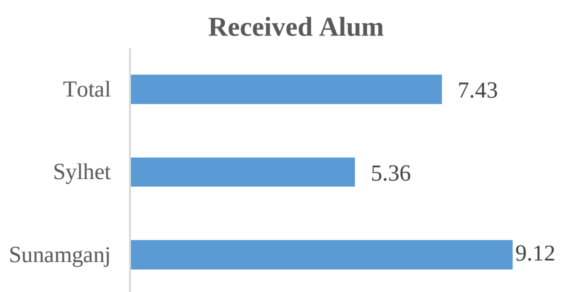


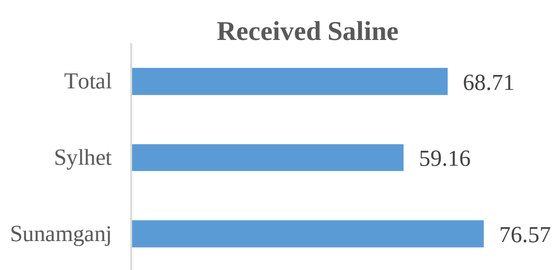


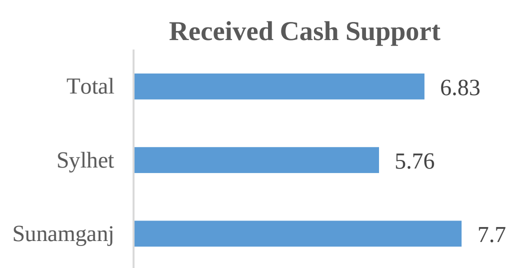


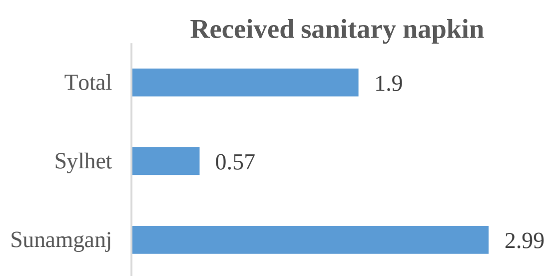












Source: Field survey

The data indicates that 9.45 percent of females received baby food after the 2022 floods, slightly exceeding the 9.24 percent reported by males. Regionally, Sunamganj reports a significantly higher proportion at 13.99 percent, while in Sylhet, the proportion is notably lower at 3.64 percent. These figures highlight gender and regional disparities in the distribution of baby food. This suggests that there was a more significant impact and targeted distribution of baby food in Sunamganj compared to Sylhet. The higher proportion in Sunamganj could be attributed to increased efforts or resources allocated to address the specific needs of women and infants in the post-flood relief initiatives.

The data reveals that 37.27 percent of females received fireboxes after the 2022 floods, surpassing the 27.39 percent reported by males. Regionally, Sunamganj reports a substantial majority of 50.79 percent, while in Sylhet, the proportion is notably lower at 9.20 percent. These findings indicate gender and regional disparities in the distribution of fireboxes.

The data indicates that 9.12 percent of individuals in Sunamganj and 5.36 percent in Sylhet received alum after the 2022 floods. The overall proportion is 7.43 percent. Alum is commonly used for water purification and other purposes. The higher proportion in Sunamganj suggests a more significant impact or targeted distribution of alum in addressing specific needs related to water purification or other applications in that region.

The data indicates that 76.57 percent of individuals in Sunamganj and 59.16 percent in Sylhet received saline after the 2022 floods. The overall proportion is 68.71 percent. Saline is often used for medical purposes, especially in situations where individuals may experience dehydration or other health-related issues. The higher proportion in Sunamganj suggests a more significant impact or targeted distribution of saline in addressing health-related concerns in that region. This could be indicative of a higher prevalence of health issues or a more extensive healthcare response in Sunamganj compared to Sylhet.

The data reveals that 7.7 percent of individuals in Sunamganj and 5.76 percent in Sylhet received cash support after the 2022 floods, with an overall proportion of 6.83 percent. Cash support is a flexible form of aid that allows individuals to address their specific needs and priorities in the aftermath of a disaster. 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, or meeting other urgent requirements.

Supply of sanitary napkin is essential for managing personal hygiene during floods. The data indicates that meagre 2.99 percent of individuals in Sunamganj and 0.57 percent in Sylhet received sanitary napkins after the 2022 floods. The overall proportion is 1.9 percent. This suggests a relatively low prevalence of distribution, with Sunamganj having a higher impact in this aspect compared to Sylhet.

Quality of supply and living condition at flood shelter

The survey also aimed to assess quality of supply, facilities and living condition at flood shelter, especially considering women and girls, persons with disability (PWD) and 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 shelter. Overall, 41.27 percent of individuals reported facing challenges related to the inadequacy of processed (cooked) food during their shelter stay. This highlights a significant portion of shelter occupants grappling with difficulties in accessing sufficient cooked meals, emphasizing the importance of robust meal planning and distribution in shelter management. Analysing gender differences, males (47 compared to females (36 percent). This gender disparity suggests potential variations in dietary needs or preferences between male and female shelter occupants, underlining the importance of considering gender-specific requirements in food provision strategies. Regarding regional variations, both Sunamganj and Sylhet exhibit the same proportion of individuals facing challenges related to the inadequacy of processed food at 41.27 percent. This indicates a uniform experience across the two regions concerning the availability of cooked meals.

The figure provides information on the shortage of safe drinking water experienced by individuals during their stay at flood shelters, considering both gender and regional perspectives. Overall, 69.58 percent of individuals reported facing a shortage of pure drinking water during their shelter stay. This indicates a significant portion of shelter occupants encountering challenges related to access to clean and safe drinking water, emphasizing the critical need for proper water supply management in shelter planning. When examining gender differences, females (71.69 percent) reported a slightly higher proportion of challenges related to the shortage of pure drinking water compared to males (67.16 percent). While the difference is marginal, it suggests a shared concern across genders, highlighting the need for gender-neutral approaches in addressing water scarcity. Regional disparities reveal that in Sunamganj, a higher proportion (81.59 percent) experienced a shortage of pure drinking water, while in Sylhet, the proportion is comparatively lower at 46.94 percent. These regional variations may be influenced by factors such as water infrastructure, water quality, or the impact of the flood, emphasizing the need for context-specific interventions.

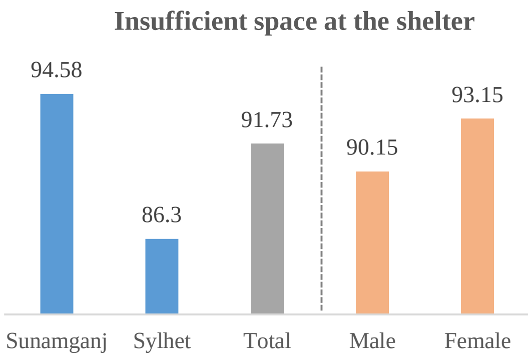
The figure presents data on the food crisis experienced by individuals during their stay at flood shelters, considering both gender and regional perspectives. Overall, 70.28 percent of individuals reported facing a food crisis during their shelter stay. This indicates a substantial portion of shelter occupants encountering challenges related to food availability, emphasizing the critical need for adequate food provisions in shelter planning and management. When examining gender differences, both males (70.1 percent) and females (70.78 percent) reported similar proportions of challenges related to the food crisis. This suggests a relatively uniform experience across genders, highlighting the need for gender-neutral strategies in addressing food shortages. Regional disparities reveal that in Sunamganj, a higher proportion (79.42 percent) experienced a food crisis, while in Sylhet, the proportion is comparatively lower at 53 percent. These regional variations may be influenced by factors such as the severity of the flood impact, access to food resources, or the efficiency of local relief efforts.

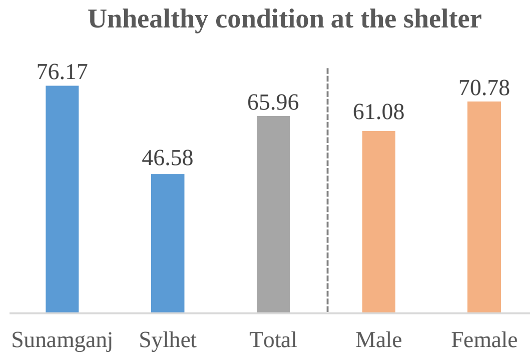
The figure provides information on the inadequacy of toilet facilities at flood shelters, considering both gender and regional aspects. Overall, 66.43 percent of individuals reported facing challenges related to inadequate toilet facilities during their shelter stay. This indicates a significant proportion of shelter occupants grappling with insufficient sanitation infrastructure, emphasizing the critical need for proper toilet facilities in shelter planning and management. When examining gender differences, females (66.97 percent) reported a slightly higher proportion of challenges related to inadequate toilet facilities compared to males (66.18 percent). While the difference is marginal, it suggests that both genders encounter similar issues, underlining the importance of gender-neutral approaches in addressing sanitation challenges. Regional disparities reveal that in Sunamganj, a higher proportion (74.64 percent) experienced challenges due to inadequate toilet facilities, while in Sylhet, the proportion is comparatively lower at 51.02 percent. These regional variations may be influenced by factors such as the availability and capacity of sanitation facilities, emphasizing the need for context-specific interventions.

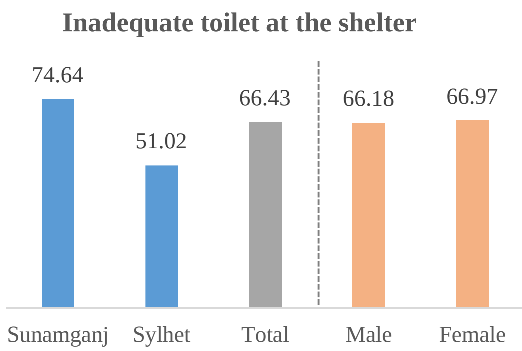
The table provides insights into the prevalence of challenges related to unhealthy conditions at flood shelters, considering both gender and regional perspectives. Overall, 65.96 percent of individuals reported facing issues associated with unhealthy conditions during their shelter stay. This highlights a substantial portion of shelter occupants grappling with health-related challenges, emphasising the critical importance of maintaining sanitary and conducive environments in shelter facilities. Examining gender differences, females (70.78 percent) reported a higher proportion of challenges related to unhealthy conditions compared to males (61.08 percent). This gender disparity suggests potential variations in health vulnerabilities or hygiene needs between male and female shelter occupants, emphasizing the need for gender-sensitive health interventions in shelter management. Regional disparities reveal that in Sunamganj, a higher proportion (76.17 percent) experienced challenges due to unhealthy conditions, while in Sylhet, the proportion is comparatively lower at 46.58 percent. These regional variations may be influenced by factors such as shelter infrastructure, access to sanitation facilities, or overall disaster response capacities, highlighting the importance of tailored health and hygiene strategies based on regional contexts.

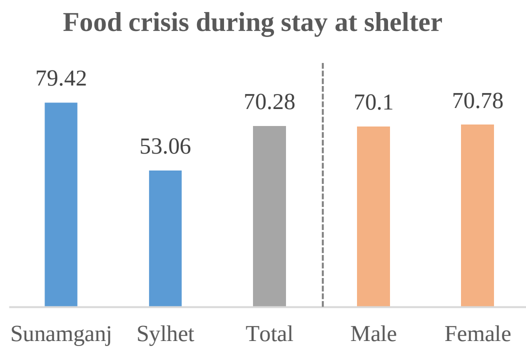
The table illustrates the prevalence of challenges related to insufficient space at flood shelters, considering both gender and regional aspects. The overall data indicates that 91.73 percent of individuals faced issues with insufficient space during their stay at the shelters. This highlights a significant majority grappling with spatial constraints, emphasizing the critical need for proper shelter planning and resource allocation. Examining gender differences, females (93.15 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 utilization or requirements between male and female shelter occupants. Regional disparities reveal that in Sunamganj, a higher proportion (94.58 percent) experienced challenges due to insufficient space, while in Sylhet, the proportion is comparatively lower at 86.30 percent. These regional variations may stem from differences in shelter infrastructure, capacity, or the number of displaced individuals, emphasizing the importance of tailoring shelter management strategies to specific geographical contexts.

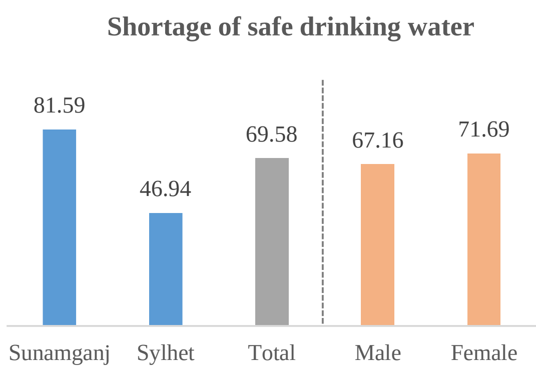
Figure 4.10: Quality of supply and living condition at flood shelter (percent)

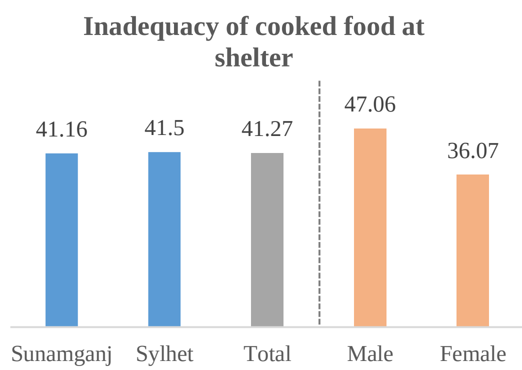

Insufficient space at the shelter
94.58
86.3
91.73
90.15
93.15
Sunamganj
Sylhet
Total
Male
Female

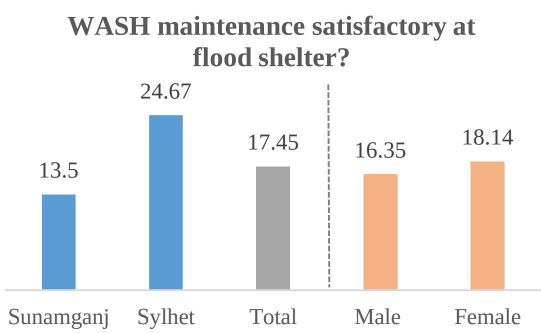

Unhealthy condition at the shelter
76.17
46.58
65.96
61.08
70.78
Sunamganj
Sylhet
Total
Male
Female

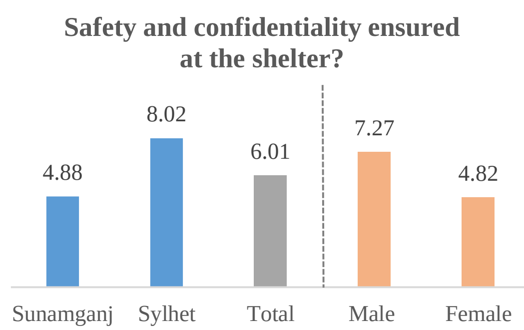

Inadequate toilet at the shelter
74.64
51.02
66.43
66.18
66.97
Sunamganj
Sylhet
Total
Male
Female

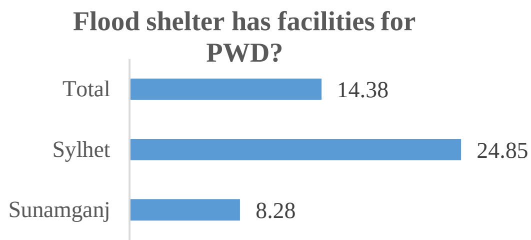

Food crisis during stay at shelter
79.42
53.06
70.28
70.1
70.78
Sunamganj
Sylhet
Total
Male
Female

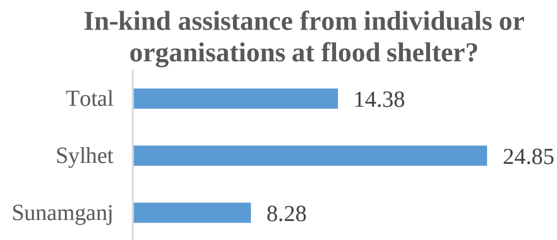

Shortage of safe drinking water
81.59
46.94
69.58
67.16
71.69
Sunamganj
Sylhet
Total
Male
Female

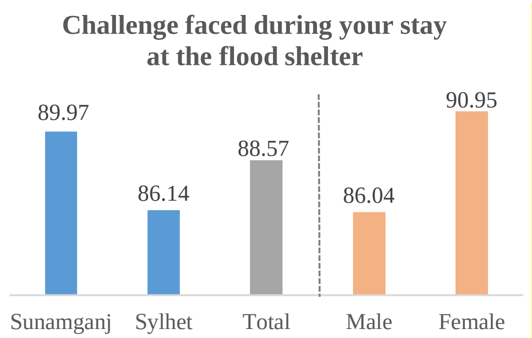

Inadequacy of cooked food at shelter
41.16
41.5
41.27
47.06
36.07
Sunamganj
Sylhet
Total
Male
Female


WASH maintenance satisfactory at flood shelter?
13.5
24.67
17.45
16.35
18.14
Sunamganj
Sylhet
Total
Male
Female


Safety and confidentiality ensured at the shelter?
4.88
8.02
6.01
7.27
4.82
Sunamganj
Sylhet
Total
Male
Female







Source: Field survey (2023)

Figure 10 provides insights into the perceived cleanliness, availability of clean water, and sanitation facilities in terms of hygiene maintenance during individuals' stay at the flood center. The data is categorized by gender and region, specifically Sunamganj and Sylhet. Overall, 17.45 percent of individuals reported that the cleanliness, availability of clean water, and hygiene maintenance of sanitation facilities were satisfactory during their time at the flood center. This suggests that a moderate but notable portion of individuals found the hygiene conditions and water facilities acceptable.

