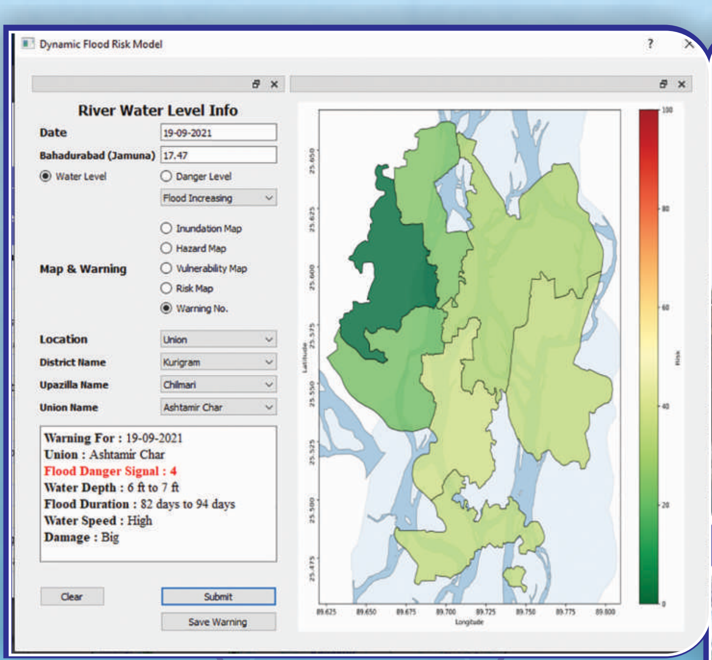
National Resilience Programme

Dynamic Flood Risk Model
Flood Preparedness Programme

July 2021



National Resilience Programme (NRP)
Department of Disaster Management
Ministry of Disaster Management and Relief

UKaid from the British people
Sweden Sverige
UN WOMEN United Nations Entity for Gender Equality and the Empowerment of Women
UNOPS
UNDP

National Resilience Programme (NRP)

Developing Institutional Framework of Flood Preparedness Programme

Draft Final Report

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Institute of Water and Flood Management

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Executive summary

Bangladesh is one of the most vulnerable countries in the world due to hydro-geological and socio-economic factors such as geographical location, topography, extreme climate variability, high population density, poverty incidence and heavy dependency of agriculture on climate. Under the National Resilience Programme (NRP) of the Government of Bangladesh with the technical assistance of United Nations Development Programme (UNDP), UN Women and United Nations, the Institute of Water and Flood Management (IWFM) BUET has been assigned to develop a sustainable strategy for community-driven Flood Preparedness Programme (FPP) through inclusive, gender-responsive disaster management. Focusing to build a Flood Resilient Community through enhancing flood early warning and preparedness, improved coping and response mechanisms in line with the changing trends of the flood incidents, in Jamalpur and Kurigram district, a Dynamic Flood Risk Model (DFRM) has been developed.

This community-based warning system (DFRM) aims to improve the national level early warning disseminated by FFWC and generate local flood event data (inundation area, depth, velocity, duration and risk). The model combines the flood information generated by two-dimensional numerical simulation, from the closed scenario of the current situation and gives inundation, hazard and risk information to the local community. An institutional framework was also presented including the local volunteers' activity for the flooding of the year 2021. The unit consisted of several volunteer groups supposed to work into 3 sub-units such as Preparedness & Warning Group, Shelter & Rescue Group, Relief & Rehabilitation Group. Each group was formed by three volunteer's one male, one female and one group leader (male/female). The number of volunteers should be sufficient to cover 2 sq. km, providing service to 2-3 thousand people. For the initial piloting four unions have been selected with the discussion among NRP-DDM, Care-Bangladesh and IWFM- Holokhana, Ramna, Astamir Char and Chikajani. With the increase of water level, the DFRM showed the warning number from 1 to 5. The local volunteers were suggested to display the yellow and red flags according to the warning numbers. The instructions to the local communities were also suggested according to the warning number. It was hoped that the information generated by this system will facilitate the administrators and planners to identify areas vulnerable to flood hazards and will enhance their capability to respond and recover. At the same time, the model generated flood hazard, risk maps and the warning will support the communities to respond adequately in saving their life and livelihoods.

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1 Introduction

Bangladesh is one of the most vulnerable countries in the world due to hydro-geological and socio-economic factors such as geographical location, topography, extreme climate variability, high population density, poverty and heavy dependency of agriculture on climate. The damage caused by a flood is relatively high as one-fifth to one-third of the country is annually flooded by overflowing rivers during the monsoon. Extreme rainfall within the country also exaggerates the flooding situation during the same period. Though normal floods are considered a blessing for Bangladesh-providing vital moisture and fertility to the soil through alluvial silt deposition in floodplains, moderate to extreme floods are of great concern, as they inundate large areas (more than 60% of the country are inundated in large flood events) and cause widespread damage to crops and properties (Rahman and Salehin 2013; Chowdhury et al. 1997). Two-thirds of the country's territories are less than 5 meters above sea level. The population is expected to rise to 259.9 million by 2100. Furthermore, Bangladesh is ranked 142 of 187 on the Human Development Index, indicating a low level of human development. Among the countries affected by climate change, Bangladesh, with its strong exposure to natural hazards, is ranked 10 out of 180 in the World Risk Index indicating high exposure to natural disasters with a low quality of institutions and infrastructure management capacity (Forster et al. 2019). The socio-economic impact of floods is profound; the flood-prone zones represent areas with the highest incidence of the extreme poor, and the number of poor living in high flood risk areas is on the rise. To reduce such huge vulnerability of flood in the path of achieving the Sustainable Development Goals (SDGs) by 2030, the Government of Bangladesh under the National Resilience Programme (NRP) of the with the technical assistance of the United Nations Development Programme (UNDP), UN Women and United Nations assigned the Institute of Water and Flood Management (IWFM) BUET to develop a sustainable strategy for community-driven Flood Preparedness Programme (FPP) through inclusive, gender-responsive disaster management. Focusing to build a Flood Resilient Community through enhancing flood early warning and preparedness, improved coping and response mechanisms in line with the changing trends of the flood incidents. This research has been focused on the local community of Jamalpur and Kurigram district (Fig. 1). The overall aim of the research is to build the Flood Resilient Community through enhancing flood early warning and preparedness, for improving community resilience by creating replicable, cost-effective methods for local disaster risk reduction and risk management.

2 Objectives and the expected outcome

The overall objective of the study is to enhance the resilience of the community in the way of Build Back Better (BBB) through Flood Preparedness Programme (FPP).

Specific Objectives

1. Formulating a sustainable strategy for community-driven Flood Preparedness Programme (FPP)
2. Developing community-driven flood risk and resilience model that need to be tested under FPP

3. Customize flood warning system including a flood inundation model based on the river water level, flood staging and its dissemination strategy to the end-users
4. Assist partner NGO (nominated sub-consultant) to implement community-based FPP model
5. Strengthening the flood early warning system and its dissemination at the community level
6. Assist PNGO for raising community awareness on flood preparedness
7. Developing an institutional framework of from community to national level
8. Assist PNGO in developing policies for advocating FPP

The expected outcome of the study to generate risk-based flood early warnings at the community level through the development of the Dynamic Flood Risk Model (DFRM). It is expected that the model generated information that will enhance the communities' flood preparedness and emergency response mechanism and thus will help to grow the more resilient community.

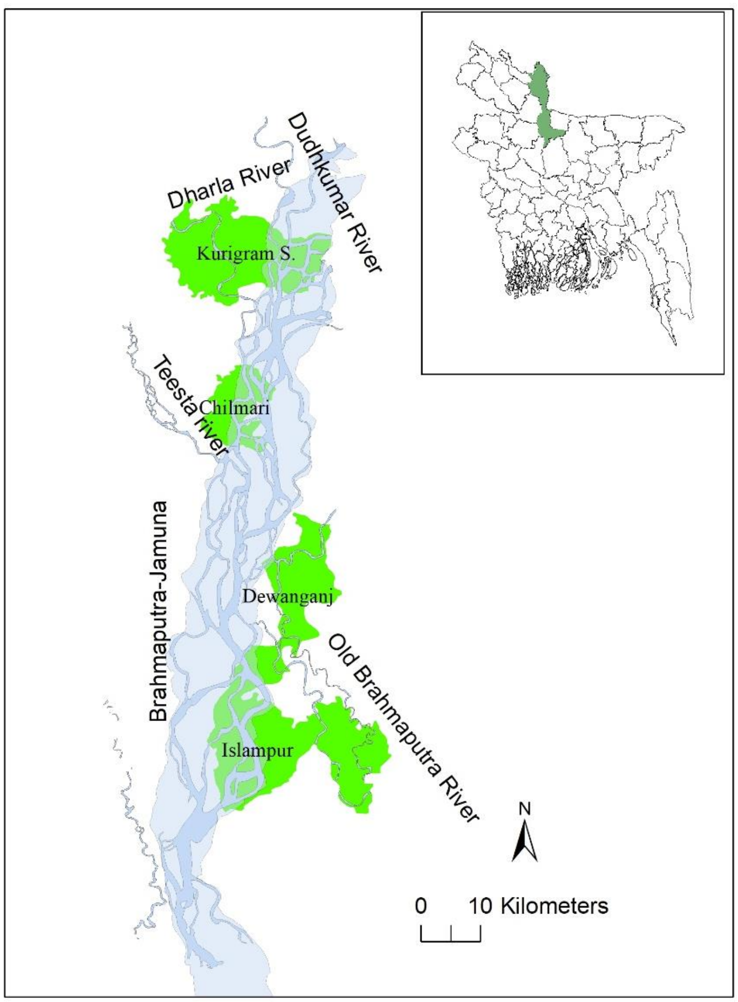


Fig. 1: Map of the study area

3 Situation and operational context of Flood preparedness and Early Warning

3.1 Global Scale

International Attention to Early Warning Systems

Over the past decade, the international community has paid significant attention to the topic of early warning systems, including, three international conferences (1998, 2003, 2006, hosted by the government of Germany), two international experts' symposia on Multi-Hazard Early Warning System (EWS) (2006 and 2009, World Meteorological Organization), the 2006 United nations Global EWS Survey Report, and the World Disaster Report.

In 2005, during the Second World Conference on Disaster Reduction (Kobe, Japan), 168 countries adopted "Hyogo Framework for Action 2005–2015" (HFA) shifting the paradigm for disaster risk reduction from post-disaster response to a more comprehensive approach that would also include prevention and preparedness measures.

The HFA outlines five priority areas for action, including:

- ✓ Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation.
- ✓ Identify, assess and monitor disaster risks and enhance early warning.
- ✓ Use knowledge, innovation, and education to build a culture of safety and resilience at all levels.
- ✓ Reduce the underlying risk factors.
- ✓ Strengthen disaster preparedness for effective response at all levels.

The second high-priority area of the HFA stresses the need for, "identifying, assessing and monitoring disaster risks and enhancing early warning." The Second International Conference on Early Warnings (2003) concluded that effective EWS are comprised as

- ✓ **Monitoring and warning service:** Hazards are detected, monitored, forecasted, and hazard warnings are developed.
- ✓ **Risks knowledge:** Risks are analyzed and this information is incorporated in the warning messages
- ✓ **Dissemination:** Warnings are issued (by a designated authoritative source) and disseminated in a timely fashion to authorities and public at-risk
- ✓ **Response capacity:** Community-based emergency plans are activated in response to warnings, to reduce potential impacts on lives and livelihoods.

Various assessments and the outcomes of the mid-term HFA review in 2010 have revealed that many nations around the globe operate EWS for various natural and man-made hazards. However, the governmental priority, stage of development and overall effectiveness of the EWS at national to local levels, vary widely. Many countries, especially those with the highest risks and least resources, remain highly challenged in building and sustaining their EWS at national to community levels.

Throughout these international events and assessments, it has become clear that governments and various agencies could benefit from experiences of other governments, with good practices in EWS that had been demonstrated to reduce the loss of lives and livelihoods. It also has been voiced in many international and regional forums that there is a need for systematical documentation of such good practices, lessons learned and synthesizing the factors that had contributed to their successes (Golnaraghi et al. 2007, 2008).

Methodology for Identification and Documentation of Good Practices in Multi-Hazard EWS

The process for systematic identification of good practices might be said to have commenced during the Third International Early Warning Conference (EWC-III). The EWS-III, WMO, in cooperation with other UN and international partner organizations held two international experts' symposia on multi-hazard EWS to develop a clear methodology for identification and documentation of good practices.

The First International Experts' Symposium on Multi-Hazard EWS

WMO hosted the First International Expert's Symposium on Multi-Hazard EWS (MHEWS-I) in May 2006, which brought together experts from various disciplines and organizations, working at national and international levels. The Symposium had the following main goals:

i. To provide recommendations for an integrated approach to warning systems, building on and linking existing capacities of different stakeholders, including identification of actions at the national level to strengthen early warning capabilities and regional and international actions to support these national efforts.

ii. To explore further the concept of a "multi-hazard approach" to EWS, including potential economies and synergies from such approach, and to provide recommendations on additional studies and/or demonstrations that might be required to fully assess all aspects of this approach.

iii. To develop criteria for what constitutes good practice and identify such cases in the world.

When considering the role of technical agencies, in particular, those responsible for monitoring, detecting and forecasting of the hydro-meteorological and climate-related hazards, the symposium stressed that in many countries the National Meteorological Services (NMSs) and the National Hydrological Services (NHSs) are separate agencies, under different line ministries. The operational roles of such technical agencies could be divided into three categories based on their institutional structures and mandates for specific hazards;

- **Type I hazards:** NMS or NHS has the sole mandate to monitor, detect and develop warnings for the hazard.
- **Type II hazards:** NMS and NHS have a joint mandate between them and/or with another specialized technical agency to monitor, detect and develop warnings for the hazard.
- **Type III hazards:** NMS and NHS are required to provide data and forecast products or lend their infrastructure to other agencies that have the official mandate to monitor, detect and develop warnings for the hazard.

The Symposium also provided significant input for the development of a standard template that could be utilized by the national ministries and agencies to document systematically their respective national EWS. A "simplified" outline of this template is provided below:

Table-1: A "Simplified" Outline of the Template Used for Systematic Documentation of Good Practices in EWS

A "Simplified" Outline of the Template Used for Systematic Documentation of Good Practices in EWS

1) ***Overview of the Early Warning Systems (EWS)***
2) ***Background in the establishment of EWS***
3) ***Governance and Institutional Arrangements (national to local levels)***
    a) Policy, intuitional and legal frameworks to support emergency planning and response
    b) National to local emergency planning and related linkages to EWS
    c) Organizational structure for implementing the plans
    d) Institutional capacities and concept of operations (coordination and operational collaboration)
    e) Financial and budgetary aspects
4) **Utilization of risk information in emergency contingency planning and warnings**
    a) Organizational responsibilities and arrangements for the development of risk information
    b) Hazard assessment, quantification and mapping (national to local)
    c) Assessment of vulnerabilities and exposure (national to local)
    d) Storage and accessibility of disaster and national hazard risk information
    e) Development and utilization of hazard/risk information to support emergency planning and warnings
5) **Hazard Monitoring, forecasting, and mandates for warning development**
    a) Organizational responsibilities for monitoring, forecasting and development of hazard warnings
    b) Organizational collaboration and coordination for development of hazard warnings
6) **Development of understandable, authoritative, recognizable and timely warnings**
    a) Warning message development cycle
    b) Warning message improvement cycle
7) **Warning dissemination mechanisms (national to local)**
8) **Emergency preparedness and response activities (national to local)**
    a) Disaster preparedness and response planning and emergency response activation
    b) Community response capacities
    c) Public awareness and education
9) **Sustainability, resources and budgetary commitments**
10) **Improvement of overall operational framework of EWS through on-going drills and feedback and evaluations during and after an event**
11) **Examples of previous events where the operational EWS has led to improvements in emergency preparedness and prevention**
12) **Overall lessons learned and future steps for improving Meteorological, Hydrological**

During MHEWS-I, four examples of good practices were identified using the above criteria, including Bangladesh, Cuba, France, and City of Shanghai in China. It was recommended that these cases be documented for further analysis of commonalities and lessons learned.

- *The Second International Experts' Symposium on Multi-Hazard EWS with focus on the Role of NMHS*

In 2009, WMO convened the Second International Experts' Symposium on Multi-Hazard EWS, (MHEWS-II) that reviewed the outcomes of the first four documented good practices, discussed lessons learned, and identified additional good practices in MNEWS including Japan, United States of America, Italy and Germany, for further expansion of this initiative. They provide a detailed analysis of seven of these good practices with a particular focus on multi-hazard EWS for meteorological and hydrological hazards. These include,

1. Bangladesh Cyclone Preparedness Programme
2. Cuba Tropical Cyclone Early Warning System
3. The French "Vigilance" System
4. The Warning Management of The Deutscher Wetterdienst in Germany
5. Multi-Hazard Early Warning System in Japan
6. Multi-Hazard Early Warning System of the United States.
7. Shanghai Multi-Hazard Emergency Preparedness Programme.

This work has clearly revealed that the specific design and implementation of EWS in each of the seven cases vary according to their governance mechanisms, specific history, culture, socio-economic conditions, institutional structure, capacities and resources for the sustainability of their respective systems. However, there are principles common to all of them that have led to the reduction of the impacts of hazards, particularly through saving of lives.

These 10 common principles are provided below:

1. There is a strong political recognition of the benefits of EWS reflected in harmonized national to local disaster risk management policies, planning, legislation, and budgeting.
2. Effective EWS is built upon four components: (i) hazard detection, monitoring and forecasting; (ii) analyzing risks and incorporation of risk information in emergency planning and warnings: (iii) disseminating timely and "authoritative" warnings, and, (iv) community

planning and preparedness and the ability to activate emergency plans to prepare and respond, with coordination across agencies involved in EWS, at national to local levels;

3. EWS stakeholders are identified and their roles and responsibilities and coordination mechanisms clearly defined and documented within national to local plans, legislation, directives, MoUs, etc., including those of the technical agencies such as the NMHS.
4. EWS capacities are supported by adequate resources (e.g., human, financial, equipment, etc.) across national to local levels and the system is designed and implemented accounting for long-term sustainability factors.
5. Hazard, exposure and vulnerability information are used to carry-out risk assessments at different levels, as critical input into emergency planning and development of warning messages.
6. Warning messages are; (i) clear, consistent and include risk information, (ii) designed with consideration for linking threat levels to emergency preparedness and response actions (e.g., using color, flags, etc.) and understood by authorities and the population, (iii) issued from a single (or unified), recognized and "authoritative" source.
7. Warning dissemination mechanisms are able to reach the authorities, other EWS stakeholders and the population at risk in a timely and reliable fashion.
8. Emergency response plans are developed with consideration for hazard/risk levels, characteristics of the exposed communities (e.g., urban, rural, ethnic populations, tourists, and particularly vulnerable groups such as women, children, the elderly and the hospitalized), coordination mechanisms and various EWS stakeholders.
9. Training on risk awareness, hazard recognition and related emergency response actions is integrated in various formal and informal educational programs and linked to regularly conducted drills and tests across the system to ensure operational readiness at any time.
10. Effective feedback and improvement mechanisms are in place at all levels of EWS to provide systematic evaluation and ensure system improvement over time.

- *The French Vigilance System. Contributing to the Reduction of Disaster Risks in France*

In December 1999, a severe storm occurred and the impact could have been lessened by the provision of better information to the public, it was decided to introduce a new mechanism that utilized a common language – a four-color scheme reflecting different risk levels. This would be applied at the scale of the French department, the administrative division of the national territory/. It would also be applied on a 24-hour time frame that combined satisfactory forecasting reliability with sufficient advance warning for action. This simple common language allows the French weather service to disseminate widely its "potential risk" forecasts linked to meteorological criteria in the form of a "Vigilance map". Information is transmitted simultaneously to civil defense authorities, national operators, the media and the general public, even though, this information is basically a meteorological forecast. As the general public receives clear risk information from the authorities accompanied by safety guidelines, it can also play a role in ensuring its security. This mechanism, originally designed for five types of weather hazards, namely high winds, heavy precipitation, storms, snow/ice and avalanches, was broadened in 2003 to include heat waves and intense cold episodes. In 2007, the parameter "heavy precipitation" was changed to "rains/flooding".

- *Policy, Institutional and Legal Frameworks in Support of Emergency Relief Planning and Implementation*

In recent years, French legislation on natural risks has been updated by the passage of two new laws;

1. Prevention of Technological and Natural Risks and Repairing the Damage Caused was designed to remedy shortcomings identified during floods in the south of France in September 2002

   Two main goals:

   a) developing risk awareness
   b) adjusting or establishing the necessary frameworks for intervention to tackle the root causes of risks and reduce vulnerability

   Four main Principles:

   i. strengthening information and coordination
   ii. controlling urbanization in exposed zones
   iii. prevention targeting the root causes of risks

iv. and improving terms for the compensation of disaster victims

2. The organizational structure of the nationwide civil defense system: This law reflects risk management policy in France towards enhanced protection at all levels. It emphasizes the importance of awareness of severe weather phenomena and their consequences, the legal allocation of responsibility, risk anticipation, and the preparedness of the public and emergency services.

- *Organizational Structure of the Vigilance Early Warning System*

On the basis of management responsibilities can be classified according to;

- **Responsibility/field of action** – detection, alert, communication, response;
- **Level of action** – national, zonal, department, communal, general public; and
- **Type of weather or hydrological risk –** meteorological, hydrological, health.

For flood risk monitoring, there are 22 Flood Prediction Services (FPS) that divide up the national territory according to the hydrographic limits of the main catchment areas. Health risks are concerned, the *Institute National de Veille Sanitaire* 45 (INVS), which comes under the Ministry of Health, provides special monitoring, particularly with regard to heatwaves and related health monitoring signals.

Organizational Responsibilities and Steps for the Development of Risk-Related Information

The DDRM lists the major risks identified in each *department* as well as their foreseeable impact on persons, property and the environment, on the basis of available knowledge. The DDRM provides background on the events and accidents that can constitute a risk record and summarizes the main studies, Internet sites or reference documents available for consultation by those seeking complete information. Based on up-to-date knowledge of weather hazards and critical sites at the local level, the DDRM makes it possible to define regulatory prescriptions in the communes, particularly with regard to urbanization and spatial planning. Its primary goal is to delimit zones exposed to risks, more particularly to floods, landslides, earthquakes, avalanches or forest fires. It produces maps (at least one map providing information on natural phenomena, a map of weather hazards, and a map of critical sites.

Assessment of Risks, Quantification and Mapping

The most serious risk in metropolitan France is that of flooding. To the north (e.g. the Seine, Somme, Meuse and Moselle), water levels rise slowly. Near the Mediterranean, however, flooding occurs rapidly with heavy rains, especially in the autumn. Other weather hazards stemming from natural risks are storms, drought, heat and cold waves and snowfalls/icing. In the mountains, avalanches are a deadly form of weather hazard. On mountain slopes, hillsides and cliffs, there are also mudslides, landslides and rock falls that can pose a threat to houses or other facilities.

Assessment of Vulnerability and Exposure

During the vulnerability assessment process, Météo-France may take part in studies focusing on correlations between meteorological parameters and measurements that are representative of impacts (e.g. the link between temperatures and excess mortality during heat waves). In addition, Météo-France provides local authorities with historical weather data to facilitate risk assessment studies. Furthermore, Météo-France participates in various exercises to test crisis management mechanisms, providing support in terms of real-time weather information delivery. The meteorological service is also invited to help prepare and evaluate these exercises that are, primarily, aimed at reducing vulnerability and risk exposure.

Organizational responsibilities to observe predict risks and issue warnings:

i. Météo-France is responsible for observing, forecasting, detecting and warning for all meteorological hazards.
ii. Responsibility for monitoring health risks and issuing health warnings lies with the Institute National de Veille Sanitaire (INVS).

Development Cycle for Vigilance Products:

Weather monitoring in metropolitan France is built around a Vigilance map showing the required warning level for each department in terms of meteorological and hydrological dangers for the upcoming 24 hours. Warning levels are identified by means of four colors that correspond to the following risk thresholds:

- Green – No particular vigilance required.
- Yellow – Be careful if you engage in activities that are sensitive to meteorological risk or vulnerable to flooding; forecasts call for phenomena that are usual in the region but may be dangerous occasionally and locally; keep informed of any developments in the situation.
- Orange – Be extremely vigilant; forecasts call for dangerous phenomena; keep informed of any developments in the situation and follow the safety guidelines issued by the authorities;
- Red – Utmost vigilance is required; forecasts call for exceptionally intense dangerous phenomena; keep regularly informed of any developments in the situation and make sure you follow the safety guidelines issued by the authorities

This procedure pursues three basic goals – focusing on major phenomena; anticipating these events as well as possible; and providing the public with ever broader and increasingly effective information.

Risk Levels for flood

- Situation normal

- Be alert

- Be prepared / be careful

- Protect yourself / be extremely careful

There are two additional levels for cyclones only,

- Stay indoors

-Stay Careful

Mechanisms for the Dissemination of Warning Messages:

There are two key characteristics of the Vigilance System. First, Vigilance products are circulated simultaneously to the operational services of the civil defense authorities and to the general public. Second, this task falls to the national weather and hydrological services.

- ✓ Operational actors – the prefectures, COGIC, the MEEDDM Ministerial Operational Monitoring and Alert Centre, the directorates for road equipment and safety, and the health services – by e-mail;
- ✓ The media – audiovisual (radio, TV) and press agencies – by e-mail or fax;
- ✓ The general public via the Internet site www.meteo.fr ;
- ✓ Customers – private sector (energy, industry, building, etc.), town councils, NGOs, etc. – by mail, site or dedicated Internet site (these services are provided free of charge)

Improvements to the Operational Framework of the Early Warning System

- ✓ Evaluating the services provided;
- ✓ Drafting requests or recommendations;
- ✓ Proposing ways of responding to new needs which have emerged;
- ✓ Making proposals to secure the corresponding funding; and
- ✓ Following up on action taken

Dissemination and Communication

All available media are currently used to disseminate information in real time with the shortest possible notification times to ensure an optimum response. From the orange vigilance level, TV and radio teams can send journalists and transmission equipment directly to the *«departmental»* weather centers to be at the source of the information. For disseminating the information, Météo-France relies on:

- Telephone-based systems including:

i. answering machine
ii. SMS messages

- Digital media including:
    i. map and status reports sent by e-mail
    ii. posting on the internet
    iii. follow-up reports, in text and audio form
- Paper based media, including fax transmission to civil protection and a few subscribers of the map adapted for black and white format and the follow-up reports

3.2 Global Scale

Flood Action Plan (FAP 14 & 23)

Flood response was defined as any activity that prepares for, copes with, or recovers from flood, within the constraints of the society, its technology, and the environment. There are common and widespread measures to help the rural population cope with the flood. Improved flood and early warning systems are much needed, as, currently; most information is disseminated by word-of-mouth or, for some areas, on the radio. The timing and use of warnings should differ between flood environments. For example, flash flood areas need short-term, rapidly spread warnings, while those subject to more gradual but extensive flooding need to be warned differently. Agricultural production systems are closely adjusted to monsoon cycles, with depth and duration of normal inundation or average flood dictating the choice of crops during the Kharif-l and Kharif-2 growing seasons. A common agricultural response to the severe flood was to increase production of dry season (rabi) crops, such as boro rice, that depends upon irrigation, fertilizers and other inputs. This response indicates that there is a general need for policies to increase access to irrigation facilities, inputs such as seeds and fertilizer, and credit or other financial support for those suffering crop losses. Another widespread agricultural problem in flood was the protection of animals, especially those used as draft animals. Not only does severe flood threaten animals' health, it also can force distress sales by poor families of these very important productive assets.

The study was conducted in three parts.

- The main activity was a house-to-house questionnaire survey of 30 villages (29 flood-affected and one flood-free), two each in 15 different Upazilas' selected to represent different flood plain agro-ecological zones.
- The second part of the study was an institutional level survey of village representatives and local government officials on the general characteristics, and group or organizational support needs, of each village and its region. This second part expanded the group of study villages from 30 to 81. This survey used more open-ended interview techniques to gather information on perceptions of local trends, history and the efficacy (actual or hoped-for) of a specific neighborhood, village or governmental institutions during recent floods. It also gathered some information through the household survey questionnaire.
- A third, gender survey of a small subsample of senior women in 86 study households, was intended to supplement information on household flood experience and gain insight into the sexual division of labor and other gender-related issues in flood response. A survey research of these three types was supplemented by the collection of case studies on specific issues or people.

The study analyzed responses to three types of water situations. One was normal monsoon inundation *(shabhabik borsha).* The second was average flood *(bonna),* which normally covers fields but rarely homesteads. The third was severe flood *(marattak bonna),* which covers fields and also many homesteads. Each village was classified for analysis as being in one of eight possible flood environments (plus one hitherto flood-free area) according to its predominant flood response characteristics. The concept of flood environment was based on a combination of normal monsoon conditions, with which cropping patterns were closely aligned, and frequency and duration of average and severe flood events. The study populations of the flood environments had distinctive patterns of flood response, with additional variations associated with differences in flood experience or socioeconomic status.

The eight flood environments which form the basis of the analysis are:

1. main river areas;
2. secondary river areas;
3. empoldered villages in the semi-saline, tidal southwest;
4. chars, large, mostly new landmasses within the major rivers;
5. haors, tectonically formed depressions prone to annual water accumulation;

6. beels, former river channels that are deeply flooded seasonally and may be fed by either rivers or rainfall;
7. flash flood areas; and
8. areas protected by embankments but which have suffered from floods caused embankment breaches

Flood Environments

The idea of a flood environment first evolved within the FAP-14 study as a simple list of distinct, loosely organized, flood characteristics. The key characteristics were:

- Flood sources categorized as an overbank spill, rainfall congestion, flash flooding, and embankment breaches. The categories found to have some explanatory validity for people's flood responses were: overbank spill (including flooding within the active floodplain), combinations of the overbank spill and rainfall back-up, simple rainfall or drainage congestion, flash flooding, flash flooding plus later prolonged overbank spill, and embankment breaches.
- For the village in general, flood frequency categorized as never, rare (one to two years in the last 10), occasional (three to seven years in the last 10) and frequent (eight to 10 years in the last 10).
- Flood duration, categorized as short (up to two months), medium (two to four months) and long (over four months).
- Overall land level of the village categorized as mainly high, mainly medium, or mainly low.
- Whether protected from flooding categorized as fully protected, partly protected (by infrastructure such as roads and railway embankments), and not protected.
- In general, the lesser rivers tended to flood more than others from local rainfall. Because most radio announcements applied only to the main rivers and had little relevance to lesser river areas, improved localized warnings are needed. Another problem on the lesser rivers was flash flooding, which was somewhat unpredictable, rapid, and destructive. This indicates a need for house repair and other flood recovery assistance programs.
- In secondary river villages and empoldered, semi-saline villages drainage congestion can be a problem, often more serious than flooding, and it requires further investigation and action.

- Warnings of flash floods, storms, and breaches would help residents of such areas to harvest crops early when possible. Safe places to store and dry soaked paddy were of great interest to beel and haor respondents.
- A char to re-emerge. Homes in the chars arc already movable, but access to boats can be a problem. Needs of the char population are many, ranging from warnings to assist people in evacuation, to provision of shelter and public support services, to income generation opportunities for those who are displaced.

Local Needs During and after floods

- Storm and flood Warning
- Emergency shelter (which allows sufficient privacy)
- fuel for cooking
- Safe drinking water
- Access to food
- Cooking and eating facilities
- Sanitation facilities
- Animal care
- Fodder supply
- Protecting crops and pond fish
- Grain storage/drying facilities
- Receiving timely inputs to plant/replant crops
- Repairing homes
- Employment continuity
- Road. Embankment and other infrastructure repairs
- Access to health care facilities

Floodproofing

Floodproofing is the provision of long-term, non-structural or minor structural measures to mitigate the effects of floods. The objectives of floodproofing are to avoid the loss of human life and reduce the disruption to normal activities during and after a flood. The purpose of floodproofing is to provide people with the security and motivation necessary to make and sustain improvements in their economic and social welfare and achieve prosperity in an environment that frequently floods.

- Structural floodproofing measures include raising floor levels of homesteads and industrial facilities above flood levels, provision of refuge (flood shelters, ensuring that water supplies and other health-related facilities operate throughout floods, designing roads to be above peak flood levels, provision of additional bridges or culverts to improve water flows through an area and also to ensure embankments or structures are not washed away.
- Non-structural measures include institutional measures to coordinate development activities related to flood control and drainage, planning controls on developments in flood-prone areas and ensuring

Comprehensive Disaster Management Programme (CDMP)

CDMP is a collaborative effort by the Government of the People's Republic of Bangladesh, UNDP, the UK Department for International Development (DFID), and the European Union (EU) which seeks to move the Bangladesh disaster management emphasis from a response and relief focus to a broader and more encompassing risk management framework. It was designed as a two-phased program. The first [pilot] phase 2004 – 2009 was to undertake a thorough review of existing disaster management systems, and policy and legislative frameworks with a view to lay the foundations for longer-term disaster risk reduction programs and reforms.

The primary focus of CDMP interventions was to facilitate the transition of the Bangladesh existing response and relief emphasis to a more comprehensive risk management culture. The strategies for achieving this goal evolved around five key areas: 1) Professionalizing the disaster management system; 2) Mainstreaming disaster risk management within development and investment planning processes; 3) Strengthening community institutional support systems; 4) Expanding mitigation and preparedness programs to cover a wider range of hazards and geographical areas; 5) Operationalizing response management systems. Based on these directives, the major sub-programs of CDMP included: (a) Capacity building, (b) Partnership Development, (c) Community Empowerment, (d) Research and Information Management, and (e) Response Management.

The second phase, working with the goals of the Hyogo Framework for Action as an over-arching reference, aims to reduce Bangladesh's vulnerability to adverse natural and manmade hazards and extreme events, including the devastating potential impact of climate change. The key areas of focus for CDMP Phase II are: **1) Institution Strengthening in Risk Reduction,** through the development of strong, well-managed and professional disaster management institutions in Bangladesh. **2) Managing Adaptation to Climate Risks,** through Effective management of community-level adaptation to a changing climate, and the mainstreaming of DRR and climate change adaptation linkages; **3) Disaster-proofing of Development Funding**, including disaster-proofing development programs across 12 Ministries for better long-term planning and investment decisions; **4) Rural Risk Reduction,** aimed at reducing the risks of rural populations through structural and non-structural interventions, empowerment of communities, and improved awareness and planning; **5) Urban Risk Reduction**, focused on reducing the risks of urban populations through structural and non-structural interventions, improved awareness, and the piloting of extreme poor-targeted urban community risk reduction methodologies; **6) Improving Disaster Preparedness and Response,** through strengthening early warning systems, national management capacity, and coordination.

Standing Orders on Disaster (SOD)

Standing Orders on Disaster (SOD): SOD describes the detailed roles and responsibilities of Committees, Ministries, Divisions, Departments and other organizations involved in disaster risk reduction and emergency response management. The Standing Orders on Disaster in the current format was first published in 1997 in Bangla. It was modified and translated in English in 1999. Finally, it was revised in 2019.

Role and Responsibilities of the different organization according to SOD

National Disaster Management Council (NDMC): It is headed by the Hon'ble Prime Minister to formulate and review the disaster management policies and issue directives to all concerns. It promotes awareness regarding disaster risk reduction among top policymakers and provides strategic advice. It evaluates response and recovery measures, particularly after a large-scale disaster**.**

Inter-Ministerial Disaster Management Coordination Committee (IMDMCC): IMDMCC works under the MDMC which is consists of 33 members including 11 ministries chaired by Minister, Ministry of Disaster Management and Relief (MoDMR). IMDMCC will meet at least twice a year or it may meet when the chair desire. It establishes at the national level to facilitate policy making, planning, programming and implementing relating to disaster risk reduction and emergency response management in Bangladesh. It ensures the whole of government coordination in emergency response, relief and rehabilitation operations and approves guideline for multi-agency incident management.

National Disaster Management Advisory Committee (NDMAC): NDMAC was formed on 19 November 2009. It is to be headed by an experienced person having been nominated by the Hon'ble Prime Minister to advise NDMC, IMDMCC, DMRD, and DDM on technical matters and socio-economic aspects and propose long term recovery plans. It creates a forum for discussion by experts on the risk of disaster, opening opportunities for cooperation towards the solution of problems relating to disaster management and recommends a solution of problems identified by the DDM or any other agency/person. Finally, it submits a report with recommendations to the NDMC.

The Ministry of Disaster Management and Relief (MoDMR): The Ministry of Disaster Management and Relief (MoDMR) of the Government of Bangladesh (GoB) has the responsibility for coordinating national disaster management efforts across all agencies. In 2009, the Food division and Disaster Management and Relief Division (DM&RD) was formed under the Ministry of Food and Disaster Management (MoFDM). In 2012, Disaster Management and Relief Division (DM&RD) was renamed as the Ministry of Disaster Management and Relief (MoDMR).

Department of Disaster Management (DDM): The Department of Disaster Management (DDM) under the Ministry of Disaster Management and Relief was set up in November 2012. Its responsibilities are noted below.

Normal Time

- To provide secretarial support to the NDMAC on disasters and undertake various activities for creating awareness among the people, government employees and people of other professions for reducing risks during the disaster.

- Impart training to the government employees, elected representatives and others on disaster management in cooperation with different Ministries, local authorities, training institutions, Academies, and NGOs.
- To Collect and preserve lists with location, condition, and ownership of cyclone shelters, embankments, platforms at higher than flood level (flood-proofing).
- Organize meetings/seminars/workshops at national, District, Upazila and Union levels.
- Facilitate publicity of cyclone signals at the community level through posters, cultural functions, documentary films, etc.

Alert and Warning stage

- To ensure receipt of warning signals of imminent disasters by all concerned officials, agencies, and mass communication media.
- To Activate EOC and keep in touch with other agencies for making their Action Plan effective and also to activate the Control Room.
- To publish daily bulletins during the disaster period for foreign embassies and UN Missions.
- Instruct local authorities for assessment of loss and damage and requirement of relief.

Disaster Stage: In this stage, it opens EOC on a non-stop basis (24 hours) and institutionalize damage, loss and need assessment cell at DDM. It assists the IMDMCC for ensuring coordination among government, NGOs and different agencies for relief and rehabilitation activities. It also monitors the progress of rescue, relief and rehabilitation operations to identify the problems and needs and to draw the attention of the proper authority and supplying required information to the Economic Relations Division, Ministry of Information, foreign agencies, NGOs etc.

Rehabilitation Stage: To Supply information/input to the concerned authority for the preparation of the rehabilitation plan and ensure the adoption of steps for minimizing future disaster risks in the rehabilitation plans.

District Disaster Management Committee (DDMC): DDMC is Headed by Deputy Commissioner includes all concerned departments at the District level and all UNO under this district to coordination all of the disaster-related activities in the district level.

Upazila Disaster Management Committee (UzDMC): UzDMC is chaired by the Upazila Nirbahi Officer includes all concerned departments at Upazila level and all union chairman under this Upazila to coordination all of the disaster-related activities in Upazila level.

Union Disaster Management Committee (UDMC): UDMC is Headed by union chairman includes all of the Union Parishad members, school teachers, and some of the other people.

Ward Disaster Management Committee (WDMC): WDMC is Headed by the elected union Member includes some of the other people such as school teachers, Mosque Imam, Small Businessman and others.

Table 3. 1: Major roles and responsibilities of DDMC, UzDMC, UDMC and WDMC

Situation	Responsibilities of DDMC, UzDMC, UDMC and WDMC
Normal time	• Ensure the constitution of Disaster Management Committee at all level. • Arrange training and workshops on disaster-related issues regularly by keeping the DDM/DDMC/UzDMC/ informed. • Identify the most vulnerable or people at high risk by sex, age, physical ability, social status, occupation and economic status. • Build the capacity of local institutions, volunteers and people in a way that they can help and motivate people to adopt disaster-resistant housing features. • Ensure the supply of safe water and if necessary other services from specific points near the shelters/centers. • To train the students, youths, local clubs and volunteers on community-based water purification technology, so that during a disaster, they can supply water-purifying technology during emergencies in their community until external support reaches the high-risk people. • Plan for preparing some community-based high land, which can be used as a playground in normal time and can be used as a shelter place during disaster period and where livestock, poultry, emergency food, kerosene, lamp, candle, matches, fuelwood, radio and other important resources could be shifted along with the people. • Stock emergency life-saving medicines for use during a disaster.

Situation	Responsibilities of DDMC, UzDMC, UDMC and WDMC
	• Monitor the activities and Progress of Implementation of Action Plans and submit a progress report to the higher authorities.
Warning Period	• Dissemination of early warning messages to the vulnerable community and monitor the whole security and warning message dissemination activities. • Visit the pre-determined emergency shelter centers and be sure that for essential services and security different organizations and volunteers are alert and ready to provide services. • Review the practicality of water supply sources nearby the shelters/centers. • Take emergency measures to fill up the stock of lifesaving drugs after carefully scrutinizing the stock of life-saving drugs.
During Disaster	• Organize emergency rescue work by using locally available facilities in times of need and if directed, assist others in rescue works. • Coordinate all relief activities (GO-NGO) at Union, Pourashava, Upazila and District level so that relief materials are distributed impartially. • Protect people from becoming upset due to rumors during the hazard period by providing correct and timely information. • Ensure the security of women, children, and persons with a disability during a hazard. • Take necessary actions to protect environmental degradation by the quick funeral of corpses and burying the animal dead bodies. • Help people to transfer their essential resources (livestock, poultry, essential food, kerosene, candle, matches, fuel, radio, etc.) to safe places.
Post Disaster Period	• Collect statistics of loss incurred in disaster and send the same to a higher authority. • Supervise and keep accounts of the relief and rehabilitation materials distributed and send it to a higher authority and other relief donor organizations. • Ensure that due to hazard the people who were displaced can return to their previous place.

Situation	Responsibilities of DDMC, UzDMC, UDMC and WDMC
	• Instruct the health-related personnel of the District and Upazila level to provide appropriate and adequate care to disaster-affected people and if needed, request the District health authority for assistance.