Analysing gender and regional differences, the data reveals that females (18.14 percent) reported a slightly higher proportion compared to males (16.35 percent). Additionally, Sylhet (24.67 percent) reported a considerably higher satisfaction rate compared to Sunamganj (13.5 percent). These variations indicate potential differences in the perception of hygiene conditions, cleanliness, and water availability, emphasizing the need for continuous efforts to improve and maintain satisfactory standards.

The figure presents information regarding the implementation of special safety and confidentiality measures for specific groups, including children, teenagers, women, pregnant women, and disabled persons, at flood shelters. The focus is on gender and regional perspectives, with data provided for males and females in Sunamganj and Sylhet. Overall, 6.01 percent of individuals reported that special safety and confidentiality measures were ensured for these specific groups during their stay at the shelter. This indicates a modest but notable effort to address the unique needs and vulnerabilities of children, teenagers, women, pregnant women, and disabled persons.
Analyzing gender and regional differences, the data shows that females (4.82 percent) reported a slightly lower proportion compared to males (7.27 percent). Additionally, in Sunamganj (4.88 percent), a lower proportion was reported compared to Sylhet (8.02 percent). These variations suggest potential disparities in the implementation of safety and confidentiality measures, emphasizing the need for consistent and inclusive practices across genders and regions. The findings highlight the importance of ensuring specialized safety measures for vulnerable groups in flood shelters. The variations in reporting indicate the need for continuous efforts to improve and

standardize practices, ensuring that all individuals, irrespective of gender or region, receive adequate safety and confidentiality support during their shelter stay.

The figure provides information about the availability of facilities to accommodate PWD, such as stairs with handrails and handicap-friendly sanitation facilities, in flood shelters. The focus is on two regions: Sunamganj and Sylhet. Overall, 14.38 percent of individuals reported that the flood shelters had facilities to accommodate persons with disabilities. Analyzing regional differences, Sunamganj (8.28 percent) had a lower proportion of individuals reporting the availability of facilities for persons with disabilities compared to Sylhet (24.85 percent). This indicates a significant regional disparity in the provision of disability-friendly infrastructure, with individuals in Sylhet being more likely to have access to such facilities during their time in flood shelters. These findings underscore the importance of ensuring inclusive infrastructure in flood shelters, particularly for persons with disabilities. The regional variation suggests potential differences in the prioritisation or availability of facilities, emphasizing the need for comprehensive and uniform accessibility standards across regions to ensure equitable support for all individuals seeking refuge in shelters.

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, with a focus on two regions: Sunamganj and Sylhet. Overall, 14.38 percent of individuals reported receiving in-kind assistance during their stay at flood shelters. This suggests that a modest but notable portion of shelter occupants benefited from support in the form of goods or services provided by individuals or organizations. Analyzing regional differences, Sunamganj (8.28 percent) had a lower proportion of individuals receiving in-kind assistance compared to Sylhet (24.85 percent). This indicates a significant regional disparity in the receipt of assistance, with individuals in Sylhet being more likely to receive support from individuals or organizations during their time in flood shelters. The regional variation suggests potential differences in the availability or accessibility of support networks, emphasizing the need for tailored assistance strategies that consider the specific context and resources available in each region.

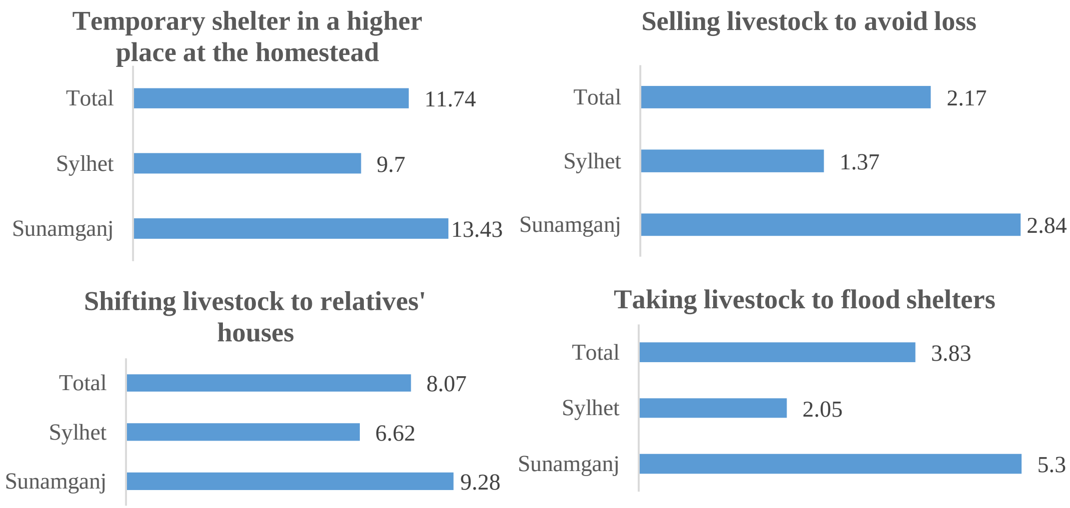
The survey result provides insights into the challenges experienced by individuals and their families during their stay at flood shelters, considering both gender and regional perspectives. The overall proportion of individuals facing challenges during their shelter stay is 88.57 percent indicates a significant majority encountering difficulties, emphasizing the need for comprehensive support in shelter environments. Gender dynamics reveal that females (90.95 percent) reported a slightly higher proportion of facing challenges compared to males (86.04 percent). This gender disparity suggests unique vulnerabilities or needs among women, underlining the importance of gender-sensitive approaches in shelter assistance programs. Regional variations show that in Sunamganj, a higher proportion (89.97 percent) reported facing challenges, while in Sylhet, the proportion is slightly lower at 86.14 percent. These regional differences highlight varying experiences or support systems, emphasising the necessity for context-specific interventions and localised disaster response strategies. The collective findings stress the importance of tailoring support initiatives to address distinct challenges faced by different demographic groups and geographic locations, ensuring more effective and responsive assistance during and after flood events.

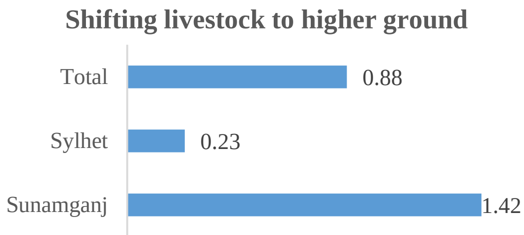
Autonomous response and coping

The survey tries to understand the state of autonomous response and coping strategy during floods. The result presents information about the practice of arranging temporary shelter in a higher place at the homestead during flood events, with data for two regions: Sunamganj and Sylhet. The data indicates that 11.74 percent of individuals reported the practice of arranging temporary shelter at a higher place within their homestead as a strategy during floods. This suggests a moderate prevalence of this adaptive measure among the surveyed population. Analysing regional differences, Sunamganj (13.43 percent) reported a higher proportion compared to Sylhet (9.70 percent). While both regions demonstrate a notable prevalence of this practice, the variation may stem from differences in flood vulnerability, topography, or community practices. In summary, the findings highlight a considerable adoption of the strategy involving the arrangement of temporary shelter in a higher place at the homestead during floods. The regional variation suggests potential differences in the awareness or implementation of this adaptive strategy, emphasizing its importance in flood-prone areas.

The result provides insights into the practice of selling livestock to avoid loss during flood events, with data presented for two regions: Sunamganj and Sylhet. The data indicates that 2.17 percent of individuals reported the practice of selling livestock to avoid loss as a strategy during floods. This suggests a relatively low prevalence of this adaptive measure among the surveyed population. a small proportion of the surveyed population chose to sell their animals to minimize the economic impact of the flood on their livelihoods. Analysing regional differences, Sunamganj (2.84 percent) reported a higher proportion compared to Sylhet (1.37 percent). While both regions demonstrate a limited prevalence of this practice, the variation may reflect regional differences in livestock management practices, economic considerations, or flood preparedness. Results highlight a modest adoption of the practice of selling livestock to avoid loss during floods. The regional variation suggests potential differences in the awareness or implementation of this adaptive strategy, emphasising the importance of understanding and promoting such practices to mitigate economic losses during flood events.

Figure 4.11: Autonomous response during flood (percent)





Source: Field survey (2023)

The result reveals that during flood events, 8.07 percent of surveyed individuals employed the strategy of relocating their livestock to relatives' houses. Upon closer examination of regional disparities, Sunamganj reported a higher prevalence at 9.28 percent, compared to Sylhet's 6.62 percent. While both regions exhibit a significant prevalence of this practice, the variation may stem from differences in livestock management practices, flood preparedness levels, or proximity to relatives' houses. The results underscore a considerable uptake of the strategy involving the relocation of livestock to relatives' houses during floods. The regional differences highlight the need for targeted interventions, recognizing varying levels of awareness and implementation of this adaptive measure. Promoting and enhancing such practices can contribute to better safeguarding livestock during flood events.

The table provides insights into the practice of taking livestock to flood shelters during flood events, with data presented for two regions: Sunamganj and Sylhet. The data indicates that 3.83 percent of individuals reported the practice of taking livestock to flood shelters as a strategy during floods. This suggests a modest but notable adoption of this adaptive measure among the surveyed population. Analyzing regional differences, Sunamganj (5.30 percent) reported a higher proportion compared to Sylhet (2.05 percent). While both regions demonstrate a relatively low prevalence of this practice, the variation may reflect regional differences in livestock management practices or flood preparedness. The findings highlight a moderate adoption of the practice of taking livestock to flood shelters during floods. The regional variation suggests potential differences in the awareness or implementation of this adaptive strategy, emphasising the importance of promoting such practices for safeguarding livestock during flood events.

The result provides information on the practice of shifting livestock to higher ground during flood events, with a focus on two regions: Sunamganj and Sylhet. The data indicates that 0.88 percent of individuals reported the practice of shifting livestock to higher ground during floods. This suggests a relatively low prevalence of this adaptive strategy among the surveyed population. Analyzing regional differences, Sunamganj (1.42 percent) reported a slightly higher proportion compared to Sylhet (0.23 percent). While both regions show a low prevalence, the variation may reflect regional differences in livestock management practices or flood preparedness. These findings highlight a limited adoption of the practice of shifting livestock to higher ground during floods. The regional variation suggests potential differences in the awareness or implementation of this adaptive strategy, emphasizing the importance of promoting such practices for safeguarding livestock during flood events.

Social protection

Social protection programmes play important role among disaster-affected and climate vulnerable populations to promote adaptation and respond effectively to shocks. The survey results provide insights into the disbursement of social protection schemes among the surveyed population, distinguishing between genders and regions (Sunamganj and Sylhet).

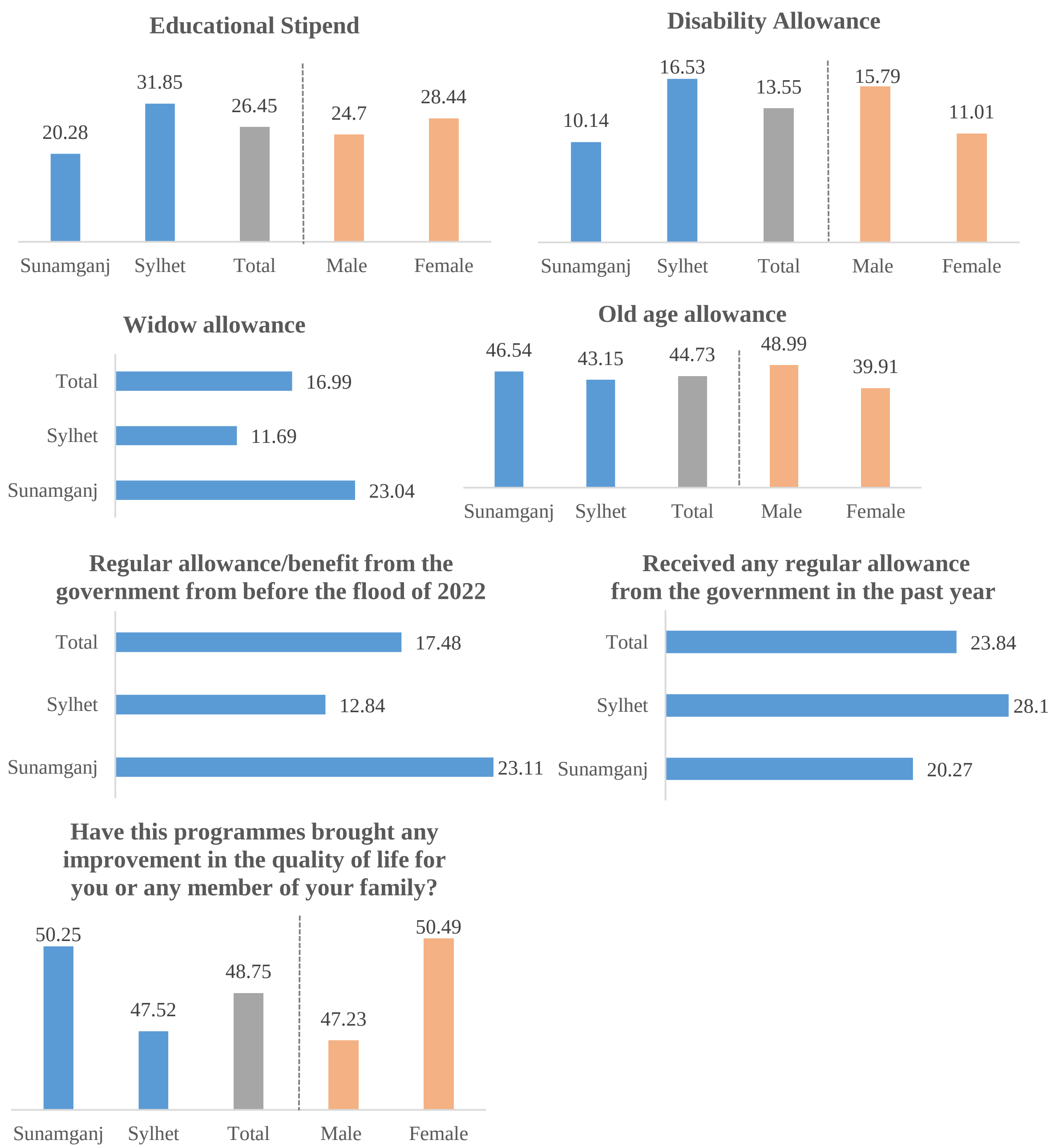
Educational stipends are essential in supporting access to education, particularly for individuals facing financial challenges. The findings reveal that 26.45 percent of the surveyed population benefits from educational stipends. Breaking down the data by gender, males have a participation rate of 24.70 percent, while females show a slightly higher rate at 28.44 percent. Regionally, Sunamganj reports a lower engagement at 20.28 percent, while Sylhet demonstrates a higher participation rate at 31.85 percent. These variations may be influenced by factors such as educational policies, awareness of the stipend programme, or regional disparities in access to education. The data underscores the significance of educational stipends in facilitating educational pursuits, with a focus on addressing potential gender and regional gaps.

The result provides insights into the distribution of disability allowance among the surveyed population, distinguishing between genders and regions (Sunamganj and Sylhet). This government assistance program aims to support individuals with disabilities, and the data sheds light on its accessibility and impact. The findings indicate that 13.55 percent of the surveyed population receives disability allowance. Analysing gender differences, males have a higher prevalence at 15.79 percent, compared to females at 11.01 percent. Regionally, Sunamganj reports a lower participation rate of 10.14 percent, while Sylhet shows a higher engagement at 16.53 percent. These variations may be influenced by factors such as the prevalence of disabilities in different demographics, awareness of the programme, or outreach efforts. The data emphasizes the importance of the disability allowance programme in providing financial support to individuals with disabilities, although regional and gender-specific considerations are evident.

The figure illustrates the distribution of widow allowance among the surveyed population, between Sunamganj and Sylhet. The data provides valuable insights into the accessibility and impact of this government assistance program, particularly for widowed individuals. The findings reveal that 16.99 percent of the surveyed population receives widow allowance. Examining the regional differences, Sunamganj reports a higher prevalence at 23.04 percent, while Sylhet shows a lower participation rate of 11.69 percent. These regional variations may be influenced by factors such as awareness, outreach efforts, or demographic differences. The result emphasises the significance of the widow allowance program in providing financial support to a considerable portion of the surveyed population. However, the observed regional disparities suggest the need for targeted strategies to address specific challenges or barriers in accessing this assistance, particularly in Sylhet.

The figure shows the distribution of old age allowance among the surveyed population, segmented by gender and region (Sunamganj and Sylhet). The data provides valuable insights into the accessibility and impact of this government assistance programme. The overall findings indicate that 44.73 percent of individuals surveyed receive old age allowance. Breaking it down by gender, the data reveals a notable gender disparity, with 48.99 percent of males benefiting compared to 39.91 percent of females. This highlights the need for a closer examination of factors influencing the gender-specific participation in the program. Examining the regional dynamics, Sunamganj reports a prevalence of 46.54 percent, while Sylhet shows a slightly lower participation rate at 43.15 percent. These regional variations may be attributed to factors such as awareness, outreach, or differing demographic structures. The gender-specific disparities persist at the regional level, emphasising the importance of tailored strategies to address the specific needs and challenges faced by both males and females in Sunamganj and Sylhet.

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



Source: Field survey (2023)

The figure presents information on whether individuals or their family members have been receiving any regular allowance or benefit from the government before the flood of 2022. The data is categorized for two regions: Sunamganj and Sylhet. The results indicate that 17.48 percent of the surveyed individuals reported receiving regular allowances or benefits from the government before the flood of 2022. Analyzing the regional differences, Sunamganj (23.11 percent) reported a higher proportion compared to Sylhet (12.84 percent). The findings also suggest that a notable portion of the surveyed population was already receiving regular allowances or benefits from the government before the flood of 2022, with variations observed between the two regions. The higher proportion in Sunamganj might indicate a greater prevalence of government assistance programmes or eligibility in that region.

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 OMS (Open Market Sale), and Food for Work/Work for Money (FFW/WFM) out of the respondents receiving benefits (469).

The result reveals information regarding the receipt of regular government allowances by individuals or their family members over the past year, distinguished between the Sunamganj and Sylhet regions. The data illustrates that 23.84 percent of those surveyed acknowledged receiving government allowances during the specified period. Upon closer examination of regional disparities, Sunamganj reported a comparatively lower proportion of 20.27 percent, while Sylhet exhibited a higher rate of 28.10 percent. The results highlight a significant proportion of the surveyed population benefiting from government allowances, with discernible variations between the two regions. The elevated proportion in Sylhet implies potential distinctions in government assistance initiatives or eligibility criteria across the surveyed areas.

The survey assesses the perceived impact of a specific program on the quality of life among the surveyed population, distinguishing between genders and regions. The programme’s success is evaluated based on reported improvements in the quality of life for individuals or their family members. The data indicates that 48.75 percent of respondents believe that the programmes has brought about positive changes in their quality of life. Breaking down the results by gender, males report a perception of improvement at 47.23 percent, while females express a slightly higher belief at 50.49 percent. Regionally, Sunamganj reports a positive impact of 50.25 percent, and Sylhet registers 47.52 percent. These variations stem from individual experiences, programme effectiveness, or regional nuances. The data suggests that, according to the surveyed population, the programme has made a positive difference in their quality of life.

Adaptation and resilience

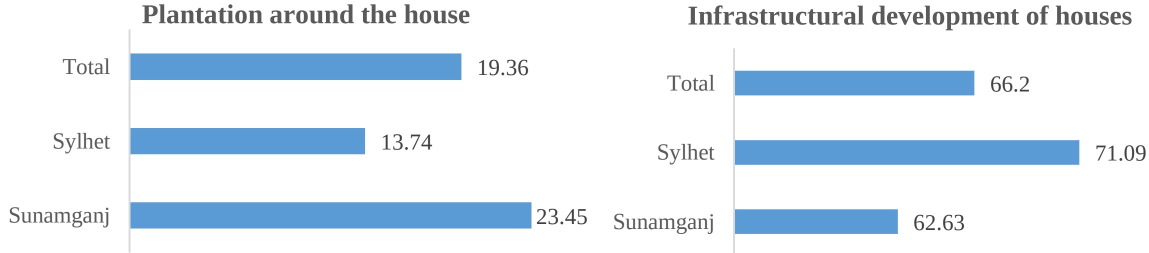
The survey results provide important insights into various measures to promote adaption and resilience among the flood-affected households. It highlights the consideration of plantation around houses as a long-term measure to reduce the risk of flooding following the 2022 flood. The data is differentiated by region, focusing on Sunamganj and Sylhet. The results reveal that 19.36 percent of respondents are contemplating the plantation around their houses for flood risk mitigation. Analysing regional variations, Sunamganj (23.45 percent) and Sylhet (13.74 percent) demonstrate differences in the proportion of individuals considering this particular flood resilience strategy. This data suggests a noteworthy interest among respondents in adopting plantation measures around their houses to address potential future flood risks. The higher proportion in Sunamganj may indicate a greater emphasis on this approach, possibly influenced by local environmental conditions, cultural practices, or community initiatives.

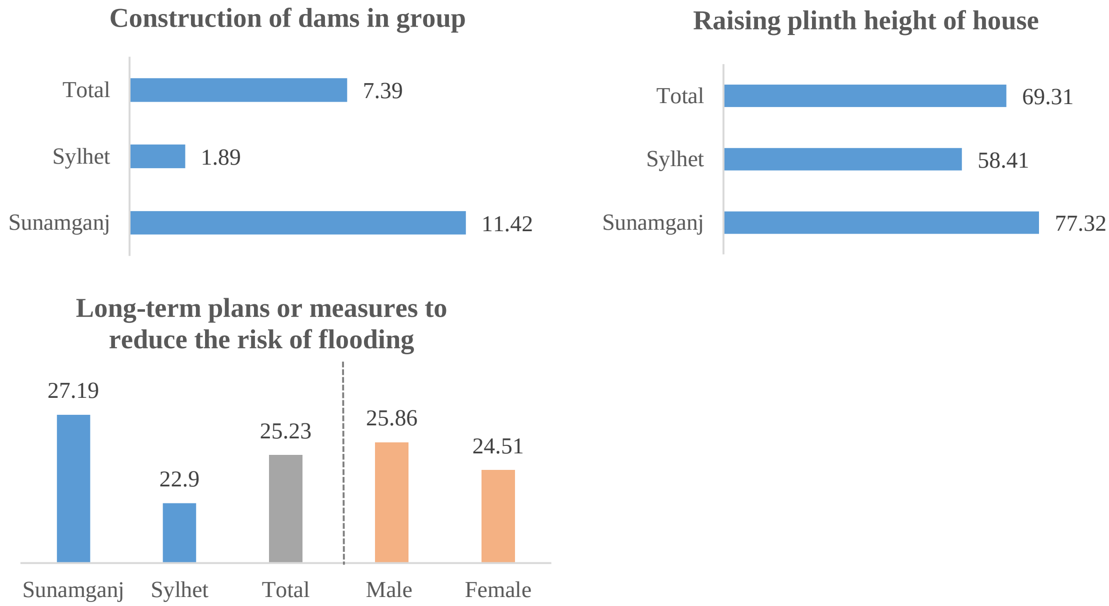
The result reveals insights into the inclination towards long-term infrastructural development of homes as a strategy to mitigate the risk of flooding post the 2022 flood. The findings suggest that 66.20 percent of participants are considering enhancing their home infrastructure to combat future flood risks. A closer look at regional variations highlights differences between Sunamganj (62.63 percent) and Sylhet (71.09 percent) in the proportion of individuals contemplating this flood mitigation approach. This information indicates a substantial interest among respondents in improving their home infrastructure to address potential future flood challenges. The higher proportion in Sylhet might signify a greater emphasis on this measure, potentially influenced by local geography, community-led initiatives, or awareness efforts.

The figure presents data on the consideration of constructing dams in groups as a flood mitigation measure after the 2022 flood. The information is disaggregated by region, focusing on Sunamganj and Sylhet. The results reveal that 7.39 percent of respondents are contemplating the construction of dams in groups. Upon closer inspection, Sunamganj (11.42 percent) and Sylhet (1.89 percent) exhibit variations in the proportion of individuals considering this specific flood mitigation strategy. This data suggests 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, possibly influenced by the local geography, community dynamics, or past flood experiences.

The figure provides insights into the consideration of raising the plinth height of houses as a flood mitigation measure after the 2022 flood. The data is segmented by region, focusing on Sunamganj and Sylhet. The results indicate that 69.31 percent of respondents are contemplating raising the plinth height of their houses. When analysed by region, Sunamganj (77.32 percent) and Sylhet (58.41 percent) show variations in the proportion of individuals considering this flood mitigation strategy. 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 or urgency in that region, possibly influenced by the local topography, flood severity, or community initiatives.

Figure 4.13: Awareness of and need for increasing adaptation and resilience (percent)



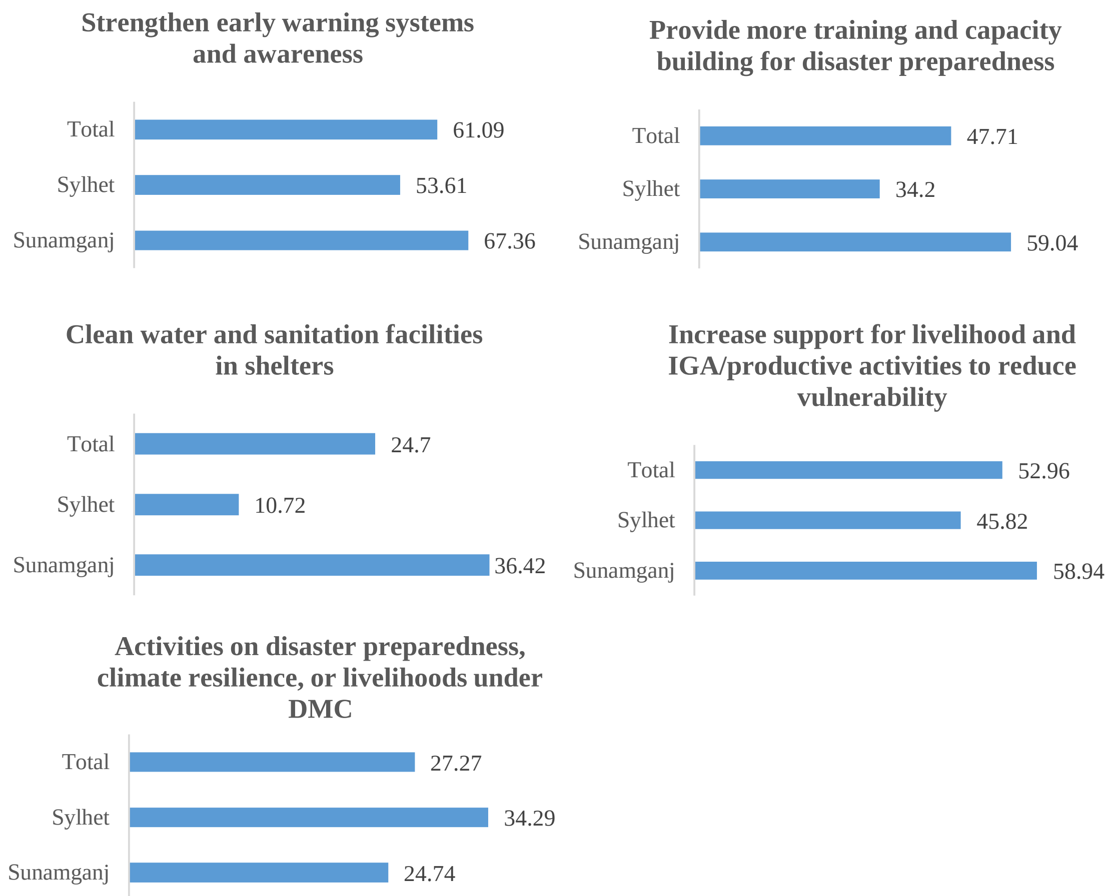


Source: Field survey (2023)

Avenues of capacity building

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 individuals' 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. When analyzed by gender, males and females report proportions of 25.86 percent and 24.51 percent, respectively. Regionally, Sunamganj (27.19 percent) and Sylhet (22.90 percent) exhibit variations in the proportion of individuals contemplating long-term measures. These findings suggest a notable but moderate inclination among respondents to address the risk of flooding through sustained and proactive strategies. The regional differences underscore the need for tailored approaches to flood risk reduction, taking into account the unique challenges and characteristics of each area.

Figure 4.14: Avenues of capacity building (percent)



Source: Field survey (2023)

The figure sheds light on the involvement of the communities in activities related to disaster preparedness, climate resilience, or livelihood improvement under the DMC. According to the results, 27.27 percent of respondents are engaged in activities under the Disaster Management Committee. Analysing regional differences, Sunamganj (24.74 percent) and Sylhet (34.29 percent) exhibit variations in the percent of individuals participating in these initiatives.

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, possibly influenced by local initiatives, community awareness, or specific regional priorities. The figure reveals insights into the community's stance on boosting support for livelihood and income-generating activities to mitigate vulnerability following the 2022 flood. The figure shows that 52.96 percent of respondents are advocating for increased support in livelihood initiatives to reduce vulnerability. A closer look at regional disparities indicates a higher inclination in Sunamganj at 58.94 percent, while Sylhet, with a slightly lower but notable proportion of 45.82 percent, also emphasises the significance of such assistance. This data underscores a prevalent consensus on the need for intensified support in livelihood activities for enhanced resilience and reduced vulnerability post-flood. The regional variations may stem from distinct community needs, economic landscapes, or the severity of flood impacts.

The table indicates a collective interest in enhancing clean water and sanitation facilities within shelters post-flood. Notably, 24.70 percent of respondents express this sentiment. While Sunamganj reflects a higher proportion at 36.42 percent, Sylhet exhibits a relatively lower but still significant proportion of 10.72 percent. This underscores a shared community concern for improved water and sanitation provisions, with regional differences possibly reflecting varying priorities, local conditions, or existing infrastructure.

The result reveals a strong consensus among respondents regarding the need for more training and capacity-building programs for disaster preparedness. A substantial 47.71 percent of individuals express that they need more trainings and capacity building programs for disaster preparedness. The regional breakdown shows a higher inclination in Sunamganj at 59 percent, while Sylhet also indicates a significant interest at 34.2 percent. This underscores a shared awareness of the importance of preparedness and the desire for enhanced skills and knowledge to cope with future disasters. The regional variations may be influenced by local initiatives, past experiences, or the accessibility of training programs.

The result shows that people in both Sunamganj and Sylhet are concerned about improving early warning systems and awareness. Overall, 61.09 percent of respondents express this shared interest. Sunamganj has a higher proportion at 67.36 percent, while Sylhet also shows significant interest at 53.61 percent. This suggests a community-wide acknowledgment of the importance of strong early warning systems. The differences between the regions may be influenced by local vulnerabilities, historical experiences, or ongoing awareness campaigns.

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 have an adverse effect on 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 a number of 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.

In order 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 north-eastern 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 the 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, the 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 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. 18). 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.

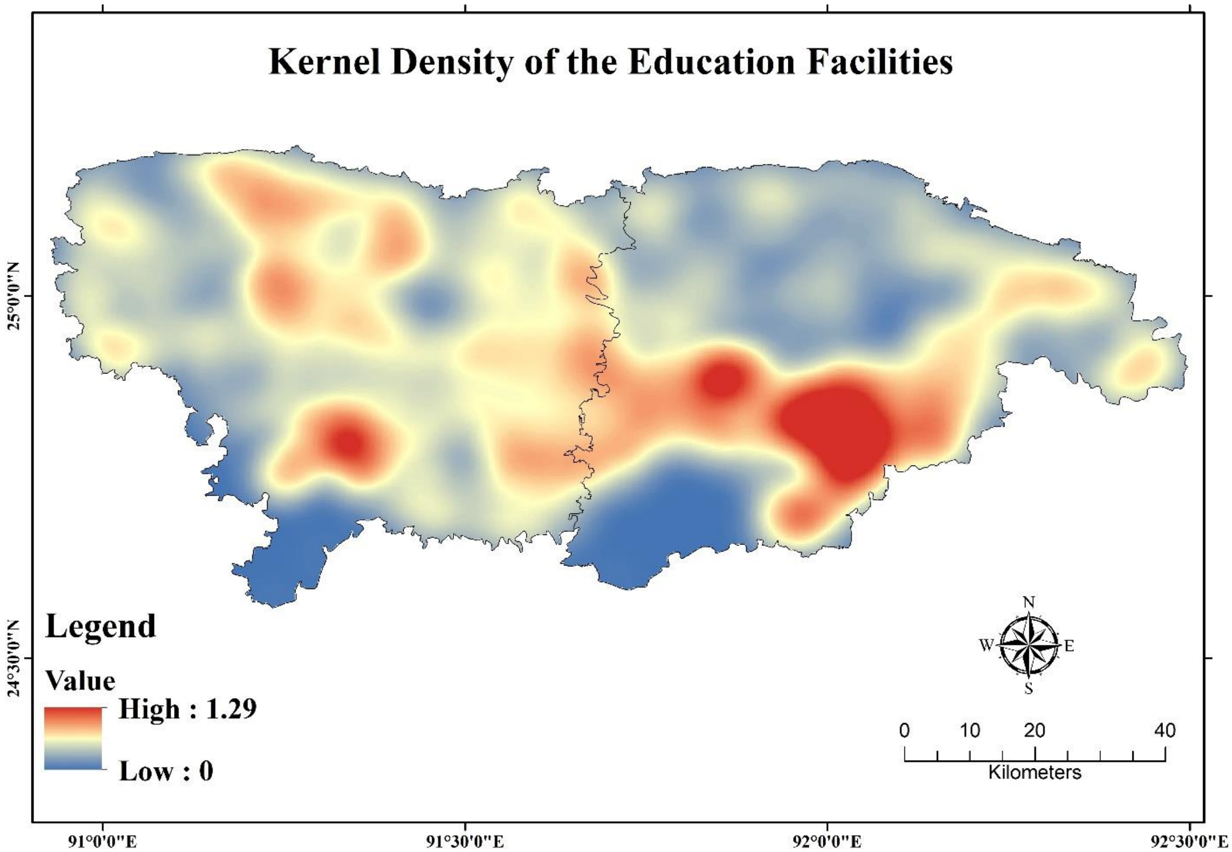


Fig 18: Spatial distribution of the Kernel density of the education facilities in the Sylhet and Sunamganj districts in Bangladesh

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.