Standing Orders During Cyclone

Policy Committee: A 7(seven) member's policy committee headed by the Minister, the Ministry of Disaster Management and Relief to provide policy directives and guideline to the CPP implementation board for effective implementation of the program.

Responsibilities of CPP Implementation Board (CPPIB): A 15 (fifteen) members "Implementation Board" headed by the Secretary, the Ministry of Disaster Management and Relief is constituted for effective implementation and administration of the program. It fulfills all other functions necessary for the effective implementation of the cyclone Preparedness Programme.

Cyclone Preparedness Programme (Headquarters):

Normal Time

- ✓ To organize preparedness programs in disaster areas continuingly and to assess the state of preparedness, hold drills in April and September every year.
- ✓ To ensure recruitment and training of volunteers before April every year and establishment of Union and Upazila Offices, holding of meetings at Union and Upazila level.
- ✓ To ensure wireless communication between CPP Headquarters and Upazila Office and between Upazila Office and Union Office.
- ✓ To make public awareness about cyclone signals and with the help of DDM, popularize preparedness plans, through discussion meetings, posters, pamphlets, films and drama etc.

Alert and Warning Stage

- ✓ To establish Control Room at CPP headquarters and in regional offices and assist District, Upazila and Union authorities in the establishment of Control Rooms

- ✓ To receive special weather bulletins from BMD and send them to Upazila and regional offices and to instruct the Upazila offices to send them to Union offices as quickly as possible.
- ✓ Keep the CPP Implementation Board Chairman and the Members informed about the cyclone and propose calling of an emergency meeting of the CPP Implementation Board.
- ✓ Alert the DCs, Upazila Executive Officers, Union Parishad Chairman, members, local nongovernmental organizations and instruct the volunteers to listen to normal radio news/CPP radio news.
- ✓ Instruct CPP Development Officer for advising Chairman of the UzDMC, Union DMC to call the meeting.

Disaster Stage

- ✓ To coordinate its' activities with those of all concerned agencies and non-governmental agencies. Ensure rescue operations and first aid by development officers and volunteers in times of need.
- ✓ To instruct development officer to maintain wireless communication and to keep touch with headquarters at regular intervals and to transmit loss and damage report as soon as it is received.

Rehabilitation Stage: It advises every Union leader to send a primary report of loss and damage in their respective areas to the Development Officer and coordinating the activities of non-governmental organizations (NGOs).

Field Level CPP (Upazila, Union):

Normal Time

- ✓ To organize simulated drills continuously in disaster areas and monitor the status of preparedness drill participated by the people in April and September every year.
- ✓ Select volunteers and complete their training according to rules of the CPP before April.
- ✓ To create awareness amongst the local people about the cyclone preparedness programme and the understanding of different warning signals.
- ✓ Make the people and the volunteers aware of the dangers of resistance to disaster preparedness activities, in coordination with Upazila and Union Parishad administration.

Alert and Warning Stage

- ✓ To set up Control Room and maintain contact with Upazila, Union offices and received special weather bulletins from CPP Headquarters.
- ✓ Alert the chairman of District/Upazila/Union DMCs, members, religious leaders, local elites, teachers and persons connected with different organizations.
- ✓ Request DC/UNO/Upazila and UP Chairman to call an emergency meeting of the respective DMC(s).
- ✓ Depute CPP volunteers for shifting the livestock, poultry and other domestic animals to raised land, kills under proper safety measures.
- ✓ Give the final warning to the people by using a megaphone, light signals and flashlights.
- ✓ Finally informed about the field level disaster situation report to Upazila and District administration, CPP Central Headquarters, DDM and others concerned.

Disaster Stage: In disaster stage, it keeps wireless in operation and maintain communication with CPP Central Office and to send the loss and damage statement to the concerned authority as soon as it is received. It also coordinates with Union and Upazila authority for rescue and provides first aid and relief.

Rehabilitation Stage: In the rehabilitation time, it collects data on loss and damage due to cyclone, prepare the report and send it to CPP Headquarters, Union DMC, Upazila and District administration and participate in the rehabilitation programme with non-governmental organizations (NGOs) and other agencies.

Standing Orders During Flood

Headquarters of BWDB:

Normal Time

- ✓ Operate “Flood Information Centre” and establish flood information Sub-Centre at field level from April to November every year.
- ✓ Collect, during the monsoon period, weather forecasts, water level of all principal rivers originating from different places in Bangladesh and India. The BWDB will request the Ministry of Water Resources regarding the receipt of information from India.
- ✓ Inform DDM and MoDMR about the operation of the Information Cell of the Board.
- ✓ Ensure Coordination with IMDMCC, MoDMR and DDM.

- ✓ Designate one Liaison Officer in Board Office to maintain a link with the EOC of the MoDMR. Deputy Director of FFWC will be in charge of this responsibility.

Alert and Warning Stage

- ✓ Appoint guards to locate leakage, breach, and holes in embankments and also alert warning centers.
- ✓ Keep the officials alert for the security of life, supplies, goods in stock and implements.

Disaster Stage

- ✓ To operate information cell and Flood Control Centre day and night and send a Liaison Officer to the EOC of the Ministry of Disaster Management and Relief.
- ✓ Inform IMDMCC and the EOC of the MoDMR about brewing up of any special situation.
- ✓ Give all support and assistance to local civil administration for rescue, evacuation and relief operations through field level administrative machinery.
- ✓ To make a plan and programme for repairing, reconstruction and reinstallation according to short- and long-term planning of the government within the shortest possible time after assessment of loss/damage and recession of water.
- ✓ In case of any difficulty in flood disasters or if any matter not possible to solve or if the help of the IMDMCC/NDMC is needed, request for intervention by the MoDMR.
- ✓ Send daily flood reports to different GO, NGOs.

Rehabilitation Stage

- ✓ Quickly assess the loss and damage and prepare required plans for repair and reconstruction work on a priority basis.
- ✓ Ensure the restoration of infrastructure, logistics and installations in the shortest possible time for domestic, industrial and export use projects.
- ✓ Prepare new plans and designs for the control, reduction of loss/damage and prevention of recurrence of floods.

Flood Forecasting and Warning Centre (FFWC)

Risk Reduction: In risk reduction time, FFWC developed a long-term risk reduction action plan for floods and another water-related disaster. It continues research in extending the lead-time for flood forecasting and main linkages with regional flood forecasting sources.

Alert and Warning Stage: In this stage, FFWC is taking steps to alert all stakeholders through telephone, cell phone, email, telex and wireless according to needs regarding floods and flash floods. It informs DDM and BMD about the long, mid and short-term flood foresting information for ensuring better preparedness.

Field Level Offices of BWDB:

Normal Time

- ✓ Inform and alert BWDB, Ministry of Water Resources and EOC of the MoDMR concerned DCs and UNOs about the increase of flood level.
- ✓ Attend the meeting of the local DMC.
- ✓ Alert all concerned speedily by telephone, fax, wireless etc. as flash floods allow very little time.
- ✓ Complete repair of leakage, holes etc. in the embankments of respective areas before April every year and keep the materials/implements for emergency work ready at a convenient place and complete the on-going projects like construction of embankments and gates.

Alert and Warning Stage

- ✓ Arrange for guards for sluice and lock gates to avoid loss.
- ✓ Send reports to higher officials about conditions of sluice gates, embankments and installations and progress of their repair.
- ✓ Take precautionary steps for the protection of life, assets, equipment and transports.

Disaster Stage

- ✓ Operate Flood Information Centre day and night (24 hrs) on a full-time basis and send Liaison Officer to the local disaster Control Room.
- ✓ Support and assist the local civil administration in rescue, evacuation and relief operations in respective areas.
- ✓ Repair the damaged installations and supply sources by managing technical manpower and materials.
- ✓ Take any suitable action in the exigency of circumstances for saving life and assets and also for evacuation.

Rehabilitation Stage

- ✓ Assess loss and damage and prepare plans and designs for repair, reinstallation or reconstruction.
- ✓ With the help of local agency/non-governmental organization, restore physical infrastructure, sluice gate, water drains and re-establish within minimum possible time.
- ✓ Prepare project designs of a new type to prevent floods in specific areas.

3.3 Flood Forecasting and Warning in Bangladesh[1]

Bangladesh is located downstream of three large river basins: the Ganges, Brahmaputra and Meghna river basins. The total catchment area of these basins is 1.72 million km^2, with almost 93% of the catchment area situated outside the territories of Bangladesh – in Bhutan, China, India and Nepal. The topography, location and discharge from each of these three basins shape the annual hydrological cycle of the country (Bhuiyan, 2006). Over the course of a year, Bangladesh experiences periods of extreme water availability – too much and too little water. Monsoon precipitation from June to September is the main source of water, and the country has less water available outside of this season, termed the "dry period." Heavy rainfall during the monsoon period is the main cause of flooding; this occurs almost every year, with a devastating flood every 5–8 years (FFWC, 2004). Such flooding causes severe damage to agriculture and infrastructure and the loss of human lives. Bangladesh has implemented flood control and drainage projects since the 1960s. However, structural measures alone cannot totally protect the people and infrastructure from floods. Complete flood control in a country like Bangladesh is neither possible nor feasible. With this understanding, Bangladesh started developing flood forecasting and warning systems (non-structural measures) for flood management (Bhuiyan, 2006). The objectives were to enable and persuade people, communities, agencies and organizations to be prepared for floods and take action to increase safety and reduce damage. The goal was to alert people on the eve of a flood event.

Developing flood forecasting services

[1] Source: https://public.wmo.int/en/resources/bulletin/flood-forecasting-and-warning-bangladesh

Bangladesh Water Development Board (the Board) is responsible for flood management through structural and non-structural measures. It also provides hydrological services in Bangladesh. As part of non-structural measures, the Board has been providing flood forecasting and warning services through its Flood Forecasting and Warning Centre (FFWC), established in 1972. Since then, the development of flood forecasting and warning services has made stepwise progress, which can be divided into three stages.

Initial stage (1972–1988): Initially, 11-gauge points were used for real-time flood monitoring and forecast purposes. In this early phase, gauge-to-gauge statistical correlation and Muskingum–Cunge methods were used for predicting water levels. In 1981, WMO and the United Nations Development Programme provided technical assistance for computerization of the hydrological database. Computer programs were also developed to carry out operations that had previously been performed manually. During devastating floods in 1987 and 1988, flood forecasts of the major river systems proved to be fairly accurate.

Second stage (1989–1999): After the 1987 and 1988 floods, an initiative was launched to develop a flood forecasting system based on a numerical model. WMO engaged the Danish Hydraulic Institute (DHI) to create a flood forecasting model for Bangladesh. During 1989–1991, the national flood forecasting model was developed using a MIKE 11 modeling system. From 1991, additional deterministic flood forecasting efforts were pursued, resulting in forecast lead times being increased to 48 hours. The number of real-time forecasting stations was increased to 16. From 1995 to 1999, the flood forecasting model was further upgraded to improve its forecast accuracy, under the Bangladesh Flood Action Plan. A geographic information system (GIS) module was added to the flood forecasting model, and the number of stations used to support forecast modeling was increased from 16 to 30. Bangladesh again experienced severe flooding in 1998, for which the flood forecasting and warning services yielded productive and successful results. An internal analysis of the 1998 flood concluded that flood forecasting and warning services should be extended to all flood-prone areas of the country. In addition, the need for dissemination of flood information to vulnerable communities became very evident.

Third stage (2000 to date): Many lessons were learned from the 1998 floods. Foremost was that the people of vulnerable communities require flood information with a greater lead time. Further, they wish to know when their homesteads are going to be inundated and for how long. This showed that people were demanding area-specific flood forecasts. Moreover, field-level flood and water-related disaster managers also expressed their eagerness to receive timely flood forecasting information. In this third stage, FFWC received support to improve the accuracy and extend the lead time of flood forecasts, expand the provision of flood forecasting services to all flood-prone areas of the country, improve flood information dissemination at the vulnerable community level and build a sustainable institution. FFWC efforts focused on improving the forecast lead time. It started to use ensemble precipitation forecasts from the European Centre for Medium-Range Weather Forecasts to provide medium-range flood forecasts. Since 2004, FFWC has provided deterministic flood forecasts to 3 days and medium-range probabilistic forecasts to 10 days. FFWC also started to develop its basin model in 2012.

Development of the basin model

The concept for the basin model was introduced under the Comprehensive Disaster Management Programme Phase-II to increase forecast lead time. As Bangladesh is located downstream of three big river basins, an integrated basin model was needed to effectively increase the forecast lead time for Bangladesh. Fundamental to this was using the advances that have been made in numerical weather modeling and ensemble forecasting.

FFWC uses the Weather Research Forecast (WRF) model for precipitation forecasting. The basin model, which is currently used for flood forecasting purposes in Bangladesh, uses quantitative precipitation WRFs for establishing a deterministic flood forecast with a lead time extended from 3 to 5 days.

Flood forecasting and warning activities

Flood forecasting and warning activities run from April to October every year in Bangladesh. In this period, the field-level hydrological measurements division works closely with the flood forecasting center to provide observed data. FFWC remains open 24 hours a day, 7 days a week during this period.

Data collection and transmission

Today, the hydrology division of the Board has an extensive network of 60 rain gauges and 90 hydrological stations where water level, discharge, sediment or water quality are measured. Network design reflects the need for field data based on requirements of the flood forecasting model. Daily operational requirements of the flood forecast model are for real-time water level and rainfall data. Water level gauge readers for the 90 stations send data to FFWC twice daily. Data are usually collected from 6 a.m. to 6 p.m. at 3 hourly intervals every day. Rainfall records are available for 24 hour periods for the 60 gauges all over the country. Data are now transmitted from the field using a mobile SMS system. Prior to this development, hydrological data had been orally transmitted using landline telephones. The Board piloted automatic collection of water level data using a radar level sensor as part of another project.

Oper*ation of the flood forecast model*

The flood forecast basin model is based on the DHI MIKE 11 hydrodynamic modelling system. The computational core of the hydrological forecasting system is the DHI MIKE 11 software, which contains two modelling components: (i) a hydrodynamic model and (ii) a hydrological model (NAM; a rainfall-runoff model). The hydrodynamic module contains an implicit finite-difference computation of unsteady flows in the rivers based on St Venant equations. The flood forecasting model is customized with the Flood Watch database, which uses a GIS. The MIKE GIS module is also integrated with the digital elevation model (DEM) of Bangladesh to generate an inundation model. Quality checked, processed data are used in the model to generate 5-day deterministic forecasts. The operational flood forecasting system is based on real-time data received from available stations in Bangladesh, relevant online data received from riparian countries (based on an existing data-sharing protocol), and quantitative precipitation forecasts from numerical weather prediction models provided by the Bangladesh Meteorological Department and the Indian Meteorological Department. FFWC also uses satellite-based observation data for flood forecasting purposes.

Forecast products

- Daily water level and rainfall situation reports
- Flood conditions summary (provided both in Bangla and English)

- Forecast bulletins for 24, 48, 72, 96 and 120 hours
- Rainfall surface map
- Flood inundation map
- Interactive voice response (mobile voice message)
- Special outlook

Flood warning dissemination

There is no doubt that effective early warning system can save lives and property. Early warning systems can also help disaster preparedness programmes to establish measures, such as emergency relief operations and evacuations, in advance. Flood forecasting and warning activities have proven very effective in recent years to combat the damaging effects of flooding. FFWC disseminates flood warning information through media and communication outlets using the Internet, fax, telephone, mobile SMS, etc., and uploads the forecasted information daily on its user-friendly website (www.ffwc.gov.bd). Moreover, FFWC has also started to disseminate flood warning messages using an interactive voice response system. Anyone in the country can receive a short message regarding current flood information pertaining to Bangladesh's major rivers by calling 1090. This novel system provides timely information to a variety of different users including government departments, agencies, disaster managers, non-governmental organizations, news, media, local government institutions and individuals.

The FFWC has a number of recommendations based on its experience with early warning systems for flood forecasting. The top three are below.

1. **Area-specific forecasting:** FWC provides flood forecasts based on predefined danger levels for the major rivers. It is essential to provide area-specific inundation-based flood forecasts for better flood management.
2. **Flood inundation map:** FFWC currently generates flood inundation maps using old DEM data. To increase the accuracy of the flood inundation maps, it is recommended that updated high-resolution DEMs be used.
3. **Long-term and seasonal flood outlooks:** Long-term (greater than 10 days) flood forecasts are essential for agricultural planning. Due to improvement of numerical computational schemes, sub-seasonal to seasonal weather forecasts are increasingly available. However, effort is needed to apply these long-term forecasts to hydrological issues. FFWC has experimented with ensemble weather forecasts for flood forecasting in Bangladesh for the

medium range (up to 10 days). Based on the available tools and long-range weather forecasts, FFWC can now develop sub-seasonal to seasonal flood outlooks.

Coastal flood forecasting

One third of Bangladesh is vulnerable to coastal-influenced flooding; this is expected to worsen due to the effects of climate change. The coastal area can experience flooding during astronomical high tides as well as due to tropical cyclones, or both combined. In addition, flood waters from the Ganges, Brahmaputra and Meghna rivers can be confronted with coastal saltwater intrusion, compounding the overland flooding of Bangladesh's low-lying areas.

The WMO Coastal Inundation Forecasting Demonstration Project was carried out in Bangladesh from 2011 to 2017. Previously, this part of Bangladesh had not received operational flood forecasting services due to the complex interaction of coastal and overland flooding processes, including storm surges that may reach several metres at the coast. It is essential that additional efforts be undertaken to maintain and strengthen this new coastal inundation forecasting system, to enhance operationalization of such flood forecasting services delivering flood warnings for the coastal region of Bangladesh.

3.4 Cyclone Preparedness Programme (CPP)

The idea of a Cyclone Preparedness Programme developed in 1965 when the National Red Cross Society, now the Bangladesh Red Crescent Society (BDRCS), requested the International Federation of Red Cross and Red Crescent Societies (IFRC) to support the establishment of a warning system for the population living in the costal belt. In 1966, the International Federation and the Swedish Red Cross began the implementation of a pilot scheme for Cyclone Preparedness, which consisted of providing warning equipment such as transistor radios, sirens etc. and training the local militia (Ansars). Following the withdrawal of the International Federation as a direct implementation partner in July 1973, the GoB and the Bangladesh Red Crescent Society created a partnership which led to a new programme management structure in a form of joint partner venture. An agreement was signed by both parties spelling out that this programme would be known as the Cyclone Preparedness Programme (CPP) of the Bangladesh Red Crescent Society. Operations would remain, primarily, under the leadership of the Red Crescent Society and there would be increased involvement of local communities. A Policy Committee and an Implementation Board were created to jointly administer and implement the programme (Habib, et, al., 2012). A 7(seven) members policy committee headed by the Minister, the Ministry of Disaster Management and Relief is constituted to give policy directives and allocate resources for the programme. A 15 (fifteen) members "Implementation Board" headed by the Secretary, the Ministry of Disaster Management and Relief is constituted for effective implementation and administration of the programme.

Operational Method of CPP:

CPP is a mechanism which relies on technical skills and volunteers commitment for ensuring that all potential victims of an approaching cyclone are given sufficient warning to 11 million coastal people so as to enable them to move to safe- sites including cyclone shelters and buildings. The system starts with the collection of meteorological data from the Bangladesh Meteorological Department (BMD), which issues bulletins including the designated warning signals of an approaching cyclone. The bulletins are transmitted to the 6 zonal offices and the 30 Upazilas level offices (sub-district) over HF radio. The union team leaders then conduct the unit team leaders immediately. The unit team leaders with his volunteers spread out in the villages and disseminate cyclone warning signals almost door to door using megaphones, hand sirens and public address system.

Telecommunication System of CPP:

CPP operates and extensive network of radio communication facilities, in the coastal areas, linked to its communication centers at its head office at Dhaka. The purpose of this network is exclusively for the disaster management task. The network consists of a combination of HF/VHF radios which covers most of the high risk cyclone prone areas. CPP is now operating a total of 130 HF/VHF radio stations, out of which 60 stations are located in the cyclone shelters, built by the BDRCS in the high risk cyclone prone areas.

Volunteer's organization and their role of CPP:

CPP is organized in 32 Upazilas (sub-district) in 274 unions (village level) divided into 2845 units. Each unit serves 1 or 2 villages with an approximately population of 2 to 3 thousand. 10 male and 5 female volunteers are recruited from the respective unit with popular support of the villagers. In each unit the 10 male volunteers are divided into 5 groups, 3 in each, to discharge the following responsibilities.

a. Warning
b. Shelter
c. Rescue
d. First aid
e. Food and clothing

Public Awareness and Education

Public awareness is an integral and very important part of the Cyclone Preparedness Programme (CPP), for its successful implementation. Keeping this in mind, the CPP undertakes the following public awareness activities in the cyclone-prone coastal areas:

- **Public Awareness through Volunteers** – Local volunteers, through their social contacts, motivates village people in a continuous process. This is an important subject for volunteer training.
- **Cyclone Drills and Demonstrations** – Cyclone drills and demonstrations are held frequently for volunteers, with local people also participating. These drills and demonstrations are attended by large numbers of villagers.
- **Film/video Shows** – Documentary films/videos on disaster and preparedness are shown in coastal villages, in cooperation with the BMD and the Films and Publications Department of the Government.
- **Publicity Campaigns** – Immediately prior to the cyclone season, a publicity campaign is organized with government officials, NGO's and local public to familiarize people and create awareness of cyclone preparedness.

- **Radio and Television** – Arrangements are made with national TV to telecast films relating to disaster preparedness prior to the cyclone season. Special features on disasters and preparedness are also broadcast over Bangladesh Betar (Radio).
- **Posters, Leaflets, and Booklets** – Posters, leaflets, booklets etc. dealing with preparedness are regularly distributed to coastal inhabitants. Special directives on evacuation, the interpretation of warning signals, instructions for the fishermen etc. have been published in the form of posters and leaflets and are distributed to community people.
- **Staging of Dramas** – A specially written drama depicting the significance of preparedness is staged in coastal areas to make the village people realize the importance of preparedness. To date, more than 600,000 people have witnessed this drama.

Social welfare/other activities

Other than the mandatory responsibilities, the volunteers are very much involved in performing social welfare activities by integrated themselves with local government administration, NGO's, Upazilas disaster management committee, educational institutions, religious institutions, social club and other agencies in the event of road accident, fire, boat capsize, river erosion, epidemic etc. On those situations the volunteers stand beside the helpless people with sincerity and offers wholehearted cooperation. The community people have recognized the services rendered by the volunteers with satisfaction.

Regional award

The effective role and dedication of the volunteers in a cyclonic disaster has been acclaimed nationally and also regionally. This programme has been awarded with "Smith Tumsaroch award-1998" from Thailand for its outstanding effort that has saved many thousands of lives in Bangladesh.

Evolving role of NGOs in cyclonic disaster management in Bangladesh

Role of CARE Bangladesh in cyclone disaster management

Focuses On-

- Coverage
- Efficiency
- Effectiveness
- Coordination

- Impact

Role of BRAC in cyclone disaster management

Focuses On-

- Relief and rehabilitation program areas
- Needs assessment Beneficiaries
- Relief and recovery
- Rehabilitation
    a) Agriculture based livelihood rehabilitation
    b) Non-agriculture based livelihood rehabilitation
- Structural measures: Core house and cyclone shelters

Role of Muslim Aid in cyclone disaster management

Focuses On-

- Emergency response and recovery
- Rehabilitation
    a) Shelter and employment
    b) Agricultural rehabilitation
    c) Educational support

Problems faced by the NGOs during response, recovery, and rehabilitation to disaster management

- Less opportunity to exchange views among development agencies.
- Lack of co-ordination among different stakeholders during emergency response.
- To maintain accurate jurisdiction of work among NGOs and other development agencies
- Lack of trust and respect to NGOs involved with relief activities (Sarkar, 2019)

CPP is an effective; grass-root oriented, disciplined and tightly knits organization which is dedicated to the task of protecting the population along with community capacity build up activities. Its 42675 volunteers are respected and becoming increasingly integrated and influential within their community and with the local government agencies. They exhibit a high level of commitment to their programme and readiness to meet the community requirements for better disaster preparedness. Since the inception of the cyclone preparedness program in 1972, a total of 178 depressions have formed in the Bay of Bengal out of which 20 intensified into a severe cyclonic storm. The program faced the entire situation with determination and courage and gradually achieved greater success in moving people to shelters and saving lives and property of the coastal people. 710 km long coastline of Bangladesh with numerous off-shore islands is inhabited by 11 million people who are direct beneficiaries of the program and they depend on CPP. Its devoted and committed volunteers are well organized to face any eventualities for saving lives and properties of their own communities. These extra ordinary volunteers team need to be supported for the very well-being of the 11 million coastal people of Bangladesh.

4 Geographical and Risk context of Kurigram and Jamalpur

This study aims towards improving community resilience by creating replicable, cost-effective methods for local flood risk reduction and management through Flood Preparedness Programme (FPP). Focusing to build a Flood Resilient Community through enhancing flood early warning and preparedness, improved coping and response mechanisms in line with the changing trends of the flood incidents, two field visits were performed in January and November 2020 in Jamalpur and Kurigram district (Fig. 2). The aim was to find out the existing flood forecasting systems, dissemination practices, and prioritizing their choices in early warning systems including dissemination processes in the study area.

4.1 Geographical context

The study was conducted in one of the villages of Kurigram district under the Rangpur division which is in the northern part of Bangladesh along the border of India. There are 9 upazillas in Kurigram district. Chilmari Upazila of this district is situated in between 25°26' and 25°40' North latitude and between 89°38' and 89°48' East longitude and is highly vulnerable to upstream floods and riverbank erosion. It is located by the Indo-Bangladesh frontier. Chilmari Upazila is bounded by Ulipur Upazila on the north, Char Rajibpur and Sundarganj Upazilas on the south, Raumari and Char Rajibpur Upazila on the east, Ulipur and Sundarganj Upazilas on the west. It has 6 unions, 58 mouzas and 144 villages. Among the six unions, Ashtamirchar union is the most flood vulnerable union as it is intersected by the mighty Brahmaputra river. There are 23 Mouzas (under Ashtamirchar union where total population is 17701 with 23.5% literacy rate. Char Mudafat Kalikapur Village of Char Mudafat Kalikapur mouza of this union is found out as the most flood-prone area. And that’s why it has been selected as the study area. The number of the household of Char Mudafat Kalikapur Mouza is 715. According to BBS 2011, the Total population is 2963 which is 16.74% of Astamirchar union. The literacy rate is 21.9% which is lower than the literacy rate of Union. The demographic information of the surveyed area is listed in Table 1.

Table 1: Demography of study area (BBS 2011)

	Ashtamir Char	**Patharsi**
Total area (Acres)	18,528	8,451
Population	17,701	28,009
Household	4,077	7,547

Density (per km^2)	236	819
Literacy rate (%)	23.5	39.7
Sex ratio	96	97
Mouza (no.)	13	11
village (no.)	14	12

Patharsi is a union under Islampur Upazila of Jamalpur District located between 24°34' and 25°26' North and between 89°40' and 90°12' East with a total area of 8,451 acres. The Zila shares an international border with the Indian state of Meghalaya in the North East. Geographically Jamalpur Zila is a river floodplain in the left bank of Brahmaputra river and situated beside the old Brahmaputra river. There are 7 Upazilas on which 4 Upazilas are directly in riverside highly vulnerable for riverine flood in every year. As there are no embankment along the left bank of Brahmaputra river, the flood water coming from upstream spread out rapidly in the floodplain. So, the flood is a regular hazard in this Zila. With flood, river erosion is a major problem that occurs in Dewanganj and Islampur Upazila. Most of the Upazilas of Jamalpur are highly fertile with a regular inundation every year. So, rice production hampers a lot due to the monsoon flood. This event fluctuates the socio-economic conditions of the rural people involved with agriculture especially rice production. The study area is Pathorshi village of Pathorshi mouza in Pathorshi Union near the Brahmaputra river in Islampur Upazila. Most of the people is engaged with agriculture and some of them are involved with capture fishing as a secondary occupation. The monsoon flood hit the area every year and hampers the Amon rice production. The area is inundated 2-3 times in every monsoon. But, in 2020 the recurrent flood occurs 4-5 times in a single monsoon period. It costs a huge loss of their Amon production and falls their economic condition.

4.2 Vulnerability Mapping

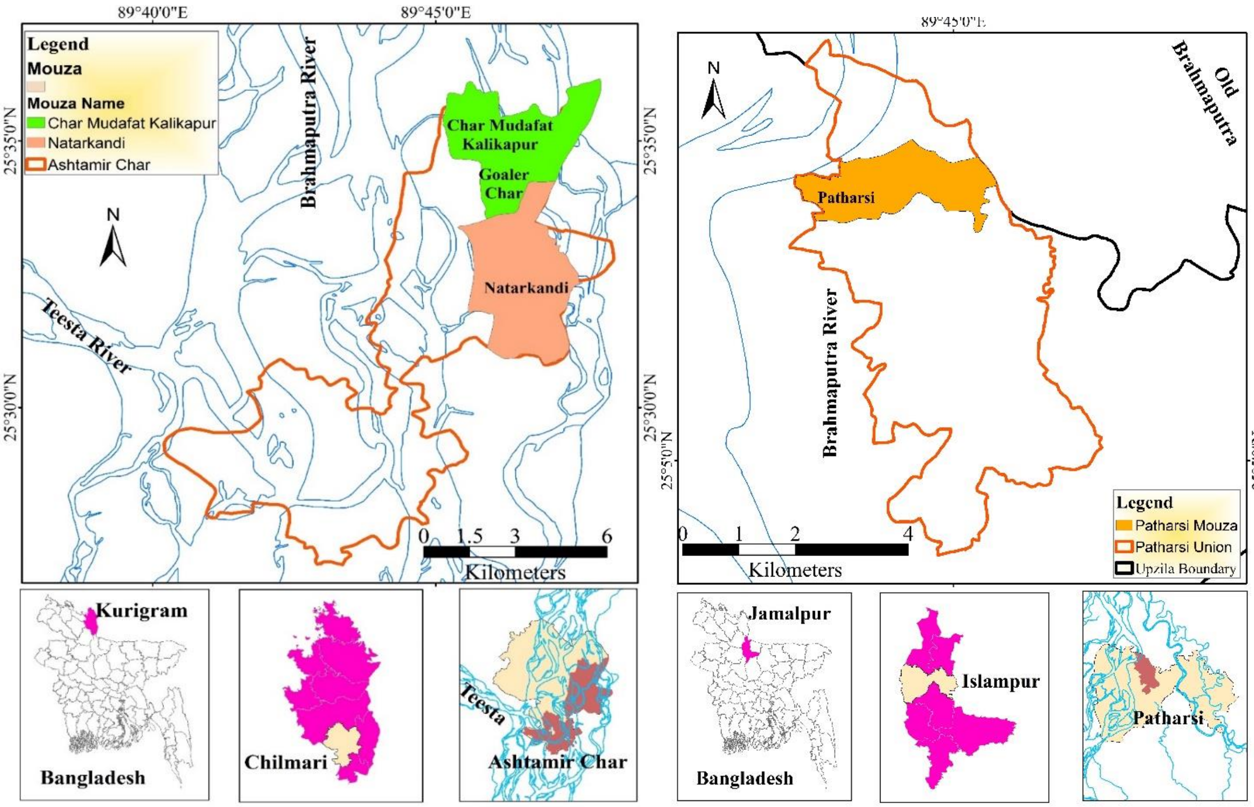


Fig. 2: Ashtamir Char in Chilmari Upazila & Pathorshi in Islampur Upazila

In IPCC AR5, the risk is defined as the results of the interaction of hazards with vulnerability and exposure of human and natural systems (IPCC, 2014). Where vulnerability AR5 is computed as a linear relation of sensitivity and adaptive capacity. The formulae for risk and vulnerability are discussed in section 6.1.

In this study, the following exposure and hazard domains have been used.

Exposure Domain

Population Density
Household Size
Total number of para/mouza/village
Kacha and Jhupri houses

Hazard Domain (Flood)

Flood pattern
Water Depth
Flood Velocity
Flood Duration

Selection of Indicators

Indicators for different capitals have been selected based on reviewing literature, expert's judgments and data availability. The following indicators have been used for different capitals:

Human Capital

i. Literate People
ii. Employed people
iii. Male : Female
iv. Capable people
v. People access to the tube well

Social Capital

i. Literate People
ii. Employed people

Physical Capital

i. Religious place (Mosque)
ii. Educational Institution
iii. Community Clinic
iv. Shelter Centre
v. Puka and Semi paka house
vi. Tube well

Financial Capital

i. Number of HH with access to microcredit
ii. Growth Center
iii. Employed People
iv. No. of market/hat

Natural Capital

1. Tube wells

Human Capital & Vulnerability

Human Capital at Unions

Literate, employed, physically strong and capable people are the human capitals. Again, people's access to tube wells (safe drinking water source) are also been categorized in human capital.

In the following Fig. 3, a human capital map has been shown.

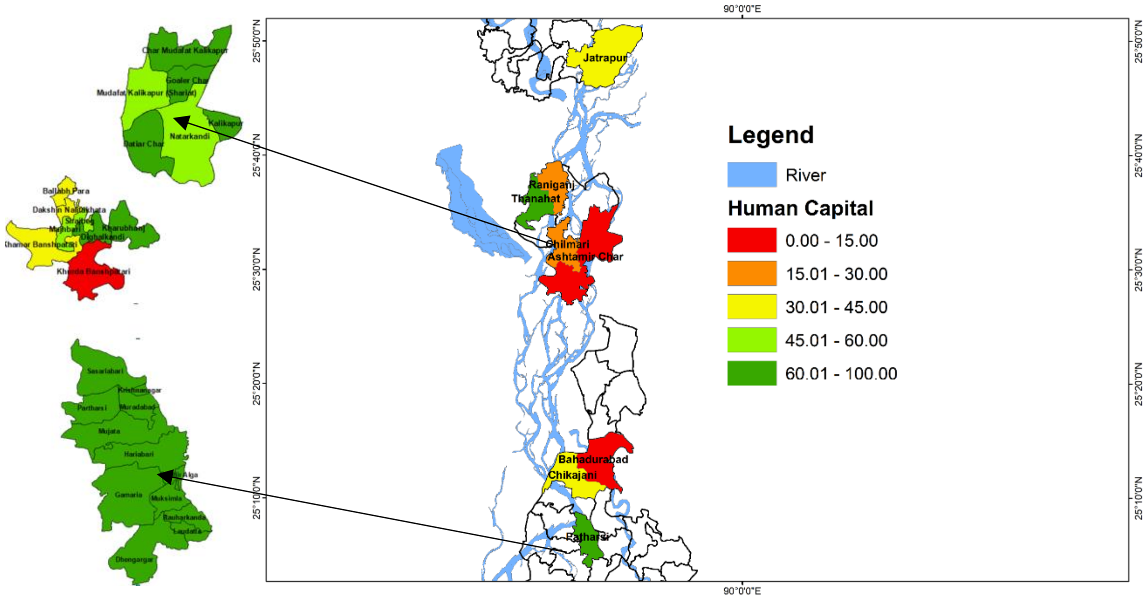


Fig. 3: Human Capital Mapping of union and village level;

Source: Author, 2020

According to the figure, human capital at Ashtamir char union from Kurigram and Bahadurabad union from Jamalpur are critically low. Whereas the condition of human capital at Thanahat union from Kurigram and Patharsi union from Jamalpur is very good.

Human Capital at Villages

Ashtamir Char has 13 mouzas and 14 villages in total. From these only one village namely Khurda Banshpatari has the critical quantity of human capital shown in the above map. Whereas total 7 villages of the union is under very high human capital range. Rest villages have fallen in the range of moderate and high human capital range. So, in this union distribution of human capital among the villages is very uneven. The focus should be given to the specific village (Khurda Banshpatari) in improving human capital. On the other hand, all villages of Patharsi have very high human capital that represents an even distribution of human capital.

Human Vulnerability at Unions

As the concept of vulnerability is just the opposite of Capital the following figure shows the vulnerability for human capital. From the figure below, it is clear that only two unions one from Kurigram and the other from Jamalpur is low vulnerable to flood due to human capital. The unions are Thanahat and Patharsi as these two unions have a good quantity of human capital which has been illustrated above.

And the rest of the unions have high vulnerability having a critical quantity of human capital. So, these unions should be prioritized while on human capital improvement projects.

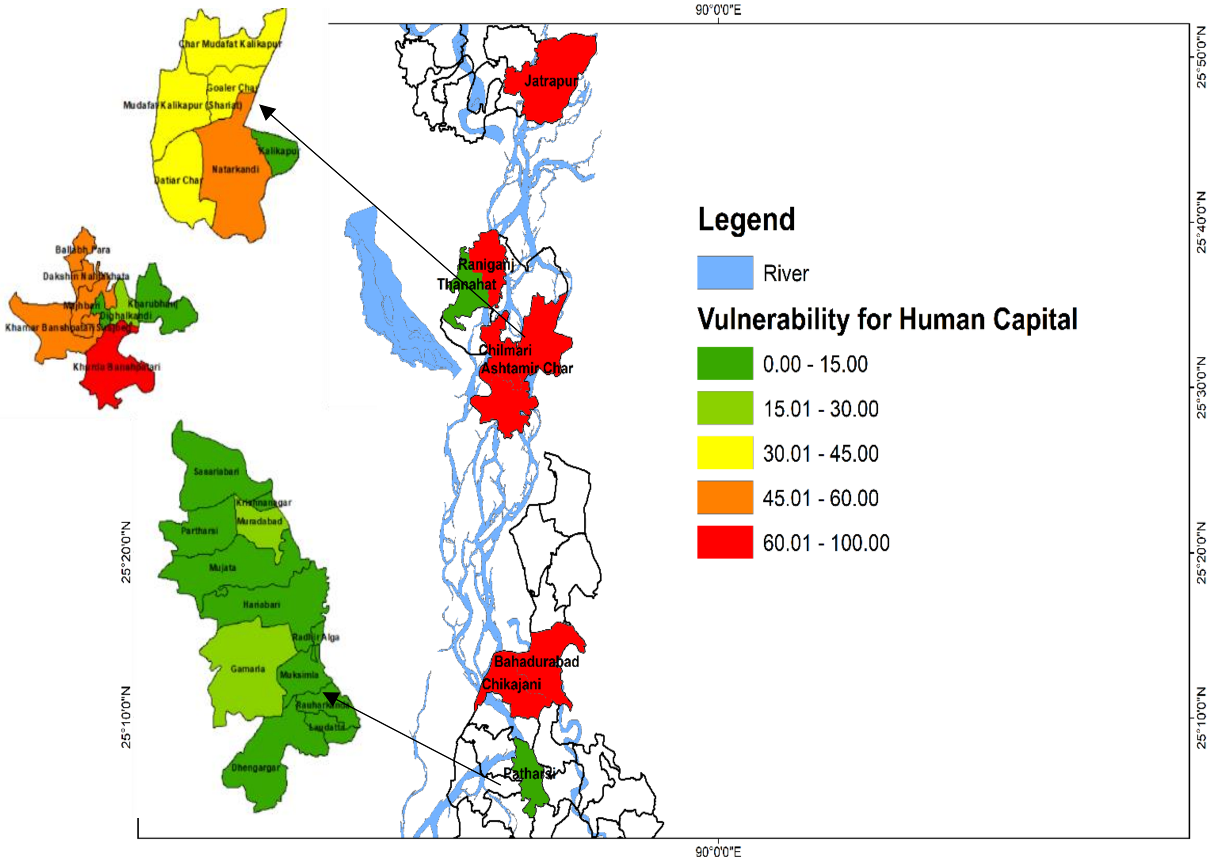


Fig. 4: Human Vulnerability Mapping of union and village level

Table 2: Percentage of human capital and vulnerability

Human Capital/ Vulnerability	**Percentage of area (Human Capital) (%)**	**Percentage of area (Human Vulnerability) (%)**
Very High	18	82
High	22	0
Moderate	8	0
Low	16	0
Very Low	36	18
Total	100	100

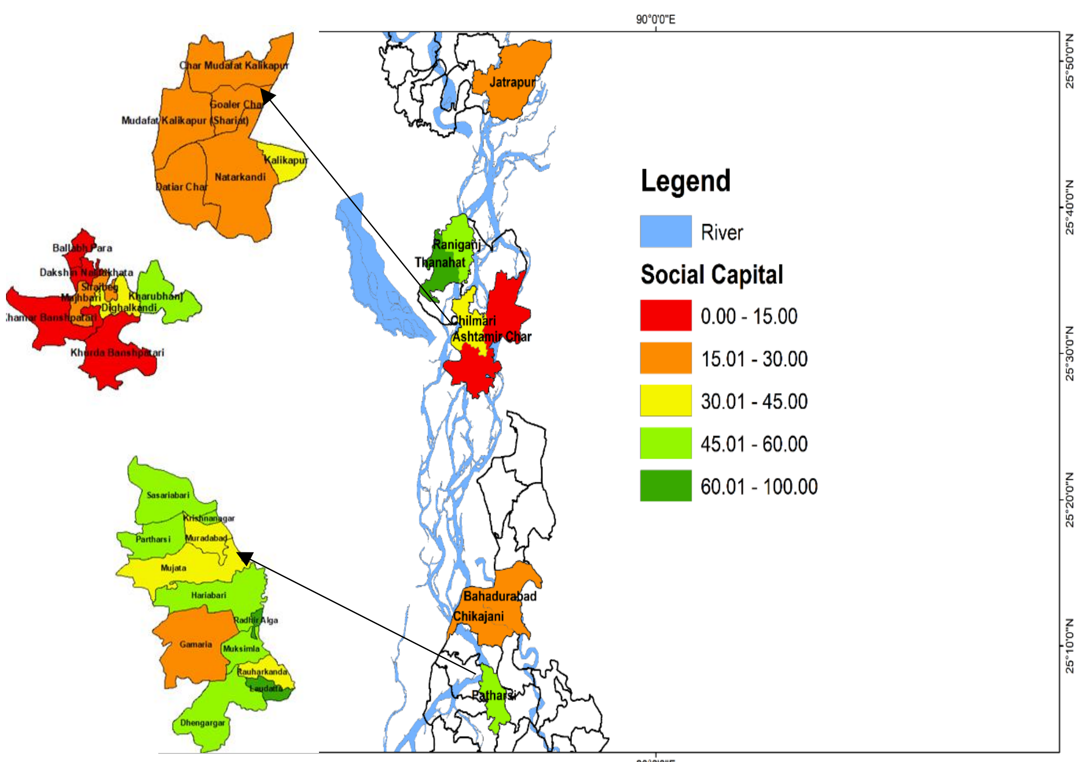
Table 2 shows that the percentage of the area having the lowest capital in the whole study area is the highest and that is about 36% whereas that of the lowest percentage belongs to moderate human capital. Again, the percentage of the area having very high human capital is only 18%. This figure of area percentage shows an unsustainable livelihood condition. On the other hand except for 18% area of the whole study area is highly vulnerable to human capital.