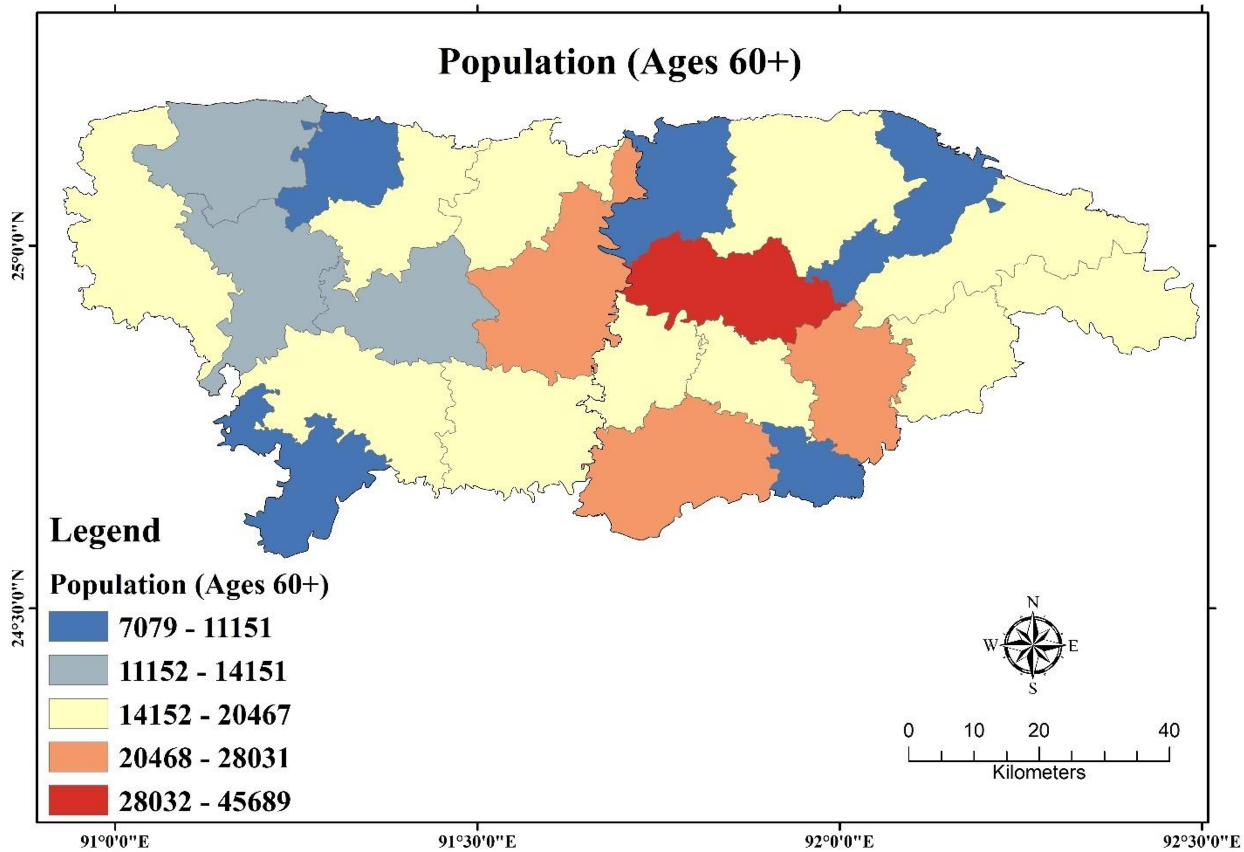


Fig 19: The spatial distribution of the population with ages above 60 years at the upazila level in the Sylhet and Sunamganj districts in Bangladesh.

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).

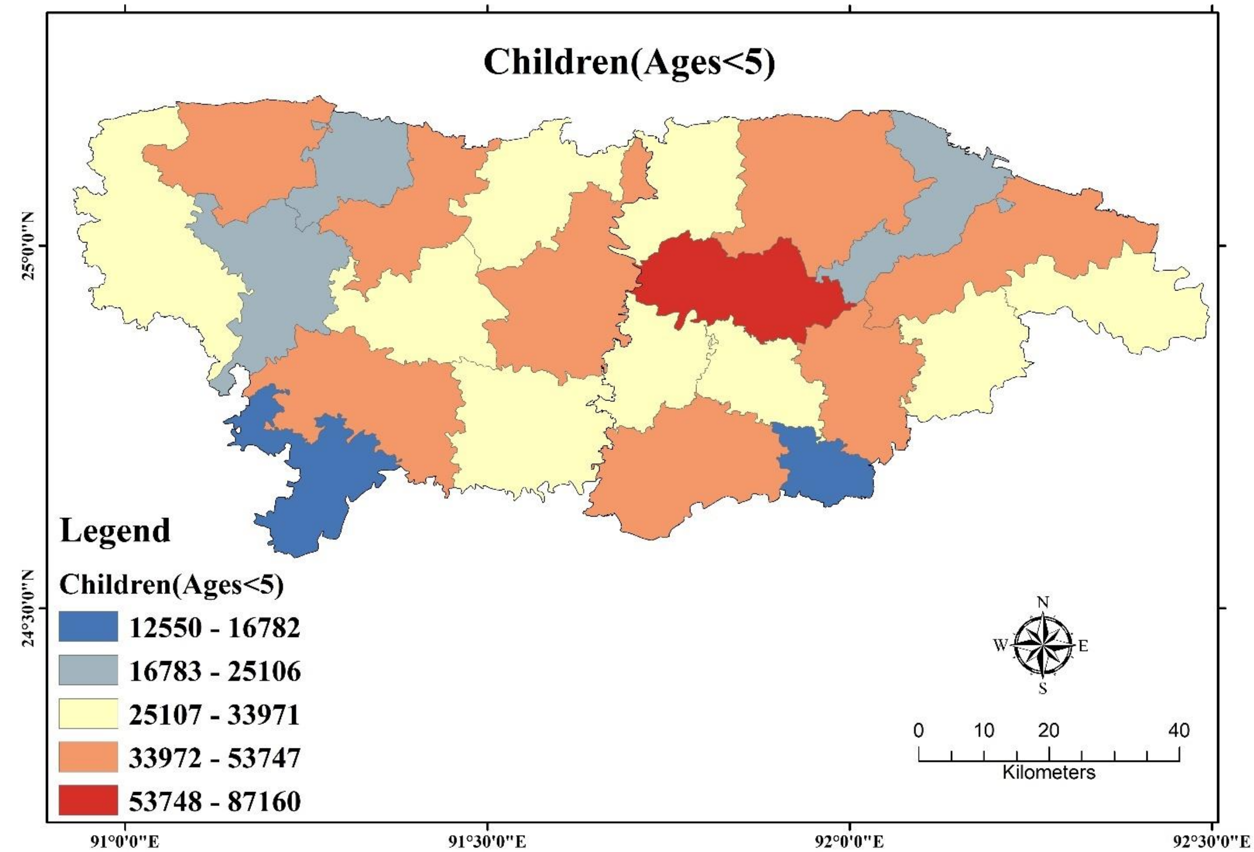


Fig 20: The spatial distribution of the children with ages below 5 years at the upazila level in the Sylhet and Sunamganj districts in Bangladesh.

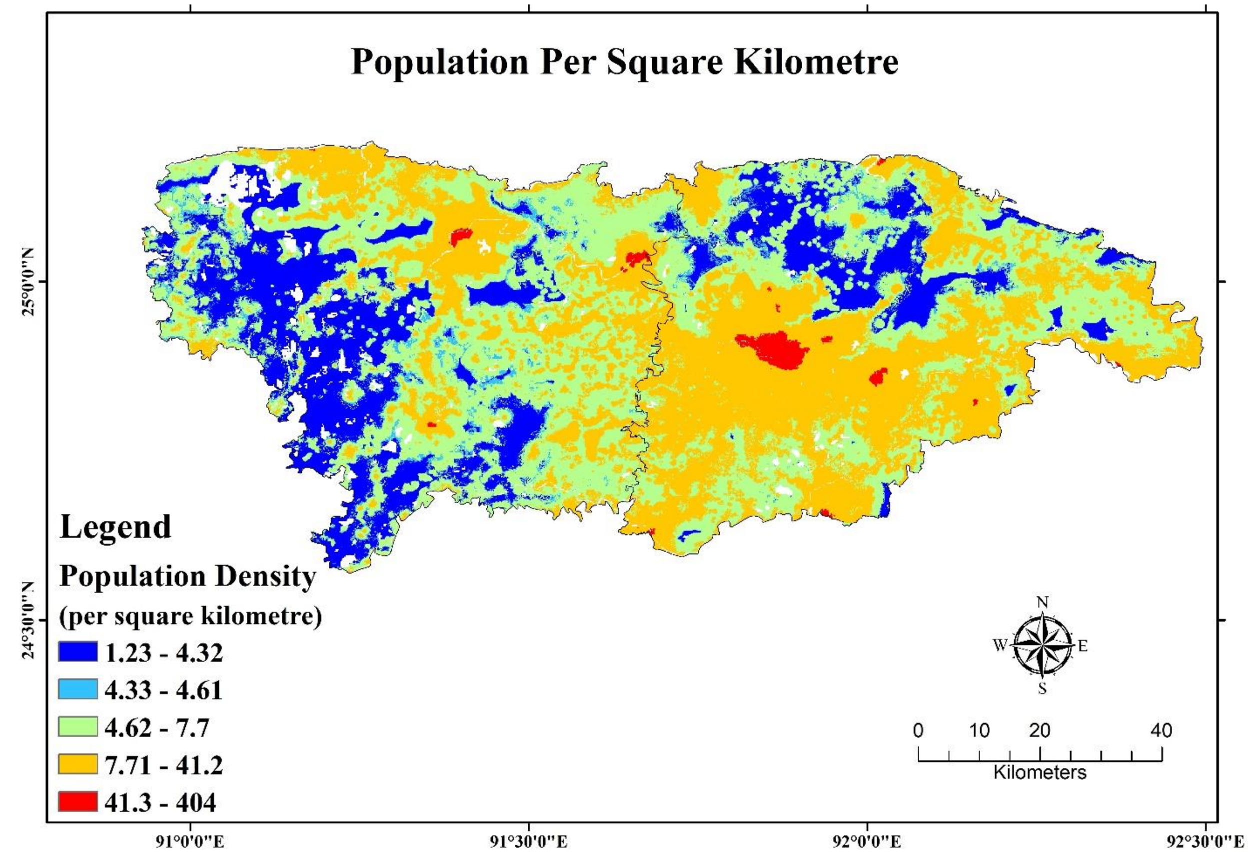


Fig 21: Population density (people per square kilometre) in the Sylhet and Sunamganj district of Bangladesh.

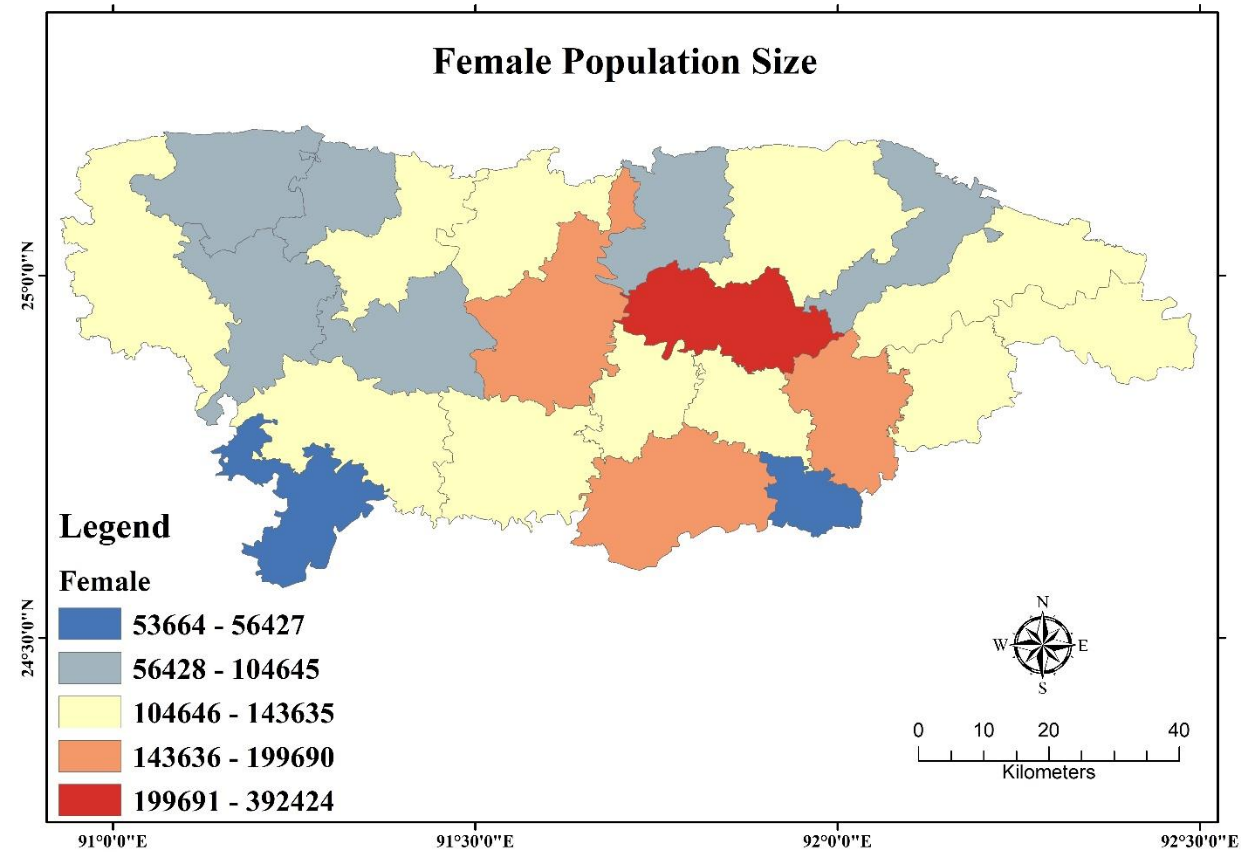


Fig 22: The spatial distribution of the female population size at the upazila level in the Sylhet and Sunamganj districts in Bangladesh.

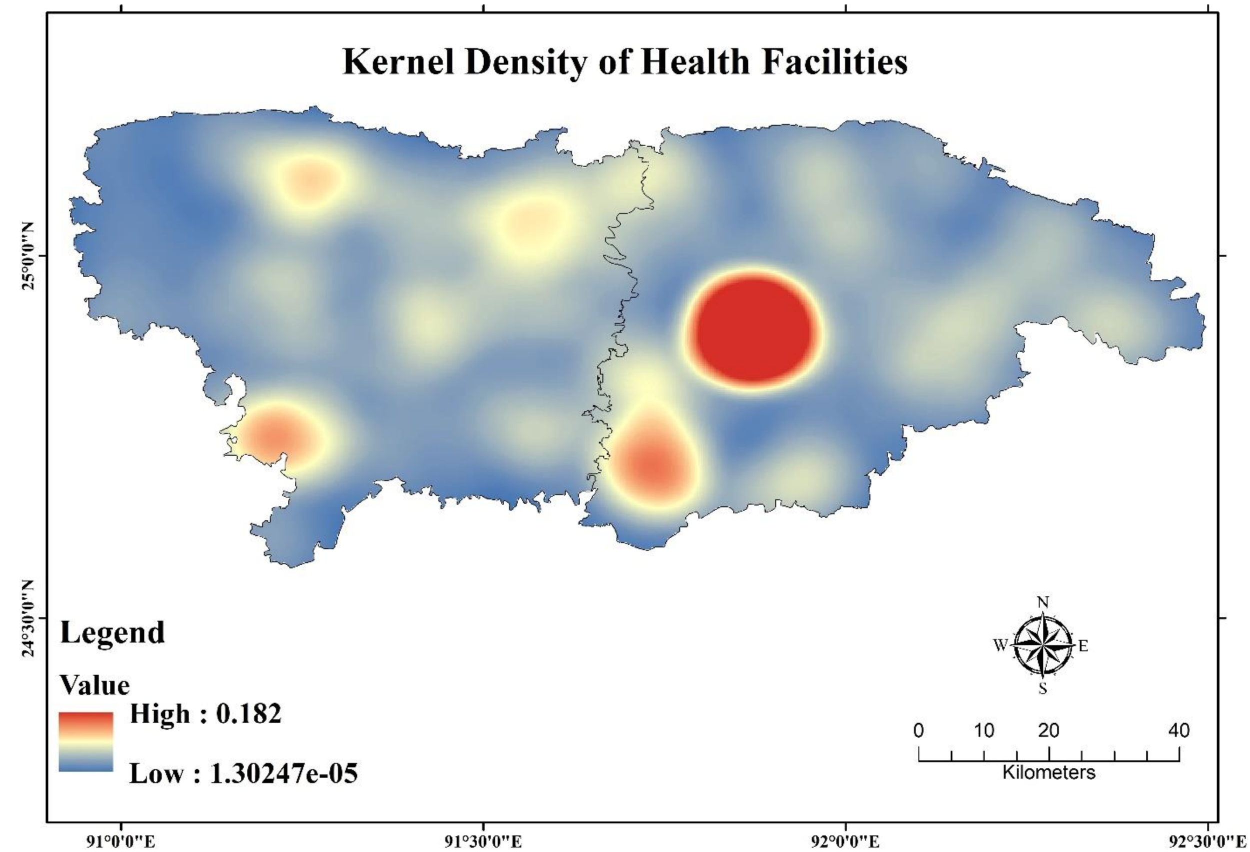


Fig 23: Spatial distribution of the Kernel density of the education facilities in the Sylhet and Sunamganj districts in Bangladesh.

2.2 Economic Resilience Component

The economic resilience of the community to flood events was estimated based on three indicators: income in USD, Demographic and Health Surveys (DHS) wealth index, and the likelihood of income being 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 of 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 of the likelihood of the income being below $2.5 is shown in Fig. 26.

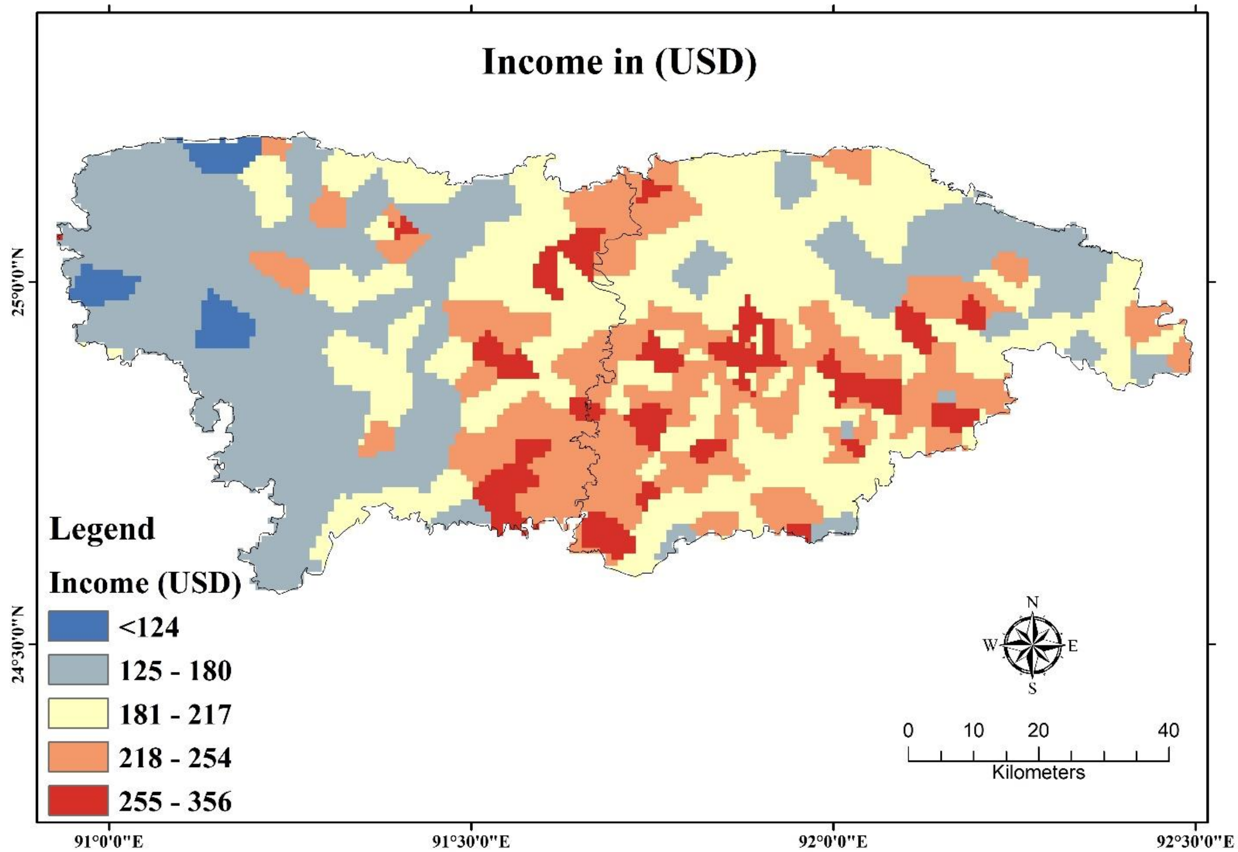


Fig 24: Spatial distribution of income in USD in the Sylhet and Sunamganj districts in Bangladesh

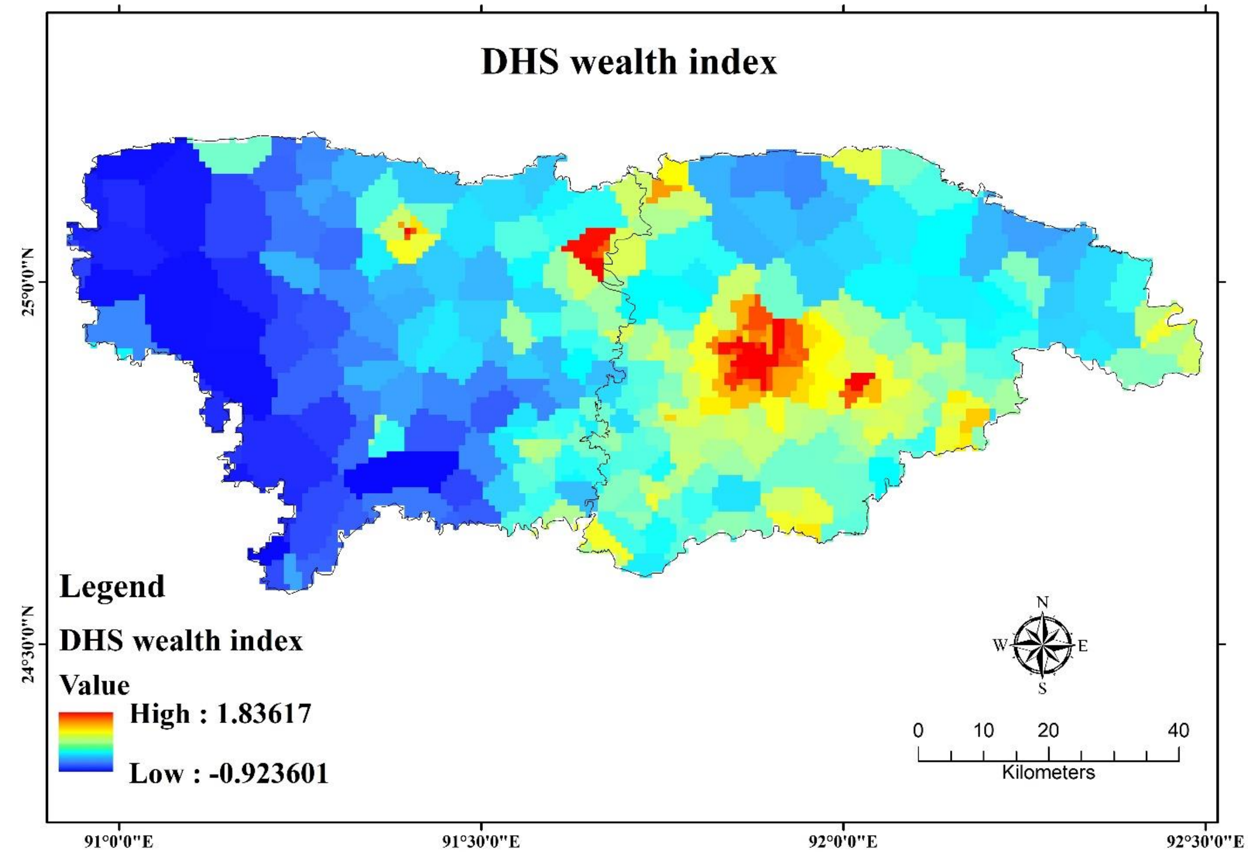


Fig 25: Spatial distribution of DHS wealth index in the Sylhet and Sunamganj districts in Bangladesh

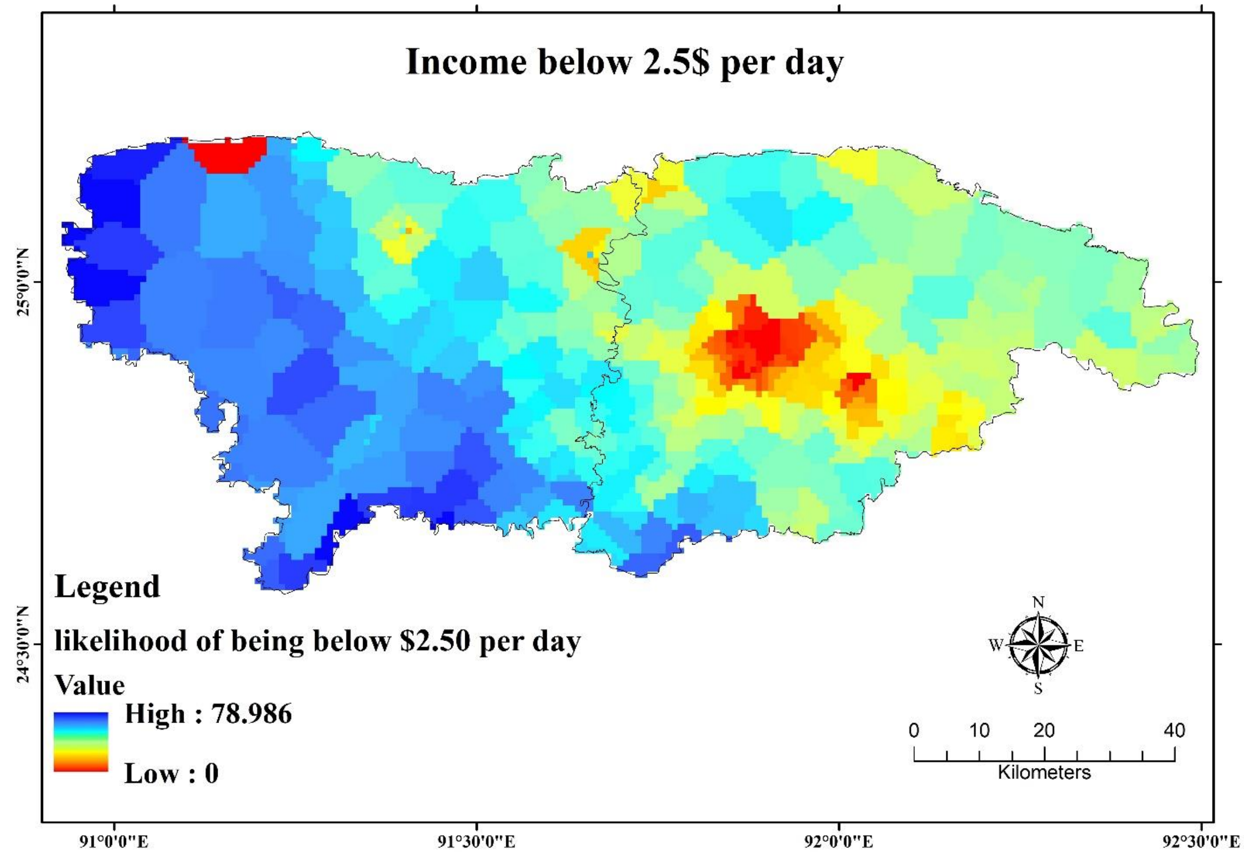


Fig 26: Spatial distribution of the likelihood of being below $ 2.5 per day in the Sylhet and Sunamganj districts in Bangladesh.

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 first indicator was the built-up area, which was collected from the satellite images (Sentinal 2) with 10 m spatial resolution. 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).

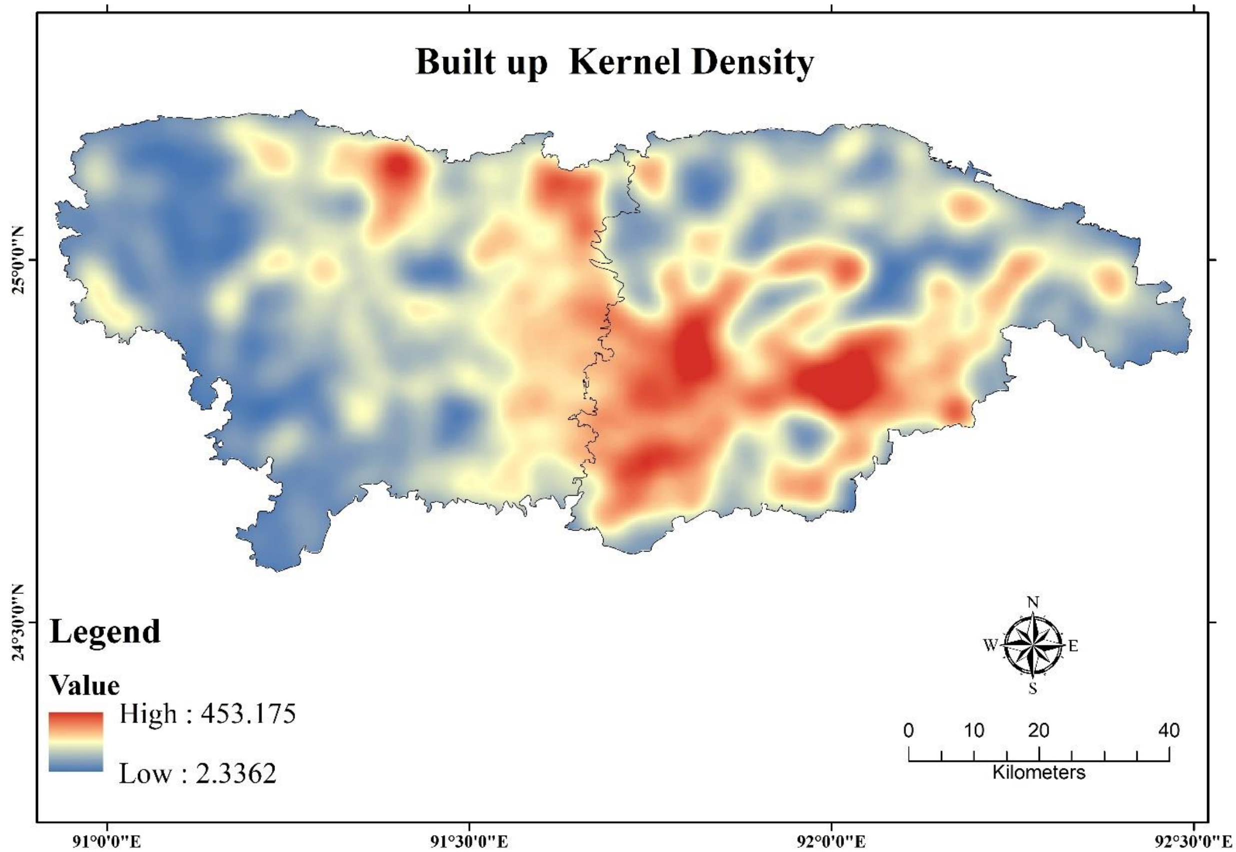


Fig 27: Spatial distribution of the built-up area Kernel density in the Sylhet and Sunamganj district in Bangladesh

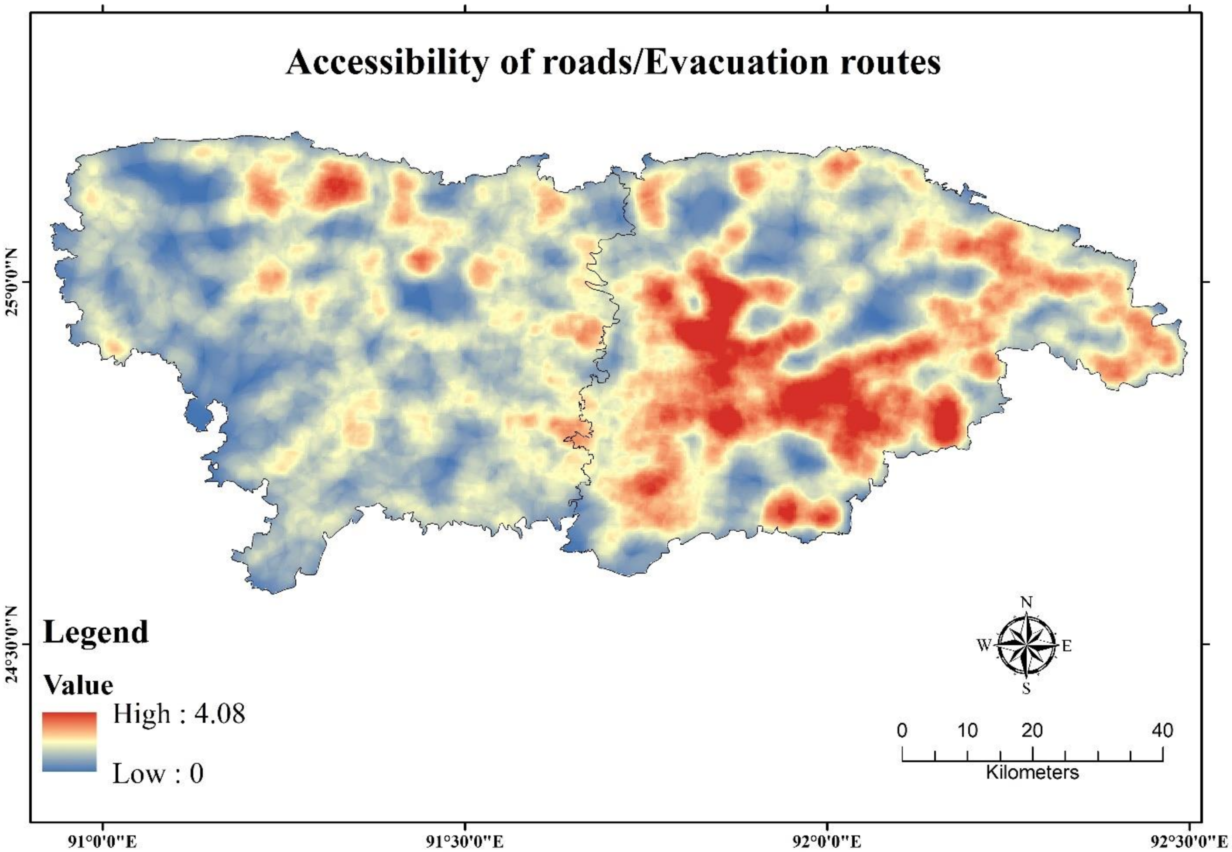


Fig 28: Spatial distribution of the accessibility of roads or evacuation routes kernel density in the Sylhet and Sunamganj district in Bangladesh