Social Capital & Vulnerability

Social Capital at Unions

Literate and employed people are the social assets. As they can be a good leader in any crisis and also they can be a medium of awareness for the whole society. In Fig. 5, the social capital map has been shown.

According to the figure, social capital at Ashtamir char union from Kurigram is critically low. Whereas the condition of human capital at Thanahat union from Kurigram is very good. Again Raniganj and Patharsi union have high social capital and Chikajani, Bahadurabad and Jatrapur union has low social capital. However, Chilmari from Kurigram has moderate social capital.



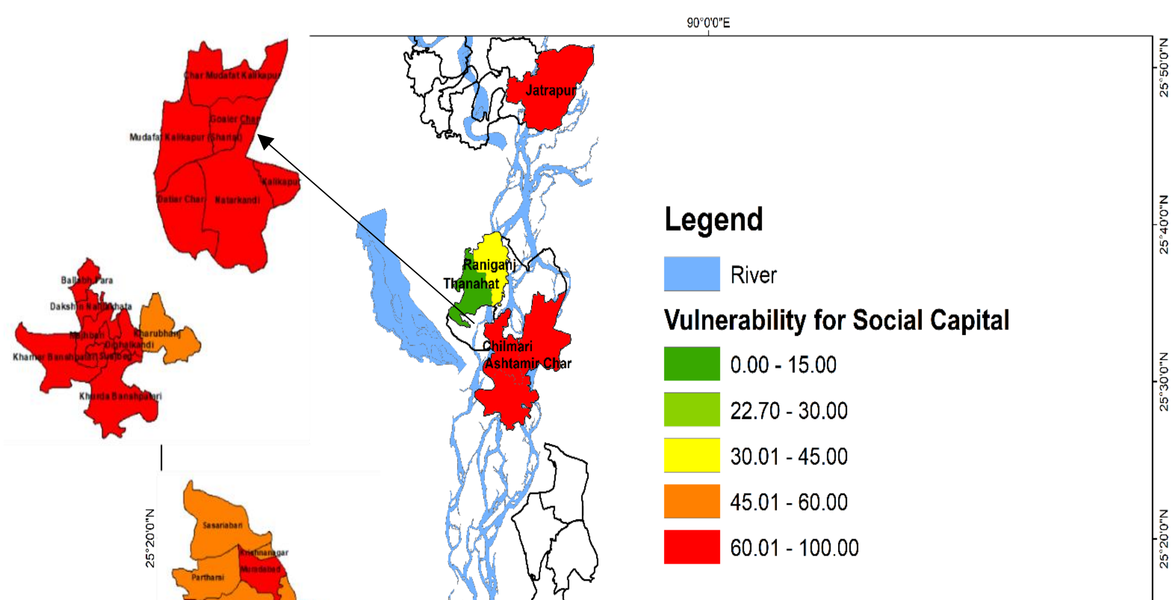
Social Capital at Villages

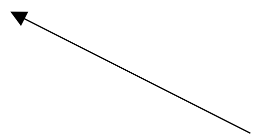
Ashtamir Char has 13 Mouzas and 14 villages in total. From these four villages namely Khurda Banshpatari, Ballabh Para, Dakshin Nalitakhata and Khamar Banshpatar has the critical quantity of social capital shown in the above map. Whereas Kharubhanj village has high social capital. Rest villages are in low to medium social capital range. So, in this union distribution of social capital among the villages is very uneven. The focus should be given to the specific villages in improving social capital.

On the contrary, two villages of Patharsi named Radhir Alga and Laudatta have very high social capital where Gamaria has low social capital. In the rest villages, social capital varies from high to medium. However, in this union distribution of social capital is more or less even.

Social Vulnerability at Unions

As the concept of vulnerability is just the opposite of Capital the following figure shows the vulnerability for social capital.





It is clear that only one union from Kurigram is low vulnerable to flood due to social capital. Again Raniganj from Kurigram and Patharsi from Jamalpur has medium and high vulnerability respectively.

Except these 3 unions, all unions are in very high vulnerability condition. So, these unions should be prioritized while social capital improvement projects.

Table 3 : Percentage of Social capital and vulnerability

Social Capital / Vulnerability	**Percentage of area (Social Capital) (%)**	**Percentage of area (Social Vulnerability) (%)**
Very High	11	74
High	27	10
Moderate	12	8
Low	16	0
Very Low	34	7
Total	100	100

Table 3shows that the percentage of the area having the lowest capital in the whole study area is the highest and that is over 34% whereas that of the lowest percentage (11%) belongs to very high social capital. Again, the percentage of the area having high social capital is only 27%. This figure of social capital shows a poor distribution of social capital over the study area.

On the other side, very high vulnerability covers the maximum portion of the study area and that is over 74% were very low vulnerability present at only 7% area.

Social Vulnerability at Villages

From 14 villages of Ashtamir Char, all villages except one village namely Kharubhanj are highly vulnerable as these villages have the critical quantity of social capital discussed in the above section. Hence, the focus should be given to the whole union in improving social capital.

On the other hand, two villages of Patharsi namely Radhir Alga and Laudatta have very low social vulnerability as these villages have enough social capital discussed in the above section. However, the rest villages are in medium to very high vulnerability range.

Physical Capital & Vulnerability

Physical Capital at Unions

Physical infrastructure such as mosques, schools, community clinic, shelter center, housing condition and availability of tube well is the physical capitals as shown in Fig. 7. According to the figure, the Physical capital at Ashtamir char, Chilmari, and Jatrapur union from Kurigram is critically low having the highest vulnerability. Whereas the availability of physical capitals at Thanahat union from Kurigram and Patharsi union from Jamalpur is abundant. These two unions should have the minimum vulnerability. Again, the rest unions have low physical assets.

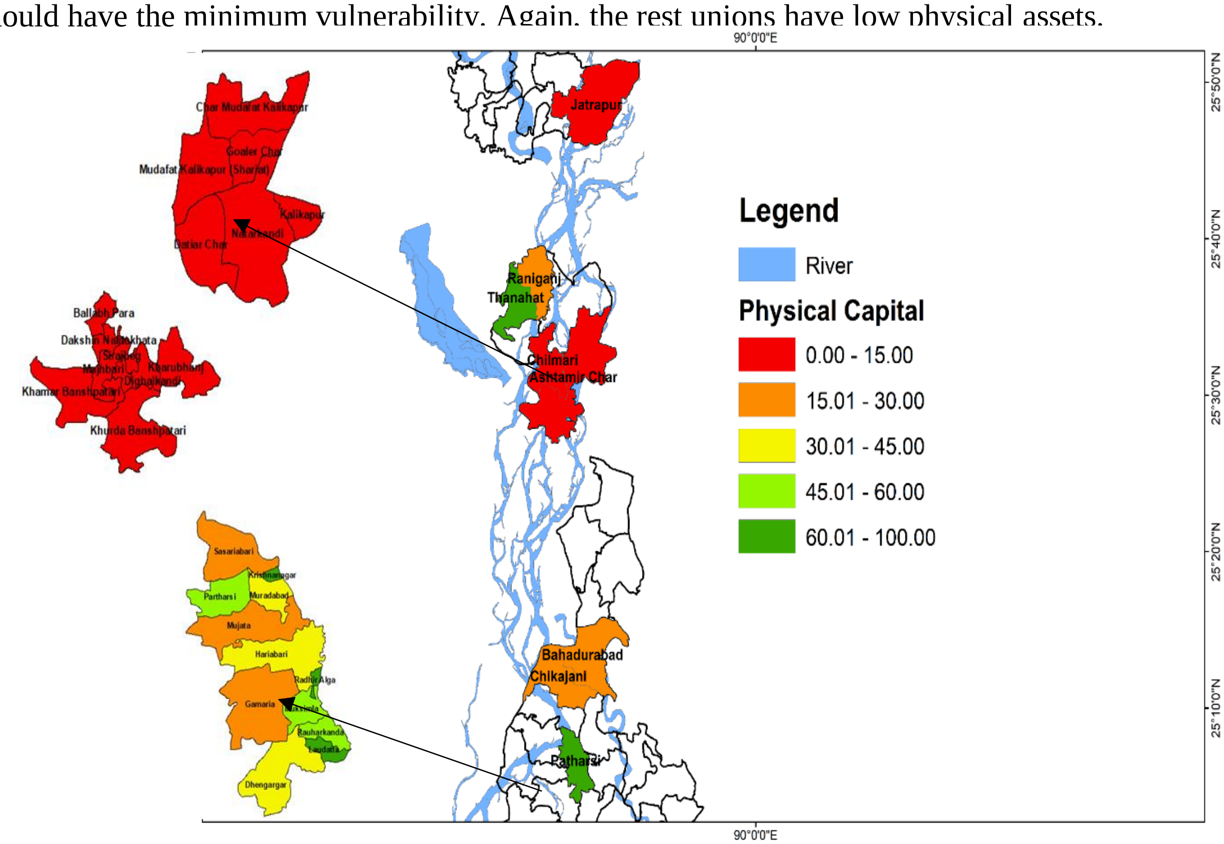


Fig. 7: Physical Capital Mapping of union and village level

Physical Capital at Villages

Among 14 villages of Ashtamir Char, all villages have the lowest physical capital. The reason behind this scenario is locational disadvantages. The accessibility of the union is very low, which influenced the union to lag in every case. The focus should be given to the whole union in establishing physical capitals.

On the other hand, Patharsi union gave a mixed result in physical capital analysis. Krishnanagar, Radhir Alga and Laudatta villages have an abundant number of physical capital. Besides Patharsi, Muksimla and Rauharkanda villages also have high physical capital. However, the rest villages have moderate to low physical capital.

Physical Vulnerability at Unions

As the concept of vulnerability is just the opposite of Capital, the following figure shows the vulnerability for human capital. From the figure below, it is clear that except for two unions one from Kurigram and other from Jamalpur all unions are highly vulnerable to flood due to physical capital. The exceptional two unions are Thanahat and Patharsi as these two unions have a good quantity of physical capital which has been illustrated above. Patharsi union has the lowest vulnerability and Thanahat has that of the moderate.

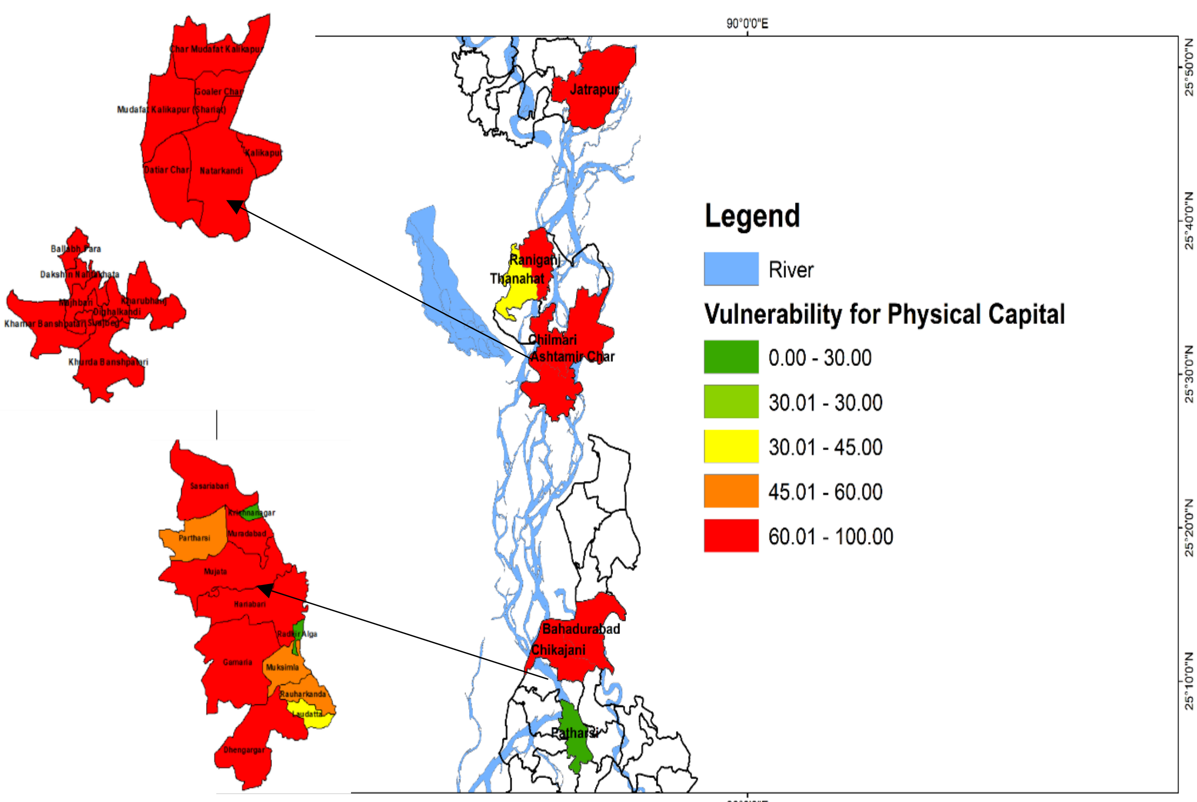


Fig. 8: Physical Vulnerability Mapping of union and village level

Table 4 : Percentage of Physical capital and Vulnerability

Physical Capital/ Vulnerability	**Percentage of area (Physical Capital) (%)**	**Percentage of area (Physical Vulnerability) (%)**
Very High	18	82
High	0	0
Moderate	0	7
Low	29	0
Very Low	53	10
Total	100	100

Table 4 shows that the percentage of the area having the lowest capital in the whole study area is the highest and that is about 53% whereas only 18% area of the whole study area has high physical capital. This figure of area percentage shows an unsustainable livelihood condition. On the other hand except for 10% area of the whole study area is highly vulnerable for physical capital.

Physical Vulnerability at Villages

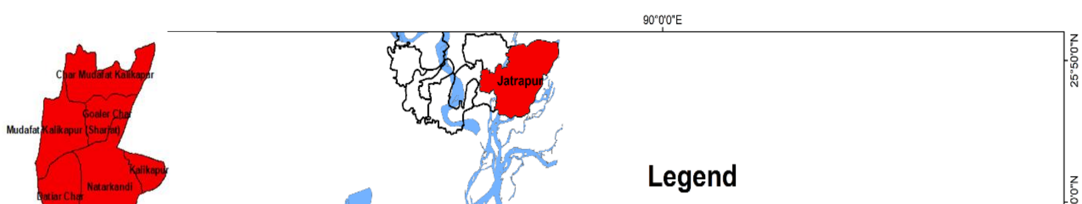
From 14 villages of Ashtamir Char, all villages is highly vulnerable as these villages have the critical quantity of physical capital discussed in the above section. Locational disadvantages is the main reason for the very low establishment of physical capital. Hence, the focus should be given to the whole union in improving physical capital.

On the contrary, two villages of Patharsi union namely Radhir Alga and Krishnanagar have very low physical vulnerability as these villages have enough physical capital discussed in the above section. However, the rest villages are in the medium to very high vulnerability range.

Natural Capital & Vulnerability

Natural Capital at Unions

No. of tube wells is the only indicator for analyzing Natural capitals as shown in Fig. 9. No of tube wells represent the condition of groundwater. According to the figure, the Natural capital of all unions of the study area is critically low except for two unions. The condition of Natural capital at Thanahat union from Kurigram and Patharsi union from Jamalpur is slightly good.



Natural Capital at Villages

Ashtamir Char has 13 Mouzas and 14 villages in total. All villages have the critical quantity of natural capital shown in the above map. The focus should be given to this union in improving natural capital.

At the same time, the condition of natural capital at Patharsi union is not that satisfactory. Only Krishnanagar village has abundant natural capital where all other villages have been ranked medium to very low natural capital.

Natural Vulnerability at Unions

As the concept of vulnerability is just the opposite of Capital the following figure shows the vulnerability for human capital. From Fig. 10 below, it is clear that all unions of the study area are highly vulnerable to flood due to natural capital. So, these unions should be prioritized while natural capital improvement.

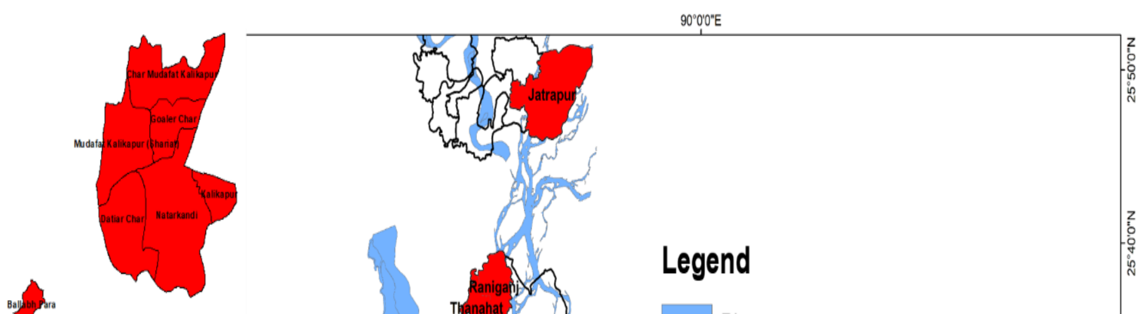


Table 5: Percentage of Natural capital and Vulnerability

Natural Capital/ Vulnerability	**Percentage of area (Natural Capital) (%)**	**Percentage of area (Natural Vulnerability) (%)**
Very High	0	100
High	0	0
Moderate	0	0
Low	18	0
Very Low	82	0
Total	100	100

Table 5 shows that the percentage of the area having the lowest capital in the whole study area is the highest and that is about 82% whereas the rest area is covered by low natural capital.

On the other hand, 100% area of the whole study area is highly vulnerable for natural capital. The reason behind this dramatic result is the no of the indicator. This analysis has been used only one indicator that is not desirable. So, it can be said, a different result could be shown if there were more indicators.

Natural Vulnerability at Villages

Among the villages of Ashtamir Char and Patharsi, only Krishnanagar from Patharsi has very low vulnerability with an abundant number of natural capital. And rest of the villages are in highly vulnerable conditions for natural capital.

Financial Capital & Vulnerability

Financial Capital at Unions

Number of HH with access to microcredit, no of Growth Center, Employed People and no. of market/hat are the indicators of measuring financial capital. According to Fig. 11, financial capital at Chilmari, Raniganj and Thanahat unions from Kurigram and Patharsi union from Jamalpur is critically low. Whereas the condition of financial capital at Ashtamir Char union from Kurigram is high. The rest 3 unions have medium to low financial capital.

Financial Capital at Villages

Among the 14 villages of Ashtamir Char, only one village namely Kharubhanj has lower financial capital shown in the above map. Rest villages have fallen in the range of high and very high financial capital's range. The focus should be given to the specific village (Kharubhanj) in improving financial capital.

On the other hand, all villages of Patharsi union show a mixed distribution of financial capital. The most disappointing village in respect of the financial capital of Patharsi union is Laudatta. Again, Radhir Alga and Muksimla have low and medium financial capital. But the rest of the villages of the union have high to very high financial capital.

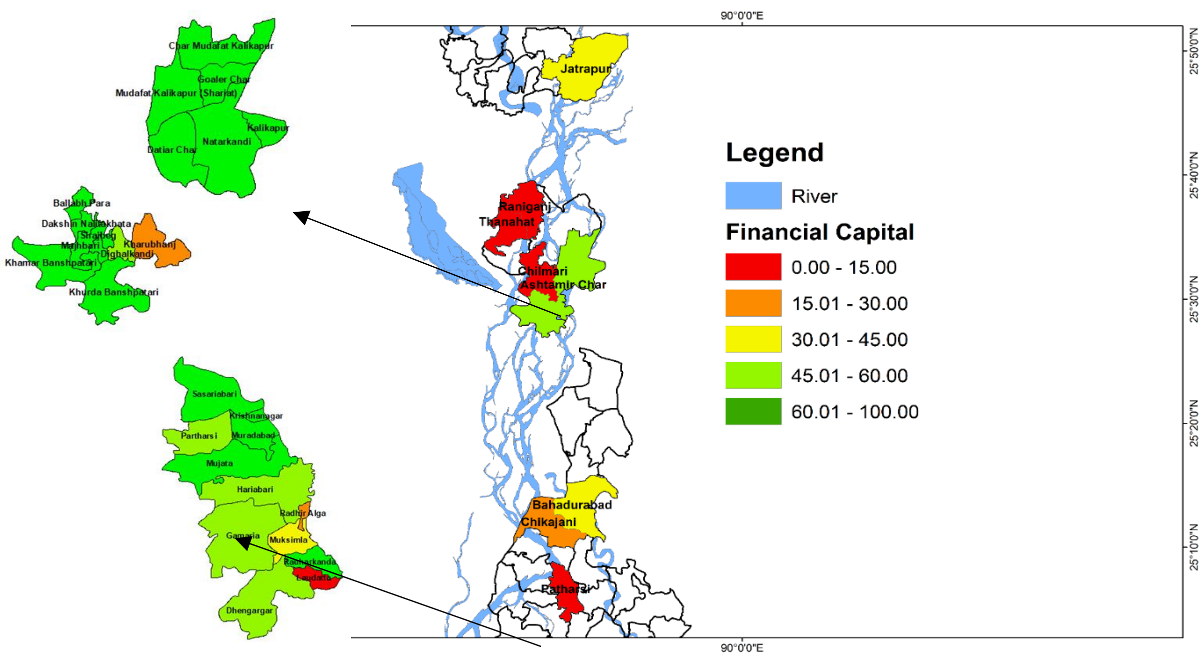


Fig. 11: Financial Capital Mapping of union and village level

Financial Vulnerability at Unions

As the concept of vulnerability is just the opposite of Capital the following Fig. 12 shows the vulnerability for human capital. From the figure below, it is clear that all unions of the study area is high to very high vulnerable to flood due to financial capital.

Table 6 : Percentage of Financial capital and Vulnerability

Financial Capital/ Vulnerability	**Percentage of area (Financial Capital) (%)**	**Percentage of area (Financial Vulnerability) (%)**
Very High	0	77
High	23	23
Moderate	35	0
Low	8	0
Very Low	34	0
Total	100	100

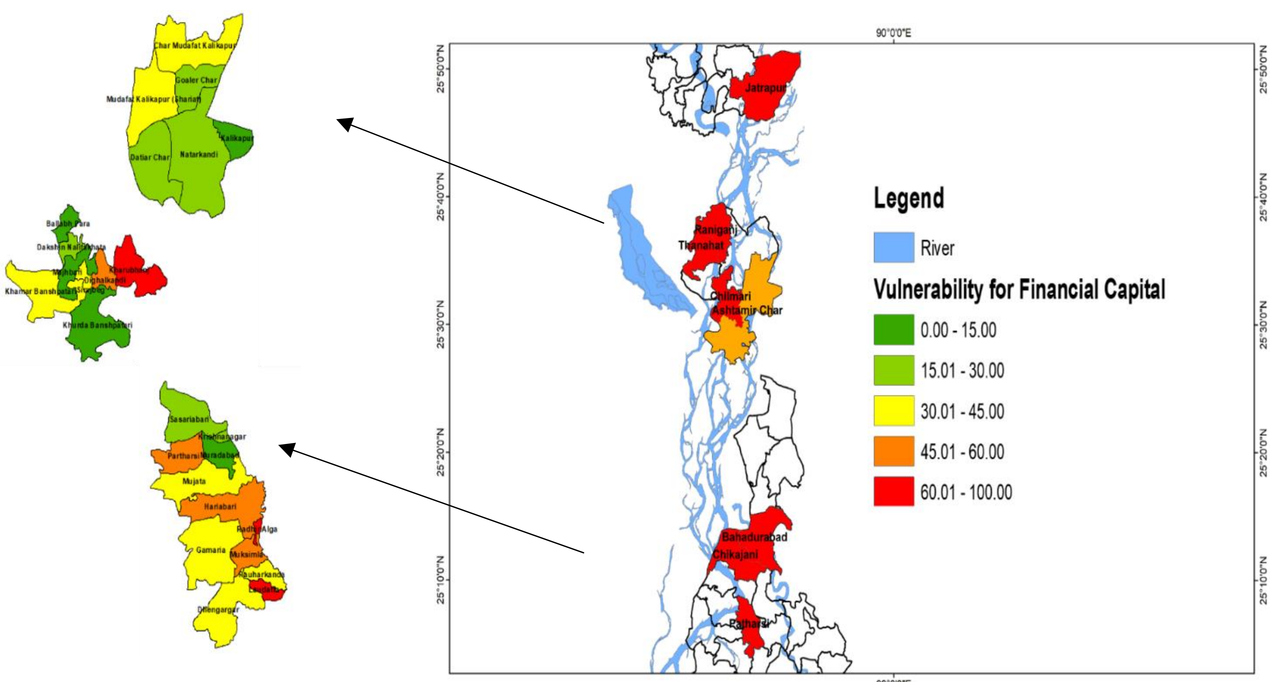


Fig. 12: Financial Vulnerability Mapping of union and village level

The Table 6 shows that the percentage of area having moderate capital in the whole study area is the highest and that is about 35% whereas that of the lowest percentage belongs to very high financial capital. Again, the percentage of area having high financial capital is only 23%. This figure of area percentage shows an unsustainable livelihood condition. On the other hand, the whole study area is highly and very highly vulnerable for financial capital.

Financial Vulnerability at Villages

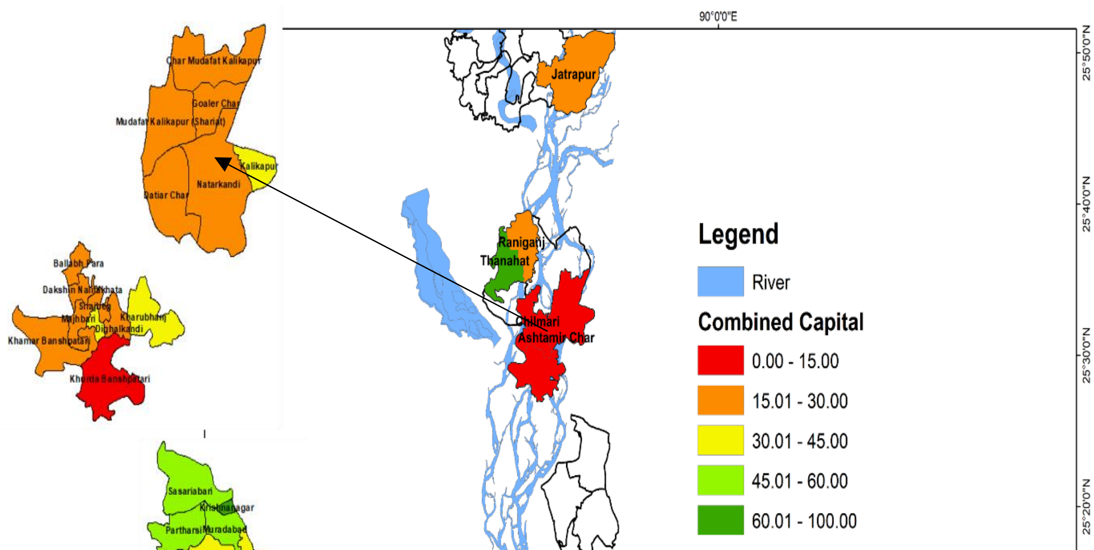
From Fig. 12 villages of Ashtamir Char, two villages namely Kharubhanj, Dighalkandi is highly vulnerable as these villages have the critical quantity of financial capital. Whereas total 4 villages of the union is under very low vulnerability range and the other 4 villages under a low vulnerability range. Rest villages have fallen in the range of moderate financial vulnerability range. Hence, the focus should be given to the specific villages (Kharubhanj, Dighalkandi) in improving financial capital.

At the same time, Patharsi union shows different results. Laudatta and Radhir Alga villages have the highest vulnerability whereas Mudarabad village has that of the lowest. The rest of the villages of Patharsi have low to very low financial vulnerability.

Total Capital & Vulnerability

Total Capital at Unions

In Fig. 13, the total capital map has been shown. This map has been prepared giving equal weightage to all the capitals. This map will represent the availability of the total capital of the unions and villages.



According to the figure, the combined capital at Chilmari and Ashtamir Char unions from Kurigram is critically low. Whereas Thanahat of Kurigram and Patharsi of Jamalpur have the highest combined capital. However, Jatrapur and Raniganj unions have low combined capital and the rest unions have high to moderate capital levels.

Total Capital at Villages

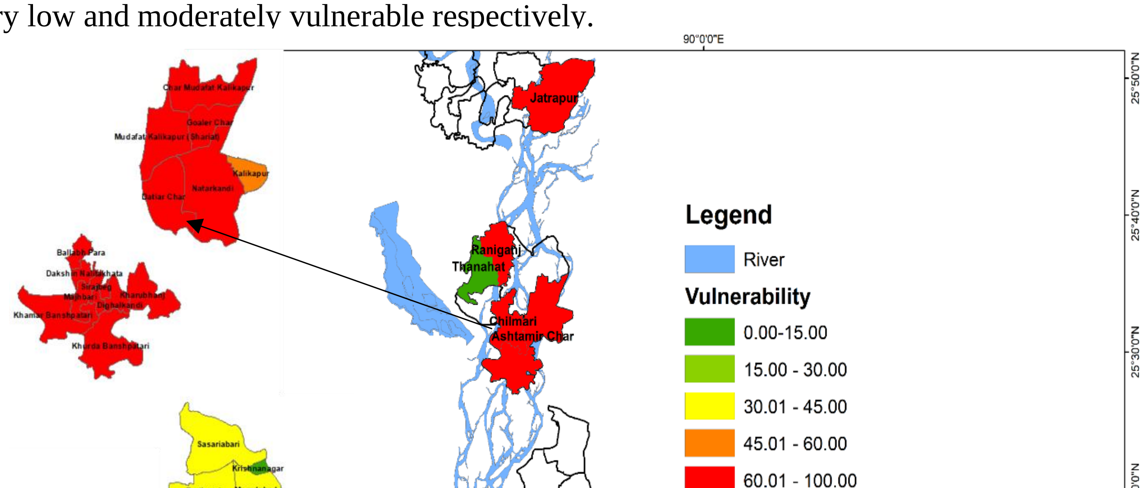
Among the 14 villages of Ashtamir Char one village namely Khurda Banshpatari has the lowest capital shown in the above map. Rest villages have fallen in the range of moderate to high capital's range. So, this union should be focused in improving capital.

On the other hand, all villages of Patharsi union show that total capital of the villages is very high to moderate. The highest capital found in Krishnangar, Radhir Alga and Laudatta villages in respect of combined capital calculation. Again, Mujata and Gamaria have a medium level of capital. And rest of the villages of the union have high combined capitals.

Vulnerability for Total Capital

Total Vulnerability at Unions

As the concept of vulnerability is just the opposite of Capital, Fig. 14 shows the vulnerability for combined capital. From the figure below, it is clear that all unions of the study area is highly vulnerable to flood due to combined capital except Thanahat and Patharsi. These two unions are very low and moderately vulnerable respectively.



The Table 7 shows that the percentage of area having very low capital in the whole study area is highest and that is about 31% whereas that of the lowest percentage belongs to low capital. Again, the percentage of area having high capital is only 13%. This figure of area percentage shows an unsustainable livelihood condition. On the other hand over 80% of the whole study area is highly vulnerable for combined capital and only 10% area has very low vulnerability.

Table 7 : Percentage of Combined capital and Vulnerability

Combined Capital/ Vulnerability	**Percentage of area (combined Capital) (%)**	**Percentage of area (combined Vulnerability) (%)**
Very High	18	82
High	13	0
Moderate	8	10
Low	0	0
Very Low	31	7
Total	100	100

Total Vulnerability at Villages

From 14 villages of Ashtamir Char, all villages are highly vulnerable as these villages have critical quantity capitals. Hence, the focus should be given to the whole union in improving 5 capitals.

On the other hand, Patharsi union shows different results. Krishnanagar and Radhir Alga villages have the lowest vulnerability whereas Mujata, Hariabari and Gamaria villages are highly vulnerable. Rest of the villages of Patharsi have moderate vulnerability due to combined capital.

4.3 Exposure Mapping

The exposure map shows the exposed elements in both union and village level. In this study for exposure mapping, 4 indicators have been selected. These are population density, household size, number of para for villages and number of villages for unions. Again, housing condition is categorized to be an exposure. In the following figure (Fig. 15), the exposure map has been shown. From the above figure, it is clear that all unions except Patharsi of the study area is highly exposed to flood. As the population density of the unions is very high. Again their literacy rate is not that high thus household size is big and also their socioeconomic condition is not improved. All of these are the reason for being highly exposed. On the other hand, the condition of Patharsi is improved hence has lower exposure.

All villages of Ashtamir char are highly exposed to floods. Whereas the condition of Patharsi union is different. Krishnanagar and Radhir Alga villages have the lowest exposure because these villages are very low densified. And Mujata and Gamaria villages have the highest exposure. Rest of the villages have moderate to high exposure.

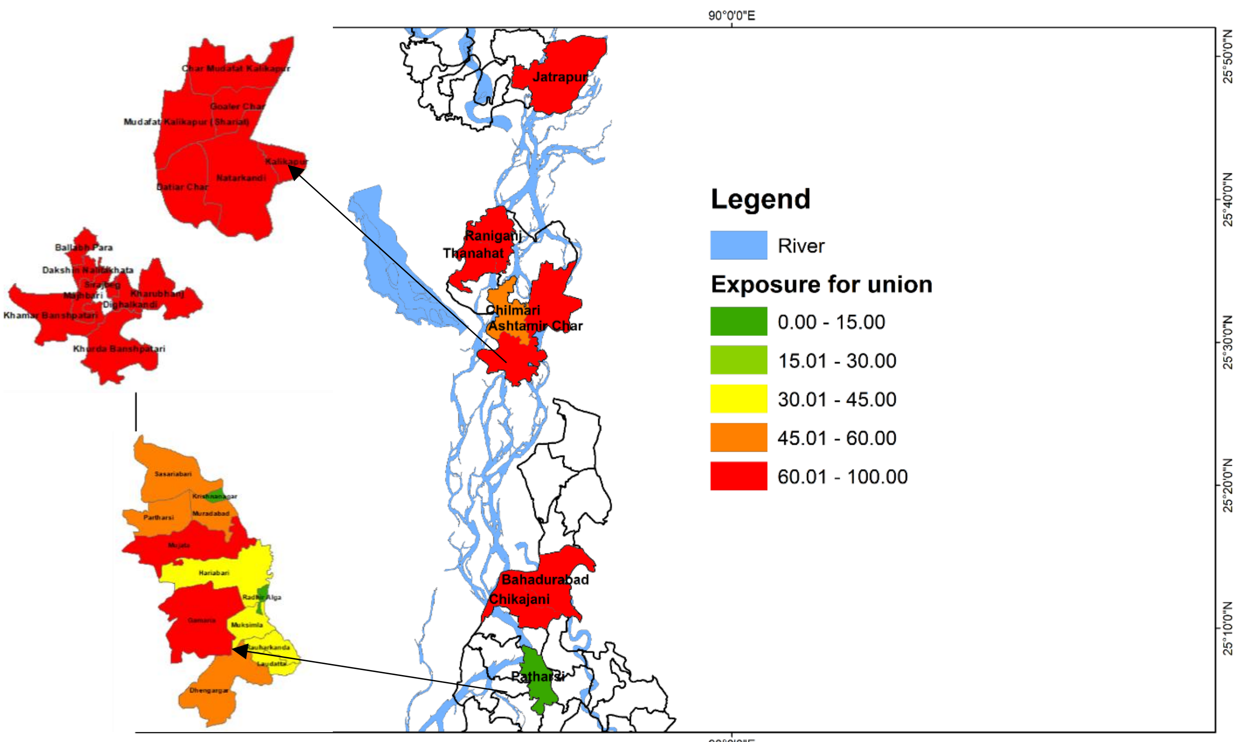


Fig. 15: Exposure Mapping of union and village level

4.4 Risk Mapping

Risk is a function of hazard, exposure, and vulnerability. Again vulnerability is linked to susceptibility and adaptive capacity. Fig. 16 shows the risk map of the study area. Chilmari and Chikajani unions are the highest risk-prone area having highest exposure, vulnerability and lowest capital. On the contrary Jatrapur, Thanahat, Bahadurabad and Patharsi union have the least risk. The rest unions have a moderate risk. The risk at Ashtamir char is moderate. So, the villages of the union have medium to low-risk profiles. However, Patharsi union itself is in a low-risk zone and the villages of the union are also in very low-risk zone.

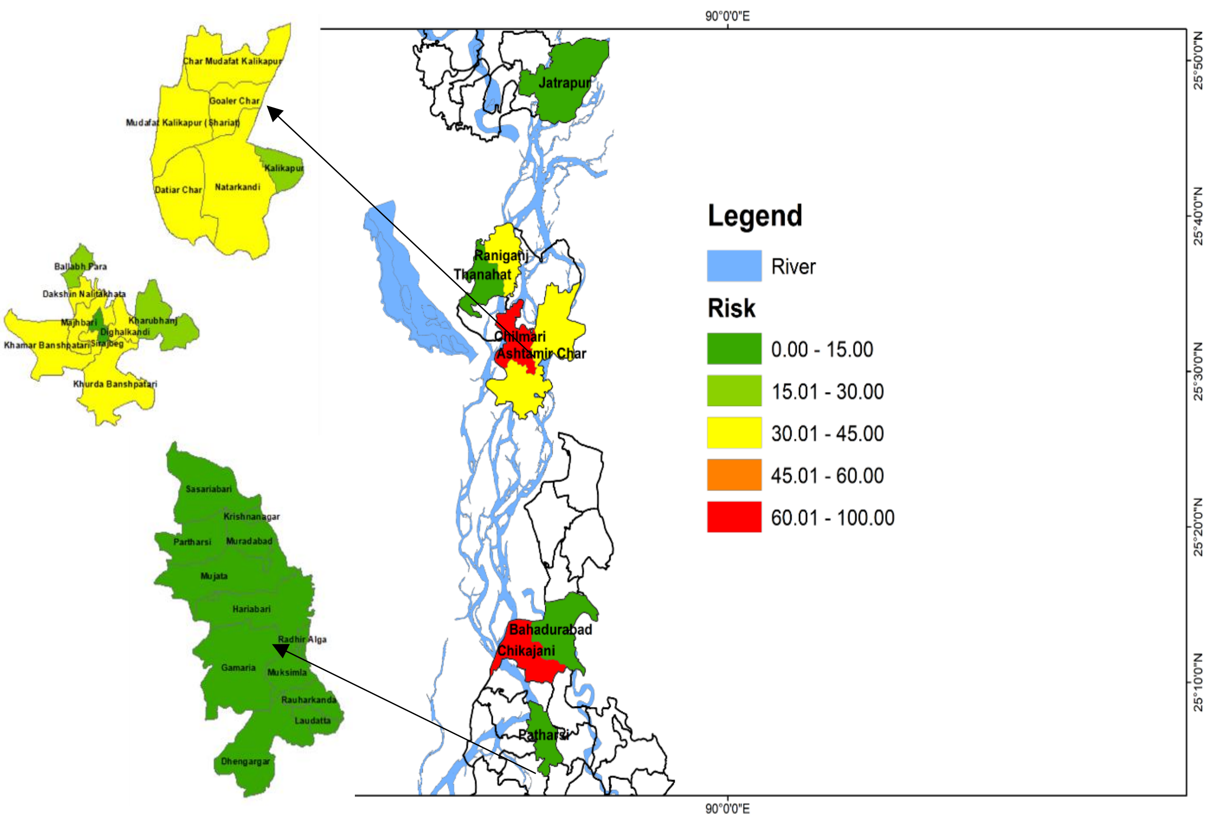


Fig. 16: Risk Mapping of union and village level

5 The current practice of Flood EW and risk communication and the remaining gap

Bangladesh is located downstream of three large river basins: The Ganges, Brahmaputra and Meghna river basins. The total catchment area of these basins is 1.72 million km², with almost 93% of the catchment area situated outside the territories of Bangladesh – in Bhutan, China, India and Nepal. The topography, location and discharge from each of these three basins shape the annual hydrological cycle of the country (HKH-HYCOS project).

Over a year, Bangladesh experiences periods of extreme water availability – too much and too little water. Monsoon precipitation from June to September is the main source of water, and the country has less water available outside of this season, termed the "dry period." Heavy rainfall during the monsoon period is the main cause of flooding; this occurs almost every year, with a devastating flood every 5–8 years (FFWC, 2004). Such flooding causes severe damage to agriculture and infrastructure and the loss of human lives.

Bangladesh has implemented flood control and drainage projects since the 1960s. However, structural measures alone cannot protect the people and infrastructure from floods. Complete flood control in a country like Bangladesh is neither possible nor feasible. With this understanding, Bangladesh started developing flood forecasting and warning systems (non-structural measures) for flood management (Bhuiyan, 2006). The objectives were to enable and persuade people, communities, agencies and organizations to be prepared for floods and take action to increase safety and reduce damage. The goal was to alert people on the eve of a flood event.

Developing flood forecasting services

Bangladesh Water Development Board is responsible for flood management through structural and non-structural measures. It also provides hydrological services in Bangladesh. As part of non-structural measures, the Board has been providing flood forecasting and warning services through its Flood Forecasting and Warning Centre (FFWC), established in 1972. Since then, the development of flood forecasting and warning services has made stepwise progress, which can be divided into three stages.