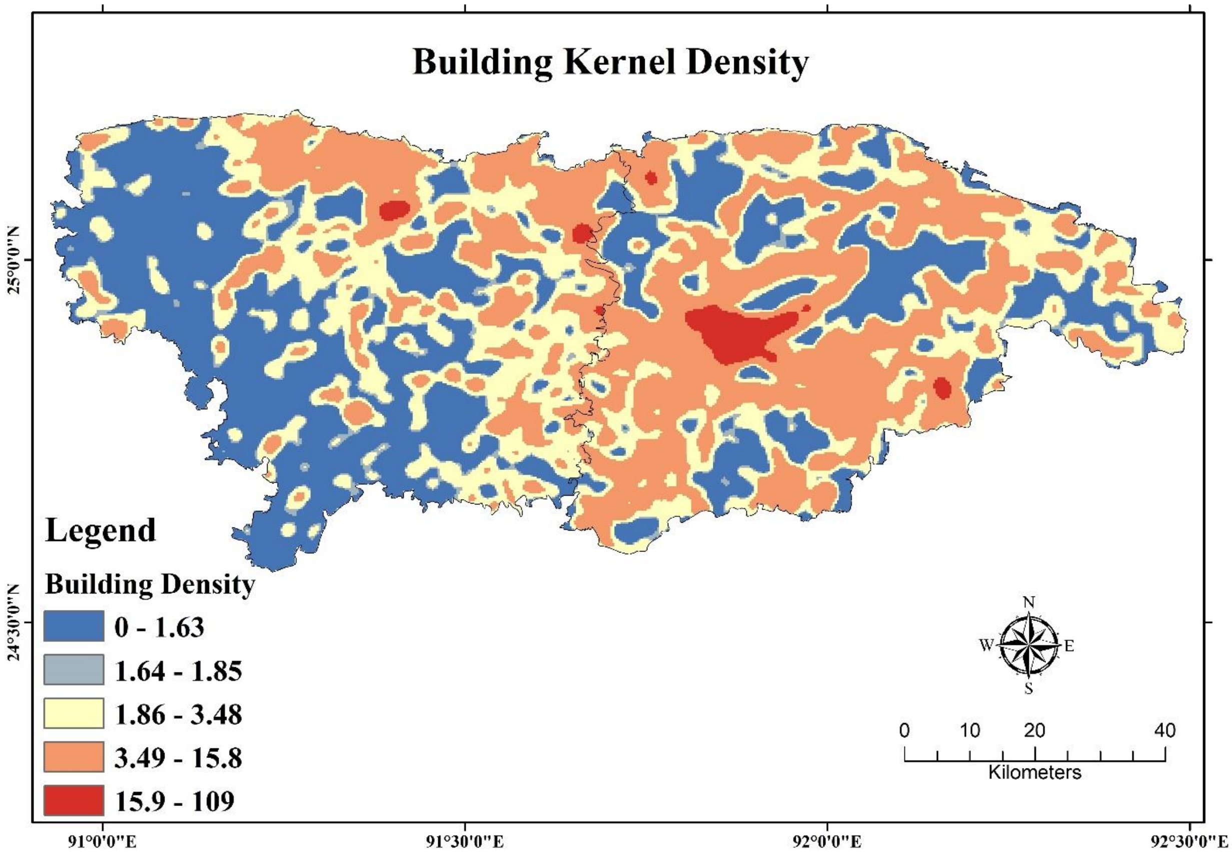


Fig 29: Spatial distribution of the building kernel density in the Sylhet and Sunamganj district in Bangladesh

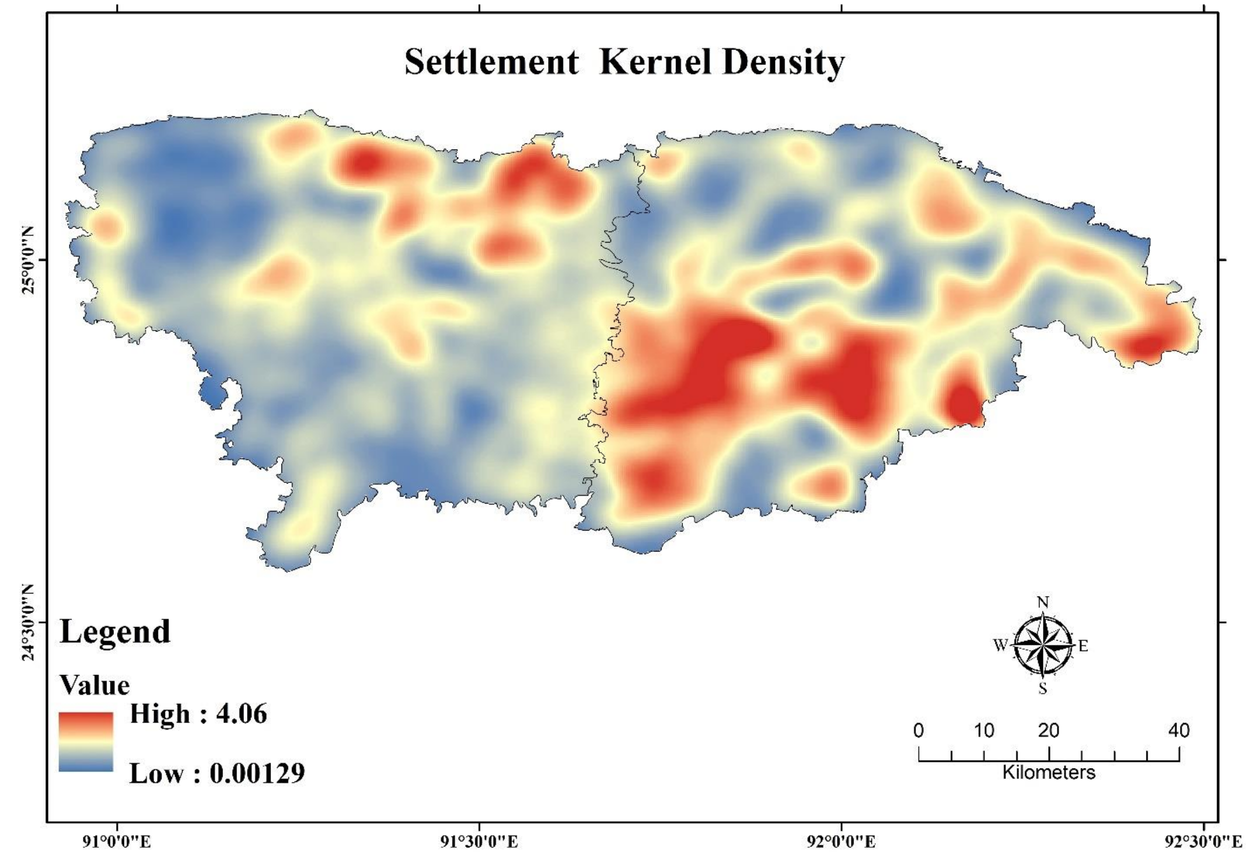


Fig 30: Spatial distribution of the settlement kernel density in the Sylhet and Sunamganj district in Bangladesh

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 individual 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 (B. 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 output of the social resilience map obtained from the overlay operation is shown in Fig. 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.

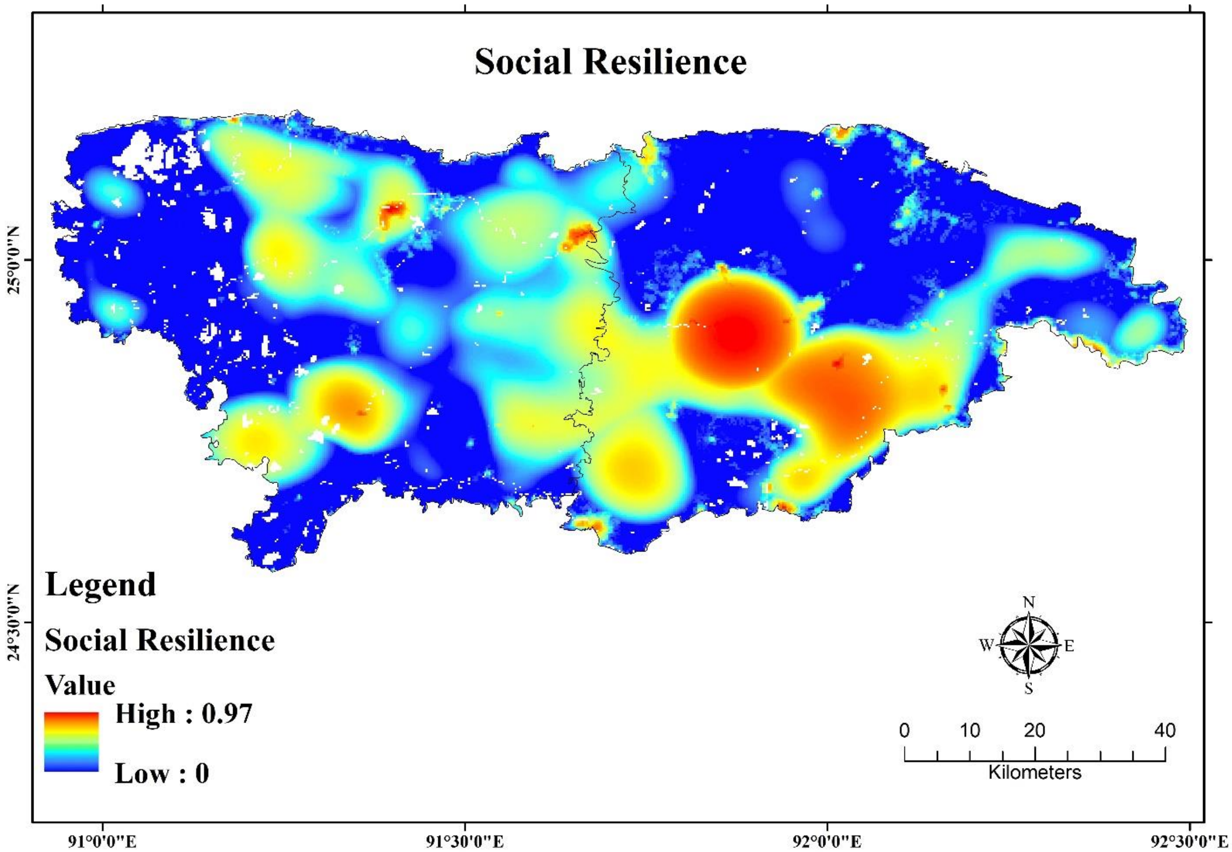


Fig 31: The spatial distribution of the estimated social resilience in the Sylhet and Sunamganj district in Bangladesh

3.2 Economic Resilience

The output of the Economi resilience map obtained from the overlay operation is shown in Fig. 32. The result shows 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.

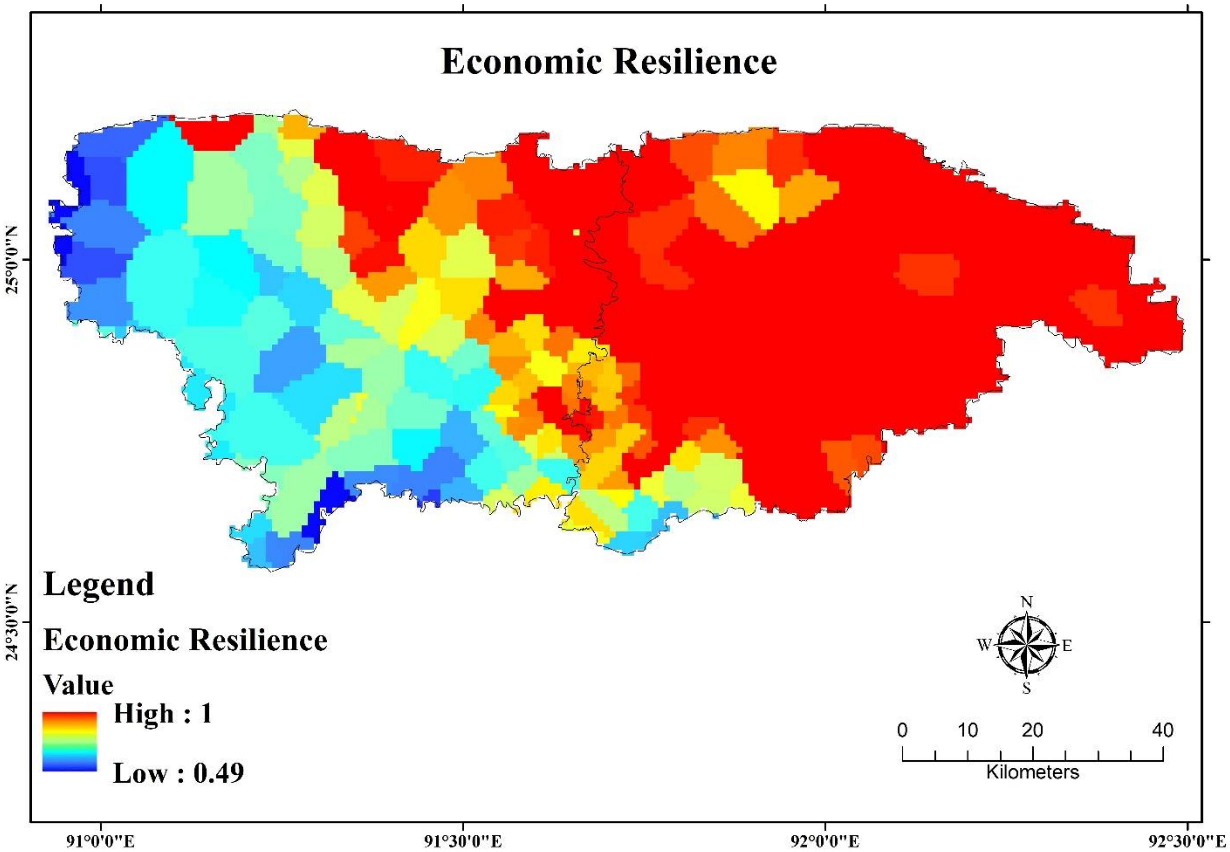


Fig 32: The spatial distribution of the estimated economic resilience in the Sylhet and Sunamganj district in Bangladesh

3.3 Physical/ Infrastructure Resilience

The output of the physical/infrastructure resilience map obtained from the overlay operation is shown in Fig. 33. The result shows 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.

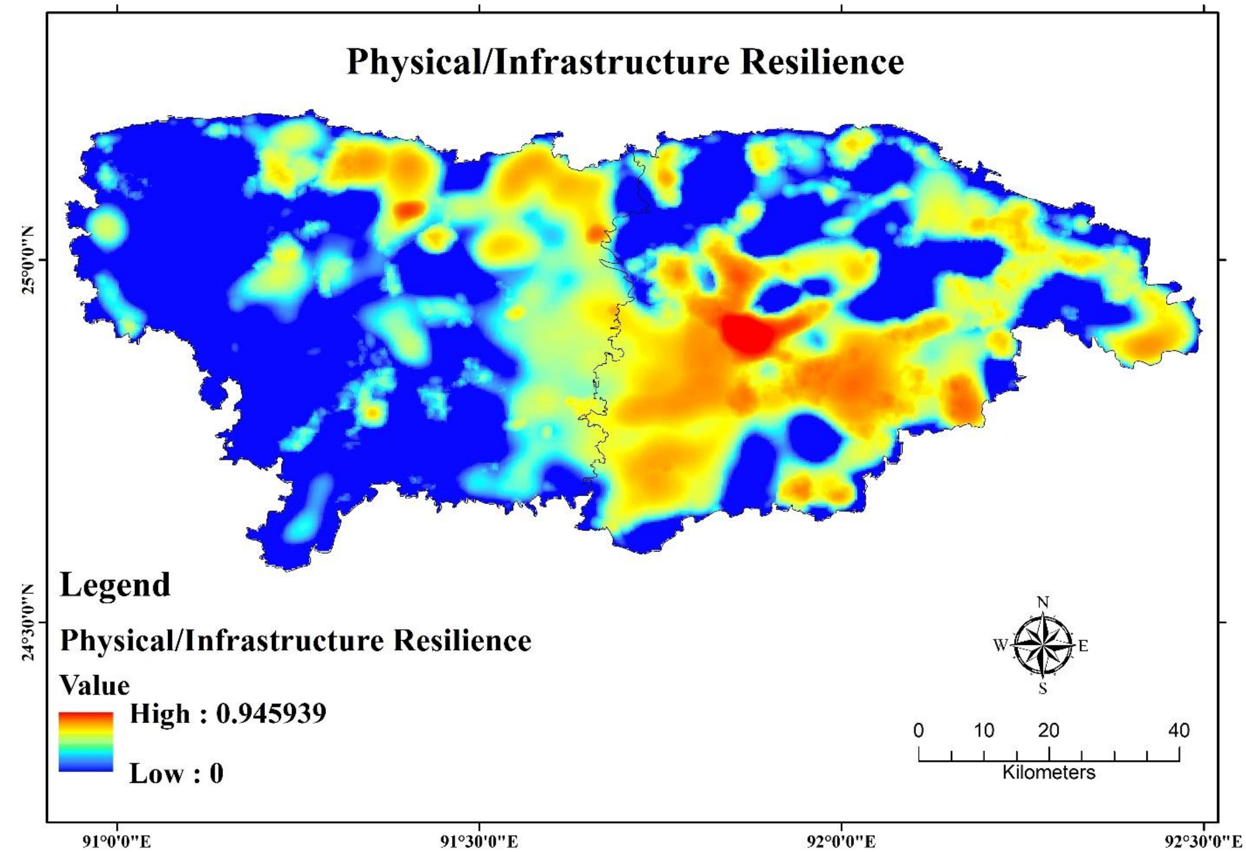


Fig 33: The spatial distribution of the estimated physical/infrastructure resilience in the Sylhet and Sunamganj district in Bangladesh

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 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 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.

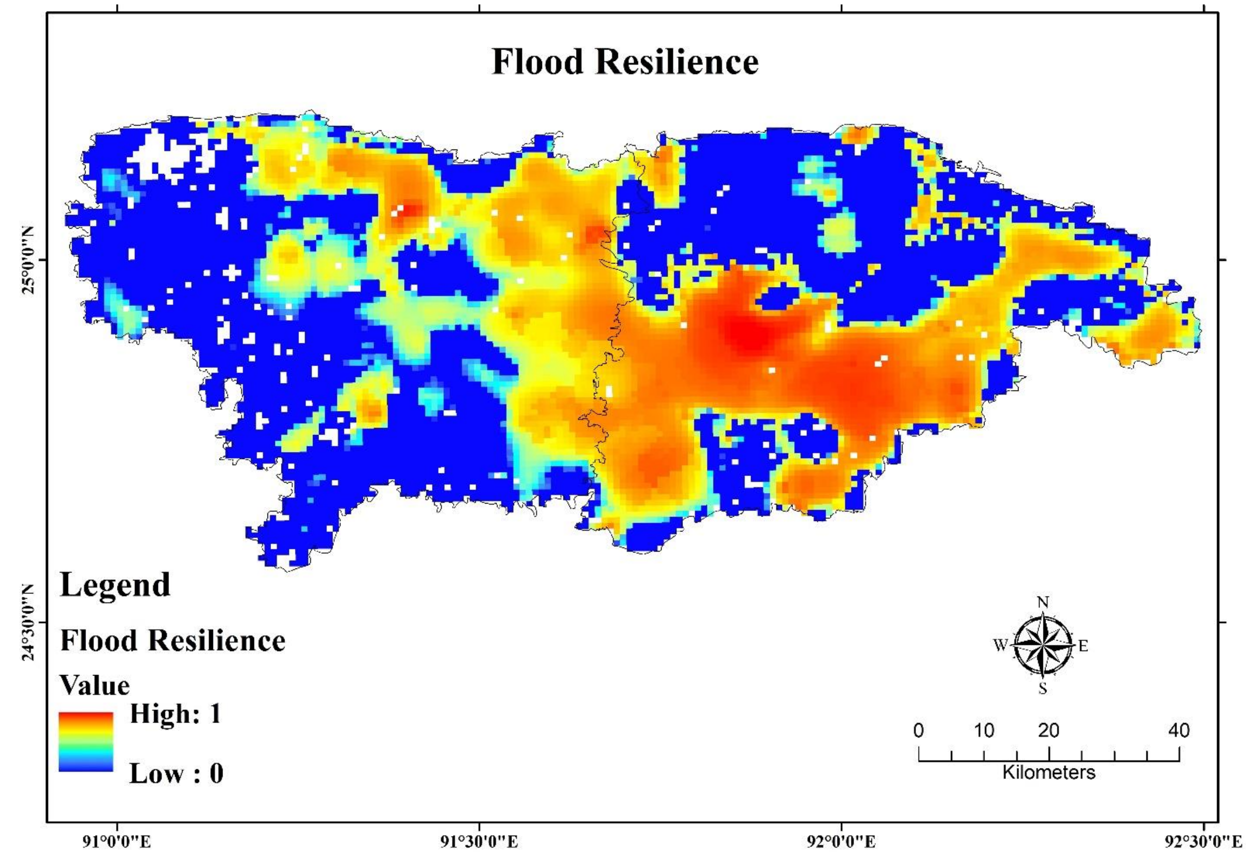


Fig 34: The spatial distribution of the estimated flood resilience in the Sylhet and Sunamganj district in Bangladesh

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.

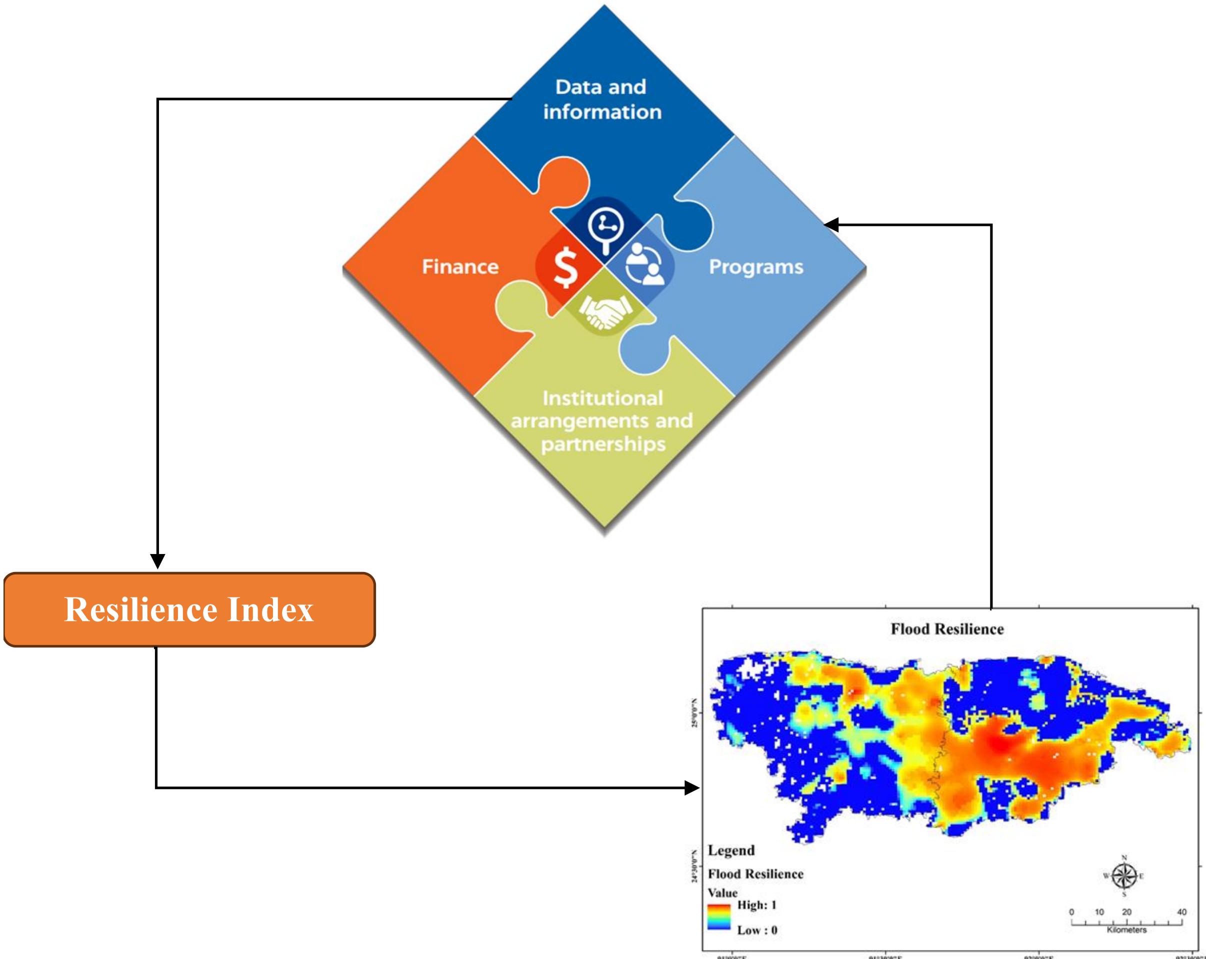


Fig 35: Conceptual framework of flood resilience with the building block of adaptive social protection.

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 part 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

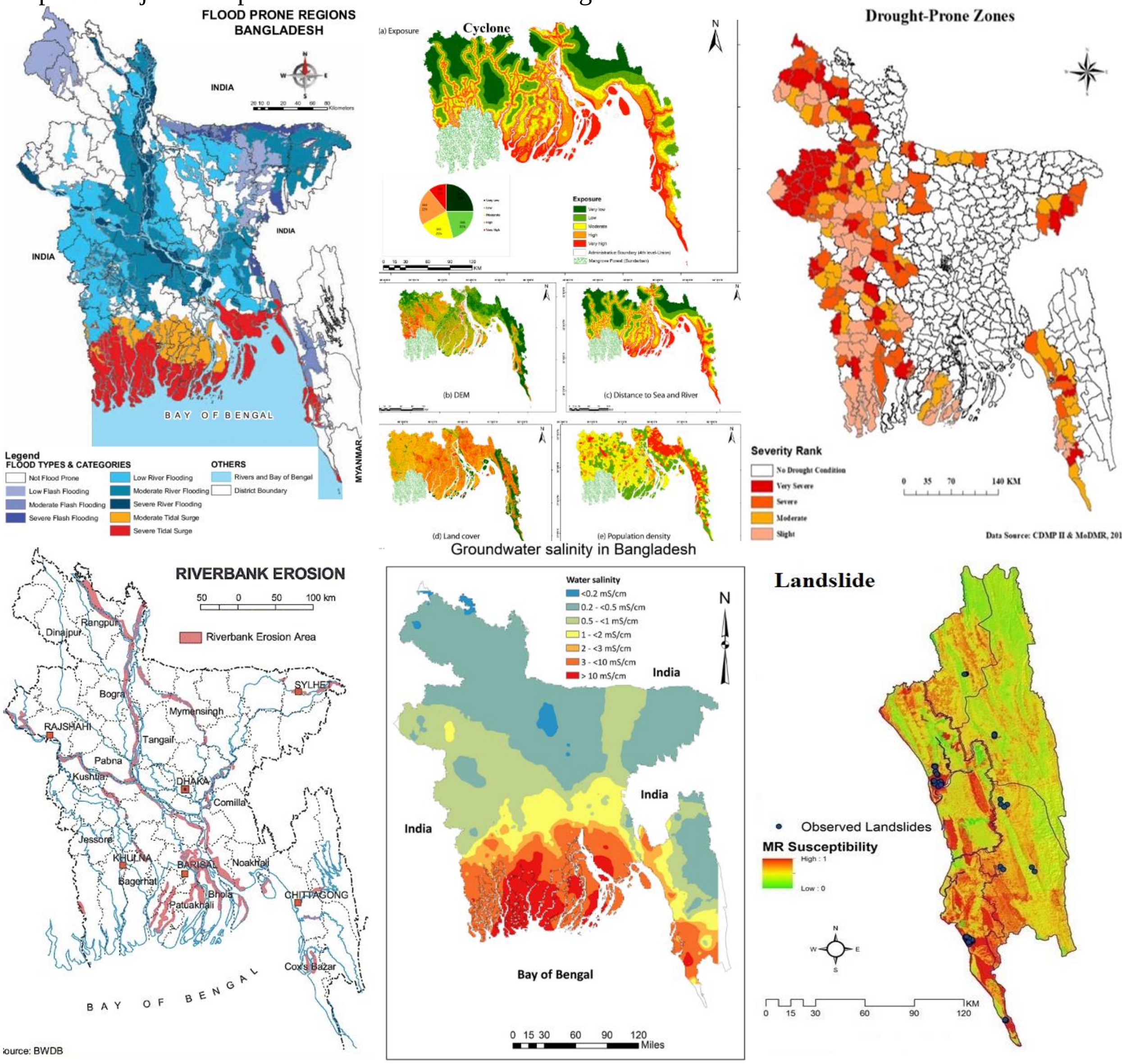
The 8th Five Year Plan (8FYP) 2020-2025, Bangladesh Delta Plan 2100 (BDP2100) and the Perspective Plan 2041 (PP2041) present detailed strategies for flood risk management, fresh water management, and strategies for haor and flash flood areas. In haor areas, where pre-monsoon flash floods from neighboring hilly regions are common, efforts are needed to protect agriculture and vulnerable communities. Existing Flood Control, Drainage & Irrigation (FCDI) projects have 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 mechanization 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 has also mainstreamed climate change into the planning process of 72 Union Parishads 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.

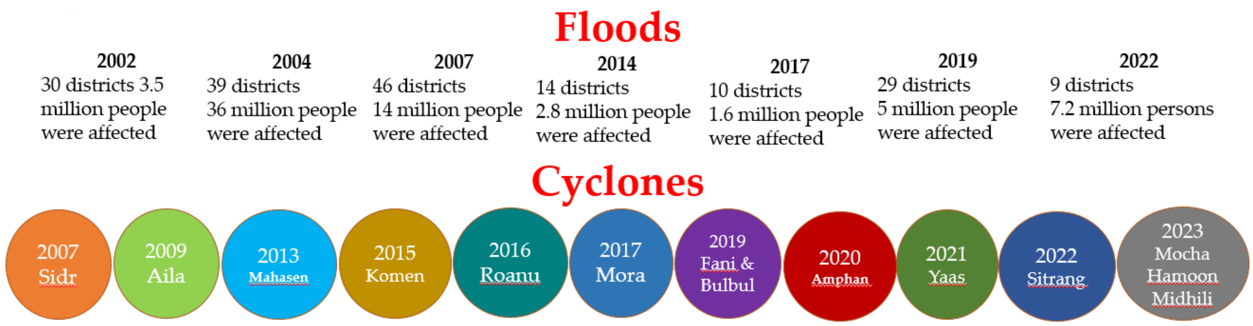
National Social Security Strategy (NSSS) of Bangladesh 2015 recognised the growth of the social protection agenda in Bangladesh has been driven by both demand and the need to respond to crisis events and democratic aspirations. The country initiated social security programnmes on food security through 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

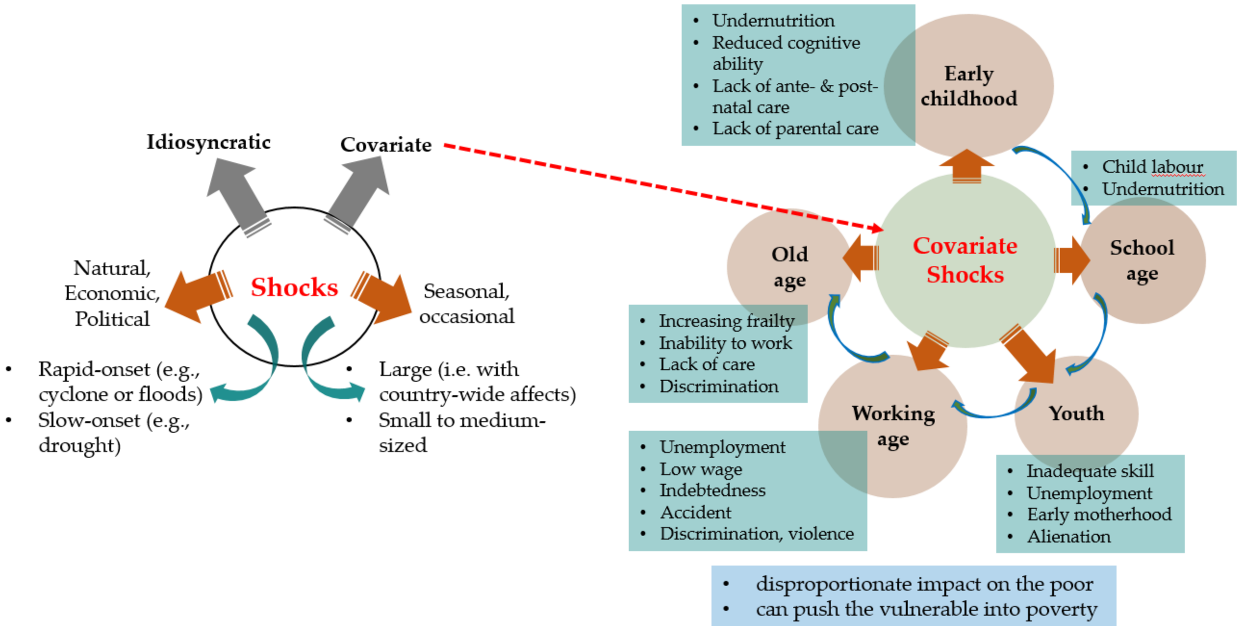
Figure 6.1: Chronology of major natural and climate-induced disasters in Bangladesh



Food security and rural employment programs 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 (General Economics Division, 2015).

Figure 6.2: Shocks and their impacts on life cycle



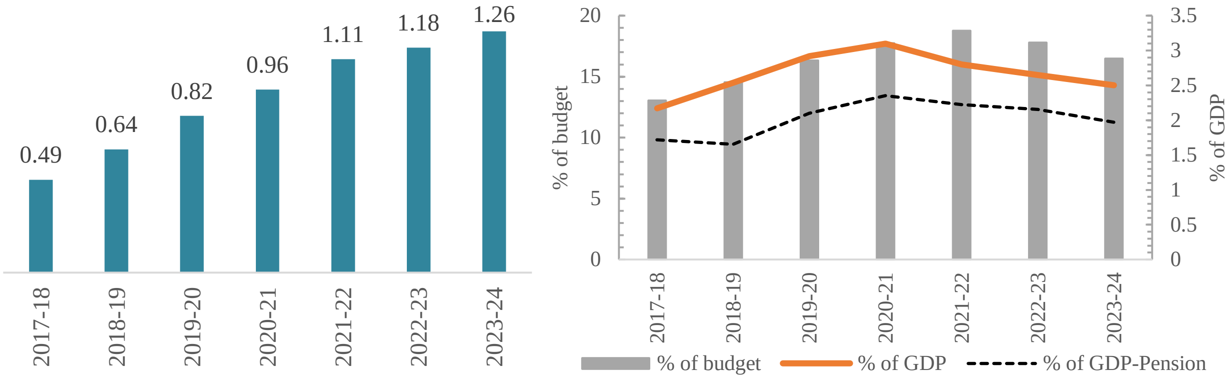
Source: Author

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).