Initial stage (1972–1988) Initially, 11-gauge points were used for real-time flood monitoring and forecast purposes. In this early phase, gauge-to-gauge statistical correlation and Muskingum–Cunge methods were used for predicting water levels. In 1981, WMO and the United Nations Development Programme provided technical assistance for the computerization of the hydrological database. Computer programs were also developed to carry out operations that had previously been performed manually. During devastating floods in 1987 and 1988, flood forecasts of the major river systems proved to be fairly accurate.

Second stage (1989–1999) After the 1987 and 1988 floods, an initiative was launched to develop a flood forecasting system based on a numerical model. WMO engaged the Danish Hydraulic Institute (DHI) to create a flood forecasting model for Bangladesh. During 1989–1991, the national flood forecasting model was developed using a MIKE 11 modeling system. From 1991, additional deterministic flood forecasting efforts were pursued, resulting in forecast lead times being increased to 48 hours. The number of real-time forecasting stations was increased to 16. From 1995 to 1999, the flood forecasting model was further upgraded to improve its forecast accuracy, under the Bangladesh Flood Action Plan. A geographic information system (GIS) module was added to the flood forecasting model, and the number of stations used to support forecast modeling was increased from 16 to 30.

Bangladesh again experienced severe flooding in 1998, for which the flood forecasting and warning services yielded productive and successful results. An internal analysis of the 1998 flood concluded that flood forecasting and warning services should be extended to all flood-prone areas of the country. Besides, the need for the dissemination of flood information to vulnerable communities became very evident.

Third stage (2000 to date) Many lessons were learned from the 1998 floods. Foremost was that the people of vulnerable communities require flood information with a greater lead time. Further, they wish to know when their homesteads are going to be inundated and for how long. This showed that people were demanding area-specific flood forecasts. Moreover, field-level flood and water-related disaster managers also expressed their eagerness to receive timely flood forecasting information. In this third stage, FFWC received support to improve the accuracy and extend the lead time of flood forecasts, expand the provision of flood forecasting services to all flood-prone areas of the country, improve flood information dissemination at the vulnerable community level and build a sustainable institution.

FFWC efforts focused on improving the forecast lead time. It started to use ensemble precipitation forecasts from the European Centre for Medium-Range Weather Forecasts to provide medium-range flood forecasts. Since 2004, FFWC has provided deterministic flood forecasts to 3 days and medium-range probabilistic forecasts to 10 days. FFWC also started to develop its basin model in 2012.

5.1 Flood forecasting and warning activities in Bangladesh

Flood forecasting and warning activities run from April to October every year in Bangladesh. In this period, the field-level hydrological measurements division works closely with the flood forecasting center to provide observed data. FFWC remains open 24 hours a day, 7 days a week during this period.

Forecast products

- ✓ Daily water level and rainfall situation reports
- ✓ Flood conditions summary (provided both in Bangla and English)

- ✓ Forecast bulletins for 24, 48, 72, 96 and 120 hours
- ✓ Rainfall surface map
- ✓ Flood inundation map
- ✓ Interactive voice response (mobile voice message)
- ✓ Special outlook
- ✓ Press briefing

5.2 Early flood warning dissemination in Kurigram and Jamalpur

There is no doubt that an effective early warning system can save lives and property. Early warning systems can also help disaster preparedness programs to establish measures, such as emergency relief operations and evacuations, in advance. Flood forecasting and warning activities have proven very effective in recent years to combat the damaging effects of flooding in this area. FFWC disseminates flood warning information through media and communication outlets using the Internet, fax, telephone, mobile SMS, etc., and uploads the forecasted information daily on its user-friendly website (www.ffwc.gov.bd).

Moreover, FFWC has also started to disseminate flood warning messages using an interactive voice response system. People receive a short message regarding current flood information about Bangladesh's major rivers by calling 1090. This novel system provides timely information to a variety of different users including government departments, agencies, disaster managers, non-governmental organizations, news, media, local government institutions, and individuals. The two methods chosen were Voice Message Broadcast (VMB) for top-down warning dissemination from national to district and local levels simultaneously and Short Message System (SMS) for bottom-up water level data collection from the local to national level. The available 5-day forecast warning message content was made more localized (union level).

Although the villages of Ashtamirchar and Pathorshi were hit by the floods of 2020, due to the well socio-economic conditions of the people here and much awareness before the floods so they do not accept too many attacks. Most of the people (80%) in the area usually receive early flood warning signals through television. However, in public and private initiatives, local representatives announce the flood to the general communities by announcing the mike. Besides, few local people who are relatively educated (25%) collect early flood warning signals and river water level news through SMS system. In this area, many school and college teachers teach their students before, during, and after the flood what they can do to reduce the damage and easily return to normal life after the flood. In addition to this, they have warned the students about the flood warning and announced the closure of educational institutions, and requested the common people to go to safe shelters. However, there are very few people in this area who understand the flood warning signal by practicing indigenous knowledge. Although there are several reasons for this, according to the local people, the main reason is technological enhancement, electronic media, and globalization as well.

In the recent era, people of both inland and char lands are gradually leading into the dependency of technological instruments and advancement. Nowadays, the main conventional source to get weather forecasting are Mobile Phones, TV and Radio for char land inhabitants (Table 8). The main source of early warning systems in the local area is Television and Radio operated by the government and private sectors. But the early warning information that they get from television news doesn't contain localized forecast and impact information. Moreover, Only Growth center (Such as Hat/Bazar) is the only place where they get access to TV or radio. They also informed that they do not receive any early flood warning formally. The Union Disaster Management Committee (UDMC) is well functioning in its areas, and it meets every three months and calls emergency interim meetings in case of disasters. The union also sets up an emergency operation center during floods to monitor and coordinate activities. The union is also developing disaster response volunteers at the ward level, who could act as good disseminators of flood information. Locally volunteers are also actively working in the Early Warning system. There is no telephone tree (channels) being developed with telephone numbers, though there is a toll-free IVRS to enquire and get information on flood levels and flood forecasts from the national level FFWC. However, the community was not aware of the IVRS. The national structure for warning communication lacks the capacity and resources to reach out to the communities effectively. Again, no specified communication equipment is systematically used for warning communication.

The community believed that, to ensure widespread dissemination of warning information, the community focal points or members of disaster management committees can make arrangements for loudspeakers in crowded places like village markets in the locality. They also emphasized the direct dissemination of forecasts to the community from national and sub-national levels. They believed that direct communication would reduce the lag time in reaching information to them.

Table 8: Dissemination system in the study area

Dissemination System	Percentages
TV	56.8%
Radio	4.8%
Phone	35.6%
None	2.8%

Though People have also a dependency on Indigenous knowledge. Indigenous knowledge can be broadly defined as the knowledge that an indigenous (local) community accumulates over generations of living in a particular environment. Most elderly people have trust in their knowledge practiced by them for years. Frog, Ant, Bird, Cloud, etc. are the natural elements used as to get flood forecasting.

Cloud: Black cloud at the western side of the sky is the symbol of heavy rain and flood.

Frog or Ant or different insects: People believes that if frog or ant or insects climbs up the roof of the house of a tree, there is a possibility of a heavy flood.

Bird: A bird name “Suichora” gives them a signal of the heavy flood. As their perceptions when a flock of birds roams around the char, there is a risk of flood drowning the char.

Like these, there are much more indigenous knowledge believed by people. Though each of the knowledge is effective in some way, effectiveness is not the same. The following Table 9 the percentages of the practiced indigenous knowledge.

Table 9: Effectiveness of different indigenous knowledges in the study area

Indigenous Knowledge	Very High	High	Low	Very Low	Unknown
Cloud	20%	78.4%	1.6%	-	-
Wind	13.2%	84.8%	2%	-	-
Red ant	5.6%	85.2%	8%	.8%	.4%
Frog	20.8%	68.4%	10%	.8%	-
Bird	5.2%	35.2%	58.4%	.4%	.8%
M.Lizard	2.8%	11.2%	51.2%	1.6%	33.2%
Taro	6%	6.4%	11.6%	2.4%	73.6%
EarthWorm	4.8%	10.8%	6.8%	2.4%	75.2%
Proverb	7.2%	8.4%	11.6%	.4%	72.4%

Both of the systems is helping people in an early warning system. Climate change and change in biodiversity and generation gaps make people more dependent on TV and mobile phone in the area.

5.3 Risk communication and gaps and challenges in flood early warning system

The current flood early system relies on hydro-meteorological data from across the country. Data from river gauges and rainfall is collected several times a day, phoned into a central Dhaka office and then manually added to a computer register – a time-consuming process that is vulnerable to error. The existing system is well established and produces reasonable forecasts, but the information provided by the warning stations is too technical for ordinary people to understand. The information of increase and decrease water level against the BWDB monitoring stations cover only major rivers and is related to the rise and fall of water levels of various rivers. This is not the vertical and lateral inundation of specific districts or sub-districts which is valuable at the local level. Indigenous knowledge and information at the local level is always not taken into account and as a result, people in vulnerable locations cannot relate these warnings to their lives and livelihoods.

Dissemination of flood warnings is much less developed and works predominately at the national level. FFWC disseminate forecasting through electronic and print media, but most of the Bangladeshi people are very poor and are living vulnerable life in areas where they do not have access to electronic media. The communication system below the district level is not fully operative. Lack of coordination and insufficient communication between Upazila and union levels about flood warnings causes a greater problem, although they are closer to where floods have their main impact and could benefit from receiving flood warnings. Besides, consequences of changing climate, higher seasonal variability and more frequent extreme meteorological events have made communities more vulnerable.

Good overall progress in disaster management is one of the major achievements, but challenges remain in the implementation of effective early warning systems. For such systems to be effective, four elements must be in place: accurate hazard warning; an assessment of likely risks and impacts associated with the hazard; a timely and understandable communication of the warning; and the capacity to act on the warning, particularly at the local level. Although authorities may be capable of disseminating early warnings, the warning dissemination chain is often not enforced through policy or legislation. In our country difficulties in coordination, such as a lack of clarity about roles and responsibilities across institutions with responsibility for early warning for flood hazard.

Perhaps the key challenge for Bangladesh as well as our study areas is translating warning into concrete local action, even for those with effective capacities for forecasting, detecting and monitoring hazards and suitable technologies for disseminating warnings.

Three main obstacles to undertaking comprehensive risk assessments: limited financial resources; lack of technical capacity; and a lack of harmonization among the instruments, tools and institutions involved. Data-sharing protocols and mechanisms still do not exist, information remains scattered across various departments within the sector and does not provide a complete picture of national losses. Producing reliable loss and impact information remains a challenge, especially after large disasters or in difficult environments.

Lack of Institutional Integration

A Good institutional framework stands out as a prime factor for proper flood management. This includes proper institutional arrangement, organizational structures and a strong legislative framework. Different ministries with local government bodies like Upazila Parishad, union Parishad are involved in river flood and stormwater flooding management in Chilmari Upazila. It is evident in the research that there is hardly any cooperation/coordination exists among these organizations. The rigid institutional framework has hindered the effort for coordination as well as information sharing which often leads to undesirable conflicts among the organizations. Implementation of any development requires coordination among the central and local government bodies. The implementation of plans also depends on the ability to enforce plans in terms of financial and institutional capacity. In general, all these organizations suffer from inadequate manpower, funding and logistics. The existing strength of these organizations is inadequate to cope with the immediate crisis of serious flood.

Lack of Fund

Being a developing country, fund constraints are a common phenomenon for Bangladesh. The implementation of any development plan largely depends on donor funding. Because of lack of funding the flood control project are taking longer time than the estimation. Permanent flood control projects need a huge amount of cost. Flood protecting embankment has been failed because of lack of funding as the construction quality is not up to the mark. In general, the maintenance division of any development works occupies a small percentage of the National Budget. In our economic system financial allocation for maintenance, purpose does not exist. The Ministry of Finance and Planning Commission make financial arrangement only for the implementation of the project work. But subsequent maintenance cost is not allocated for those projects. The proper maintenance and operation of the flood control structures are hindered due to a shortage of funds.

Lack of Participatory Approach

Rigid, inefficient bureaucratic practice, procedure orientation and lack of public participation all these events resist the formation of alternatives to manage floods. A guideline for Participatory Water Resource Management is prepared by WARPO. But it is not in practice. There is limited and in most cases, no participation is evident in planning, policy and decision-making phases. The flood management is driven by top-down decision-making. The flood control measures are planned without the participation of the affected people and other stakeholders. Conventional public participation can be perceived as consultation to improve the project details that the authority has designed them. The existing informal practice of the participatory planning process is not based on principles of participation. Due to lack of participation, the development plans fail to address the people's needs and integrate their demands in the plan. The absence of public involvement in the operation and maintenance of control measures and lack of awareness about their role often pose a problem in the proper management of the flood.

Flood Risk Management Strategies

An integrated approach to flood management means the best mix of structural and non-structural measures. These measures are mostly physical. Though, flood in Chilmari is managed by both measures, integration between them is not noticeable. Flood control measures are emphasized than the non-structural measure.

Mismanagement in Warning System

One of the major problems in the flood management system in Chilmari Upazila is the provision of an equal flood warning system within all the unions of the Upazila. From the analysis, it is found that the char unions are the most flood vulnerable unions in the upazila. But from the field survey it is identified that the people of the union of char unions received no warning about the recent flood while the other three unions of the upazila received warning. The consequence of this mismanagement is very bad. In the char union, people saw their seeds just before a few days of the recent floods. If they received the warning in due time a huge amount of agricultural losses could be reduced. The most surprising fact is that, in Ashtamir Char union, people saw their seeds without getting a warning and the seeds were washed away by floodwater. When the water was removed from the land, they saw their seeds for the second time. And even for the second time, all the seeds were washed away by second time flood water. This has occurred only for the mismanagement by the government bodies.

There is an immediate need to update and improve the Flood EWS so that all elements of the Flood EWS provide useful flood warnings to all potential users.

The following are the key elements of the need's assessment:

- ✓ Scale-down the macro-level forecasts to a locally specific warning signal.
- ✓ Identify and incorporate locally available traditional knowledge and techniques to transform existing early warning prediction and forecasts into easy and understandable language. This will also supplement the modeling errors (if any) and the data and information gaps in the forecasting systems.
- ✓ Develop and/or strengthen user-friendly early warning dissemination plan combining local and national flood forecasting system.
- ✓ Identify the exact type and number of the infrastructural support to enhance the local-level early warning prediction and monitoring as an overall process. This was done previously in the form of installing locally understandable rain/ water gauges and flood markers followed by a formal education and awareness process.

6 Key features of the Dynamic Flood Risk Model (DFRM) including comparative advantages (this will also include the maps)

6.1 Background of DFRM

Dynamic Flood Risk Model (DFRM) is an area-specific flood risk model which generates local flood event data (inundation area, depth, velocity, duration, vulnerability, and risk) using the FFWC forecasted information. This community-based early warning system is aimed to increase awareness among the communities to enhance flood awareness as well as enhance community resilience. Flood risk mapping facilitates the administrators and planners to identify areas vulnerable to flood hazards and to what degree they might be affected, and the capability to respond and recover. Fig. 17 shows the Schematization of Dynamic Flood Risk Model. The background work of DFRM model consists of the following tasks.

- Two-dimensional numerical simulation based on previous scenarios
- Generation of hazard information
- Generation of communities' of capitals, exposure, risk and warning

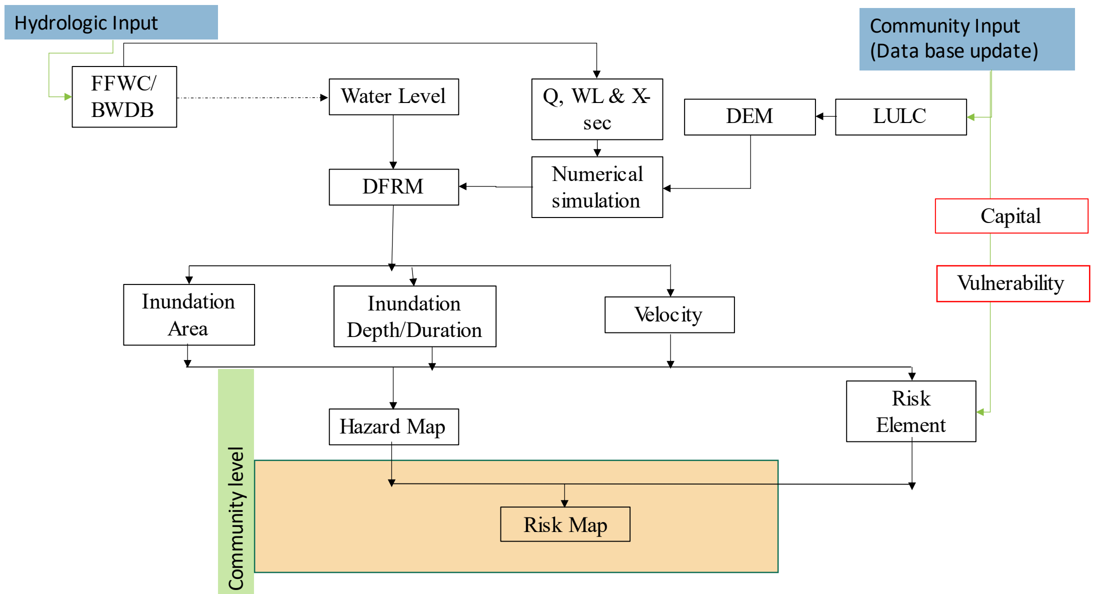


Fig. 17: Schematization of Dynamic Flood Risk Model (DFRM)

The description of each element is given below

Two-dimensional numerical simulation based on previous scenarios

A well-calibrated and validated physics-based nonlinear 2D morpho-dynamic model of Brahmaputra-Jamuna (Shampa et al., 2017) has been used to assess the impacts of several recommended management options. The numerical model was used on the open-source platform of Delft3D (flow version 4.00.01.000000)(Lesser et al. 2004). The Delft3D model has been applied in a wide range of scientific projects for the river, estuarine, and coastal systems (e.g., Van Der Wegen and Roelvink 2008). In the hydrodynamic part, the model solves the two-dimensional depth-averaged shallow water equations (derived from Navier-Stokes equations) for incompressible free surface flow (shallow water equations) with consideration of Boussinesq approximations.

For the numerical model, a 240-km long curvilinear grid was constructed with an average width of 13 km; starting from almost 27 km upstream of the Kurigram district and ending near the Aricha water level measuring station. The reach was discretized by 893x127 grid cells. This grid resolution was chosen to cover every bar by at least two grid cells (grid cell size 450x320 m^2) because the bar size ranges from 549.83x205 m^2 to 28635x10475 m^2 within the reach of Brahmaputra-Jamuna. An example of interpolated river bathymetry for the year 2020 is shown in

Fig. 18. As the bathymetry and topography data BWDB measured cross-sections, Digital Elevation Models (DEMs) of SRTM at 1-arc spatial resolution (~30 m), Google Earth DEM and WARPO DEM where is needed.

To simulate any hydrodynamic model the discharge boundary at upstream and water level boundary at downstream is necessary. Therefore from available time-series data (Discharge, Water level) from BWDB nearly 50 scenarios has been generated using the time series data discharge data of Brahmaputra-Jamuna, Teesta, Dharla, Dudhkumar from year 1956-2020 as upstream boundary (shown in Fig. 19-Fig. 22) and water level of Brahmaputra-Jamuana (Aricha), Old Brahmaputra (Jamalpur), Jhenai (Juker char) as downstream boundary (shown in Fig. 23-Fig. 24).

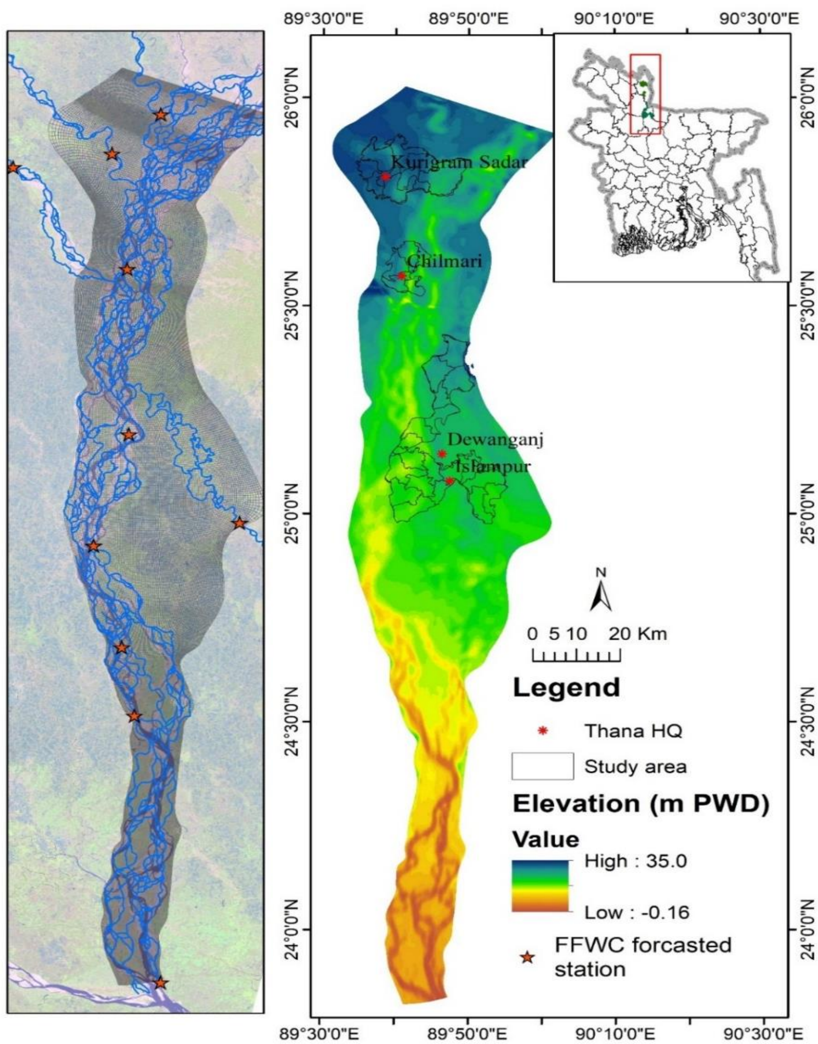


Fig. 18: Model Grid and Bathymetry

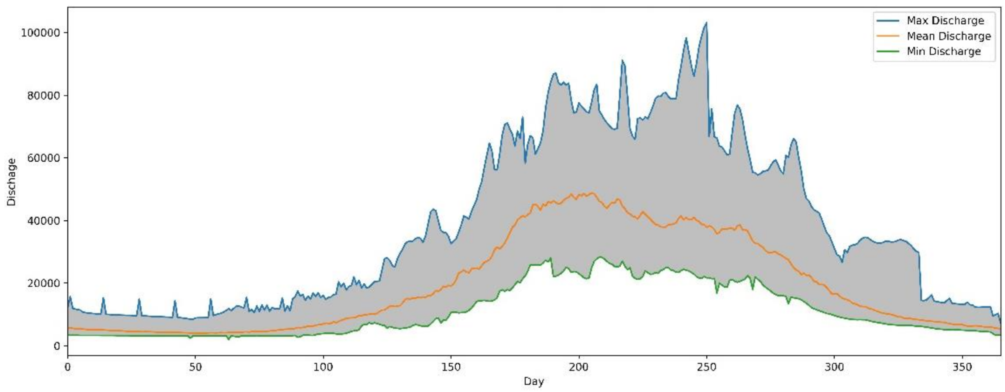


Fig. 19: Discharge range for Brahmaputra-Jamuna river at Bahadurabad (in m^3/s)

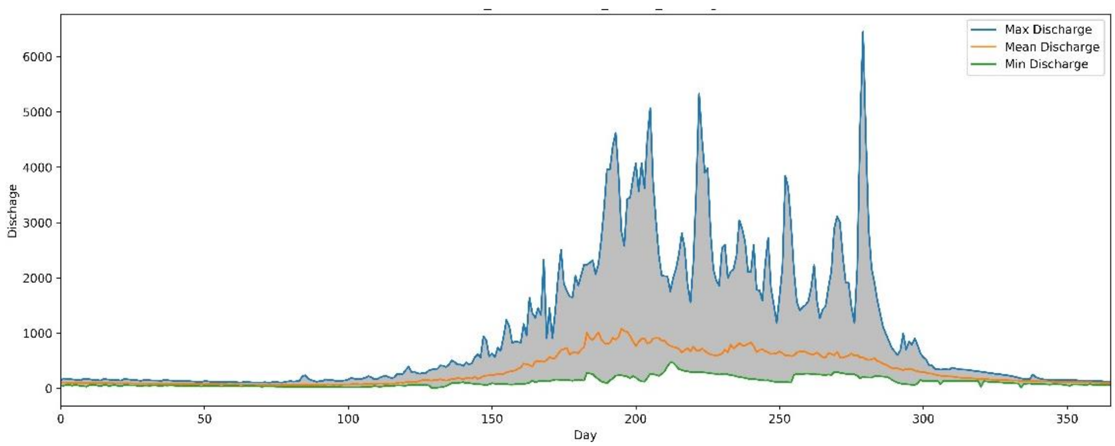


Fig. 20:Discharge range for Dharla river at Simulbari (in m^3/s)

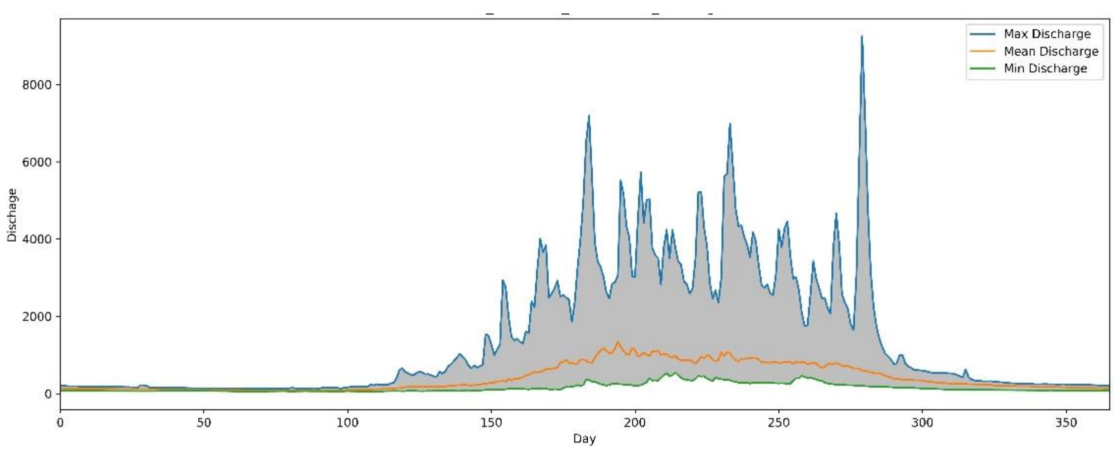


Fig. 21: Discharge range for Dudhkumar river at Pateswari (in m^3/s)

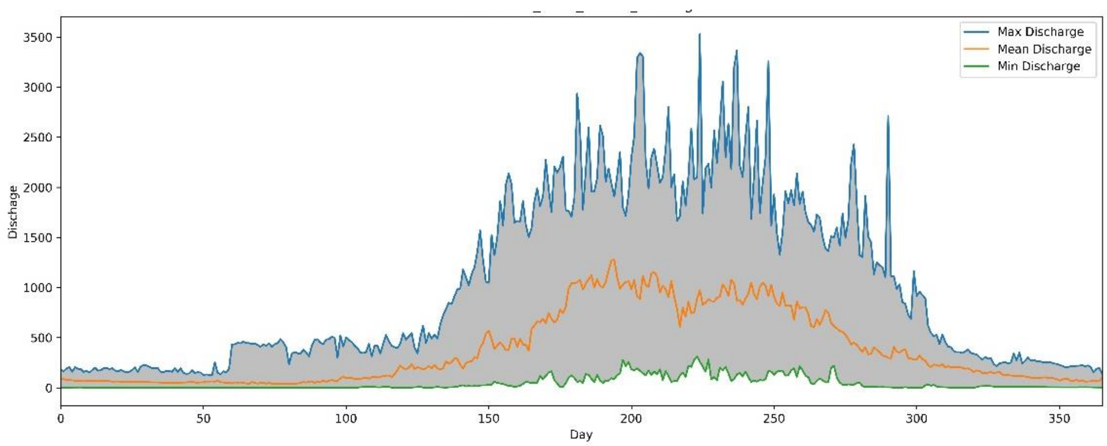


Fig. 22: Discharge range for Tessta river at Dalia (in m^3/s)

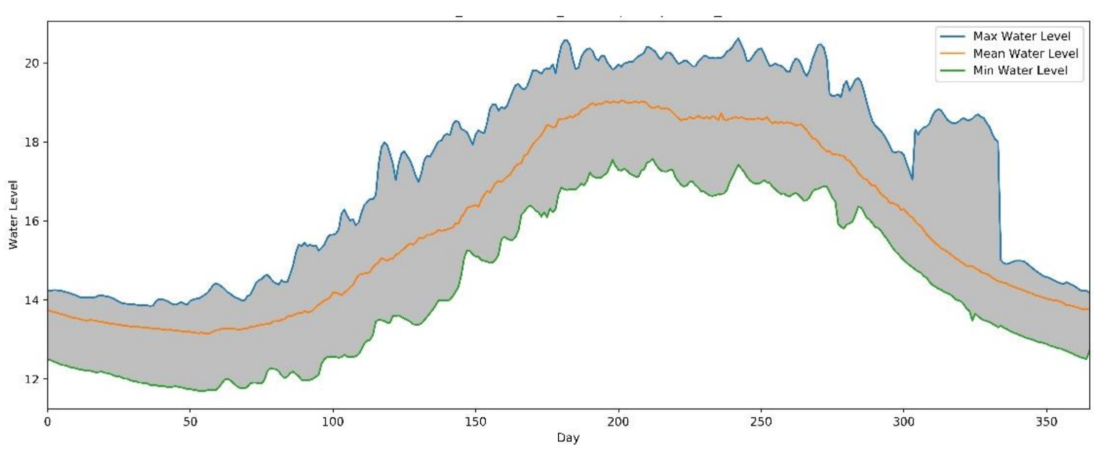


Fig. 23: Water level range for Brahmaputra-Jamuna river at Bahadurabad (in m PWD)

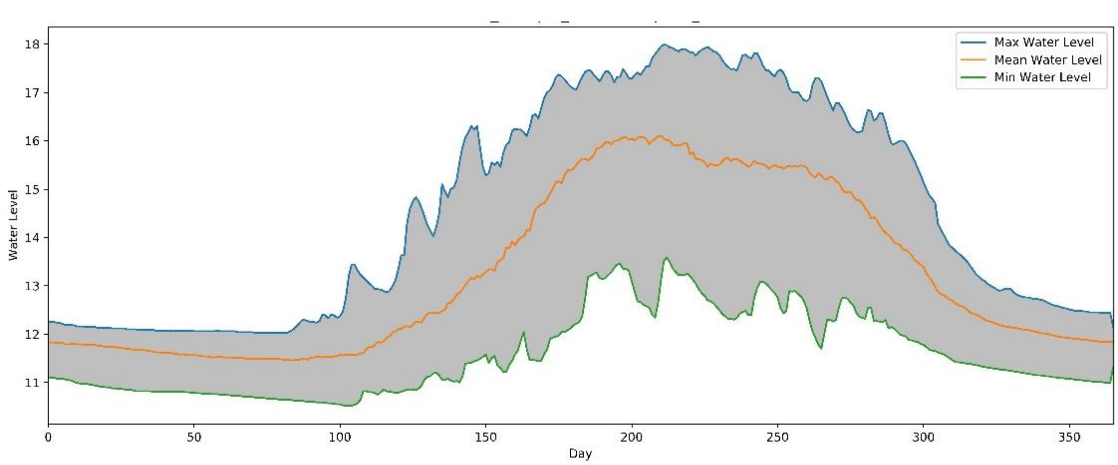


Fig. 24: Water level range for Old Brahmaputra river at Jamalpur (in m PWD)

Generation of hazard information

From the model results components of hazards such as the area of inundation, depth of inundation, duration of inundation and flood flow velocity has been extracted in all scenarios for 365 days. The char people are usually used to flood. The field survey during the study in the chars of Brahmaputra-Jamuna to assess their perception of flood hazards. Hazard ranking 0 indicates a very low hazard corresponding to the inundation is less than 0.1m, overland flood velocity is less than 0.02m with average flood duration (i.e. 60 days for riverine flood). Accordingly hazard 100 indicates a very high hazard with severe damage on life and livelihood corresponds to flooding depth with greater than 1 m, with high velocity and 90% longer duration. Finally, the hazard is calculated using the following formula

$$\text{Hazard, } H_z = a * W_d + b * W_v + c * W_{du} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

Where,

a, b, c $are\ weighting\ fact$; *Determined by Principal Component Analysis*

W_d, W_v and W_{du} $wighted\ hazard\ index$

The value of a ranges between 0.34 to 0.44, b 0.32 to 0.42 and c 0.22 to 0.24.

Generation of communities' of capitals, exposure, risk and warning

According to IPCC AR5, risk is a multiplicative function (non-linear combination) of hazard, exposure of human and natural systems and vulnerability (IPCC, 2014; Barros et al., 2014) (eq. 2)(shown in Fig. 25) where vulnerability is computed from five various capitals; physical capital, natural capital, human capital, social capital and financial capital (eq. 3). Here, Capitals are calculated from a linear combination (weighted sum) of socio-economic adaptations (UNDP, 2017) shown in Fig. 26 and Hazard component is also computed form the linear combination (weighted sum) of water depth, flood velocity and flood duration The relative weighted scores are calculated by using PCA. PCA gives a correlation matrix that identifies the principal component for a system. Pearson correlation coefficient was used to find the weights of the parameters that describe how much an indicator can explain a component vector**.** Table 1 shows the capitals corresponding to various domains that are used to assess risk.

$$Risk = Hazard * Exposure * Vulnerability \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

and

$$Vulnerability = 100\% - Capital(in\ percentage) \ \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Risk, Capital and Vulnerability assessed through the following diagrams in Fig. 25 and Fig. 26

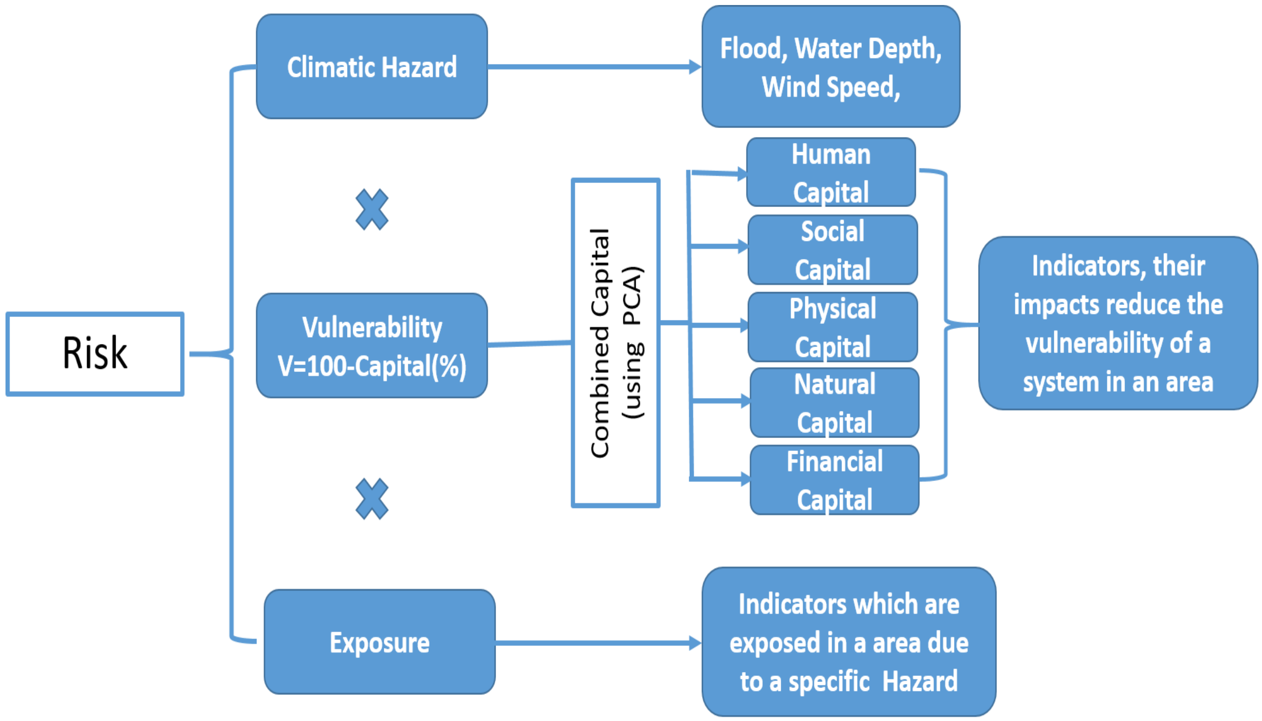


Fig. 25: Risk Assessment

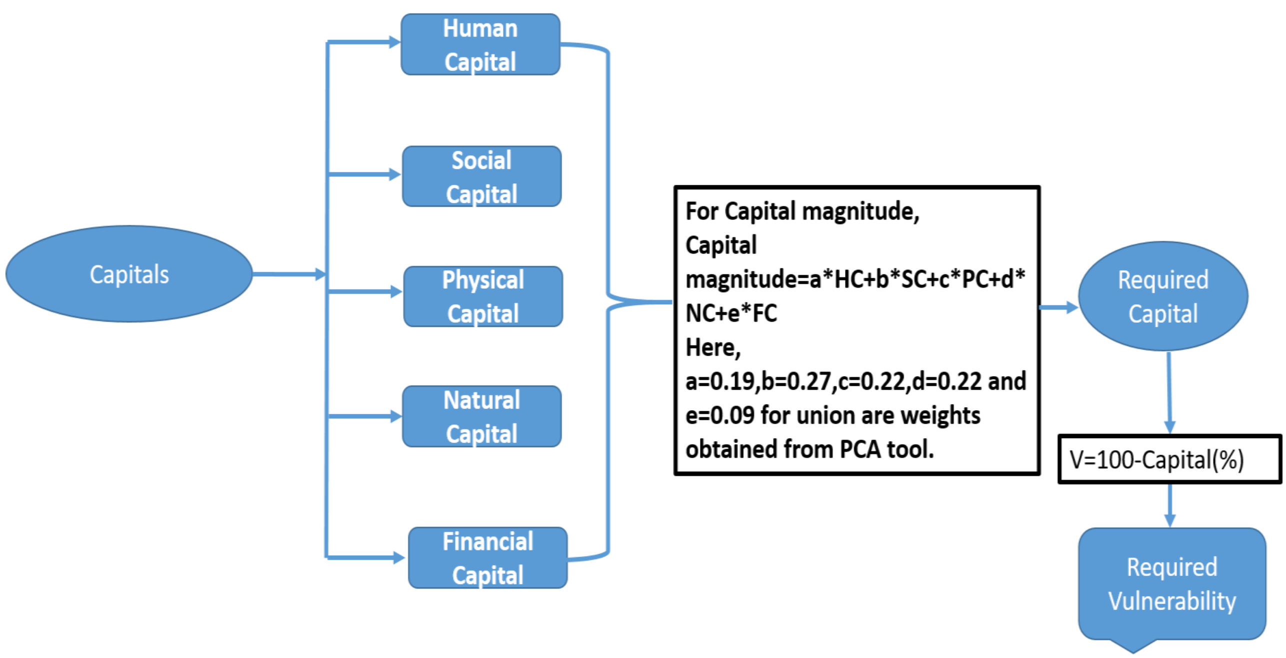


Fig. 26: Capital and Vulnerability assessment

Table 10: Total lists of exposure, hazards and socio-economic capitals.

Domain		Indicators	Explanations
Exposure		Percentage of people living per area	Exposure refers to the parameters which are directly affected due to any hazard.
		Ktacha House in percentage	
Hazard		Water Depth	Flood is caused by the combined action of fluvial flow from upstream rivers & tide from sea and occurs mainly during monsoon. The main impact zone of the flood is confined within the northern part of the coast which is not protected by polders (Haque and Nicholls, 2018).
		Flood Velocity	
		Flood Duration	
Capitals	Physical Capital	Educational Institution	Physical capital comprises the basic infrastructure and producer goods needed to support livelihoods. The infrastructure looks at changes in the environment that affect communication and access to basic services. Production goods are the tools and equipment which increase productivity
		Shelter Center	
		Tubewell	
		Paka-Semi Paka house	
		Community Clinic	
		Religious place (Mosque)	
	Human Capital	Cultivable land	Human capital encompasses the abilities, experience, work skills and good health that, when combined, allow populations to engage with different livelihood strategies and reach their objectives.
		Male : Female	
		Employed people	
		Access to relief goods	
		Number of Boat owner	
		Floating or Hanging Veg Garden	
		Homestead Plantation	
		People access to the tube well	
		Capable People	
	Social Capital	Literate People	Social capital is closely linked with structures and processes for transformation. Structures and processes can themselves be a product of
		Involved in Recovery Process	
		People using electricity	
		Access to mass media	

		Bazar	social capital. The relationship works in both directions and can be self-perpetuating.
		Moszid going people	
		Number of Volunteer	
		Indigenous knowledge	
		Primary school student	
		Radio station	
		Network Coverage	
	Financial Capital	Number of HH with access to microcredit	Financial capital refers to the financial resources that people use to achieve their livelihood objectives. The definition used here includes flows as well as stocks and it can refer to consumption as well as production. This definition has been adopted to capture an important livelihood building block, namely the availability of cash or equivalent that enables people to adopt different livelihood strategies.
		Insurance	
		Savings	
		Ghat	
		Growth Center	
		Employed People	
		Number of Cattle Owner	
	Natural Capital	Tubewell	Natural capital is the term used to describe the stocks of natural resources from which further resources and services can be developed which may prove useful to livelihoods. A broad variety of resources fall within this category.
		Pond/Deghee	
		Bamboo Bush	

6.2 Key Features of Dynamic Flood Risk Model (DFRM)

Dynamic Flood Risk Model (DFRM) is an easy-to-use software package/tool to identify flood hazard & risk-prone areas that would be useful for decision-makers to make well-informed decisions for flood management. The model interface is shown in Fig. 27. The primary input of DFRM is the water level or danger level information (provided by the BWDB) of Jamuna (at Bahadurabad point), Teesta (at Kauniya point) or Dharla (at Taluk-Simulbari point) river, DFRM generates area-specific Inundation, Hazard, Risk Map as well as Vulnerability and Capacity Map. It also provides area-specific warning from this water level or danger level information. The model also contains community capital, vulnerability and exposure database. A typical example of the vulnerability map of Kurigram and Jamalpur is shown in Fig. 28.

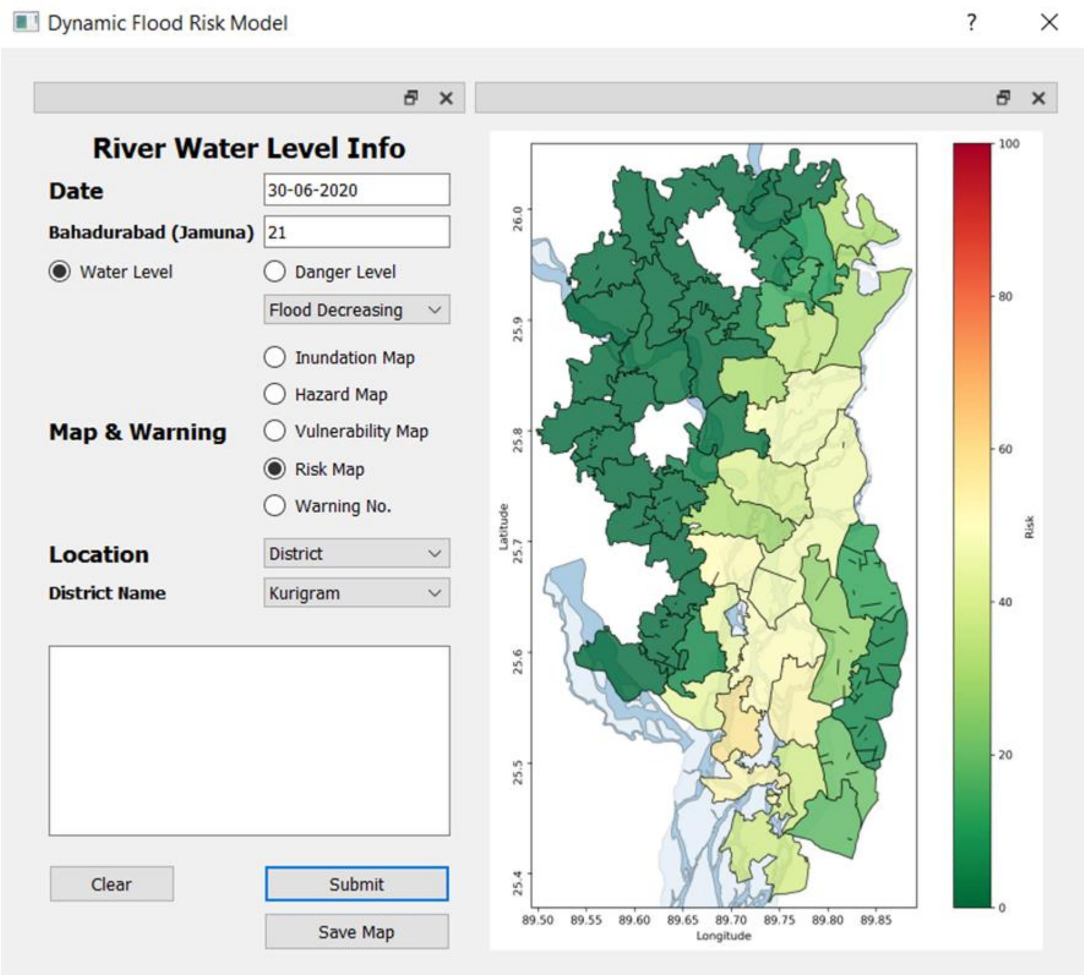


Fig. 27: DFRM interface (Bangla version)

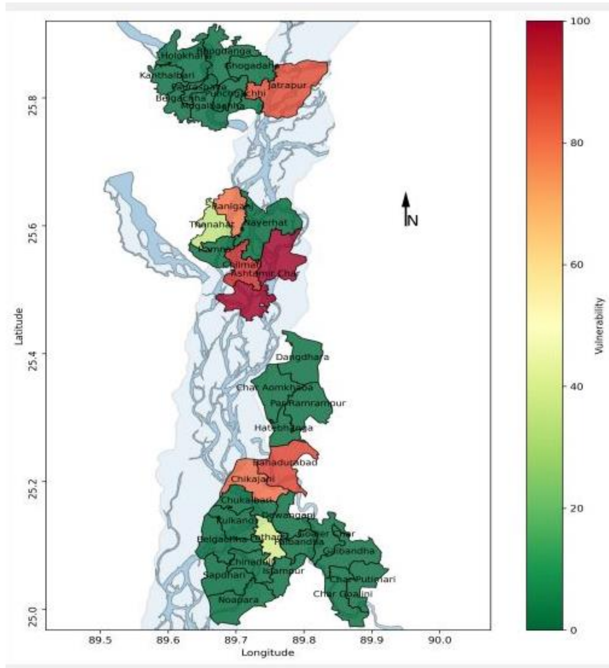


Fig. 28: An example of a Vulnerability map of the study area

Flood risk mapping and warning facilitate the administrators and planners to identify areas vulnerable to flood hazard, people, facilities, and infrastructures at risk and to what degree they might be affected, and the capability to respond and recover. Most importantly, it helps to identify and prioritize the mitigation and response efforts.

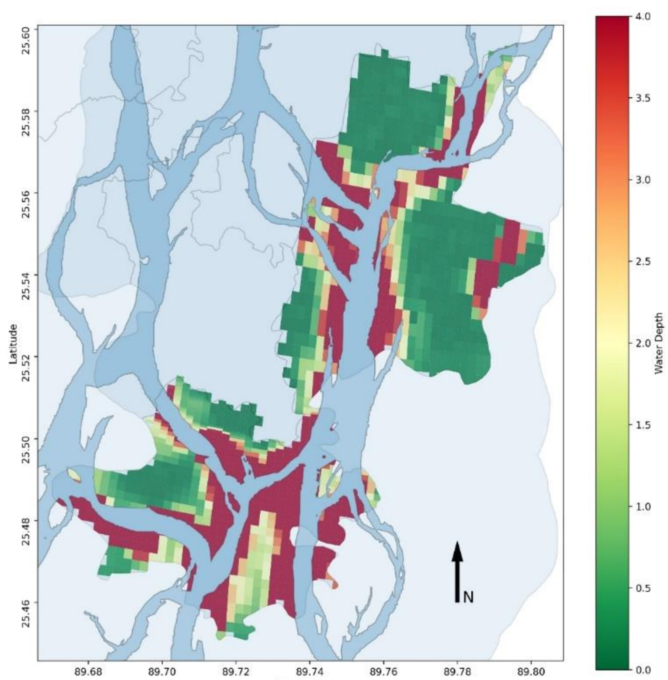


Fig. 29: An example of typical inundation Map at Ashtamir char, Kurigram

Traditionally, flood policies concentrated on the control or reduction of flood hazards, i.e., decreasing the probability of occurrence and intensity of flood discharges and inundations (Fig. 29). Flood risk management puts a much stronger emphasis on flood risk, where risk is defined as damage that occurs or will be exceeded with a certain probability in a certain period. Hence, damage aspects need to be taken into account in any deliberations on flood risk management. Mitigation of flood risk can be accomplished through reducing the intensity of hazards, by engineering or structural measures, which alter the frequency (i.e., the probability) of flood levels in an area, or reducing the exposure or damage susceptibility of the elements at risk, by non-structural measures, for example, through changing or regulating land use, through flood warning and effective emergency response, and flood-resistant construction techniques.

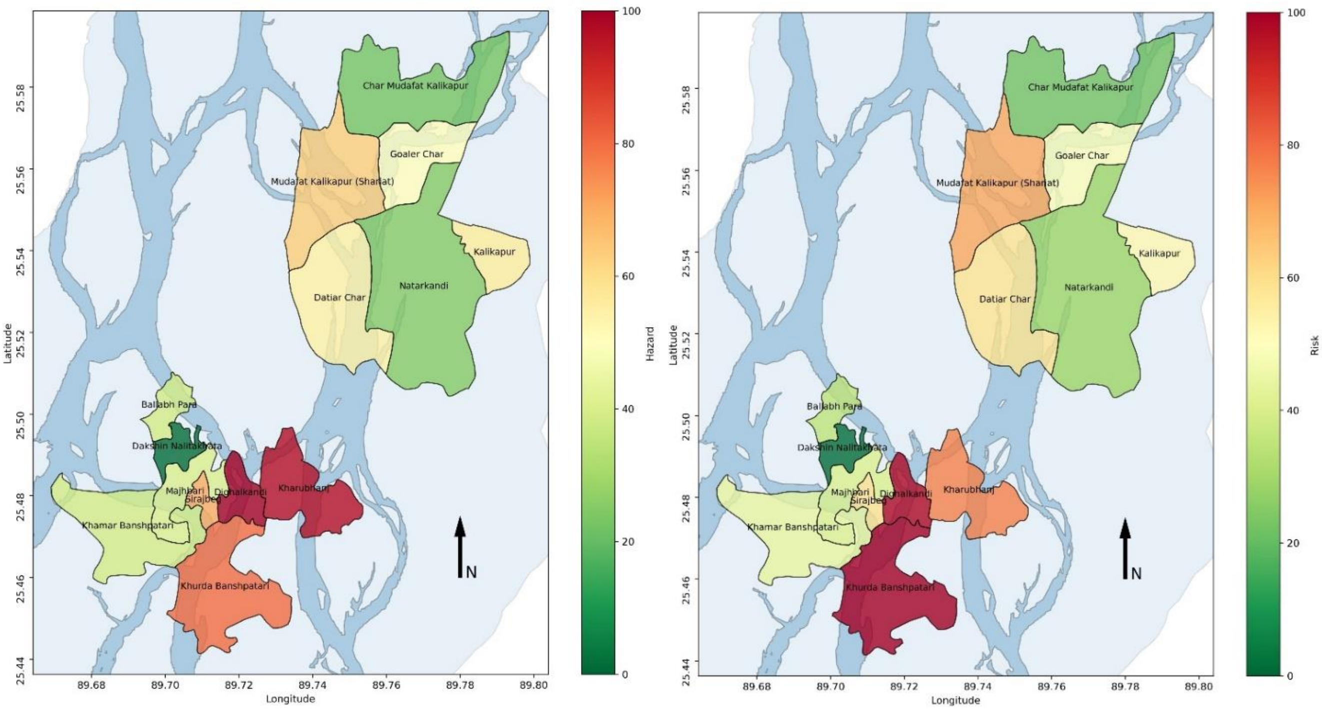


Fig. 30: An example of typical Hazard (left) and Risk (right) produced by DFRM

Identification of those areas at risk of flooding will also help inform emergency responses. For example, areas that are likely to require evacuation can be identified, and evacuation routes can be planned and signposted, so local communities are made aware in advance of an emergency. The identification of flood risk areas will also help in the location of flood shelters for evacuees (Fig. 30). It is essential that specific infrastructure, such as electricity supplies, water supply, etc., and services, such as emergency services, continue to function during a flood event. The creation of flood risk maps will, therefore, allow planners to locate these elements in low-risk areas so that they can continue to serve during an extreme event. In the longer-term, flood hazard and risk maps can support planning and development by identifying high-risk locations and steering development away from these areas. This will help to keep future flood risks down and will also encourage sustainable development.

7 Institutional framework

Flood Forecasting and Warning Center (FFWC) of Bangladesh Water Development Board (BWDB) is the focal institution for flood forecasting in Bangladesh which provides daily water level and rainfall situation report with forecast bulletins for 24, 48, 72, 96, and 120 hours from April to October every year. The operational flood forecasting system is based on real-time water level data received from available stations in Bangladesh and quantitative precipitation forecasts from numerical weather prediction models provided by the Bangladesh Meteorological Department (BMD). The forecasted information is national-level information generated in terms of *danger level* 'often difficult to understand by the local community. Furthermore, there is no hazard or risk-related information. The dissemination of FFWC warnings goes from National Disaster Management Committee (DMC) to Union DMC with available media coverage. Considering these gaps, the newly developed flood risk information (generated by DFRM) dissemination strategy will follow the existing dissemination process at the same time the community level, under the Union DMC, a new local community unit is proposed (shown in Figure 17).

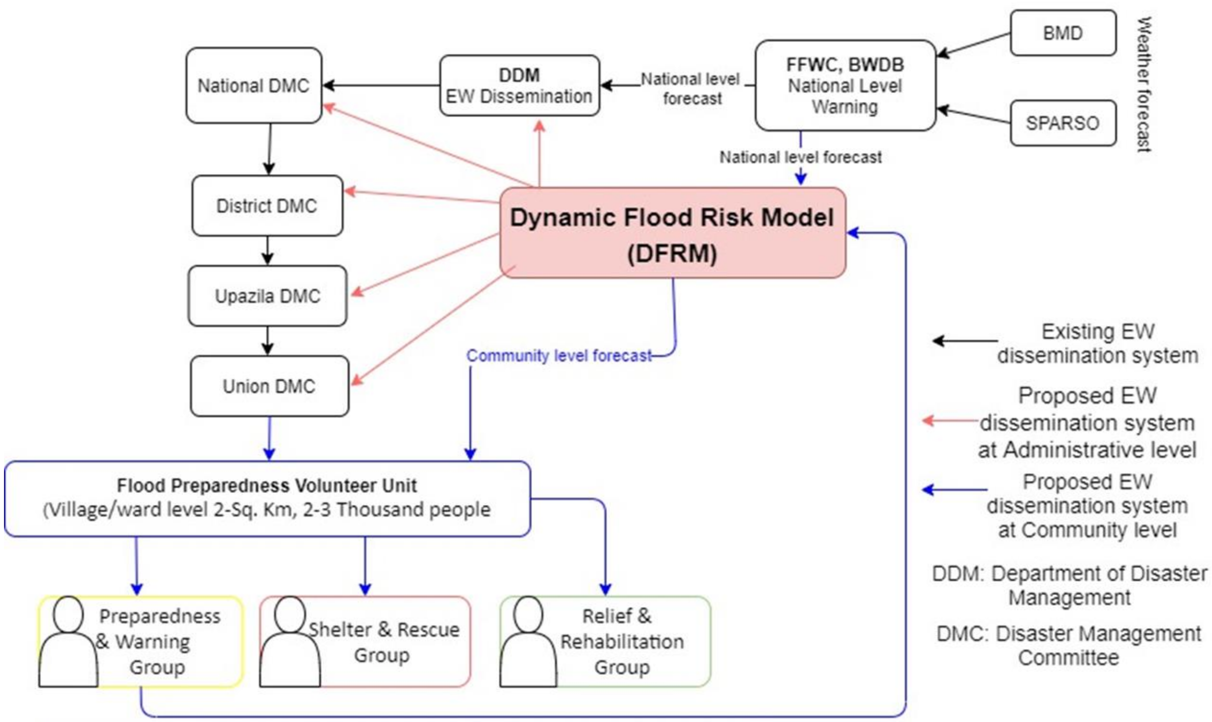


Fig. 31: Framework on Flood Forecast Dissemination Strategy

The unit will consist of several volunteer groups supposed to work into 3 sub-units such as- Preparedness & Warning Group, Shelter & Rescue Group, Relief & Rehabilitation Group. Each group will be formed by three volunteer's one male, one female and one group leader (male/female). The number of volunteers should be sufficient to cover 2 sq. km, providing service to 2-3 thousand people. For the initial piloting four unions have been selected with the discussion of NRP-DDM, Care-Bangladesh and IWFM- Holokhana, Ramna, Astamir Char and Chikajani as shown in Fig. 32. The volunteers started their work at the starting of the monsoon season initially by tracking the forecasted water level of FFWC and the generated warning from DFRM.

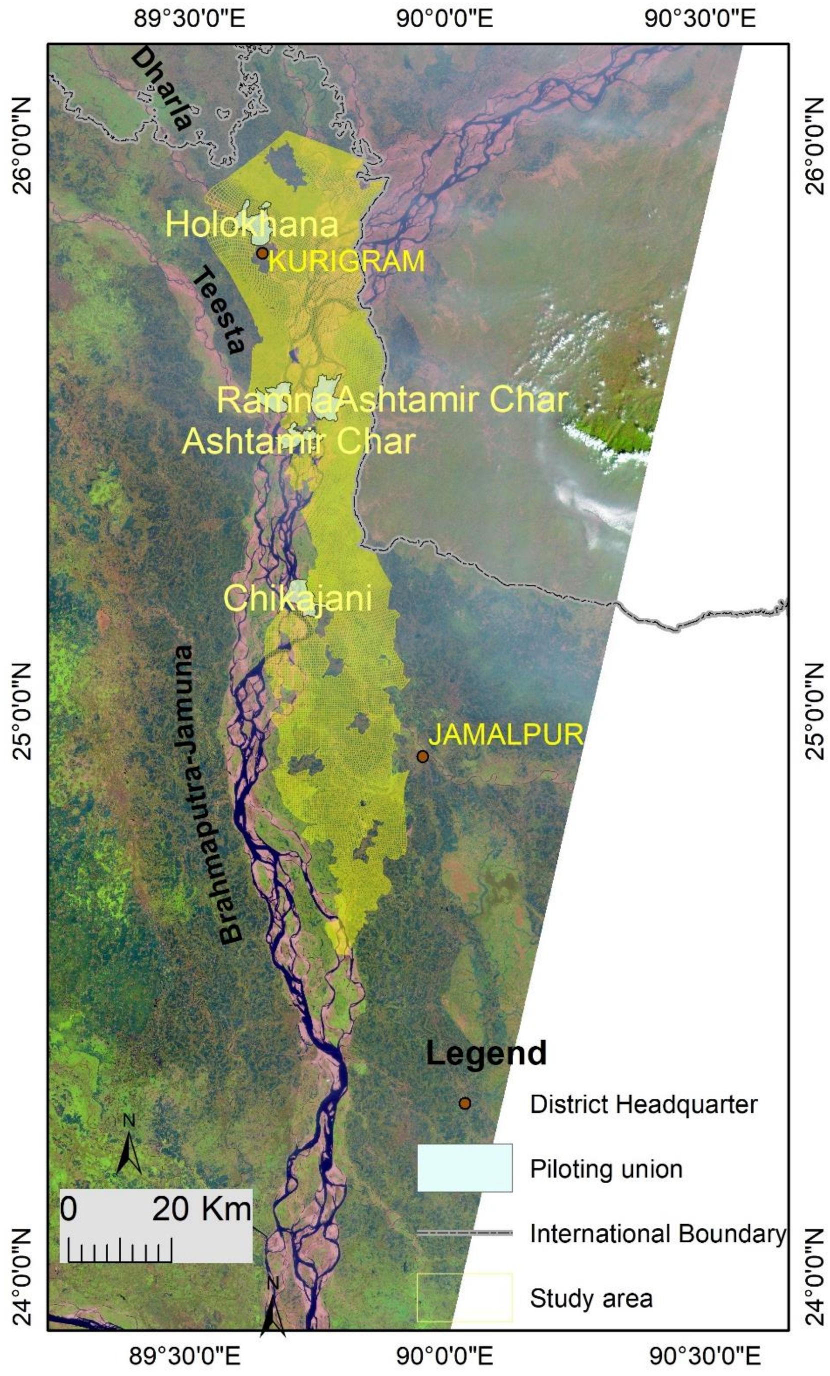


Fig. 32: The proposed piloting unions

With the increase of water level, the DFRM showed the warning number from 1 to 5. The local volunteers of advised display the one and two yellow flags when the warning no becomes 1 and 2 respectively. The dimension of the flag should be 24 inches X 18 inches. With warning number 3, one red flag will be displayed. It will be continued with three red flags up to warning no 5 as shown in Fig. 33. The explanations of all waring number in Raising stages of the flood is illustrated in Fig. 33. For example, when the warning no was 1, it indicates that within 5 to 7 days all of the low-lying areas of that village will be inundated. In case of warning no 5, all of the areas of that village are at the risk of inundation with 8-10 ft water depth with high flow velocity and damages.

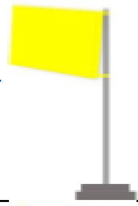
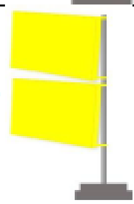
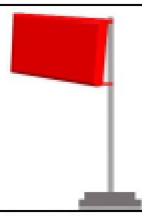
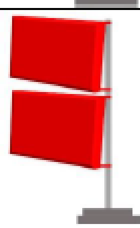
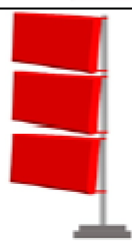
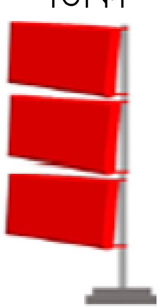
পতাকার রং ও সংখ্যা	সংকেত নম্বর	ব্যাখ্যা
হলুদ রং - ১ পতাকা 	১	৫ থেকে ৭ দিনের মধ্যে এলাকার সবচাইতে নিচু অঞ্চল নিমজ্জিত হওয়ার সম্ভাবনা আছে।
হলুদ রং - ২ পতাকা 	২	২৪ থেকে ৪৮ ঘন্টার মধ্যে এলাকার সবচেয়ে নিচু অঞ্চল স্বাভাবিক বন্যায় নিমজ্জিত হওয়ার সম্ভাবনা আছে। পানির সর্বোচ্চ উচ্চতা ২-৪ ফুট বা তার বেশি হতে পারে। পানির গতি এবং ক্ষয়ক্ষতির সম্ভাবনা কম হতে পারে।
লাল রং - ১ পতাকা 	৩	২৪ থেকে ৪৮ ঘণ্টার মধ্যে এলাকার সবচেয়ে নিচু অঞ্চল নিমজ্জিত হওয়ার সম্ভাবনা আছে। পানির সর্বোচ্চ উচ্চতা ৪-৬ ফুট বা তার বেশি হতে পারে। পানির গতি এবং ক্ষয়ক্ষতির সম্ভাবনা দুটোই মাঝারি ধরনের হতে পারে।
লাল রং - ২ পতাকা 	৪	২৪ থেকে ৪৮ ঘণ্টার মধ্যে এলাকার সবচেয়ে নিচু অঞ্চলসহ মাঝারি উচ্চতার অঞ্চল নিমজ্জিত হওয়ার সম্ভাবনা আছে। পানির সর্বোচ্চ উচ্চতা ৬-৮ ফুট বা তার বেশি হতে পারে। পানির গতি তীব্র এবং ক্ষয়ক্ষতির সম্ভাবনা বড় ধরনের হতে পারে।
লাল রং - ৩ পতাকা 	৫	২৪ থেকে ৪৮ ঘণ্টার মধ্যে এলাকার সবচেয়ে নিচু অঞ্চলসহ মাঝারি ও উঁচু অঞ্চলও নিমজ্জিত হওয়ার সম্ভাবনা আছে। পানির সর্বোচ্চ উচ্চতা ৮-১০ ফুট বা তার বেশি হতে পারে। পানির গতি অতি তীব্র এবং ক্ষয়ক্ষতির সম্ভাবনা অনেক বড় ধরনের হতে পারে।

Fig. 33: Flags showing the warning number and explanation (in Bangla) (Rasing stage)

Fig. 34 shows the instructions to the community at the rising stages of the flood. During Warning no 1 and 2, the communities should be prepared for their safety, should take precautions for harvesting their crops. During the warning, no 4 preparation should be started for evacuation for vulnerable groups- elderly people, persons with disabilities, children and pregnant women. During warning no 5, the vulnerable groups should be moved to the nearly ‘Flood shelter’. Fig. 35 and Fig. 36 show the way to lower the flags at the recession stage and the corresponding instructions.

সতর্ক সংকেত	করণীয়সমূহ
১-২	ইউনিয়ন পরিষদের সাথে সমন্বয় করে বন্যার পুর্বাভাস সংগ্রহ ও প্রচারের ব্যবস্থা করা এবং প্রস্তুতি কার্যক্রম পর্যালোচনা করা। ওয়ার্ড ও ইউনিয়ন দুর্যোগ ব্যবস্থাপনা কমিটির সভা আয়োজন এবং সাড়াদান প্রস্তুতি গ্রহণ করা।
১-২	ইউনিয়নের যে এলাকায় সর্বপ্রথম বন্যার পানি প্রবেশ করেছে সেটা চিহ্নিত করে সেখানে আগাম পুর্বাভাস প্রচার করা। প্রস্তুতি কার্যক্রম পর্যালোচনা করা এবং কর্মপরিকল্পনা অনুযায়ী সুনির্দিষ্ট কার্যক্রম গ্রহণের উদ্যোগ নেওয়া।
১-২	বন্যা আশ্রয়কেন্দ্র এবং এলাকার উঁচু স্থানগুলোকে জনসাধারণ এবং প্রাণিসম্পদের আশ্রয়ের উপযুক্ত করে প্রস্তুত করা।
১-২	পানি বিশুদ্ধকরণ ট্যাবলেট এবং শুকনো খাবার এর ব্যবস্থা করা।
১-২	প্রয়োজনীয় জিনিসপত্র বিশেষ করে টাকা-পয়সা, জমির দলিল, শিক্ষা সনদ, জাতীয় পরিচয়পত্র নিরাপদ স্থানে রাখা।
১-২	উঠতি ফসল আহরণের সিদ্ধান্ত গ্রহণ ও প্রস্তুতি নেওয়া। যেখানে সম্ভব জমির ফসল ঘরে তুলে ফেলা এবং নিরাপদ জায়গায় সংরক্ষণ করা। ক্ষুদ্র ব্যবসায়, মাছ চাষের পুকুর ও মৎস খামারসহ অন্যান্য সম্পদের সুরক্ষা নিশ্চিত করা।
৩	প্রাণিসম্পদ ও হাঁস-মুরগি নিরাপদ স্থানে দ্রুত সরিয়ে ফেলা এবং প্রাণিখাদ্য নিরাপদে মজুদ রাখা।
৩	ইউনিয়ন পরিষদের সাথে সমন্বয় করে আশ্রয়কেন্দ্র ব্যবস্থাপনাসহ সন্ধান ও উদ্ধার কার্যক্রমের প্রস্তুতি গ্রহণ করা।
৪	প্রবীণ, শিশু, প্রতিবন্ধি ব্যক্তি ও গর্ভবতী নারীদের অগ্রাধিকার দিয়ে বন্যা কবলিত হতে পারে এমন জনগোষ্ঠীকে নিরাপদ স্থানে নেওয়ার প্রস্তুতি গ্রহণ করা। অসুস্থ ও প্রবীণদের জন্য জরুরি চিকিৎসা সহায়তা দেওয়া।
৫	নিমজ্জিত স্থানে তথা ঝুঁকিপূর্ণ জনগোষ্ঠীকে দ্রুত আশ্রয়কেন্দ্র কিংবা এলাকার উঁচু স্থানগুলোতে সরিয়ে নেওয়া।

Fig. 34: Instructions to the community (Rasing stage)

পতাকার রং ও সংখ্যা	সংকেত নম্বর	ব্যাখ্যা
লাল রং - ৩ পতাকা 	৫	২৪ থেকে ৪৮ ঘণ্টার মধ্যে এলাকার সবচেয়ে উঁচু অঞ্চল থেকে পানি নেমে যেতে পারে। নিমজ্জিত অঞ্চলের পানির সর্বোচ্চ উচ্চতা ৮-১০ ফুট বা তার বেশি থাকতে পারে। নেমে যাওয়ার সময় পানির অতি তীব্র গতির কারনে অনেক বড় ধরনের ক্ষয়ক্ষতি হতে পারে।

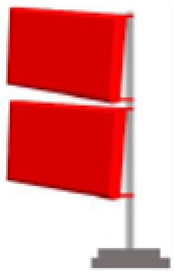
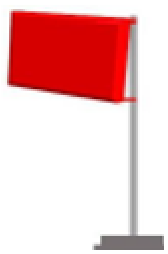
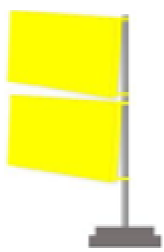
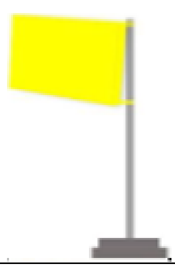
লাল রং - ২ পতাকা 	৪	২৪ থেকে ৪৮ ঘণ্টার মধ্যে এলাকার নিচু ও মাঝারি অঞ্চল ছাড়া অন্যান্য অঞ্চল থেকে পানি নেমে যেতে পারে। নিমজ্জিত অঞ্চলের পানির সর্বোচ্চ উচ্চতা ৬-৮ ফুট বা তার বেশি থাকতে পারে। নেমে যাওয়ার সময় পানির তীব্র গতির কারনে বড় ধরনের ক্ষয়ক্ষতি হতে পারে।
লাল রং - ১ পতাকা 	৩	২৪ থেকে ৪৮ ঘণ্টার মধ্যে এলাকার নিচু অঞ্চল ছাড়া অন্যান্য অঞ্চল থেকে পানি নেমে যেতে পারে। নিমজ্জিত অঞ্চলের পানির সর্বোচ্চ উচ্চতা ৪-৬ ফুট বা তার বেশি থাকতে পারে। নেমে যাওয়ার সময় পানির মাঝারি গতির কারনে ক্ষয়ক্ষতিও মাঝারি ধরনের হতে পারে।
হলুদ রঙ - ২ পতাকা 	২	২৪ থেকে ৪৮ ঘণ্টার মধ্যে এলাকার কিছু কিছু নিচু অঞ্চল ছাড়া অন্যান্য অঞ্চল থেকে পানি নেমে যেতে পারে। নিমজ্জিত অঞ্চলের পানির সর্বোচ্চ উচ্চতা ২-৪ ফুট বা তার বেশি থাকতে পারে। নেমে যাওয়ার সময় পানির নিম্ন গতির কারনে ক্ষয়ক্ষতিও কম হতে পারে।
হলুদ রঙ - ১ পতাকা 	১	২৪ থেকে ৪৮ ঘণ্টার মধ্যে এলাকার নদী তীরবর্তী কিছু নিচু অঞ্চল ছাড়া অন্যান্য অঞ্চল থেকে পানি নেমে যেতে পারে।
পতাকা নামিয়ে ফেলতে হবে	সংকেত নেই	এলাকার সব অঞ্চল থেকে বন্যার পানি নেমে যেতে পারে।

Fig. 35: Flags showing the warning number and explanation (in Bangla) (Recession stage)

সতর্ক সংকেত	করণীয়সমুহ
৫	আশ্রয়কেন্দ্র বা এলাকার উঁচু স্থানে আশ্রয় নেয়া জনগোষ্ঠীর ঘরে ফিরে যাওয়ার প্রক্রিয়া শুরু করা।
৪	এলাকার যে সমস্ত অঞ্চল থেকে পানি নেমে গেছে সেই সমস্ত অঞ্চলের ক্ষতিগ্রস্ত ঘরবাড়ি মেরামতের কাজ শুরু করা। পানি নেমে যাওয়া অঞ্চলে ব্যাপকভাবে পানি বিশুদ্ধকরন ট্যাবলেট এবং শুকনো খাবারের ব্যবস্থা করা। এলাকার যে সমস্ত ফসলি জমি হতে বন্যার পানি নেমে গেছে সেই সমস্ত জমিতে স্থানীয় কৃষকের অভিজ্ঞতা এবং কৃষি অফিসের পরামর্শ ও সহায়তায় পরবর্তী ফসলের জন্য প্রস্তুতি গ্রহণ করা।
৩	বন্যার পানিতে ক্ষতিগ্রস্ত ঘরবাড়ির মেরামতের কাজ শুরু করা। পানি নেমে যাওয়া অঞ্চলে ব্যাপকভাবে পানি বিশুদ্ধকরন ট্যাবলেট এবং শুকনো খাবারের ব্যবস্থা করা। নিরাপদ স্থানে মজুদ রাখা প্রানিসম্পদ, হাঁস-মুরগি এবং প্রানিখাদ্যের নিরাপত্তা নিশ্চিত করা সাপেক্ষে এগুলোকে যার যার অবস্থানে ফিরিয়ে আনার প্রক্রিয়া শুরু করা। যে সমস্ত ফসলি জমি বন্যা কবলিত হয়েছিল সে সমস্ত জমিতে স্থানীয় কৃষকের অভিজ্ঞতা এবং কৃষি অফিসের পরামর্শ ও সহায়তায় পরবর্তী ফসলের জন্য প্রস্তুতি গ্রহণ করা যেন স্বল্পতম সময়ে পরবর্তী ফসলের চাষ শুরু করা যায়।
১-২	বন্যার পানিতে ক্ষতিগ্রস্ত ঘরবাড়ির মেরামতের কাজ শুরু করা। এলাকায় ব্যাপকভাবে পানি বিশুদ্ধকরন ট্যাবলেট এবং শুকনো খাবারের ব্যবস্থা করা। নিরাপদ স্থানে রাখা প্রয়োজনীয় জিনিসপত্র বিশেষ করে টাকা-পয়সা, জমির দলিল, শিক্ষা সনদ, জাতীয় পরিচয়পত্র ইত্যাদির নিরাপত্তা নিশ্চিত করা সাপেক্ষে এগুলোকে নিজস্ব স্থানে রাখার ব্যবস্থা করা। স্থানীয় কৃষকের অভিজ্ঞতা এবং কৃষি অফিসের পরামর্শ ও সহায়তায় অবিলম্বে পরবর্তী ফসলের চাষ শুরু করা।
সংকেত নেই	এলাকায় অতি দ্রুত পুনর্বাসন এবং পুনর্গঠন কাজ শুরু করা।

Fig. 36: Fig. 37: Instructions to the community (Recession stage)

8 Concluding Remarks

This report demonstrates the background work of the Dynamic Flood Risk Model (DFRM) – the two-dimensional numerical simulation, scenario generation and how hazard and risk information has been generated from these modeling works and the proposed institutional framework of implementation.

The concept of the Dynamic Flood Risk Model (DFRM) is formed to disseminate community-based flood information to enhance community resilience. Therefore, the success of such a technique always depends on the proper dissemination of the information. An institutional framework is also presented including the local volunteers' activity for the flooding of the year 2021. The unit will consist of several volunteer groups. Each group will be formed by three volunteer's one male, one female and one group leader (male/female). For the initial piloting four unions have been selected with the discussion among NRP-DDM, Care-Bangladesh and IWFM-Holokhana, Ramna, Astamir Char and Chikajani. With the increase of water level, the DFRM will show the warning number from 1 to 5. The local volunteers are suggested to display the yellow and red flags according to the warning numbers. The instructions to the local communities are also suggested according to the warning number. It is hoped that this framework will facilitate the administrators and planners to identify areas vulnerable areas and enhance their capability to respond and recover. At the same time, the communities will receive the flood warning for the first time with the proper instructions which will be beneficial to save their lives and livelihoods.

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Annex 1: Training Module

National Resilience Programme (NRP)

Developing Institutional Framework of Flood Preparedness Programme

TRAINING MODULE

May 2021

Institute of Water and Flood Management

Bangladesh University of Engineering and Technology

Introduction

Bangladesh is one of the most vulnerable countries in the world due to hydro-geological and socio-economic factors such as geographical location, topography, extreme climate variability, high population density, poverty and heavy dependency of agriculture on climate. The vulnerability caused by a flood is relatively high as one-fifth to one-third of the country is annually flooded by overflowing rivers during the monsoon. Extreme rainfall within the country also exaggerates the flooding situation during the same period. Though normal floods are considered a blessing for Bangladesh-providing vital moisture and fertility to the soil through alluvial silt deposition in floodplains, moderate to extreme floods are of great concern, as they inundate large areas (more than 60% of the country are inundated in large flood events) and cause widespread damage to crop and properties (Rahman and Salehin 2013; Chowdhury et al. 1997). The socioeconomic impact of floods is profound; the flood-prone zones represent areas with the highest incidence of the extreme poor, and the number of poor living in high flood risk areas is on the rise. To reduce such huge vulnerability of flood in the path of achieving the Sustainable Development Goals (SDGs) by 2030, the Government of Bangladesh under the National Resilience Programme (NRP) of the with the technical assistance of the United Nations Development Programme (UNDP), UN Women and United Nations assigned the Institute of Water and Flood Management (IWFM) BUET to develop a sustainable strategy for community-driven Flood Preparedness Programme (FPP) through inclusive, gender-responsive disaster management. Focusing to build a Flood Resilient Community through enhancing flood early warning and preparedness, improved coping and response mechanisms in line with the changing trends of the flood incidents, this training modue has been prepared for the local community of Jamalpur and Kurigram district. The overall aim of the module is to train the local volunteers about the overall flooding and flood-warning mechanism of Bangladesh, introducing a newly developed decision-support tool named Dynamic Flood Risk Model (DFRM) and clarifying the roles and responsibilities of community volunteers during the flood to reduce the flood hazard and to make the flood resilient community.

Objectives of the module

The overall objective of the module is to train the local community comprehensively with the scientists, key stakeholders, and the community to make a flood-resilient society. The module has also targeted the following objectives to uptake the benefits of the project for society.

i. To establish a comprehensive way with the scientists, key stakeholders, and the community people for understanding the nature of flood and its basic components.

ii. To enhance a proper science communication of the flood hazard maps, land use maps, risk assessment and risk maps with the local volunteers

iii. To institutionalize the knowledge resources from the interpretation mechanism of risk map from the DFRM model developed under this project.

iv. To discuss the role of the volunteers to build a flood-resilient society.

Module One

Understanding the flood of Bangladesh

Introduction

The community-driven Flood Preparedness Programme (FPP) under the National Resilience Programme (NRP) of the Government of Bangladesh has been formulated to build flood resilient communities in selected Upazilas of Jamalpur and Kurigram district. This exercise corroborates bringing science, society and institutions together to deal with the flood risks. To address this issue, the concept of the flood is discussed in Module 1.

Key points: Flood, Inundations, Flood warning system, Flood risk mapping

Session I: Flood of Bangladesh

Facilitators' Guideline

1. Those who will conduct the session will first explain about flood and its definition for the convenience of everyone.
2. Explain the differences between flood and inundation to make them clear about the concept of the flood.
3. It would be more effective to describe the picture, map, and diagram to the volunteers for understanding the differences including the explanation about the factors that influenced the flooding mechanism in Bangladesh.
4. The severity of flooding in Bangladesh needs to be explained through graphs and diagrams which would be effective to local people for understanding the flood variation and history.

Objective

At the end of the session, the participants will be able to learn

- Learn about the concept of floods.
- Be able to understand the flood and inundation and their basic difference.
- Knowledge about the factors that influenced the flooding mechanism in Bangladesh.
- Learn about the factors determining the severity of flooding.

Methods of delivery:

- PowerPoint presentations
- Open or group discussions
- Graphical representation
- Question and answer

Material to be used

Powerpoint projector, Pointer, Flip charts, Permanent markers and/or whiteboard markers, Whiteboard, Ink remover, etc.

Process:

1. The facilitator can begin with a PowerPoint presentation or a poster by defining the "flood" and "inundation".
2. Then the facilitator can explain the differences between the flood and inundation and he/she will discuss in detail by explaining the figure seasonal inundation; the distinction between inundation and flood is linked to damage.
3. After that facilitator will deliver his/her speech about the geographical setting of Bangladesh and the factors that influenced the flooding mechanism in Bangladesh.
4. Finally, the facilitator will discuss in detail the factors determining the severity of flooding including the presentation of various reports.

Duration: 1.5 hr

Key definitions

Flood and inundation

The term ‘inundation’ or ‘flood’ depends on the relative benefits and disbenefits it generates. On an average year, overbank flow from rivers into the (active) floodplains leads to several hydrological or environmental and ecological functions. The seasonal inundation will be termed ‘Flood’ when inundation causes damages to property and crops, disrupts communication and economic activities and brings harmful effects to human beings as well as to flora and fauna.

Flood risk management should thus focus on maximizing the beneficial functions of inundation into the floodplains and at the same time minimizing the damage due to floods. This will warrant a combination of structural and non-structural mitigation measures.

Figure 1: Seasonal inundation; the distinction between inundation and flood is linked to damage

Factors influencing flooding mechanism

Geographical factors

Floods understood as a destructive abundance of water, are generated by the interaction of various processes. As Nied et al. (2013) indicated, physical controlling factors include "hydrological pre-conditions (e.g. soil saturation, snow cover), meteorological conditions (e.g. amount, intensity, and spatial and temporal distribution of precipitation), runoff generation processes as well as river routing (e.g. superposition of flood waves in the main river and its tributaries)". The combination of these factors and their spatial distribution at a regional scale may be important, as flooding can affect many sites simultaneously, whereas other sites remain unaffected (Merz and Blöschl 2008; Nied et al. 2013). Across Europe and Asia, floods have very different characteristics, depending on geography, climate/weather characteristics, and human occupancy (FloodSite 2007). Several geographical and hydro-meteorological factors, as illustrated in Rahman and Salehin (2013), play dominant roles in causing widespread river flooding in Bangladesh.