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 at early childhood, then it affects learning ability of the children that creates lifetime impact. At other stages of life, covariate shocks lead to unemployment, early motherhood, school dropout, increasing vulnerability to poverty, low wage, 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)



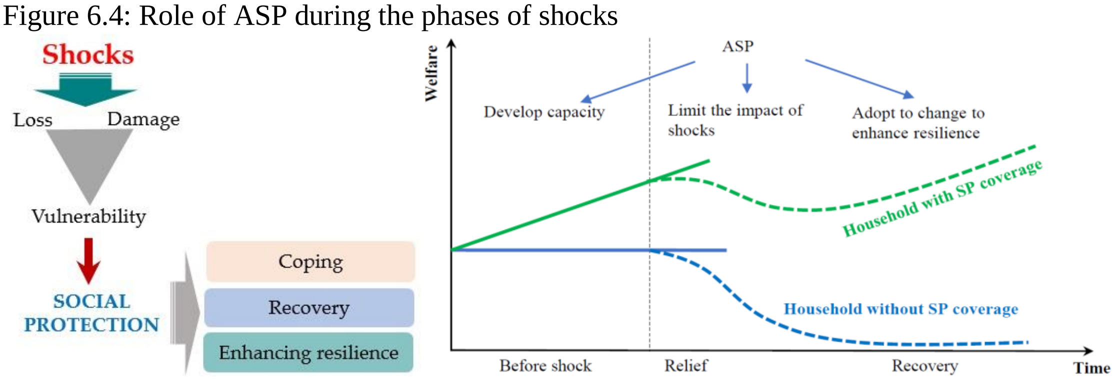
Note: Data till FY2022-23 indicate revised budget, data for FY2023-24 indicate provisional budget and GDP
Source: Author's analysis based on Finance Division's data (various years)

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

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

The GoB is spending considerable amount of resources on social protection in Bangladesh. In fiscal year 2023-24, the allocation is 16.5 percent of 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 fiscal year 2020-21 in GDP (3.1 percent) and in 2021-22 in national budget (18.78 percent of budget). Large number of small schemes 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 emphasizes on life cycle approach to social protection.

Figure 6.4: Role of ASP during the phases of shocks

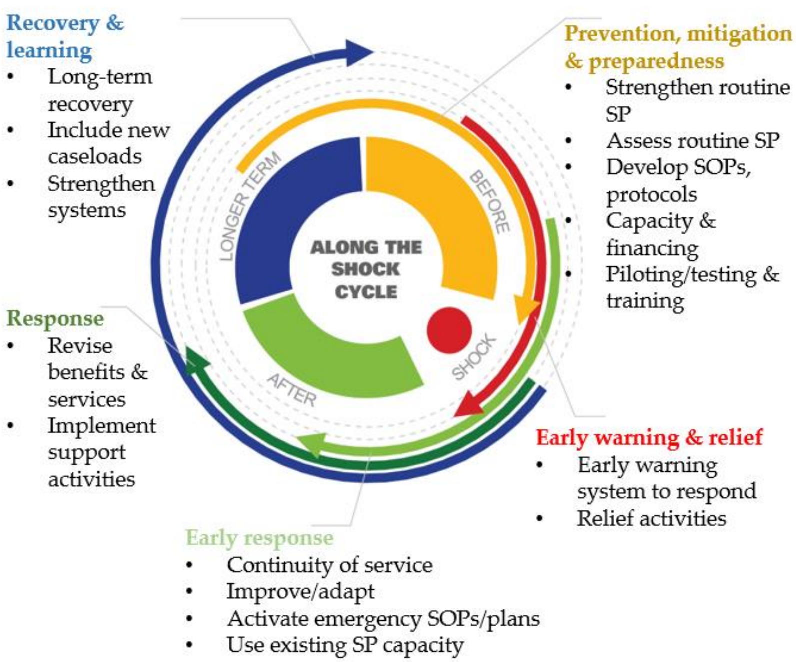


Shocks, especially emanating from natural disasters and climate change create at least three impacts: vulnerability, loss and damage. However, social protection helps develop coping capacity, supports early recovery and enhancing resilient of the affected population. Households without social protection,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

The government has been allocating considerable amount of resources on social protection focusing on the impacts of natural disasters and climate change, with special attention on climate hotspots. In fiscal year 2023-24, the allocation for disaster- and climate-related social protection programmes was Tk.200 billion, which was 15.9 percent of social protection budget. The programmes which are focused on flash flood haor areas include Relief Goods, Disaster Grant; Relief Works (flood, drought, cyclone and others); Special assistance for development of people in chars, haors and backward areas; Infrastructure and livelihood Improvement in Haor and Costal 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 supports through, among others, allowance, workfare, child and maternal support, access to essential services, and social insurance. These aims 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**

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

Philippines	**Mongolia**	**Sudan**	**Vietnam**
• Post-Haiyan cash transfers • Delivery of emergency assistance effectively and efficiently in Bangsamoro	• Poverty-targeted food support • Child-targeted income support • Emergency assistance loan	• Family Support programme • Simultaneously provided cash, and invested in building registries and payment systems • One-stop-shop provides services	• Long-term programmes to build resilience among poor and vulnerable households • Short-term measures to address immediate needs during shocks, e.g., cash transfers to affected households

Source: Author's compilation

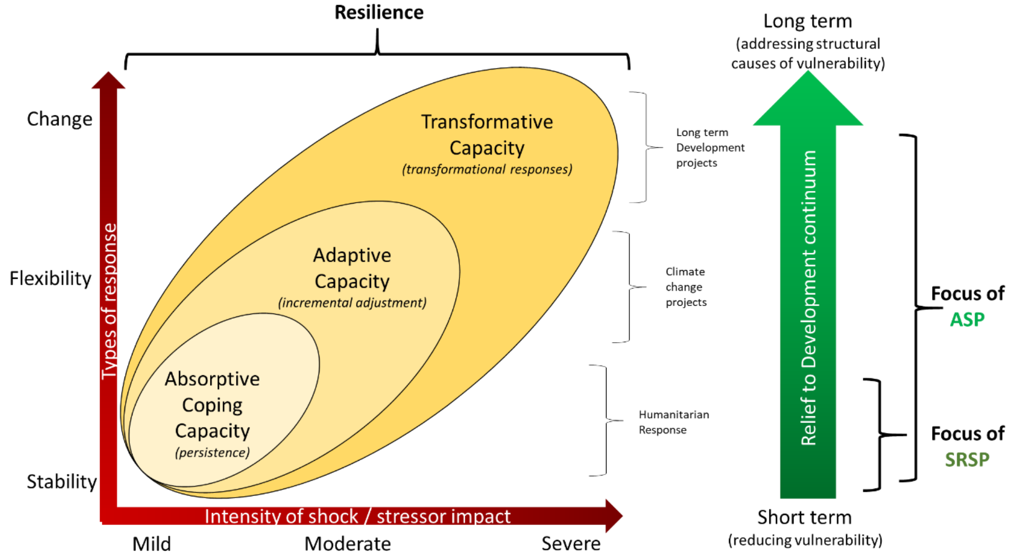
National documents have emphasised on social security for disaster-prone and climate-vulnerable areas. NSSS 2015 focused on life-cycle-based social security, focus on disasters, climate change and co-variate shocks. SOD 2019 highlighted on immediate disaster management, relief operation response, recovery, 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 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. Disasters management and climate change adaptation (CCA) are key to address developmental challenges. National Adaptation Plan of Bangladesh (2023-2050) presented long-term plan for facilitating climate change adaptation and outlined detailed plan for individual and community-based adaptation.

Shock Responsive Adaptive Social Protection in Bangladesh

Adaptive Social Protection (ASP) helps develop resilience of poor and vulnerable households through investing in their capacity to prepare for, cope with, and adapt to shocks, in order to prevent them from falling into poverty. In the short run, shock-responsive social protection (SRSP) help 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 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 global level, Vietnam, Philippines, Mongolia and Sudan practice SRSP and ASPs. However, their scale of operation is mostly limited to climate-vulnerable regions and directly affected group, 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 incidence of large and frequent climatic events, such as cyclone, 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 foundation for ASP and SRSP in the country. The NSSS 2026 will have the climate to develop the 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: Identify shocks to modify social protection

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

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, 18,707 hectares of fish cultivation area were damaged

Step 2: Assess vulnerability, damage and loss

Shock cycle persists because of lack of necessary modification of social protection schemes. The major drawbacks of the current social protection programmes are that limited assessment of damage and loss, inadequate understanding and timely monitoring of risks and vulnerability, lack of robust scientific modelling 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 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

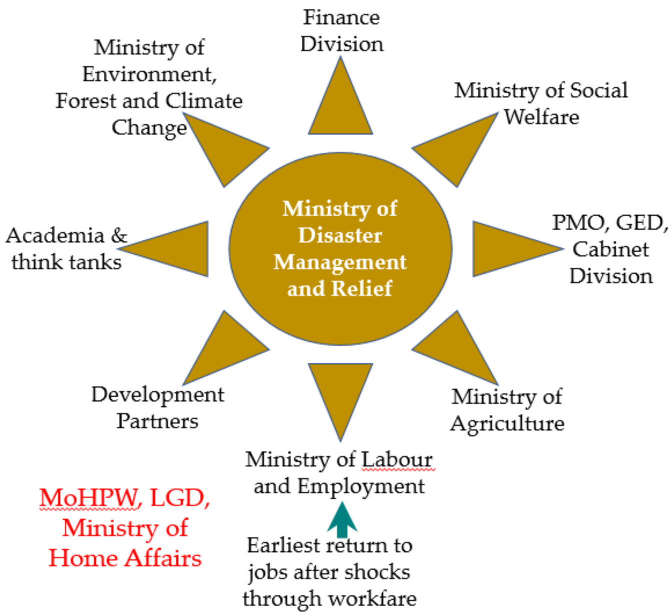
Step 3: Design and Modify Social Protection Programmes

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 Ministry of Disaster Management and Relief at the centre, which would be accompanied by, among others, 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 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 design, monitoring, research, reporting, and developing technical instruments for implementation of the programmes.

Figure 6.8: Core Agencies and Partners

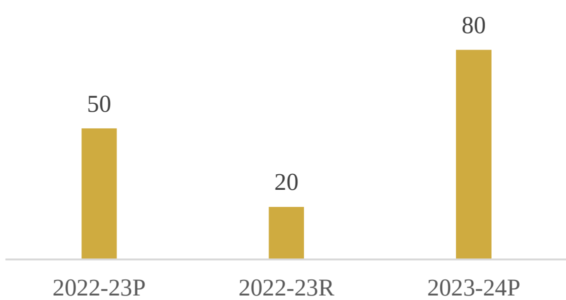


Source: Author's compilation

Step 4: Finance and Implement Interventions

After newly designing and modification of the existing programmes with 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 evident from the survey results. In addition, there are 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. Elderly population and PWD also find it difficult to access the 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 the society.

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



Source: Based on Finance Division data

"Funds to deal with economic and natural shocks" is the second largest social protection programme 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 is 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, coordinate with development partners to ensure adequate resources as technical aspects are involved for effectively implementing the schemes.

Thus, it must be ensured for the SRASP to deliver the intended support to the target group, provide access to necessary services, and monitor the effectiveness of the interventions through regular and random spot visit. 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 with regular intervals by academia and think tanks. Third part 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 the 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 micro, meso and macro level:

- 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 utilized in assessing effectiveness of SRASP:

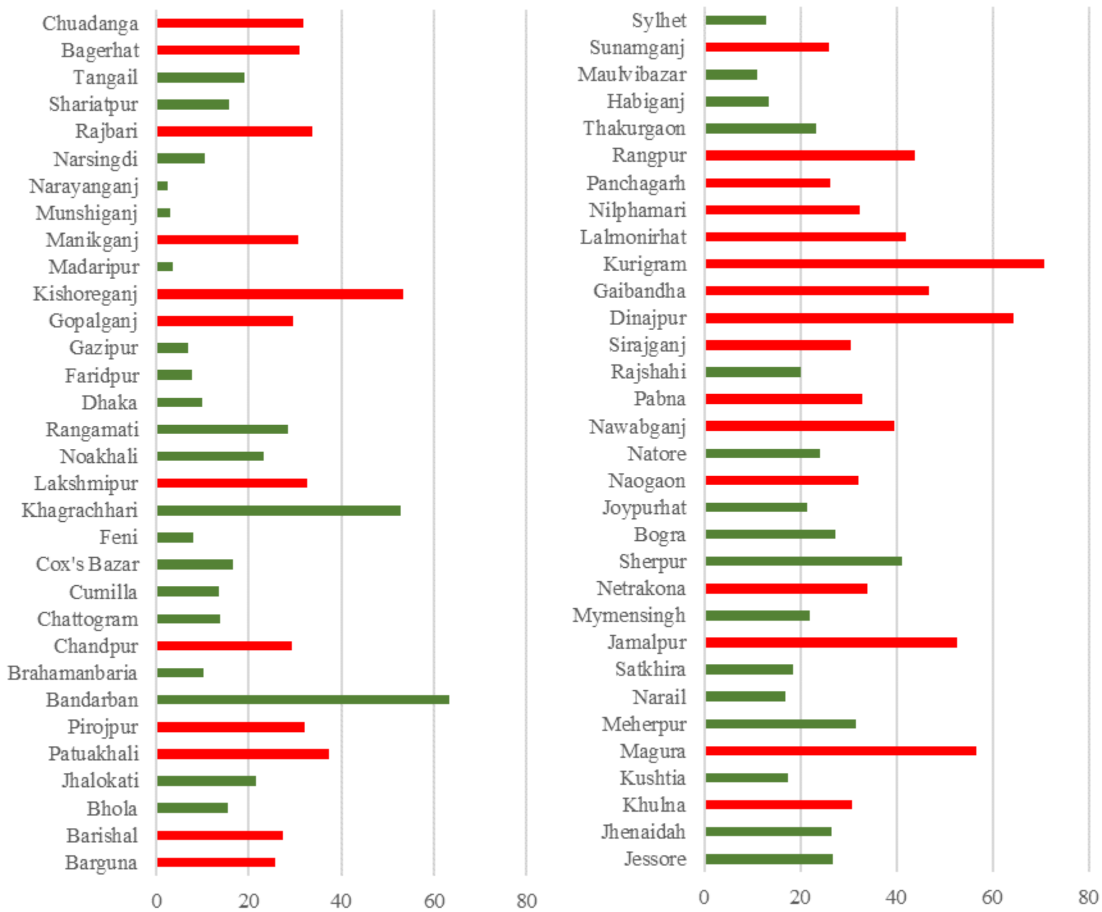
- World Bank's Software Platform for Automated Economic Analysis (ADePT)
- Benefit incidence analysis
- Performance audit
- Ethnographic study – understand life-cycle impacts

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

Step 6: Adapt and Scaling 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 of 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 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

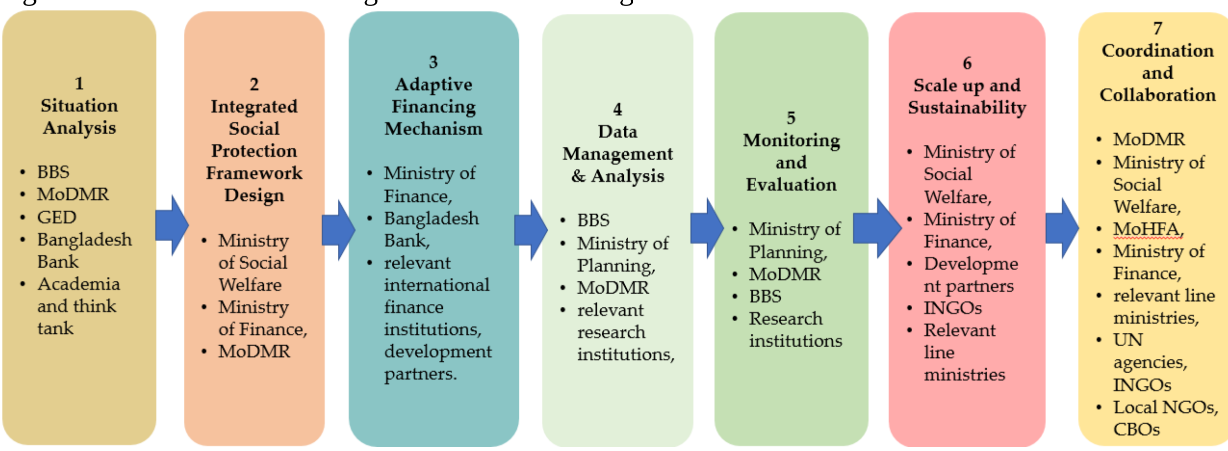
Coordination and collaboration among stakeholders will be the final and most important part of an effective SRASP strategy as lack of effective cooperation and collaboration among relevant agencies is often cited as the principal drawback of the social protection programmes in Bangladesh. The list of relevant institutions and agencies has been furnished in Figure 6.11. However, the main group of organisations are:

- Government agencies

- NGOs
- Development partners
- Academia
- Other relevant organisations

Some programmes will be completely new, 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, and monitor evaluate the programmes for scaling up after piloting of some experimental schemes. It will help ensure 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 requirement, strategic objectives and tangible outcomes along with poverty and gender impacts.

To secure external funding and technical assistance, country strategies of the development partners need to assessed. Currenlly, 'climate' component is available in Overseas Development Assistance (ODA) of IMF, World Bank and ADB, which can be utilized for designing and implementing the SRASP. Finally, 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 of addressing risks and vulnerabilities, reducing poverty and inequality, and socio-economic development for the 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.

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