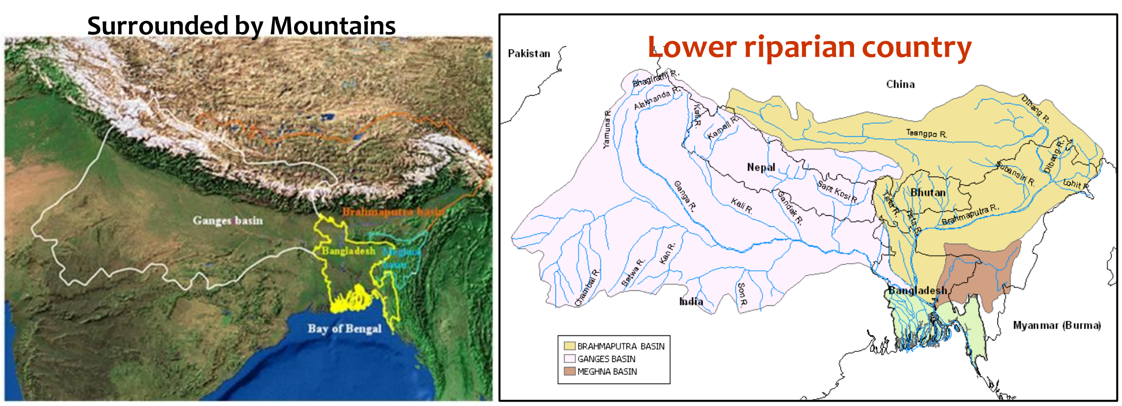

Figure 2: Geographical setting of Bangladesh

- Only 7% of the total area of the three basins lies within Bangladesh
- Excessive rainfall in GBM basins is the principal cause of riverine floods in Bangladesh
- About 1.18 TCM of water flows annually to the sea, of 90% enters Bangladesh from upstream catchments; the rest are contributed by total internal rainfall.

- The major part formed via the deltaic process by alluvial deposits of Ganges and Brahmaputra
- Ganges, Brahmaputra and Meghna along with their distributaries & tributaries formed extensive floodplains
- The major part formed via the deltaic process by alluvial deposits of Ganges and Brahmaputra
- Ganges, Brahmaputra and Meghna along with their distributaries & tributaries formed extensive floodplains

Unique hydro-meteorological system

- Highly skewed temporal variation of rainfall well as wide spatial variation in the three upstream basins as well as within the country play important roles in intensifying floods in Bangladesh
- The three major river systems discharge about 142,000 m3/s into the Bay of Bengal during high-flow periods with Brahmaputra and Ganges carrying about 85% of flood flow inside Bangladesh.
- The combined flows of the three major river systems discharge into the sea through a single outlet, which is the Lower Meghna.
- The coincidence of peak flow of lower Meghna coincides with the spring tide with tidal levels creates severe drainage problems. Monsoon wind set-up also plays a part by raising the sea level, causing further slowing down of passage of flood flow towards the sea.

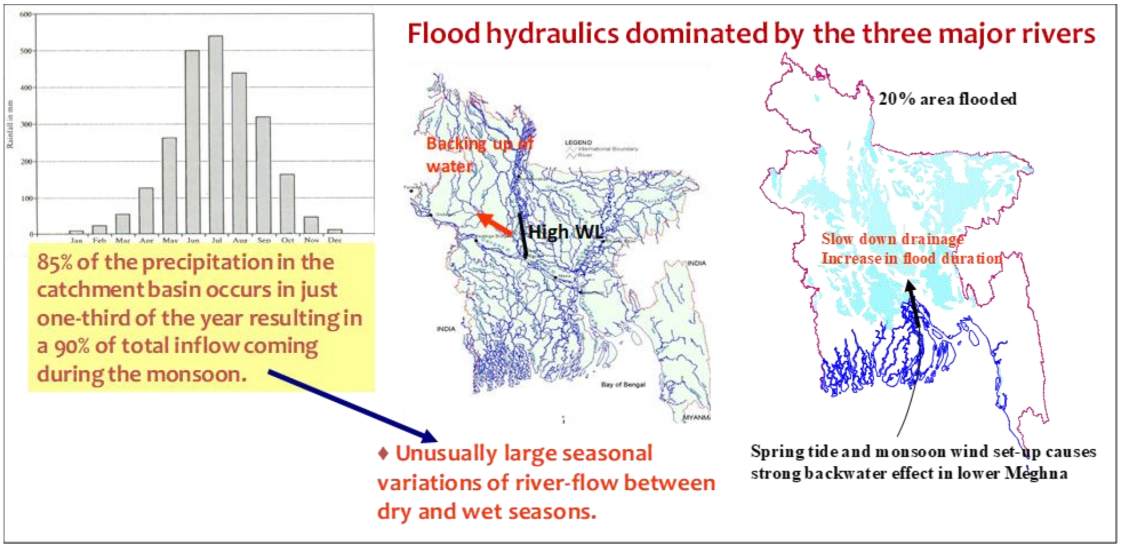

Figure 3: Hydro-meteorological system

Severity of flooding

The characteristics (e.g. area of inundation, depth of inundation, duration of inundation, flood flow velocity, rate of rising of flood, time of occurrence, etc.) of these different types of floods are different and so are their damage potentials under normal and extreme events. For river floods,

- area of inundation – important for all types of floods
- depth of inundation – important for all types of floods
- duration of inundation – important for river flood and rainfall flood
- flood flow velocity – important for flash flood, storm surge
- rate of rise of flood
- time of occurrence

For rainfall floods, depth and duration are important, while depth, duration and velocity may become important parameters for flash floods. However, it should be noted that the relative importance of these parameters on different risk elements also depend on types of elements and their susceptibility to the parameters.

In Bangladesh, the inundation depth has a direct bearing on the extent of flooding. Smaller differences in peaks of major floods can make a big difference in terms of flood affected area, since it is the spreading of floodwater evenly over a wide and flat floodplain that slows down the rate of rising in water levels. Previous studies (e.g. Chowdhury et al. 1997) found that the difference in annual maximum flood levels of different return periods is not large.

Influence on damage

In Bangladesh, the characteristics of flood may affect the damage on various ways such as

- Area-Determines which elements at risk will be affected
- Depth-Strongest influence on the damage
- Duration-Special influence to damage on building fabric
- Velocity-High velocity lead to increased damage
- Rise rate-influence on damage reducing the effects of warning and evacuation
- Time of occurrence-Specially importance of crops
- Floods in June can damage *Aus* and deepwater *Aman* paddy and jute crops
- Floods in July and early August generally do less damage
    - *Aus* and jute on flood-prone land have mainly been harvested
    - Deepwater *Aman* seems to benefit from high water-levels
    - Floods in late August and September can be particularly damaging to crops
    - Deepwater *Aman* can no longer lengthen its stems with rising water-levels
    - Submergence at panicle-initiation/ flowering stages can prevent grain formation

- On higher land, high water levels may drown transplanted *Aman* paddy seedlings or prevent them from being planted (or replanted after an earlier flood loss)

According to the research of Rahman et al. (2014), Bangladesh has experienced seventeen highly damaging floods in the 20th century. Bangladesh has experienced floods of a vast magnitude in 1974, 1984, 1987, 1988, 1998, 2000 & 2004 since its independence in 1971 (FFWC, 2005). The largest recorded flood in depth and duration of flooding in its history occurred in 1998 when about 70% of the country was underwater for several months (FFWC, 2005 & Nishat et al., 2000). Floods that affected more than 20% of the country's land area of the country are presented in Figure 4.

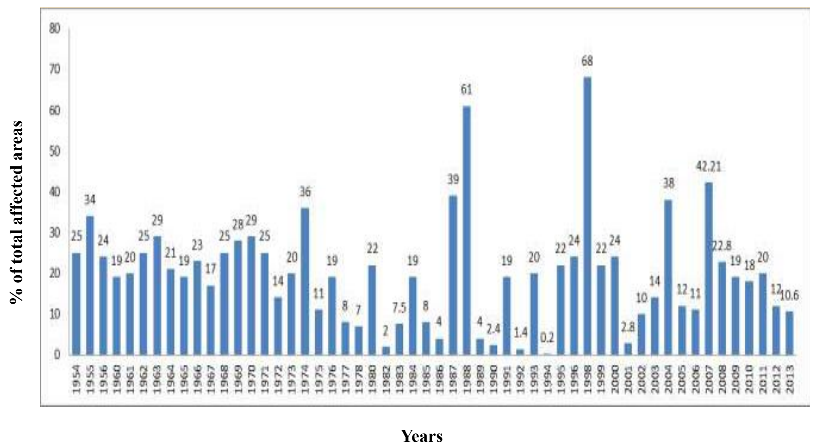

Figure 4: Different floods and their affected area (% of the total area of the country) Source: (MoDMR, 2014)

The crop damage by flood is largely compensated by substantially higher yields due to higher residual moisture available to the following crops. There was substantial damage in 2004 even though the area flooded was much lower (38%) compared to that in 1998 (67%) (Figure 5). The non-agricultural sector suffered the loss for as high as 74% of total loss, with the remaining 26% accrued to agriculture (crop plus non-crop).

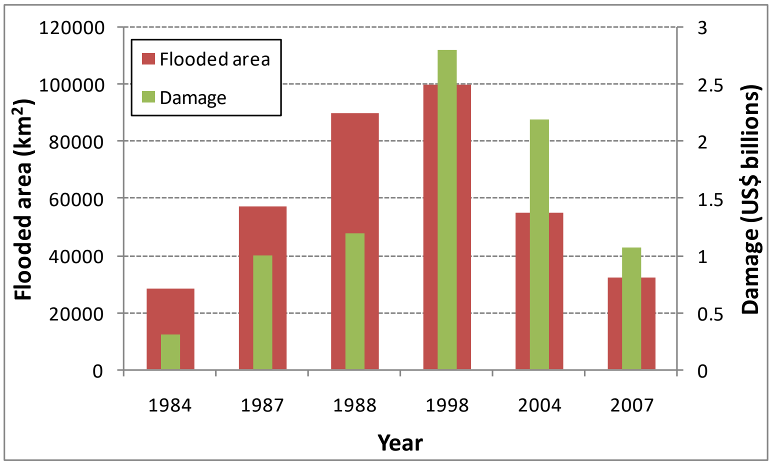

Figure 5: Flood damage during major flood years (Source: Rahman and Salehin 2013)

Session II: Overview of different types of flood and warning system

Facilitators' Guideline

1. Those who will conduct the session will first explain various scientific terms related to floods for the convenience of everyone.
2. Explain the different characteristics and causes of different types of floods to make them easier to understand.
3. The most important thing is that it would be more effective to show the map to the general public so that they can easily understand the type of floods that occur in any part of Bangladesh.
4. The role of flood warning agencies and their limitations needs to be explained, and the reasons why our proposed dissemination method will be more effective need to be explained to everyone present through graphs and flow diagrams.

Objective

At the end of the session, the participants will be able to learn

- Learn about the different types of floods that occur in Bangladesh.
- Be able to get a good idea about the cause of the flood.
- Gain detailed and clear knowledge about the various types of social, economic, and environmental damage caused by floods in Bangladesh.
- Acquire idea about the current flood warning in Bangladesh
- Learn about the problems and limitations of the existing warning signal system
- Get an overview of flood risk modeling

Methods of delivery:

- PowerPoint presentations
- Open or group discussions
- Graphical representation
- Internet browsing

Material to be used

Powerpoint projector, Pointer, Flip charts, Permanent markers and/or whiteboard markers, Whiteboard, Meta cards or sticky notes in different colors, Fixed Markers, Ink remover, Multicolor sign pen, etc.

Process

1. The facilitator can begin with a PowerPoint presentation explaining the “different types of the flood” that usually occur in Bangladesh.
2. The facilitator can then explain the advantages and disadvantages of floods in Bangladesh, and he/she will discuss in detail why different types of floods occur in different parts of Bangladesh.
3. Then the facilitator may ask the participant to list the type of flood they have experienced in their lifetime
4. After that facilitator will deliver his/her speech on the present flood warning system in Bangladesh.
5. In the meantime, the facilitator will brief on the limitations of the current flood warning system and how to overcome them.

6. Finally, the facilitator will discuss in detail the flood risk mapping and how it can reduce flood damage, including the presentation of various reports.

Duration: 1.5 hr

Key Definitions

Types of floods encountered in Bangladesh

Bangladesh generally experiences five types of flood. These are given below;

i. ***River floods:***

- The principal sources of floods are the ***river floods*** from the major river systems in the monsoon months.
- These floods are caused principally by cross-border flows, are the most dominant type, in terms of frequency of occurrence, areal extent, and yearly damage.
- The most destructive river floods occur when the discharge of both the Brahmaputra (June / July) peak and Ganga (August/September) co-inside causing downstream devastation.
- Around 80% of the total flow occurs in the 5 months of monsoon from June to October.

Figure 6: River flood in Bangladesh

ii.***Rainfall floods:***

- Rainfall floods often accompany river floods, which result from runoff of high intensity and long duration rainfalls over Bangladesh itself that cannot be drained because of high outfall water levels.
- About 80% of annual rainfall in Bangladesh occurs from May to September when the rivers flow at a high stage due to the huge inflow of water from catchments outside the country.
- Rainfall floods affect crops in the same way as do river floods in the monsoon.
- The impacts of this type of flood are on the rise because of a change in hydrological regime in the floodplains due to unplanned construction of different types of infrastructures (e.g. roads, bridges, culverts, etc), and flow obstructions on drainage canals by earthen dams.

Figure 7: Rainfall flood in Bangladesh

iii.***Flash Floods:***

- The northern and north-eastern transboundary hill streams are susceptible to flash floods from the adjacent hills in India. Sylhet, Moulvibazar, Sunamganj, Habiganj, Kishoreganj, Netrokona, Rangamati, Bandarban, and Khagrachari are the main flash flood-prone districts.
- In the pre-monsoon months of April and May, flash floods cause extensive damages to dry-season boro rice crop in the haor areas in the northeast region just before or at the time of harvesting crops, as well as to properties and infrastructures.
- Damages to boro rice and breaching of embankments are very common in some part or other of the eastern foothill regions and damages to property, especially road and railway embankments and bridges, and buildings alongside river channels, occur during very high flash floods.
- In the years 2002, 2004, 2007, 2009, 2010 and 2016 flash floods devastated the only winter crop of the northeast Haor region severely.
- Flash flood impacts are not limited to those in the pre-monsoon months as transboundary hilly rivers remain flashy throughout the year. Greater monsoonal

rainfall brings forth higher peaks in water levels, causing widespread flooding. Damages to infrastructure are more pronounced compared to crops during monsoon.

Figure: Flash flood in Bangladesh

iv.***Tidal floods:***

- The areas adjacent to estuaries and tidal rivers in the southwest and south-central parts of the country (where they are not empoldered) experience tidal floods twice a day due to astronomical tide from the Bay of Bengal.
- A considerable area in the southwest region is below the high water level of spring tide.

Figure 8: Tidal flood in Bangladesh

v.***Storm surge flood:***

- The origin and nature of storm surge flooding are distinct from fluvial, tidal and fluvio-tidal flooding.
- Approximately 12,000 sqkm of coastal land is prone to occasional storm-surge floods due to tropical cyclones in the Bay of Bengal from April to June and September to November.
- Cyclones have the most dramatic consequences among the different hazards in Bangladesh.

Figure 9: Storm Surge flood in Bangladesh

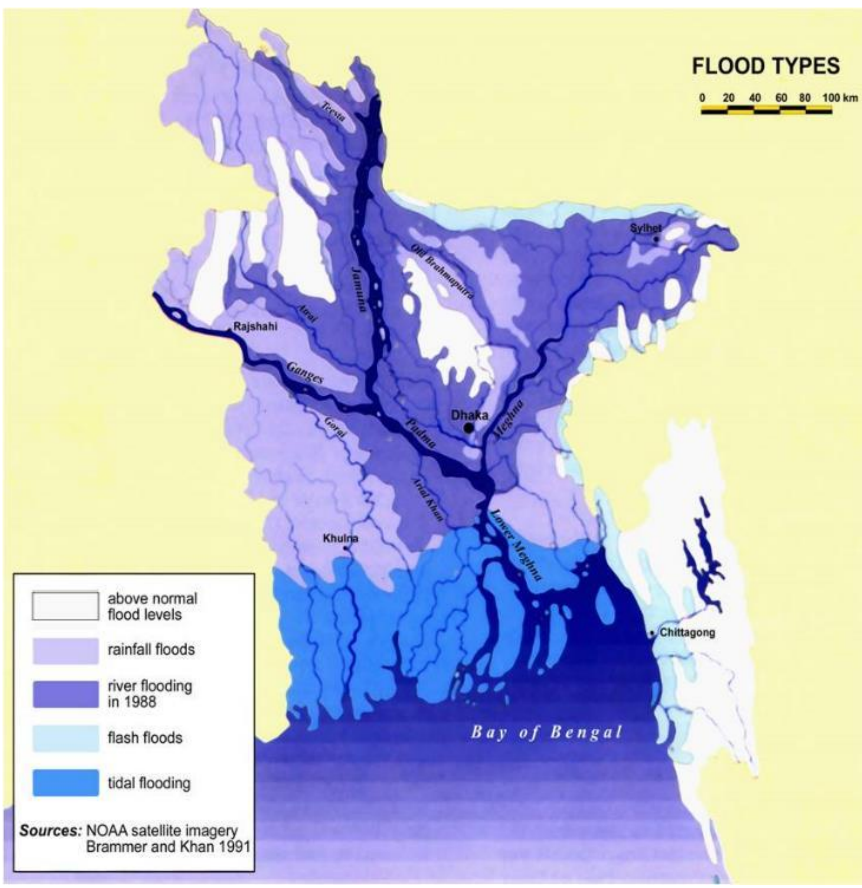

Figure 10**:** Map of flood prone areas in Bangladesh

Overview of present flood warning system

- Flood Forecasting and Warning Center ***(FFWC)*** of the Bangladesh Water Development Board ***(BWDB)*** is the focal institution for flood forecasting in Bangladesh.
- It provides ***daily water level and rainfall situation report*** with forecast bulletins for 24, 48, 72, 96 and 120 hours from April to October every year.
- In this period, the field-level hydrological measurement division works closely with the flood forecasting center to provide observed data.
- The operational flood forecasting system is based on real-time water level data received from available stations in Bangladesh and quantitative precipitation forecasts from numerical weather prediction models provided by the Bangladesh Meteorological Department (BMD).
- The forecasted information is national-level information which is often difficult to understand by the local community.
- Moreover, they circulate only inundation information. But in the case of flood, the risk information is more valuable to the local people.
- Furthermore, the dissemination of FFWC warnings goes from National Disaster Management Committee (DMC) to Union DMC with available media coverage.

Forecast products

- ✓ Daily water level and rainfall situation reports
- ✓ Flood conditions summary (provided both in Bangla and English)
- ✓ Forecast bulletins for 24, 48, 72, 96, and 120 hours

- ✓ Rainfall surface map
- ✓ Flood inundation map
- ✓ Interactive voice response (mobile voice message)
- ✓ Special outlook

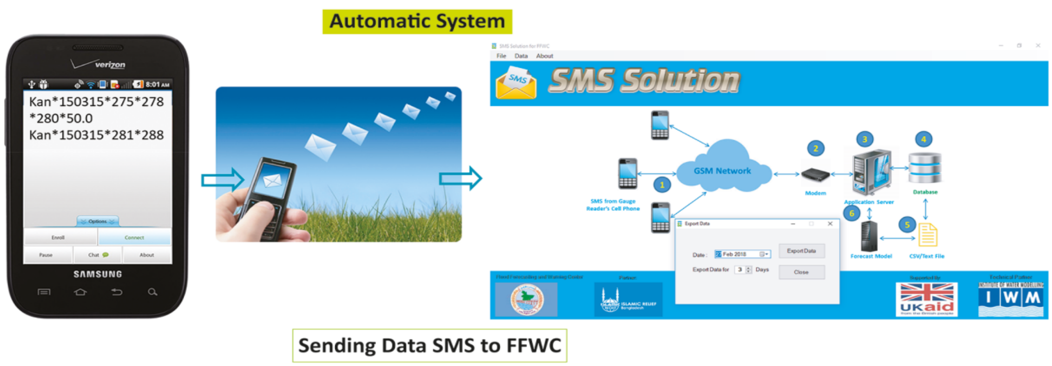

Figure 11: Present Flood Warning and Dissemination process in Bangladesh

Overview of flood risk mapping

A risk map is a special topographic map where the hypothetical flood characteristics are represented graphically. To draw a flood risk map, four phases are usually recognized: hydrologic, geomorphic, and hydraulic and land use. Flood risk maps mean more than just a map for one specific flood event. It is the basic tool and starting point of any regional intervention policy for flood control. Flood risk maps can be used for several purposes.

Importance of flood hazard and risk mapping

- Central to formulating flood mitigation strategies is the preparation of flood hazard and risk maps
- Flood **hazard mapping** is vital for appropriate land use planning; optimal exploitation and management of land and water resources; planning for structural flood mitigation options
- Traditionally, flood policies concentrated on flood control or reduction, i.e. decreasing the probability of occurrence and intensity of floods
- Flood **risk mapping** facilitates to identify areas vulnerable to flood hazard, people, facilities and infrastructures at risk and to what degree they might be affected, and the capability to respond and recover
- It helps in identifying and prioritizing the mitigation and response efforts.
- Identification of those areas at risk of flooding will also help inform emergency responses
  - Will help identify areas that are likely to require evacuation; evacuation routes can be planned
  - Identifying locations of flood shelters for evacuees
  - Will, therefore, allow planners to locate the emergency service facilities (electricity supplies, water supply, etc) in low-risk areas
  - In the longer term, flood hazard and risk maps can support planning and development by identifying high-risk locations and steering development away from these areas.

Module Two

Dynamic Flood Risk Model (DFRM) and Flood Risk Information

Introduction

A community-based early warning system has been proposed by developing the Dynamic Flood Risk Model (DFRM) to increase awareness among the community to monitor flooding events as well as enhance community resilience. The objective of this part is to demonstrate DFRM for Kurigram and Jamalpur Districts which is potentially vulnerable by flood hazard.

Key points

- Dynamic Flood Risk Model (DFRM)
- Early Warning System
- Map Interpretation
- Dissemination Strategy

Session I: Dynamic Flood Risk Model (DFRM)

Facilitators' Guideline

1. Facilitator can divide this module into two sessions;

    a. Introduction to Dynamic Flood Risk Model (DFRM)

    b. Risk, Resource and Evacuation Mapping (R&E)

2. Facilitator may start the session by conducting a Q & A session at first where the facilitator will ask questions from the participants to measure their knowledge of the respective community.

Objective

At the end of the session, participants would be able to learn:

- General overview of Dynamic Flood Risk Model (DFRM)
- How to interpret flood risk map from DFRM results

Methods of delivery:

Training of Volunteers: Discussions and Dynamic Flood Risk Model (DFRM) live presentations to explain the process, the importance of the tools, which can be used in conducting the Risk, Resource and Evacuation mapping exercise.

Material to be used

- Laptop/Desktop Computer
- Projector
- Dynamic Flood Risk Model
- Internet Connection

Process:

1. Facilitator can inaugurate the session with a PowerPoint presentation explaining what "DFRM" is, how DFRM is developed and why DFRM is necessary.

2. Facilitator can show the process of extracting flood risk map from DFRM by entering the FFWC's WL data.

3. Facilitator can then disseminate the flood risk map and interpret the results of flood risk map.

Duration: 1.5 hr

Overview of Dynamic Flood Risk Model (DFRM)

What is DFRM?

- Dynamic Flood Risk Model (DFRM) is an area-specific flood risk model which generates local flood event data (inundation area, depth, velocity, duration and damage) using the FFWC forecasted information.
- Flood risk mapping facilitates the administrators and planners to identify areas vulnerable to flood hazards and to what degree they might be affected, and the capability to respond and recover.
- Flood risk areas will help in the location of flood shelters for evacuees and in the longer term, flood hazard and risk maps can support planning and development by identifying high-risk locations and steering development away from these areas.
- The main purpose of the model is to refine the FFWC warning and generate the community level flood inundation, hazard, and risk map (Figure 12).

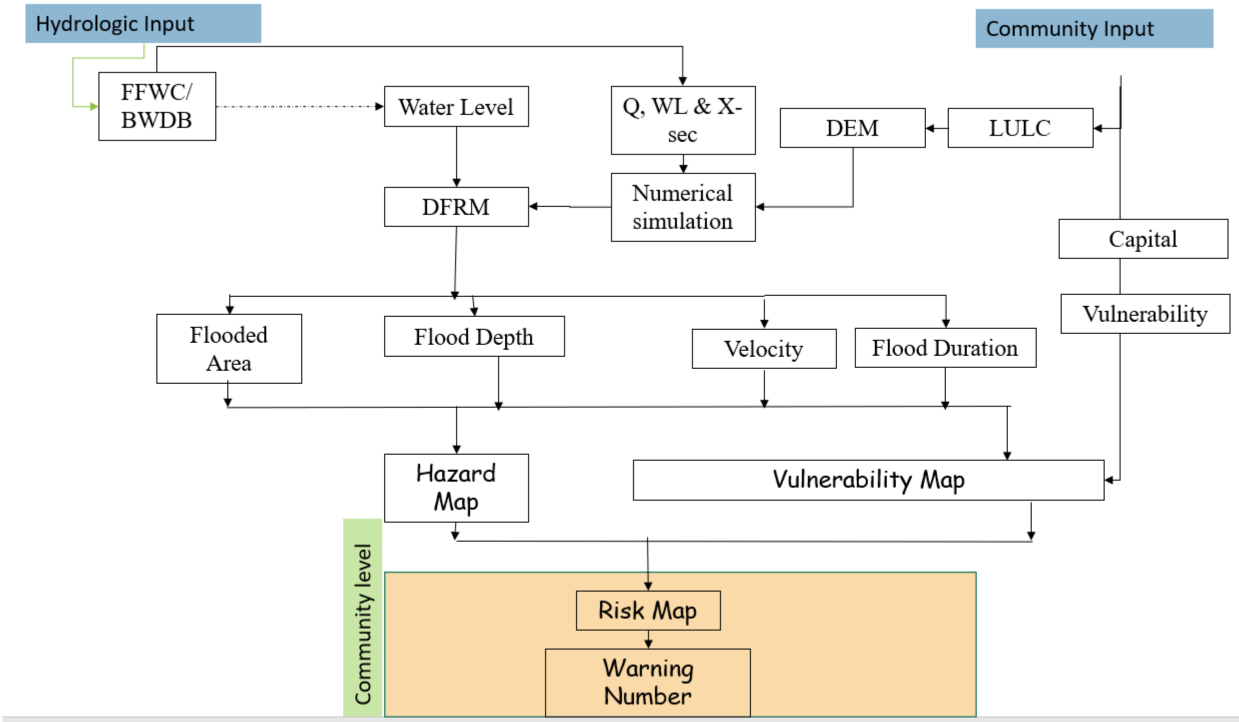

Figure 12: Schematization of Dynamic flood risk model (DFRM)

Working Principle of DFRM

- ✓ *Generation of the model grid and bathymetry*: Latest bathymetry (the year 2020) of BWDB and topographic data (satellite image- SRTM) is considered to generate the model grid and bathymetry (Figure 13). The model area consists of the whole Brahmaputra-Jamuna River and part of Dudhkumar, Dharla, Teesta and Old Brahmaputra rivers comprising 246 Km long with an average width of 33 Km. The total area has been divided into 127x893 cells curvilinear grids to perform the 2D hydrodynamic simulation.

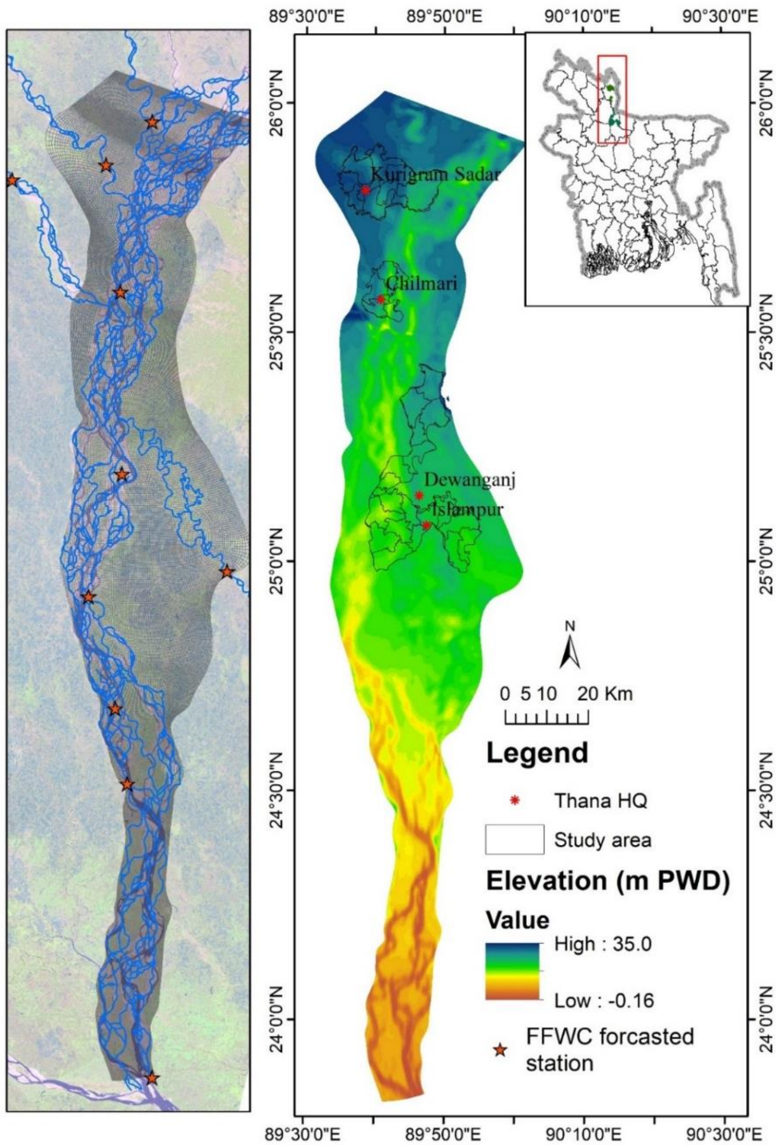

Figure 13: The Grid (left) and bathymetry (right) of the model

- ✓ *Scenario generation*: Nearly 60 scenarios have been generated from the available time-series data (mean daily) of discharge and water level of BWDB considering the hydraulic condition of the rivers from 1956 to 2020. The observed/generated discharge data of Brahmaputra-Jamuna, Teesta, Dharla, and Dudhkumar River are considered as the upstream boundary condition. At the same time observed/generated water level of Brahmaputra-Jamuana (Aricha), Old Brahmaputra (Jamalpur), Jhenai (Juker char) are considered as the downstream boundary condition.

- *Extract simulation results*: From the simulation results the information of hazards such as the area of inundation, depth of inundation, duration of inundation and blood flow velocity has been extracted in all scenarios.
- *Generation of flood risk map:* Every year from the FFWC prediction of WL, algorithms has been developed to find out the closest scenario and risk produced by that scenario will be circulated to the local people.

Mapping Capital

- Capital mapping is to show the strength of a village to combat hazards. However, the capital of a village has been shown from five different perspectives. These are human, social, physical, financial and natural capital.
- Indicators have been selected for all type of capitals those enrich the asset. For example, human capital has five indicators (literate People, employed people, male: female, capable people, people access to tubewell).
- Data of all the indicators have been used as a percentage. Then all the indicator values for a specific type of capital have been summed up with calculated weight for finding the total value of capital. This weight has been calculated applying Analytical Hierarchy Process (AHP). The result has been shown in the map through ArcGIS. In the following map, human capital has been shown in the union level firstly. Then two unions have been detailed to village level.

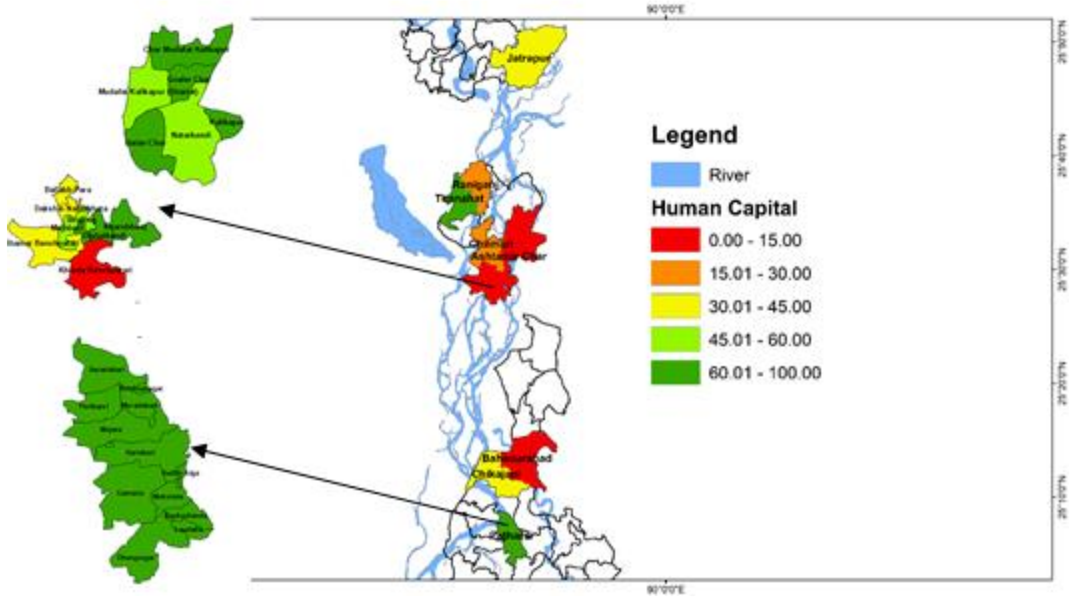

Figure 14: Human Capital Mapping of union and village level;

- ✓ Again, five capital values those were found out in the previous steps, have been weighted summed to get the final capital value. Here, weight has been calculated through AHP.

Mapping Vulnerability

Sustainable livelihood Framework links capital or assets and vulnerability context. This framework explains assets or capital will increase the income thus strengthen the livelihood. Where vulnerability context decreases the income in both individual and combined cases. So, these two components are just opposite.

Vulnerability has been also shown in different five perspectives as human, social, physical, financial and natural. Vulnerability of a specific context has been found simply by subtracting the value of that capital from 100. The following equation can explain it very well,

Human vulnerability = 100 – Human capital

Similarly, total vulnerability has been computed by subtracting the value of total capital from 100 as before.

Mapping flood hazard

- ✓ Information of hazards such as the area of inundation, depth of inundation, duration of inundation and flood flow velocity has been extracted in all scenarios for 365 days from the model. (An example is shown in Figure 15.)

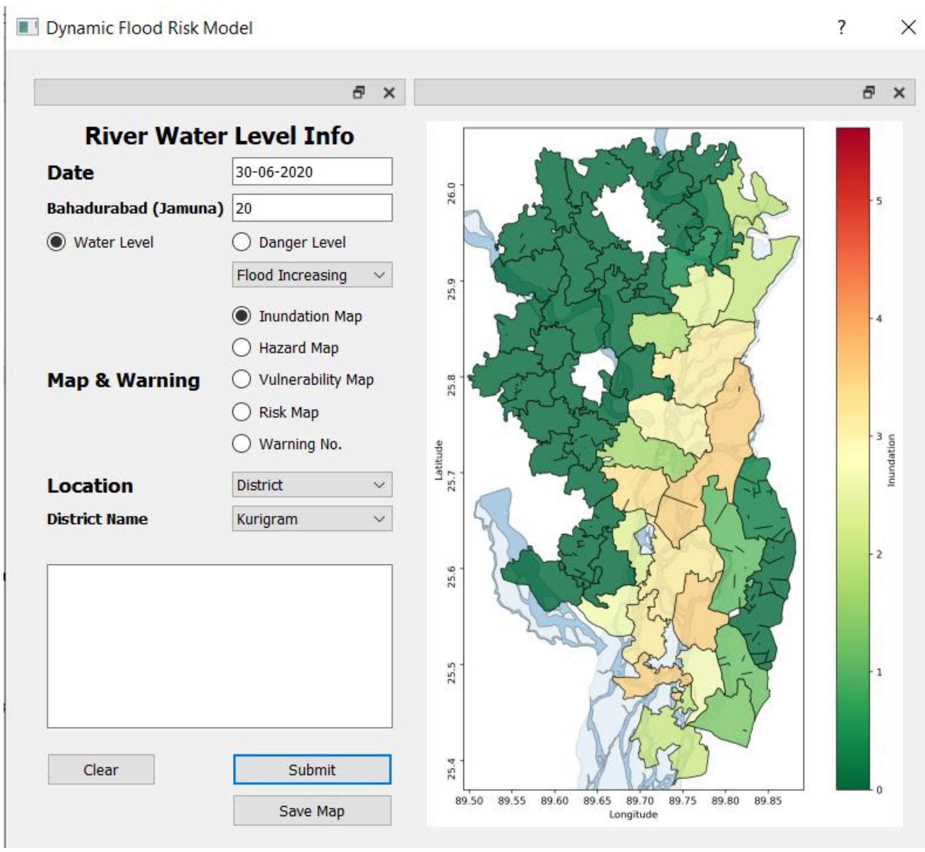

Figure 15: Flood inundation map of the study area

Hazard is classified between 0 to 100. 0 means low to no hazard where 100 elucidates extreme hazard. An example of such hazard map is shown in Figure 15.

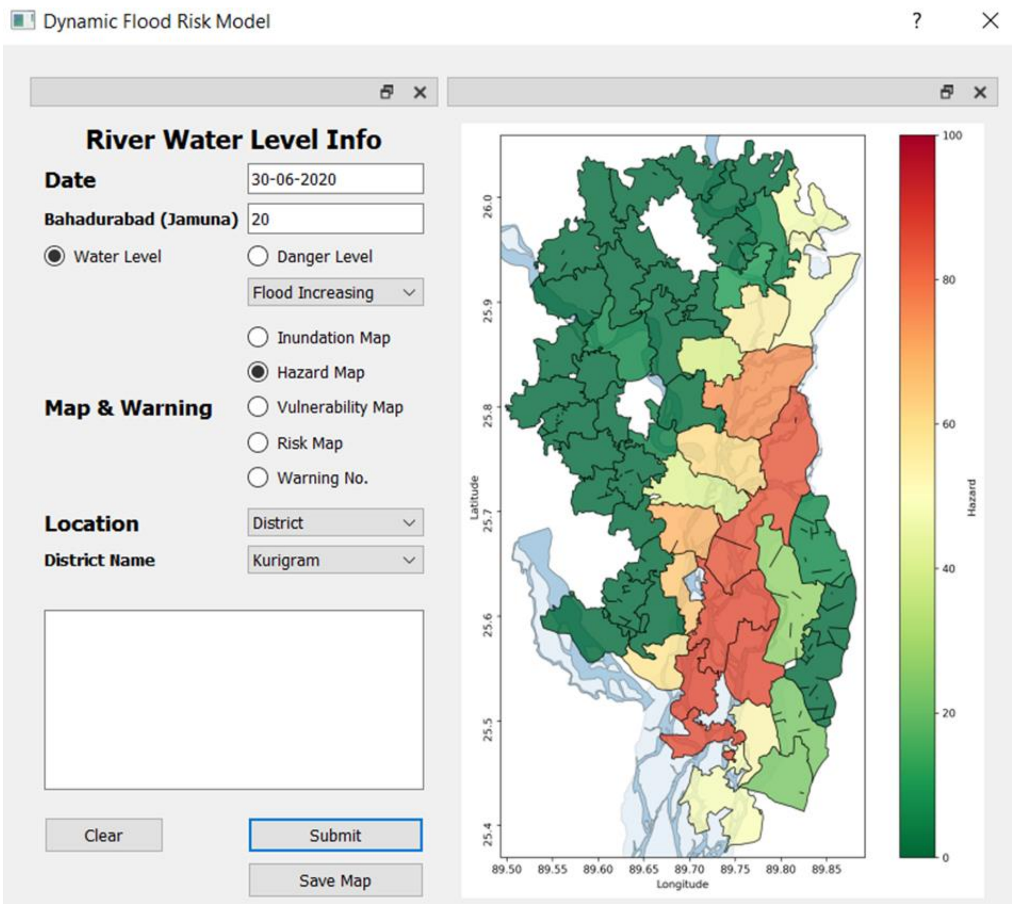

Figure 16: An example of a flood hazard map on 14 June 1998

Flood risk assessment and mapping

According to IPCC AR5, the risk is a multiplicative function (non-linear combination) of hazard, exposure of human and natural systems and vulnerability (eq. 1) (shown in Figure 16) where vulnerability is computed from five various capitals; physical capital, natural capital, human capital, social capital and financial capital (eq. 2). Here, Capitals are calculated from a linear combination (weighted sum) of socio-economic adaptations shown in Figure 17 and the Hazard component is also computed form the linear combination (weighted sum) of water depth, flood velocity and flood duration The relative weighted scores are calculated by using PCA. PCA gives a correlation matrix that identifies the principal component for a system. Pearson correlation coefficient was used to find the weights of the parameters that describe how much an indicator can explain a component vector.

$$Risk = Hazard * Exposure * Vulnerability \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

and

$$Vulnerability = 100\% - Capital(in\ percentage) \ \ldots\ldots\ldots\ldots\ldots\ldots\ (2)$$

An example of typical Hazard and Risk produced by DFRM is shown in Figure 18.

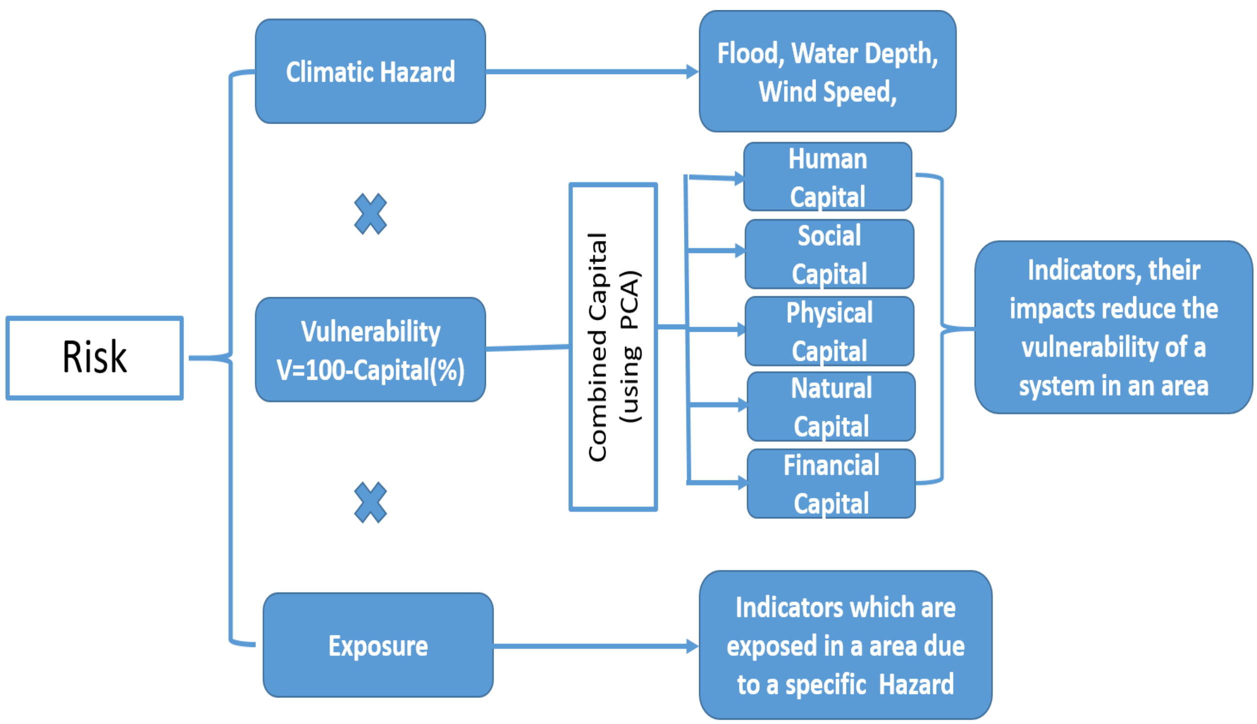

Figure 17: Risk Assessment

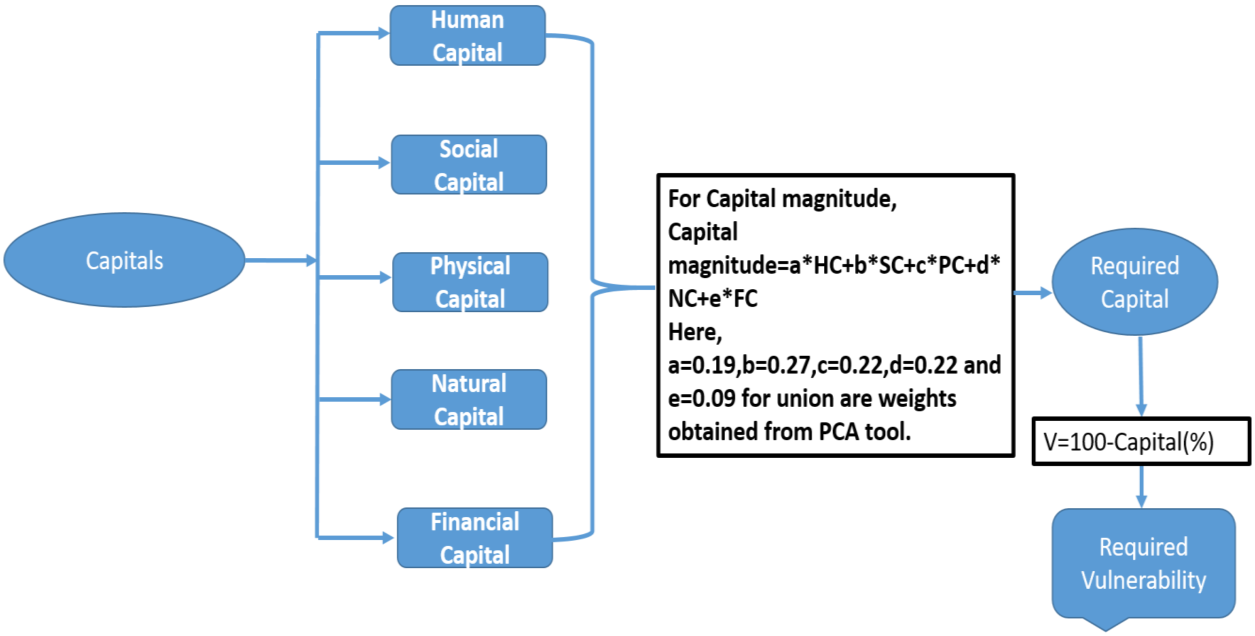

Figure 18: Capital and Vulnerability assessment

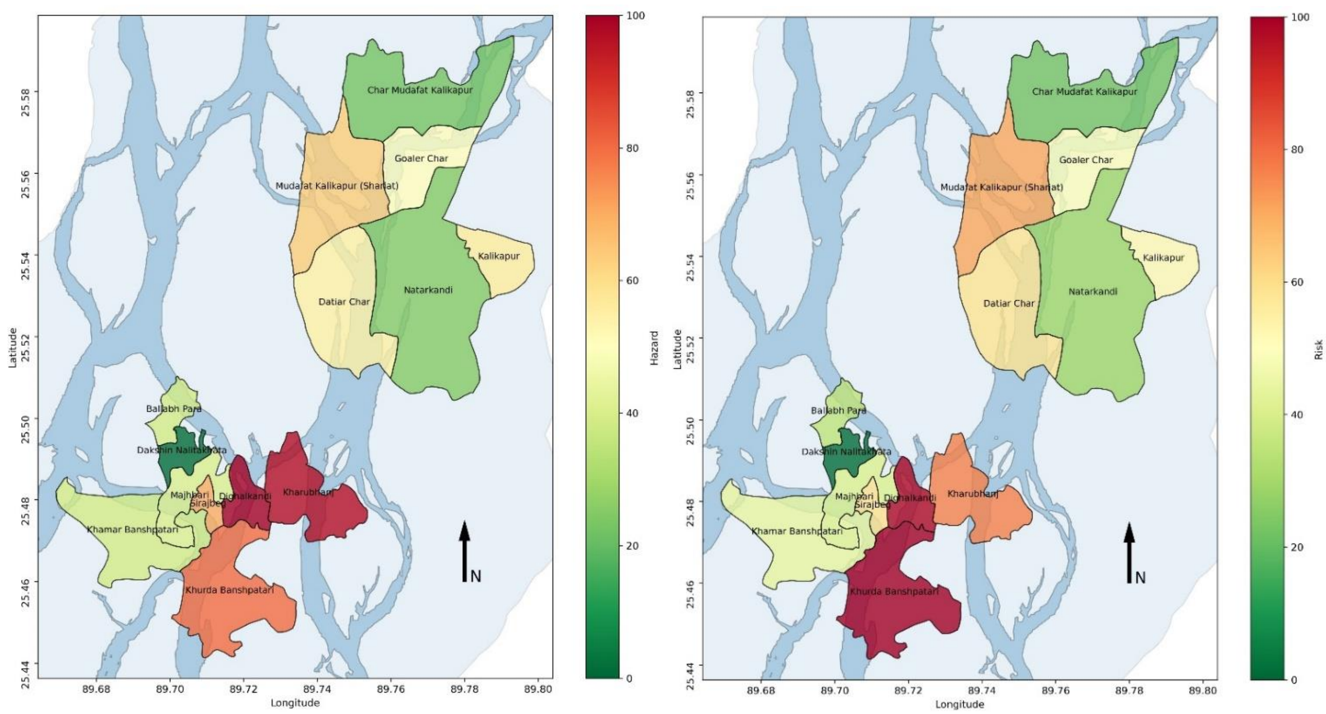

Figure 19: An example of typical Hazard (left) and Risk (right) produced by DFRM

DFRM interface

- ✓ In the DFRM model, the user should provide the real-time water level of Bahdurabad point which is forecasted by FFWC. The model will load the water level of Dudhkumar, Dharla and Tessta automatically.
- ✓ Then select desired District and Upazilla from the drop-down box and select map type.
- ✓ Then click submit button to view desired map (Figure 19)

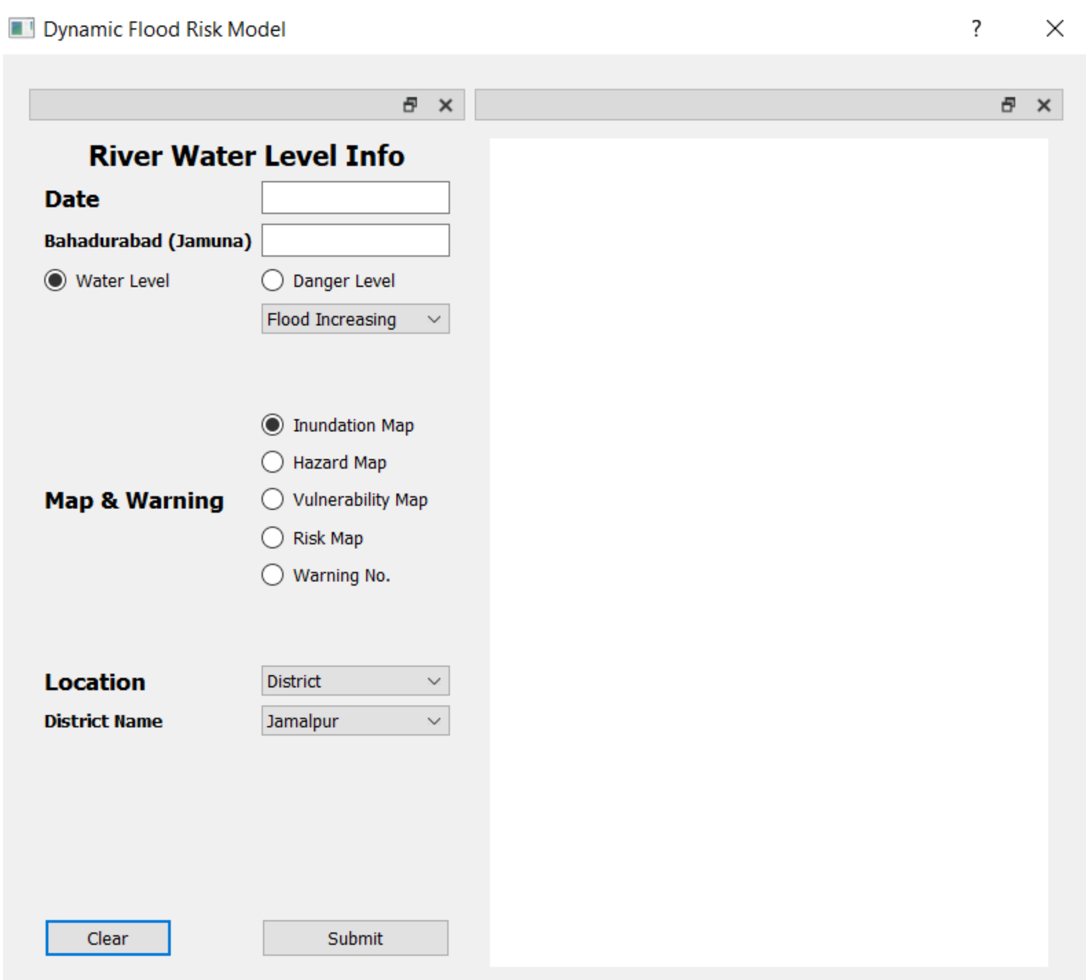

Figure 20: Dynamic Flood Risk Model (DFRM) Interface

Flood Warning

- Warning of a village is made based on risk of the village, here, risk of a village consists of various kind of floods and human and natural vulnerability of that village.
- Warning is categorized into 5 modules: Warning 1, Warning 2, Warning 3, Warning 4, Warning 5. The explanation for each warning is shown in Table 1.
- Warning 5 indicates the extreme damages on life and livelihood corresponding flooding depth, with high velocity and longer duration, while Warning 1 represents the least amount of damages with the smallest velocity as well as lower flooding depth and duration.
- Flooding depth, velocity and duration for the same warning vary from village to village.
- Besides according to char and inland, flooding depth, velocity and duration for the same warning will be different.

Table 11: Explanation corresponding to each warning.

Session II: Flood risk information dissemination strategy

Facilitators' Guideline

- ✓ The facilitator should ask the existing practice of flood risk information dissemination strategy to the community people/volunteers.
- ✓ Facilitators should maintain proper documentation of participants' views in the flip chart and Projector.
- ✓ The facilitator team will share expert's views on the above concept and make the easiest concept for better understanding through using references.

Objective

At end of this session, participants will be able

- ✓ To understand the systematic process of Flood risk information dissemination strategy.
- ✓ To learn the preliminary role of the volunteers during a flood event.

Methods of delivery:

- PowerPoint presentations
- Open or group discussions
- Internet browsing

Material to be used

Powerpoint, Multi-Media Projector, Pointer, Laptop, Whiteboard, Permanent markers and/or whiteboard markers in several different colors, Ink remover, Multicolor sign pen etc

Process

- ✓ Facilitator can begin with a PowerPoint presentation to explaining what is "Flood risk information dissemination strategy"
- ✓ Facilitator can explain why need to proper design of flood risk information dissemination strategy and its importance.
- ✓ Facilitator can also explain "what is the role of different organization in flood warning dissemination system?"
- ✓ Open Discussion

Duration: 1.5 hr

Definitions

Existing flood risk information dissemination strategy

- ➢ Flood Forecasting and Warning Center (FFWC) of Bangladesh Water Development Board (BWDB) is the focal institution for flood forecasting in Bangladesh which provides daily water level and rainfall situation report with forecast bulletins for 24, 48, 72, 96 and 120 hours from April to October every year.
- ➢ The operational flood forecasting system is based on real-time water level data received from available stations in Bangladesh and quantitative precipitation forecasts from numerical weather prediction models provided by the Bangladesh Meteorological Department (BMD).
- ➢ The forecasted information is national-level information generated in terms of '*danger level* 'often difficult to understand by the local community. Furthermore, there is *no hazard or risk-related information*.

- The dissemination of FFWC warnings goes from National Disaster Management Committee (DMC) to Union DMC with available media coverage.

Newly developed flood risk information dissemination strategy

- The newly developed flood risk information (generated by DFRM) dissemination strategy will follow the existing dissemination process at the same time the community level, under the Union DMC, a new local community unit is proposed (shown in Figure 17).

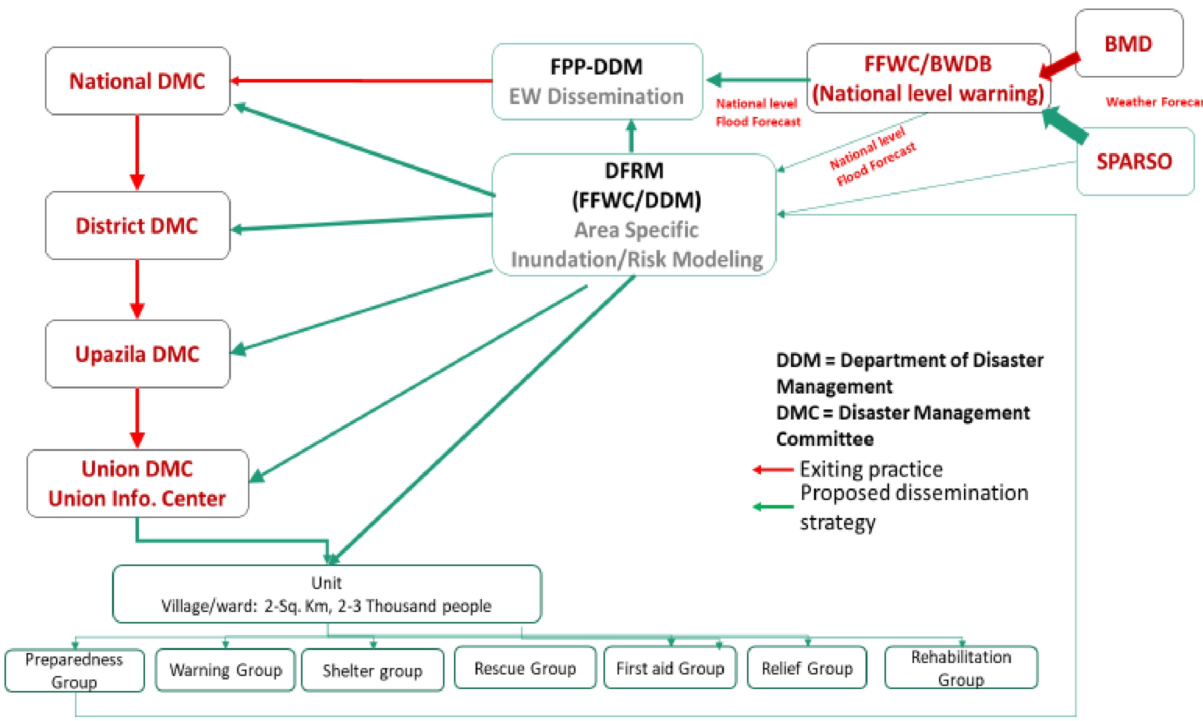

Figure 21: Expected flood forecast information dissemination strategy

- The unit will consist of several volunteers groups supposed to work into 7 sub-units such as- Preparedness Group, Warning Group, Shelter group, Rescue Group, First aid Group, Relief Group, and Rehabilitation Group.

- Each group will be formed by three volunteer's one male, one female and one group leader (male/female).
- The number of volunteers should be sufficient to cover 2 sq. km, providing service to 2-3 thousand people.

Role of the volunteers

Volunteers play a significant role in disaster management. From the beginning to the end of disasters as well as in normal times, the volunteers will have to follow certain strategies and programs to build a resilient society.

Preparedness Group

- 'Preparedness Group' members will distribute leaflets, announce through the mike, arrange community meetings, and arrange theatre for increasing awareness among the community.
- As a part of disaster preparedness, volunteers & other volunteer organization will motivate the community to store dry food such as; Rice, Puffed Rice, Chirra etc and that will ensure food security immediately after the disaster.
- To solve the problem of cooking Portable Chula is one of the options. The volunteers will take the initiatives to make the community knowledgeable about making Portable Chula so that during a disaster they can take this with them in a safe place or after disaster within a short time they can make it to continue their cooking.

- During and after the disaster, health issue becomes worst in some areas. Volunteers will operate awareness-raising programs especially on the Primary Health Care (PHC) and health problems due to disaster, shelter center and training issues so that the health and disease condition does not deteriorate during the disaster period.

Warning Group

- ‘Warning Group’ will keep close contact with the union disaster management committees who will circulate DFRM generated risk information and with the help of the media will disseminate the early warning and flood risk-related information.
- They will manage to circulate the alert through an announcement from the mosque, miking and community radio if available.
- Female volunteers will motivate and warning the females in the community to reduce the damages and losses during the flood, so they are more vulnerable.

Shelter Group

- ‘Shelter group’ will work to motivate the community to go to the flood shelter in proper time and will confirm the hygiene, safety-security of the flood shelter.
- They will ensure social security to the female persons and motivate them to stay in the shelter during the flood.

Rescue Group

- During and post-flood time ‘rescue group’ should act proactively to rescue the injured and persons with disabilities.
- This group of volunteers should be made arrangements for the burial of dead people and animals.

First Aid Group

- During and after the disaster, health issue becomes worst in some areas.
- This group will operate an awareness-raising program especially on Primary Health Care (PHC) and health problems due to disaster.
- During and post-flood time ‘first-aid group’ should act proactively to provide the first-aid to the injured people and guide them to go to the nearest health centre.

Relief Group

- This group of volunteers will develop a “Relief Distribution Chart” for the affected community by using their resources and morality and from time to time they should update it.
- The chart will incorporate the need assessment and situation of relief distribution in the affected community.
- The developed chart should be available in all volunteer units, Union Parishad, Upazilas and Districts.

Rehabilitation Group

- This group will play the biggest role in making the affected people work in a new way through motivational training and activities in livelihood, housing, relief and food, health and disease, and education sector.
- ‘Rehabilitation group’ should also arrange recovery therapy for mentally injured people.

Acknowledgment

The authors acknowledge the role of BWDB, CPP and JST-JICA funded ‘Disaster Prevention/Mitigation Measures against Floods and Storm Surges in Bangladesh’ project of BUET for preparing the document.

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Annex 2: DFRM ব্যবহারের নির্দেশিকা এবং

বন্যা বিপদ সংকেত অনুসারে জনসাধারণের জন্য কর্ম পরিকল্পনা

DFRM কি ?

DFRM হচ্ছে একটি মডেল যেটা দিয়ে আমরা গ্রাম, ইউনিয়ন, উপজেলা এবং জেলা পর্যায়ে বন্যা সতর্ক সংকেত প্রকাশ করতে পারি।

বন্যা সতর্ক সংকেত ছাড়াও DFRM দিয়ে যা যা দেখা যাবে:

১। বন্যার পানির গভীরতার মানচিত্র
২। বন্যার দুর্যোগের মানচিত্র
৩। বন্যা দুর্যোগপ্রবণ জনগোষ্ঠীর আর্থসামাজিক অবস্থার মানচিত্র
৪। বন্যা ঝুঁকি প্রবন অঞ্চলের মানচিত্র

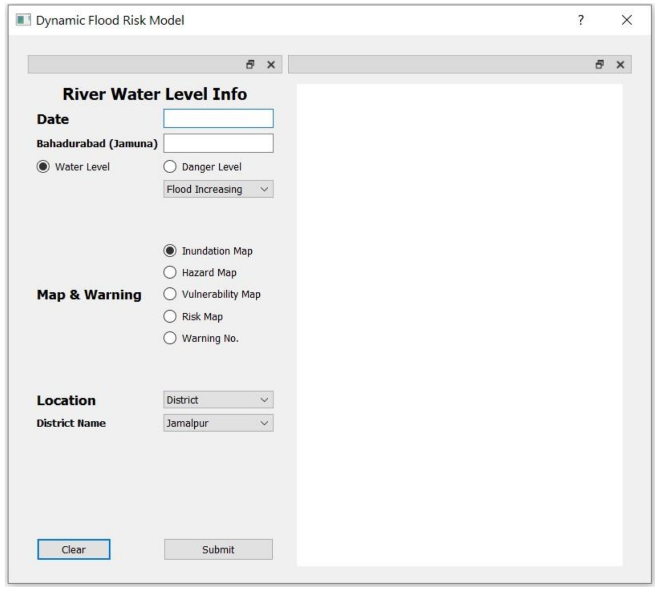
DFRM ব্যবহারের জন্য আমার কি কি থাকতে হবে?

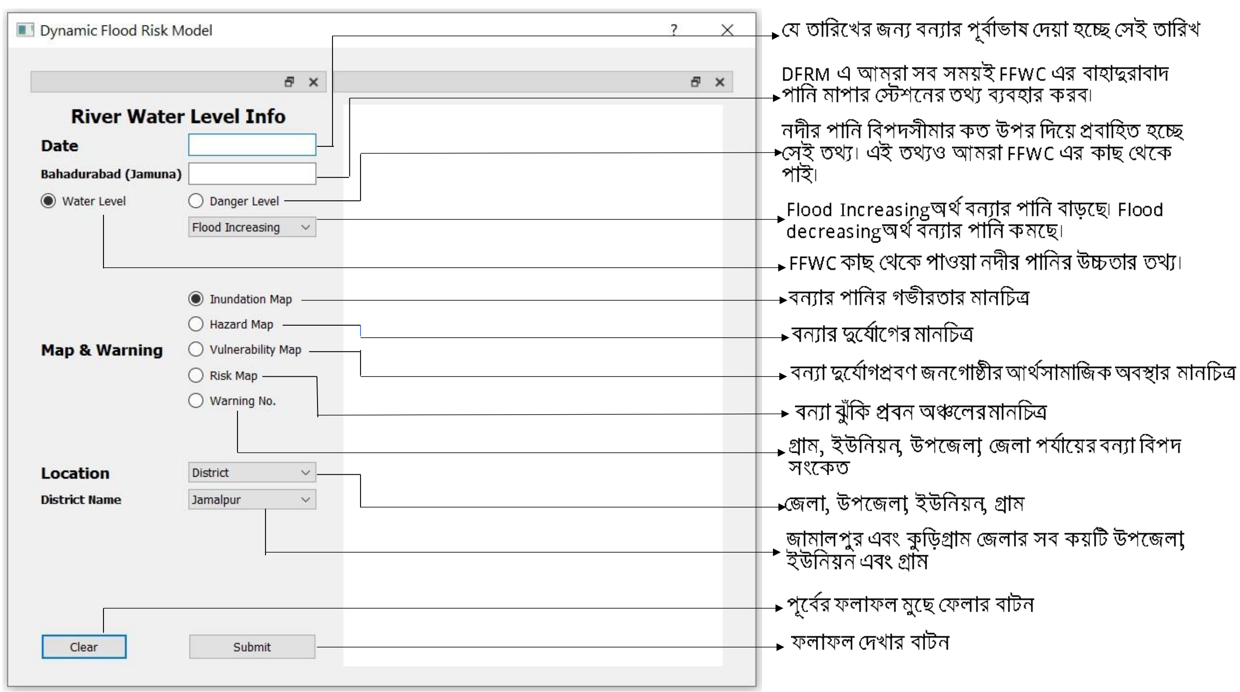
১। ল্যাপটপ কম্পিউটার অথবা
২। স্মার্ট ফোন

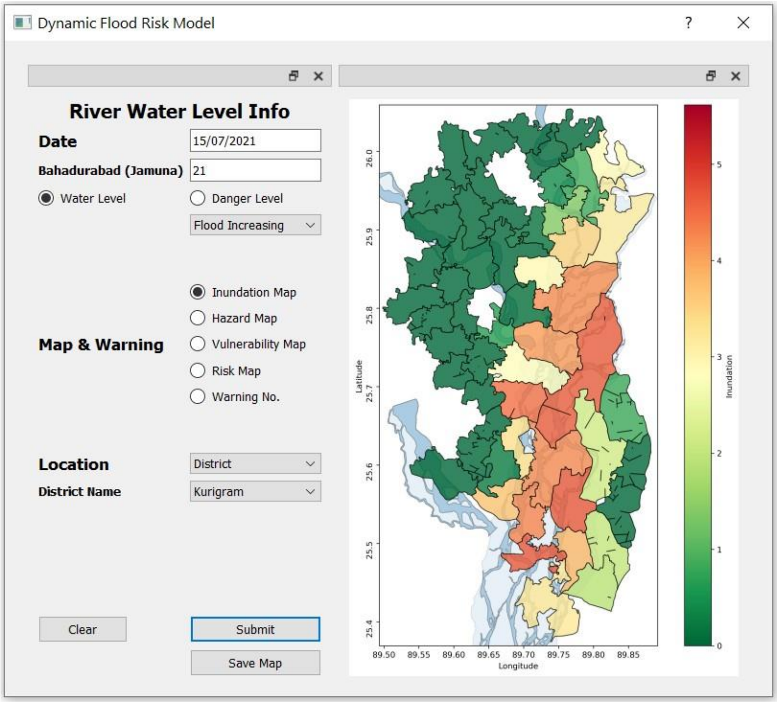
DFRM কিভাবে operate করব ?

ল্যাপটপ কম্পিউটার বা স্মার্ট ফোনের DFRM নামের APP এ ক্লিক করলেই DFRM চালু হয়ে যাবে।

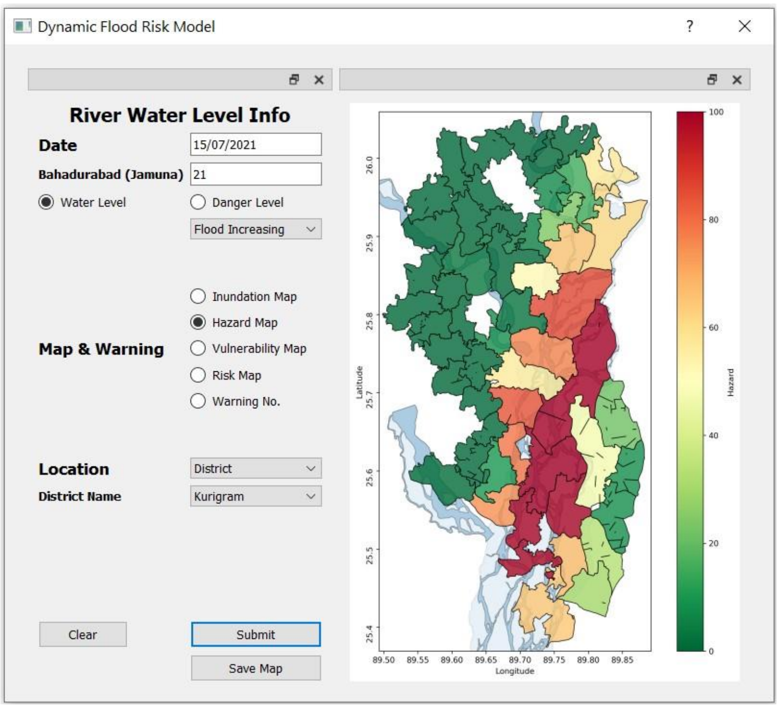
DFRM চালু হওয়ার পর যা দেখা যাবে



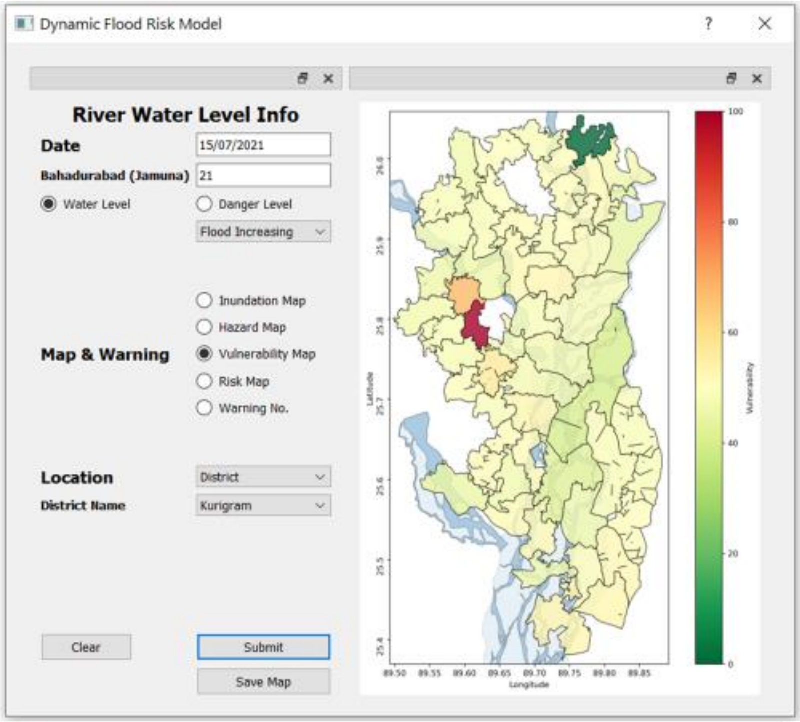




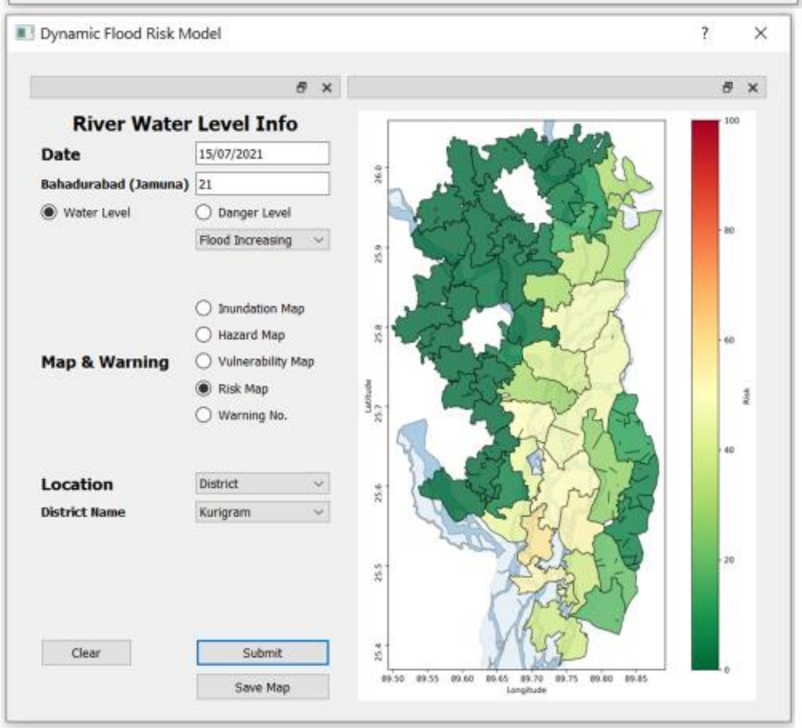
বন্যার পানির গভীরতার মানচিত্র



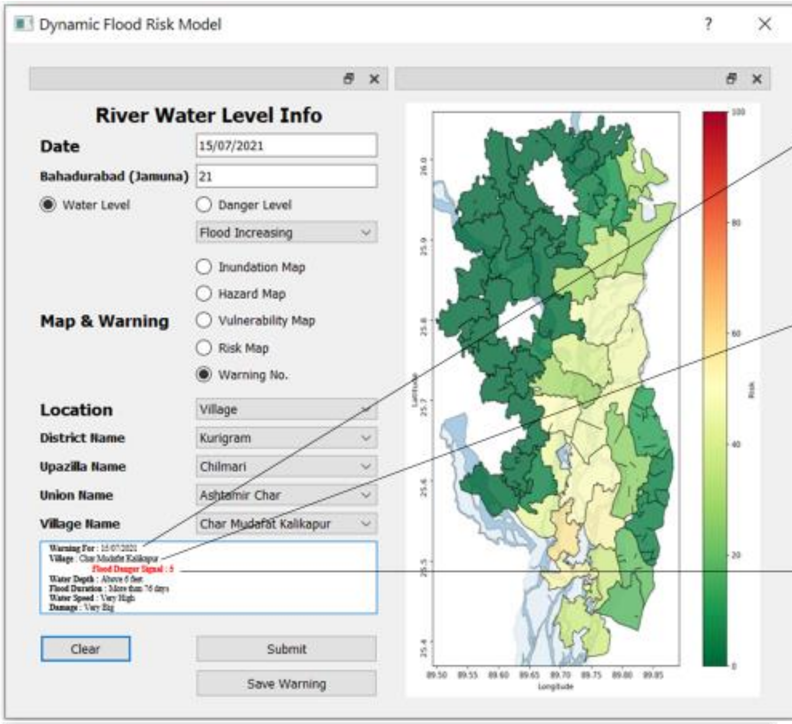
বন্যার দুর্যোগের মানচিত্র



বন্যা দুর্যোগপ্রবণ জনগোষ্ঠীর আর্থসামাজিক অবস্থার মানচিত্র



বন্যা ঝুঁকি প্রবন অঞ্চলের মানচিত্র

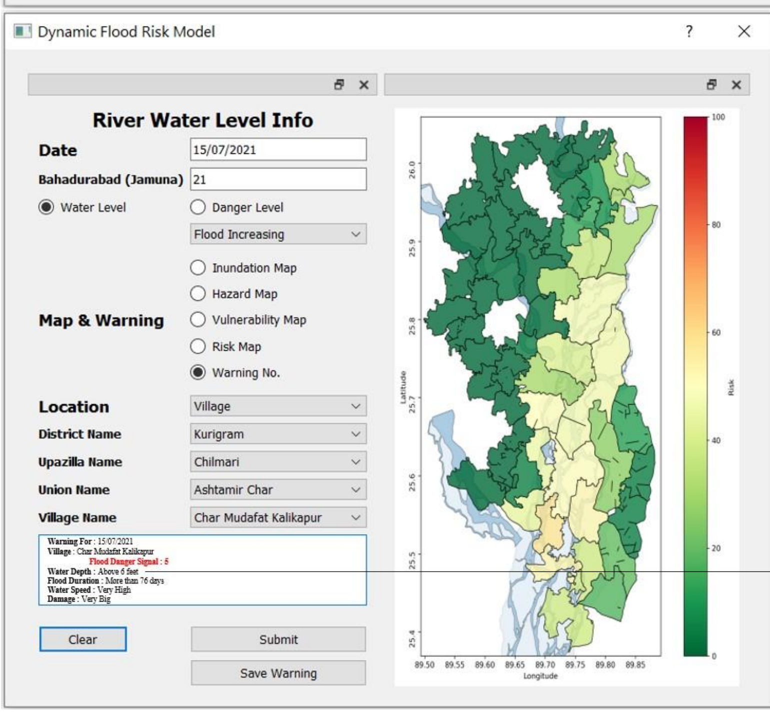


বন্যা বিপদ সংকেত

বন্যার বিপদ সংকেত ৫ দিন আগে দেয়া হবে। তার মানে 15/07/2021তারিখের জন্য যে বিপদ সংকেত দেয়া হল, সেটি প্রচার করা হবে ৫ দিন আগে 10/07/2021 তারিখে।

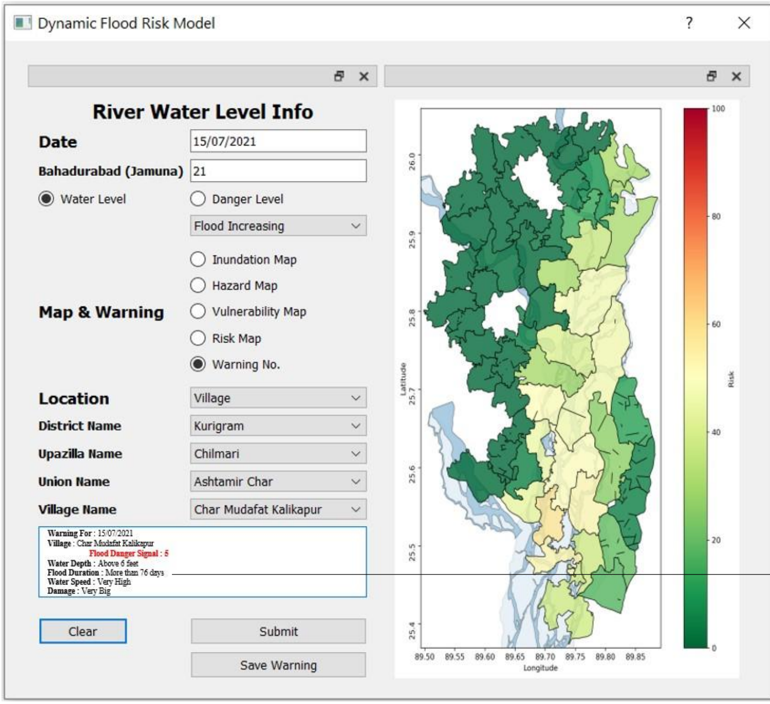
DFRM দিয়ে বন্যা বিপদ সংকেত জেলা, উপজেলা, ইউনিয়ন, গ্রাম - এই সব পর্যায়েই দেখা যাবে।

বন্যার মোট ৫ টি বিপদ সংকেত দেয়া হবে। কোন একটি স্থানের বন্যা ঝুঁকি বাড়ার সাথে সাথে বিপদ সংকেত বাড়তে থাকবে। বিপদ সংকেত গুলো হল : (1) Flood Danger Signal No:1 (2) Flood Danger Signal No:2 (3) Flood Danger Signal No:3 (4) Flood Danger Signal No :4 (5) Flood Danger Signal No :5



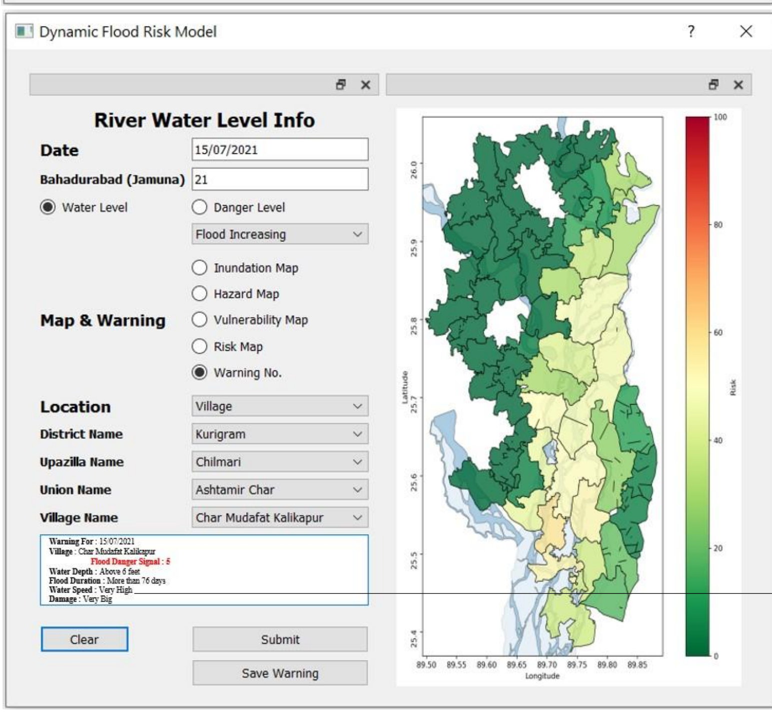
বন্যাবিপদসংকেত

- বন্যার পানির গভীরতা মাপা হয়েছে স্থানীয় ভূমি হতে।
- যেমন এখানে দেখা যাচ্ছে চর মুদাফাত কালিকাপুর গ্রামের জন্য বন্যার পানির গভীরতা ৬ ফুট। এর মানে হচ্ছে এই গ্রামের ভূমির যে কোন স্থানে বন্যার পানির গভীরতা হবে গড়ে ৬ ফুট। যদি গ্রামের কোন একটি বাড়ির ভিটের উচ্চতা ভূমি থেকে ৫ ফুটও হয়, তাহলেও ওই বাড়িটি বন্যার পানিতে ডুবে যাবে।
- এই গভীরতা হচ্ছে গড় গভীরতা। তার মানে চর মুদাফাত কালিকাপুর গ্রামে ৫ নম্বর বিপদ সংকেতের জন্য বন্যার পানির গভীরতা কোথাও কোথাও ৬ ফুটের বেশি এবং কোথাও কোথাও ৬ ফুটের কম হবে।



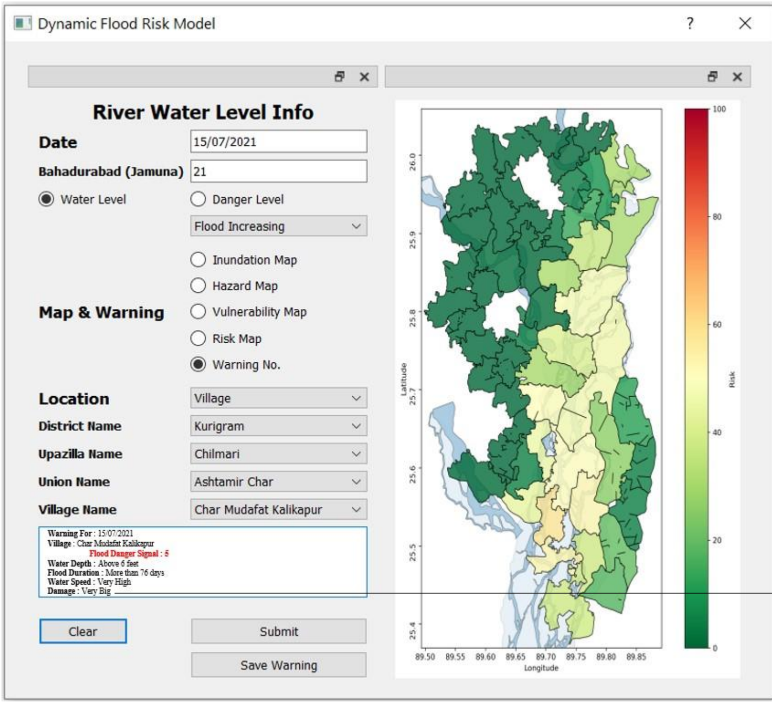
বন্যা বিপদ সংকেত

- বন্যার পানির স্থায়িত্ব বলতে এখানে বুঝানো হচ্ছে নদীর পানি লোকালয়ে প্রবেশ করা থেকে পানি নেমে যাওয়ার সময় পর্যন্ত।
- বন্যার পানি কতটা দ্রুত বা ধীরে নামবে সেটা নির্ভর করে নদীর পানির উচ্চতা, পানি নামার গতি, নদী থেকে লোকালয়ের দূরত্ব, লোকালয়ের ভূমির উচ্চতা ইত্যাদি।
- লোকালয়ে বন্যার পানি সাধারণত খুব দ্রুত প্রবেশ করে এবং খুব ধীরে নেমে যায়। সেই হিসেবে বন্যার বিপদ সংকেত খুব দ্রুত বাড়লেও নেমে যায় ধীরে ধীরে।
- পানি নামার এই গতি লোকালয়ের বিভিন্ন যায়গায় বিভিন্ন হবে। যেমন উঁচু জায়গা থেকে পানি দ্রুত নামবে, নিচু জায়গা থেকে ধীরে নামবে।



বন্যা বিপদ সংকেত

- স্থানীয়ভাবে অনেক লোকালয়ে বন্যার পানির গতি ‘পানির ধার’ হিসেবে পরিচিত।
- এখানে পানির গতিকে তার ক্ষতিকর ক্ষমতা অনুসারে পাঁচ ভাগে ভাগ করা হয়েছে। গতির তীব্রতা অনুসারে ভাগগুলো হচ্ছে (1) Very Low (2) Low (3) Medium (4) High (5) Very High ।
- সাধারণত পানির গতি বাড়ার সাথে সাথে বন্যার বিপদ সংকেত বাড়তে থাকবে।
- যেখানে বেশি গভীরতার (Water Depth) তীব্র গতির পানি (Water Speed) বেশিদিন (Flood Duration) থাকবে, সেখানে বন্যার দুর্যোগও (Hazard) বেশি হবে।



বন্যা বিপদ সংকেত

- এখানে ক্ষয়ক্ষতির সম্ভাবনা হিসেব করা হয়েছে বন্যার ঝুঁকির মাত্রা অনুসারে।
- কোন স্থানের বন্যার ঝুঁকি নির্ভর করে ওই স্থানের বন্যার দুর্যোগের তীব্রতা এবং দুর্যোগপ্রবণ জনগোষ্ঠীর আর্থসামাজিক অবস্থার উপর।
- যেখানে স্থানীয় দুর্যোগপ্রবণ জনগোষ্ঠীর আর্থসামাজিক অবস্থা খারাপ এবং বন্যার দুর্যোগ বেশি, সেখানে বন্যার ঝুঁকিও বেশি এবং সেখানে বন্যার ক্ষয়ক্ষতির সম্ভাবনাও বেশি।
- সেই হিসেবে বন্যার ক্ষয়ক্ষতির সম্ভাবনাকে ৫ ভাগে ভাগ করা হয়েছে (1) Very Small (2) Small (3) Medium (4) Big (5) Very Big ।
- এখানে ক্ষয়ক্ষতির আওতায় ঘর-গৃহস্থালী হতে জমির ফসল সবকিছুই থাকবে।

ভলান্টিয়ারদের গ্রুপ

এলাকাবাসীর মাঝে বন্যা বিপদ সংকেত প্রচার, বিপদ সংকেতের ব্যাখ্যা, বিপদ সংকেত অনুসারে কর্ম পরিকল্পনা বাস্তবায়ন এবং প্রয়োজনে এলাকাবাসীকে আশ্রয়কেন্দ্রে নেয়ার জন্য ভলান্টিয়ারদের দুইটি গ্রুপ কাজ করবে। এই দুইটি গ্রুপ হচ্ছে:

১। ওয়ার্নিং গ্রুপ

২। শেল্টার গ্রুপ

ওয়ার্নিং গ্রুপ

ওয়ার্নিং গ্রুপের কাজে শারীরিক পরিশ্রম কম হবে। এই গ্রুপ নীচের কাজগুলো করবে

১। বন্যার ৫ টি বিপদ সংকেত (যখন যেটা দেয়া হবে) তা এলাকাবাসীর কাছে পৌঁছে দেয়া।

২। বিপদ সংকেত পৌঁছে দেয়ার সময় প্রতিটি বিপদ সংকেতের বিস্তারিত ব্যাখ্যা দেয়া।

৩। প্রতিটি বিপদ সংকেতের জন্য যে কর্ম পরিকল্পনা রয়েছে তার বাস্তবায়ন নিশ্চিত করা।

শেল্টার গ্রুপ

শেল্টার গ্রুপের কাজে শারীরিক পরিশ্রম বেশি হবে। এই গ্রুপ নীচের কাজগুলো করবে

১। বন্যার বিপদ সংকেত অনুসারে পতাকা উত্তোলন করা।

২। প্রতিটি বিপদ সংকেতের জন্য যে কর্ম পরিকল্পনা রয়েছে তার বাস্তবায়ন নিশ্চিত করা।

৩। এলাকাবাসীকে আশ্রয়কেন্দ্রে যাওয়ার ব্যাপারে সাহায্য করা।

এলাকাবাসীরকাছেবন্যারবিপদসংকেতপ্রচারকরা

স্মার্ট ফোন অথবা SMS এর মাধ্যমে বন্যার বিপদ সংকেত পাওয়ার পর ভলান্টিয়ারদের শেল্টার গ্রুপের মাধ্যমে এলাকাবাসী বন্যার বিপদ সংকেত জানতে পারবে।

শেল্টারগ্রুপ

- স্থানীয়ভাবে যদি কোন মোবাইল টাওয়ার থাকে, তাহলে সেই টাওয়ারে বিপদ সংকেতের নম্বর অনুসারে পতাকা উত্তোলন করা যেতে পারে। যেমন ৫ নম্বর বিপদ সকেতের ক্ষেত্রে ৫ টি, ৪ নম্বরের ক্ষেত্রে ৪ টি, ৩ নম্বরের ক্ষেত্রে ৩ টি, ২ নম্বরের ক্ষেত্রে ২ টি এবং ১ নম্বরের ক্ষেত্রে ১ টি লাল পতাকা উত্তোলন করা যেতে পারে।
- স্থানীয় হাট-বাজার এবং অন্যান্য জায়গা, যেখানে গন জমায়েত হয়, সেখানে পতাকা উত্তোলন করা যেতে পারে।
- যদি পতাকা উত্তোলনের কোন জায়গা পাওয়া না যায়, তবে স্থানীয় মসজিদের মাইক ব্যবহার করে বিপদ সংকেতের নম্বর প্রচার করা যেতে পারে।

বন্যাবিপদসংকেতঅনুসারেজনসাধারণেরজন্য কর্ম পরিকল্পনা

বন্যার পানি বাড়ার সাথে সাথে বিপদ সংকেত বাড়তে থাকবে। আবার বন্যার পানি কমার সাথে সাথে বিপদ সংকেত কমতে থাকবে।

বন্যার পানি বাড়ার সময় জনসাধারণেরজন্য কর্ম পরিকল্পনা

বিপদ সংকেত ১ এর জন্য কর্ম পরিকল্পনা

ওয়ার্নিংগ্রুপের জন্য করনীয়

- এলাকাবাসীকে বিপদ সংকেত ১ এর অর্থ বুঝিয়ে বলা এবং এটাও বলা এই বিপদ সংকেত বাড়তে পারে। কাজেই বন্যা মোকাবেলার প্রস্তুতি এখনি শুরু করতে হবে।
- শুকনা খাবারের প্রয়োজনীয় মজুদ তৈরি করা।
- বিশুদ্ধ খাবার পানির প্রয়োজনীয় সংগ্রহ গড়ে তোলা যেন বন্যার সম্পূর্ণ সময় খাবার পানির সংকট না হয়।
- পানি বিশুদ্ধকরণ ট্যাবলেট , ওরস্যালাইনের প্যাকেট , অন্যান্য প্রয়োজনীয় জরুরী ঔষধ যেমন প্যারাসিটামল তৈরি রাখা।
- ঘরের চারপাশে পোকামাকড় মারার ওষুধ / কার্বব্লালিক এসিড / কার্বনিল এসিড ছিটিয়ে দেয়া।
- টাকা, দলিল, প্রয়োজনীয় কাগজপত্রসহ অন্যান্য প্রয়োজনীয় জিনিস পলিথিনে মুড়ে ঘরের নিরাপদ যায়গায় রাখার ব্যবস্থা করা।
- এলাকাবাসীকে বলা যে ১ নম্বর বিপদ সংকেতের পর হঠাৎ করেই বন্যার পানি বাড়তে শুরু করতে পারে এবং সর্বোচ্চ বিপদ সংকেত ৫ এ উন্নীত হতে পারে।

বন্যাবিপদসংকেতঅনুসারেজনসাধারণেরজন্য কর্মপরিকল্পনা

বিপদ সংকেত ১ এর জন্য কর্মপরিকল্পনা

শেল্টারগ্রুপের জন্য করনীয়

- বন্যার সময় যাতায়াতের জন্য প্রয়োজনীয় সংখ্যক ভেলা তৈরি করা।
- নলকূপের মুখ পলিথিন দিয়ে শক্ত করে বেঁধে দেয়া যেন বন্যার পানি নলকূপের ভিতরে প্রবেশ করতে না পারে।
- বাড়ির পায়খানাটি উঁচু স্থানে আছে কিনা নিশ্চিত করা। না থাকলে জরুরী ভিত্তিতে এর ব্যবস্থা করা।
- ঘরের ভিতর উঁচু মাচা বানানো যেখানে বন্যার পানি ঘরে প্রবেশ করলে পরিবারের সবাই আশ্রয় নিতে পারে।
- পশু খাদ্যের প্রয়োজনীয় সংগ্রহ নিশ্চিত করা যেন বন্যার সম্পূর্ণ সময়ে পশু খাদ্যের সংকট না হয়।
- গবাদি পশুর আশ্রয়ের জন্য এলাকার আশে পাশে উঁচু জায়গা ঠিক করা। সংগৃহীত পশুখাদ্য এই এলাকার কাছাকাছি মজুদ করা ।
- পুকুরের পাড় উঁচু করা যেন বন্যার পানি পুকুরে প্রবেশ করতে না পারে।
- যেখানে সম্ভব, জমির ফসল ঘরে তুলে ফেলা এবং নিরাপদ যায়গায় সংরক্ষণ করা।
- উঁচু শিক্ষা প্রতিষ্ঠানকে আশ্রয়কেন্দ্রে রূপান্তরের প্রয়োজনীয় ব্যবস্থা গ্রহণ করা।

বন্যাবিপদসংকেতঅনুসারেজনসাধারণেরজন্য কর্মপরিকল্পনা

বিপদ সংকেত ২ এর জন্য কর্মপরিকল্পনা

ওয়ার্নিংগ্রুপের জন্য করনীয়

- এলাকাবাসীকে বিপদ সংকেত ২ এর অর্থ বুঝিয়ে বলা। সাথে এটাও বলা যে যদিও এই বিপদ সংকেতে বন্যার পানির গভীরতা, বন্যার স্থায়িত্ব, পানির গতিবেগ, বন্যার সম্ভাব্য ক্ষতি - সব কিছুই কম, তবে খুব দ্রুতই এই অবস্থার অবনতি হতে পারে। কাজেই যে কর্ম পরিকল্পনা দেয়া হয়েছে, তা অবশ্যিই বাস্তবায়ন করতে হবে।

ওয়ার্নিংএবং শেল্টারগ্রুপের জন্য করনীয়

- বিপদ সংকেত ১ এর কর্ম পরিকল্পনার বাস্তবায়ন নিশ্চিত করা।

বিপদ সংকেত ৩ এর জন্য কর্মপরিকল্পনা

ওয়ার্নিংগ্রুপের জন্য করনীয়

- এলাকাবাসীকে বিপদ সংকেত ৩ এর অর্থ বুঝিয়ে বলা। এলাকাবাসীকে সতর্ক করা যে বন্যা এখন যে অবস্থায় আছে সেই অবস্থায় থাকলেও তা বেশ দীর্ঘ হতে পারে। এখন যে গভীরতার পানি আছে তা মাঝারি গতিবেগে দীর্ঘ দিন থাকলে সম্পদের বেশ ক্ষতি হবে। কাজেই অবশ্যই সবাইকে কর্ম পরিকল্পনা অনুসারে কাজ করতে হবে।

ওয়ার্নিংএবং শেল্টারগ্রুপের জন্য করনীয়

- ঘরে ঘরে যেয়ে নিশ্চিত হওয়া যে বিপদ সংকেত ১ এর কর্ম পরিকল্পনা অনুসারে এলাকাবাসী বন্যার মোকাবেলা করছে।

বন্যাবিপদসংকেতঅনুসারেজনসাধারণেরজন্য কর্ম পরিকল্পনা

বিপদ সংকেত ৪ এর জন্য কর্ম পরিকল্পনা

ওয়ার্নিংগ্রুপের জন্য করনীয়

- এলাকাবাসীকে বিপদ সংকেত ৪ এর অর্থ বুঝিয়ে বলা। বিপদ সংকেত ৪ এর অর্থ বন্যা বেশ বিপদজনক অবস্থায় পৌঁছে গেছে। আগামী ৫ দিনে পানির যে গভীরতা হবে তার গতিবেগ হবে বেশি এবং তা বেশ অনেক দিন স্থায়ী হবে। এর ফলে এলাকার নিচু অঞ্চলে যারা আছে, তাদের এখনি আশ্রয়কেন্দ্রে যাওয়ার প্রস্তুতি নেয়া প্রয়োজন। তাদের নিজেদের বাড়িঘরে থাকা এখন আর নিরাপদ নয় এবং এর ফলে তাদের সাথে থাকা সম্পদের বেশ বড় ধরনের ক্ষয়ক্ষতি হতে পারে।
- এলাকাবাসীকে আশ্রয়কেন্দ্রে যাওয়ার প্রস্তুতি গ্রহণ করতে বলা। শুধু মাত্র যে সমস্ত বসতি এলাকার নিচু যায়গায় অবস্থিত এবং ইতিমধ্যে প্লাবিত হয়েছে, সেই সমস্ত বাড়ি ঘরের বাসিন্দাদের অগ্রাধিকারের ভিত্তিতে আশ্রয়কেন্দ্রে যাওয়ার জন্য প্রস্তুত করা। আশ্রয়কেন্দ্রে যাওয়ার প্রস্তুতি হিসেবে গৃহস্থদের সাথে থাকা সম্পদ যেমন প্রয়োজনীয় টাকা, দলিল, ইতিমধ্যে জমাকৃত শুকনা খাবার, খাবার পানি, ঔষধ ইত্যাদি নিজের সাথে নেয়ার ব্যাপারে সাহায্য করা। গৃহস্থদের এই মর্মে আসস্ত করা যে তাদের অনুপস্থিতিতে তাদের বাড়ির নিরাপত্তা স্থানীয় স্বেচ্ছাসেবকরা নিশ্চিত করবে।

শেল্টারগ্রুপের জন্য করনীয়

- আশ্রয়কেন্দ্রগুলিকে এলাকাবাসীর জন্য সম্পূর্ণ প্রস্তুত করা।

বন্যাবিপদসংকেতঅনুসারেজনসাধারণেরজন্য কর্ম পরিকল্পনা

বিপদ সংকেত ৫ এর জন্য কর্ম পরিকল্পনা

ওয়ার্নিংগ্রুপের জন্য করনীয়

- এলাকাবাসীকে বিপদ সংকেত ৫ এর অর্থ বুঝিয়ে বলা। বিপদ সংকেত ৫ এর অর্থ -আগামী ৫ দিনের মধ্যে বন্যার পানির যে গভীরতা হবে, তা দীর্ঘ দিন স্থায়ী হবে। ফলে এলাকার নিচু যায়গায় যারা আছে, তাদের ঘরবাড়ি দীর্ঘ দিনের জন্য পানির নীচে ডুবে যাবে। এছাড়া এই পানির গতিবেগ তীব্র হওয়াতে তাদের সাথে থাকা সম্পদের অনেক বড় ক্ষয়ক্ষতি হতে পারে। সুতরাং নিজেদের জানমালের নিরাপত্তার জন্য এই সমস্ত ঘরবাড়ির বাসিন্দাদের এখনই আশ্রয়কেন্দ্রে যেতে হবে।
- এলাকার অপেক্ষাকৃত উঁচু জায়গার বাসিন্দাদের আশ্রয়কেন্দ্রে যাওয়ার ব্যাপারে বিপদ সংকেত ৪ অনুসারে প্রস্তুত করা, যেন অল্প সময়ের নোটিশে তারা আশ্রয়কেন্দ্রে যেতে পারে।

শেল্টারগ্রুপের জন্য করনীয়

- এলাকার নিচু যায়গায় বসবাসরত এলাকাবাসীদের আশ্রয়কেন্দ্রে নিয়ে যাওয়া।

ওয়ার্নিংএবং শেল্টারগ্রুপের জন্য করনীয়

- যে সমস্ত এলাকায় বিপদ সংকেত ১ থেকে একবারে ৫ এ উন্নীত হয়েছে, সে সব এলাকায় বিপদ সংকেত ২, ৩, ৪ এবং ৫ এর কর্ম পরিকল্পনা এক সাথে বাস্তবায়ন করতে হবে।

বন্যার পানি কমার সময় জনসাধারণের জন্য কর্ম পরিকল্পনা

বিপদসংকেত ৫ থেকে ৪ এ নামার পর কর্ম পরিকল্পনা

ওয়ার্নিং এবং শেল্টার গ্রুপের জন্য করনীয়

- আশ্রয়কেন্দ্রে অবস্থানকারীদের বাড়ি ফেরার প্রস্তুতি নিতে বলা।
- যে সমস্ত এলাকাবাসীর বাড়িঘর বন্যায় তেমন ক্ষতিগ্রস্ত হয়নি এবং অপেক্ষাকৃত উঁচু যায়গায় থাকায় পানি দ্রুত নেমে গেছে, তাঁদের আশ্রয়কেন্দ্র হতে বাড়ি ফিরে যেতে বলা।

বিপদসংকেত ৪ থেকে ৩ এ নামার পর কর্ম পরিকল্পনা

ওয়ার্নিং এবং শেল্টার গ্রুপের জন্য করনীয়

- অবশিষ্ট এলাকাবাসীকে, যাদের বাড়ি থেকে পানি নেমে গেছে, তাঁদের আশ্রয়কেন্দ্র হতে বাড়ি ফিরে যেতে বলা।

বিপদসংকেত ৩ থেকে ২ এ নামার পর কর্ম পরিকল্পনা

ওয়ার্নিং এবং শেল্টার গ্রুপের জন্য করনীয়

- কিছু কিছু নিচু এবং নদীর তীরবর্তী এলাকা থেকে পানি নামতে একটু বেশি সময় নিতে পারে। সেই সমস্ত এলাকা ছাড়া বাকি এলাকাবাসীকে আশ্রয়কেন্দ্র হতে বাড়ি ফিরে যেতে বলা।

বিপদসংকেত ২ থেকে ১ এবং ১ থেকে NO SIGNAL এ নামার পর কর্ম পরিকল্পনা

ওয়ার্নিং এবং শেল্টার গ্রুপের জন্য করনীয়

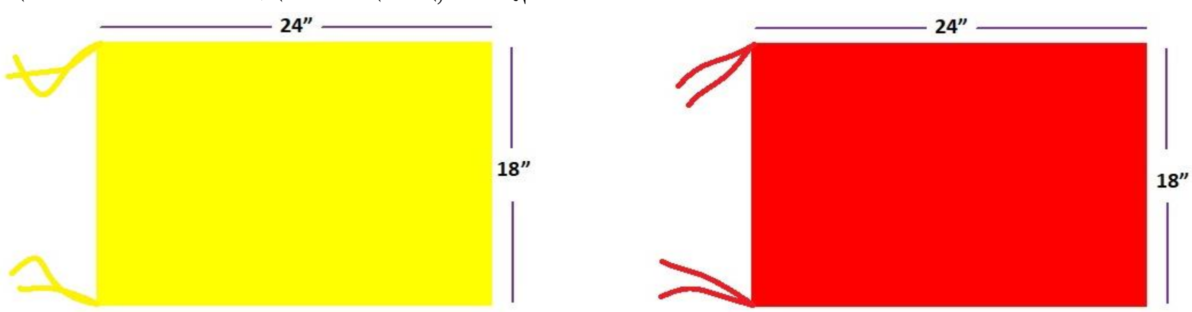
- বন্যা কবলিত এলাকাতে অতি দ্রুত পুনর্বাসন এবং পুনর্গঠন কাজ শুরু করা।

ন্যাশনাল রেজিলিয়েন্স প্রোগ্রাম ঃ দুর্যোগ ব্যবস্থাপনা অধিদপ্তর অংশ

বন্যায় সংকেত ও সতর্কবার্তা প্রচারে পরীক্ষামূলকভাবে পতাকার ব্যবহার

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার এর দুর্যোগ ব্যবস্থাপনা ও ত্রাণ মন্ত্রনালয়ের দুর্যোগ ব্যবস্থাপনা অধিদপ্তরের আওতায় ন্যাশনাল রেজিলিয়েন্স প্রোগ্রাম (এনআরপি) শীর্ষক একটি কারিগরি প্রকল্প চলমান রয়েছে এবং উপকূলীয় এলাকার ঘূর্ণিঝড় প্রস্তুতি কার্যক্রম (সিপিপি) এর অভিজ্ঞতার ভিত্তিতে বন্যাপ্রবণ এলাকায় বন্যা প্রস্তুতি কার্যক্রম (এফপিপি) তৈরী করার নিমিত্তে এই পাইলটিং প্রকল্প বাস্তবায়িত হচ্ছে। বন্যা ও নদী ভাঙ্গনজনিত দুর্যোগের ঝুঁকির মাত্রা বিবেচনায় কুড়িগ্রাম জেলার চিলমারী ও কুড়িগ্রাম সদর উপজেলা এবং জামালপুর জেলার ইসলামপুর ও দেওয়ানগঞ্জ উপজেলার মোট ২০ টি ইউনিয়ন বন্যা প্রস্তুতি কার্যক্রমের পাইলটিং এলাকা হিসেবে বাস্তবায়িত হচ্ছে এবং এই প্রকল্প মাঠ পর্যায়ে বাস্তবায়নের জন্য কেয়ার বাংলাদেশ দায়িত্ব পালন করে আসছে। এই প্রকল্পের মূল উদ্দেশ্য সার্বিকভাবে বন্যা ব্যবস্থাপনার মাধ্যমে জনগোষ্ঠীর ক্ষয়ক্ষতির মাত্রা কমিয়ে আনা। উল্লেখ্য, এই প্রকল্পের বিশেষ সহযোগী হিসেবে বাংলাদেশ প্রকৌশল ও প্রযুক্তি বিশ্ববিদ্যালয়ের পানি ও বন্যা ব্যবস্থাপনা ইনিস্টিটিউট (আই ডব্লিউ এফ এম) সরাসরি অংশগ্রহনের মাধ্যমে কারিগরি ও প্রযুক্তিগত সহযোগিতা প্রদান করে আসছে এবং আই ডব্লিউ এফ এম ইতিমধ্যে গতিশীল বন্যার ঝুঁকি মডেল (Dynamic Flood Risk Model – DFRM) তৈরি করেছে যেটা ব্যবহারের মাধ্যমে যে কেউ এন্ড্রোয়েড মোবাইল ফোন বা কম্পিউটারের মাধ্যমে (অনলাইন বা অফলাইন) তার নিজ এলাকার পানির স্তরের ভিত্তিতে পানির গভীরতা বা জলাবদ্ধতার মানচিত্র, বিপদের ও বিপদাপন্নতার মানচিত্র, ঝুঁকির মানচিত্র এবং সতর্কতা সংকেত নম্বর জানতে পারবেন, যার ভিত্তিতে তারা তাদের করণীয় ঠিক করতে পারবেন।

উল্লেখিত গতিশীল বন্যার ঝুঁকি মডেল থেকে প্রাপ্ত সতর্কতা সংকেত নম্বর ও এর বিপরীতে করণীয়সমূহকে স্থানীয় জনসাধারনের নিকট সহজবোধ্যভাবে পৌছানোর জন্য পতাকা ব্যবহার পদ্ধতির প্রচলনের সিদ্ধান্ত নেওয়া হয়, উল্লেখ্য উপকূলীয় ও ঘূর্ণিঝড় প্রবণ এলাকায় সংকেত পতাকার সফল ব্যবহার পরিলক্ষিত হচ্ছে যার মাধ্যমে বিপদাপন্ন জনগোষ্ঠী আগাম সতর্কতাসহ প্রয়োজনীয় করণীয়ের মাধ্যমে ক্ষয়ক্ষতির মাত্রা কমিয়ে আনতে সক্ষম হচ্ছে। উপোরোক্ত বাস্তবতা বিবেচনায় বন্যা সতর্ক সংকেত ও সতর্কবার্তা প্রচারের জন্য পরীক্ষামূলকভাবে দুই রঙের পতাকা ব্যবহারের বিষয়ে সিদ্ধান্ত গ্রহন করা হয়েছে, যা নিম্নরূপঃ



পতাকার বিবরণঃ

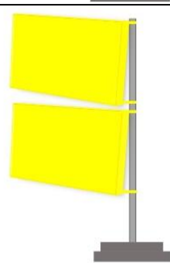
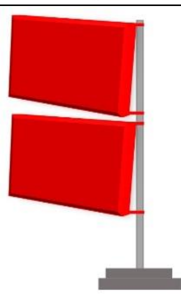
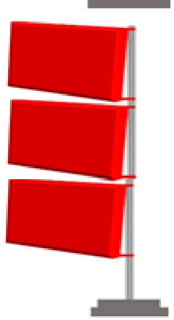
স্থানীয় পর্যায়ে গাঢ় হলুদ ও গাঢ় লাল এই দুই রঙের পতাকা ব্যবহারের কথা বিবেচনা করা হয়েছে। এই পতাকার আকার হবে আয়তাকার, দৈর্ঘ ২৪ ইঞ্চি এবং প্রস্থ ১৮ ইঞ্চি এবং এটি উড়ানোর জন্য স্ট্যান্ড বা পোলে বাধার জন্য দুইটি ফিতা সংযুক্ত থাকবে।

সাধারণভাবে নাইলন কাপড় যে কোনো ধরনের পতাকা তৈরিতে প্রথম পছন্দ হিসেবে ব্যবহার করা হয়, কারণ -

- এটি যথেষ্ট টেকসই;
- ওজনে হালকা হওয়ার কারণে খুব সহজেই এবং সামান্য বাতাসেই উড়তে সক্ষম;

- যে কোনো আবহাওয়ায় তাপ এবং ঠান্ডা প্রতিরোধী;
- স্পন্দিত রং যা ম্লান হবেনা এবং রোদে সহজে বিবর্ণ হবে না;
- এছাড়া এই ধরণের কাপড় বাংলাদেশের প্রত্যন্ত অঞ্চলেও সহজলভ্য;

পতাকার মাধ্যমে স্থানীয় জনগোষ্ঠী যা বুঝবেনঃ

পতাকার রং ও সংখ্যা	সংকেত নম্বর	ব্যাখ্যা
হলুদ রং - ১ পতাকা 	১	৫ থেকে ৭ দিনের মধ্যে এলাকার সবচাইতে নিচু অঞ্চল নিমজ্জিত হওয়ার সম্ভাবনা আছে।
হলুদ রং - ২ পতাকা 	২	২৪ থেকে ৪৮ ঘন্টার মধ্যে এলাকার সবচেয়ে নিচু অঞ্চল স্বাভাবিক বন্যায় নিমজ্জিত হওয়ার সম্ভাবনা আছে। পানির সর্বোচ্চ উচ্চতা ২-৪ ফুট বা তার বেশি হতে পারে। পানির গতি এবং ক্ষয়ক্ষতির সম্ভাবনা কম হতে পারে।
লাল রং - ১ পতাকা 	৩	২৪ থেকে ৪৮ ঘন্টার মধ্যে এলাকার সবচেয়ে নিচু অঞ্চল নিমজ্জিত হওয়ার সম্ভাবনা আছে। পানির সর্বোচ্চ উচ্চতা ৪-৬ ফুট বা তার বেশি হতে পারে। পানির গতি এবং ক্ষয়ক্ষতির সম্ভাবনা দুটোই মাঝারি ধরনের হতে পারে।
লাল রং - ২ পতাকা 	৪	২৪ থেকে ৪৮ ঘন্টার মধ্যে এলাকার সবচেয়ে নিচু অঞ্চলসহ মাঝারি উচ্চতার অঞ্চল নিমজ্জিত হওয়ার সম্ভাবনা আছে। পানির সর্বোচ্চ উচ্চতা ৬-৮ ফুট বা তার বেশি হতে পারে। পানির গতি তীব্র এবং ক্ষয়ক্ষতির সম্ভাবনা বড় ধরনের হতে পারে।
লাল রং - ৩ পতাকা 	৫	২৪ থেকে ৪৮ ঘন্টার মধ্যে এলাকার সবচেয়ে নিচু অঞ্চলসহ মাঝারি ও উঁচু অঞ্চলও নিমজ্জিত হওয়ার সম্ভাবনা আছে।

		পানির সর্বোচ্চ উচ্চতা ৮-১০ ফুট বা তার বেশি হতে পারে। পানির গতি অতি তীব্র এবং ক্ষয়ক্ষতির সম্ভাবনা অনেক বড় ধরনের হতে পারে।

সতর্ক সংকেত এর ভিত্তিতে বন্যার ঝুঁকি ও ক্ষয়ক্ষতি হ্রাসে করণীয় -

সতর্ক সংকেত	করণীয়সমুহ
১-২	ইউনিয়ন পরিষদের সাথে সমন্বয় করে বন্যার পুর্বাভাস সংগ্রহ ও প্রচারের ব্যবস্থা করা এবং প্রস্তুতি কার্যক্রম পর্যালোচনা করা। ওয়ার্ড ও ইউনিয়ন দুর্যোগ ব্যবস্থাপনা কমিটির সভা আয়োজন এবং সাড়াদান প্রস্তুতি গ্রহণ করা।
১-২	ইউনিয়নের যে এলাকায় সর্বপ্রথম বন্যার পানি প্রবেশ করেছে সেটা চিহ্নিত করে সেখানে আগাম পুর্বাভাস প্রচার করা। প্রস্তুতি কার্যক্রম পর্যালোচনা করা এবং কর্মপরিকল্পনা অনুযায়ী সুনির্দিষ্ট কার্যক্রম গ্রহণের উদ্যোগ নেওয়া।
১-২	বন্যা আশ্রয়কেন্দ্র এবং এলাকার উঁচু স্থানগুলোকে জনসাধারণ এবং প্রাণিসম্পদের আশ্রয়ের উপযুক্ত করে প্রস্তুত করা।
১-২	পানি বিশুদ্ধকরণ ট্যাবলেট এবং শুকনো খাবার এর ব্যবস্থা করা।
১-২	প্রয়োজনীয় জিনিসপত্র বিশেষ করে টাকা-পয়সা, জমির দলিল, শিক্ষা সনদ, জাতীয় পরিচয়পত্র নিরাপদ স্থানে রাখা।
১-২	উঠতি ফসল আহরণের সিদ্ধান্ত গ্রহণ ও প্রস্তুতি নেওয়া। যেখানে সম্ভব জমির ফসল ঘরে তুলে ফেলা এবং নিরাপদ জায়গায় সংরক্ষণ করা। ক্ষুদ্র ব্যবসায়, মাছ চাষের পুকুর ও মৎস খামারসহ অন্যান্য সম্পদের সুরক্ষা নিশ্চিত করা।
৩	প্রাণিসম্পদ ও হাঁস-মুরগি নিরাপদ স্থানে দ্রুত সরিয়ে ফেলা এবং প্রাণিখাদ্য নিরাপদে মজুদ রাখা।
৩	ইউনিয়ন পরিষদের সাথে সমন্বয় করে আশ্রয়কেন্দ্র ব্যবস্থাপনাসহ সন্ধান ও উদ্ধার কার্যক্রমের প্রস্তুতি গ্রহণ করা।
৪	প্রবীণ, শিশু, প্রতিবন্ধি ব্যক্তি ও গর্ভবতী নারীদের অগ্রাধিকার দিয়ে বন্যা কবলিত হতে পারে এমন জনগোষ্ঠীকে নিরাপদ স্থানে নেওয়ার প্রস্তুতি গ্রহণ করা। অসুস্থ ও প্রবীণদের জন্য জরুরি চিকিৎসা সহায়তা দেওয়া।

৫	নিমজ্জিত স্থানে তথা ঝুঁকিপূর্ণ জনগোষ্ঠীকে দ্রুত আশ্রয়কেন্দ্র কিংবা এলাকার উঁচু স্থানগুলোতে সরিয়ে নেওয়া।

সতর্কতা সংকেত প্রাপ্তির লক্ষ্যে পানির স্তরের তথ্য বা ডাটা বাংলাদেশ পানি উন্নয়ন বোর্ড এর বন্যা পূর্বাভাস ও সতর্কতা কেন্দ্রের ওয়েবসাইট থেকে সংগ্রহ করতে হবেঃ www.ffwc.gov.bd

সংকেতবাহী পতাকা বা পতাকা সমূহ একটি ইউনিয়নের ওয়ার্ড বা প্রয়োজনানুসারে গ্রাম বা পাড়ায় একটি নির্দিষ্ট ও উঁচু স্থানে উত্তোলিত হবে যেখান থেকে ওই এলাকার সাধারণ জনগণ খুব সহজেই দেখতে ও বুঝতে পারেন এবং তার ভিত্তিতে যার যার পর্যায় থেকে প্রয়োজনীয় পরবর্তী করণীয় ঠিক করতে পারেন। এই পতাকা উত্তোলনে ওয়ার্ড ভিত্তিক যারা দায়িত্ব পালন করবেনঃ

- এফপিপি স্বেচ্ছাসেবক
- ওয়ার্ড দুর্যোগ ব্যবস্থাপনা কমিটির সদস্য
- ক্ষেত্র বিশেষে ইউনিয়ন দুর্যোগ ব্যবস্থাপনা কমিটির / সাঁড়াদান গ্রুপের সদস্য
- ইউনিয়ন পরিষদ কর্তৃক মনোনীত ব্যক্তি

পানি নেমে যাওয়ার সময় পতাকার মাধ্যমে স্থানীয় জনগোষ্ঠী যা বুঝবেন

পতাকার রং ও সংখ্যা	সংকেত নম্বর	ব্যাখ্যা
লাল রং - ৩ পতাকা	৫	২৪ থেকে ৪৮ ঘণ্টার মধ্যে এলাকার সবচেয়ে উঁচু অঞ্চল থেকে পানি নেমে যেতে পারে। নিমজ্জিত অঞ্চলের পানির সর্বোচ্চ উচ্চতা ৮-১০ ফুট বা তার বেশি থাকতে পারে। নেমে যাওয়ার সময় পানির অতি তীব্র গতির কারনে অনেক বড় ধরনের ক্ষয়ক্ষতি হতে পারে।
লাল রং - ২ পতাকা	৪	২৪ থেকে ৪৮ ঘণ্টার মধ্যে এলাকার নিচু ও মাঝারি অঞ্চল ছাড়া অন্যান্য অঞ্চল থেকে পানি নেমে যেতে পারে। নিমজ্জিত অঞ্চলের পানির সর্বোচ্চ উচ্চতা ৬-৮ ফুট বা তার বেশি থাকতে পারে। নেমে যাওয়ার সময় পানির তীব্র গতির কারনে বড় ধরনের ক্ষয়ক্ষতি হতে পারে।
লাল রং - ১ পতাকা	৩	২৪ থেকে ৪৮ ঘণ্টার মধ্যে এলাকার নিচু অঞ্চল ছাড়া অন্যান্য অঞ্চল থেকে পানি নেমে যেতে পারে। নিমজ্জিত অঞ্চলের পানির সর্বোচ্চ উচ্চতা ৪-৬ ফুট বা তার বেশি থাকতে পারে। নেমে যাওয়ার সময় পানির মাঝারি গতির কারনে ক্ষয়ক্ষতিও মাঝারি ধরনের হতে পারে।
হলুদ রঙ - ২ পতাকা	২	২৪ থেকে ৪৮ ঘণ্টার মধ্যে এলাকার কিছু কিছু নিচু অঞ্চল ছাড়া অন্যান্য অঞ্চল থেকে পানি নেমে যেতে পারে। নিমজ্জিত অঞ্চলের পানির সর্বোচ্চ উচ্চতা ২-৪ ফুট বা তার বেশি থাকতে পারে। নেমে যাওয়ার সময় পানির নিম্ন গতির কারনে ক্ষয়ক্ষতিও কম হতে পারে।

হলুদ রঙ - ১ পতাকা	১	২৪ থেকে ৪৮ ঘণ্টার মধ্যে এলাকার নদী তীরবর্তী কিছু নিচু অঞ্চল ছাড়া অন্যান্য অঞ্চল থেকে পানি নেমে যেতে পারে।
পতাকা নামিয়ে ফেলতে হবে	সংকেত নেই	এলাকার সব অঞ্চল থেকে বন্যার পানি নেমে যেতে পারে।

বন্যার পানি নেমে যাওয়ার সময় সতর্ক সংকেতের ভিত্তিতে স্থানীয় জনগোষ্ঠীর জন্য করনীয়

সতর্ক সংকেত	করণীয়সমুহ
৫	আশ্রয়কেন্দ্র বা এলাকার উঁচু স্থানে আশ্রয় নেয়া জনগোষ্ঠীর ঘরে ফিরে যাওয়ার প্রক্রিয়া শুরু করা।
৪	এলাকার যে সমস্ত অঞ্চল থেকে পানি নেমে গেছে সেই সমস্ত অঞ্চলের ক্ষতিগ্রস্ত ঘরবাড়ি মেরামতের কাজ শুরু করা। পানি নেমে যাওয়া অঞ্চলে ব্যাপকভাবে পানি বিশুদ্ধকরন ট্যাবলেট এবং শুকনো খাবারের ব্যবস্থা করা। এলাকার যে সমস্ত ফসলি জমি হতে বন্যার পানি নেমে গেছে সেই সমস্ত জমিতে স্থানীয় কৃষকের অভিজ্ঞতা এবং কৃষি অফিসের পরামর্শ ও সহায়তায় পরবর্তী ফসলের জন্য প্রস্তুতি গ্রহণ করা।
৩	বন্যার পানিতে ক্ষতিগ্রস্ত ঘরবাড়ির মেরামতের কাজ শুরু করা। পানি নেমে যাওয়া অঞ্চলে ব্যাপকভাবে পানি বিশুদ্ধকরন ট্যাবলেট এবং শুকনো খাবারের ব্যবস্থা করা। নিরাপদ স্থানে মজুদ রাখা প্রানিসম্পদ, হাঁস-মুরগি এবং প্রানিখাদ্যের নিরাপত্তা নিশ্চিত করা সাপেক্ষে এগুলোকে যার যার অবস্থানে ফিরিয়ে আনার প্রক্রিয়া শুরু করা। যে সমস্ত ফসলি জমি বন্যা কবলিত হয়েছিল সে সমস্ত জমিতে স্থানীয় কৃষকের অভিজ্ঞতা এবং কৃষি অফিসের পরামর্শ ও সহায়তায় পরবর্তী ফসলের জন্য প্রস্তুতি গ্রহণ করা যেন স্বল্পতম সময়ে পরবর্তী ফসলের চাষ শুরু করা যায়।
১-২	বন্যার পানিতে ক্ষতিগ্রস্ত ঘরবাড়ির মেরামতের কাজ শুরু করা। এলাকায় ব্যাপকভাবে পানি বিশুদ্ধকরন ট্যাবলেট এবং শুকনো খাবারের ব্যবস্থা করা।

	নিরাপদ স্থানে রাখা প্রয়োজনীয় জিনিসপত্র বিশেষ করে টাকা-পয়সা, জমির দলিল, শিক্ষা সনদ, জাতীয় পরিচয়পত্র ইত্যাদির নিরাপত্তা নিশ্চিত করা সাপেক্ষে এগুলোকে নিজস্ব স্থানে রাখার ব্যবস্থা করা। স্থানীয় কৃষকের অভিজ্ঞতা এবং কৃষি অফিসের পরামর্শ ও সহায়তায় অবিলম্বে পরবর্তী ফসলের চাষ শুরু করা।
সংকেত নেই	এলাকায় অতি দ্রুত পুনর্বাসন এবং পুনর্গঠন কাজ শুরু করা।