Local Government Engineering Department (LGED)
Ministry of Local Government, Rural Development & Cooperatives
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Draft Final Report

on

Action Research on Climate Change Forecasting & Participatory Scenario Development and Assessment of the Agriculture & Fisheries Sectors, Exposure to Climate Risk

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Abbreviations and Acronyms

ALU	Agriculture and Land Use
BBS	Bangladesh Bureau of Statistics
BCCSAP	Bangladesh Climate Change Strategy and Action Plan
BDP2100	Bangladesh Delta Plan 2100
BLRI	Bangladesh Livestock Research Institute
BMD	Bangladesh Meteorological Department
BTM	Bangladesh transverse Mercator
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
DBHWD	Department of Bangladesh Haor and Wetlands Development
CO2eq	Carbon Dioxide Equivalent
CEGIS	Center for Environmental and Geographic Information Services
CALIP	Climate Adaption and Livelihood Protection
CCA	Climate Change Adaptation
CC	Community Clinics
CDMP	Comprehensive Disaster Management Programme
CPP	Cyclone Preparedness Programme
DDM	Department of Disaster Mangement
DoE	Department of Environment
DLS	Department of Livestock Services
DPHE	Department of Public Health and Engineering
DAP	Detailed Area Plan
DIA	Disaster Impact Assessment
DRR	Disaster Risk Reduction
DAPP	Dynamic Adaptive Policy Pathways
EFCC	Environment, Forestry and Climate Change
ECC	Environmental Clearance Certificate
ECR	Environmental Conservation Rules
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
FWCs	Family Welfare Centers
FY	Fiscal Year
FAP6	Flood Action Plan-6
FCD	Flood Control and Drainage
FCDI	Flood Control, Drainage and Irrigation
FGDs	Focused Group Discussions
FAO	Food and Agriculture Organization
FEC	French Engineering Consortium
GCM	General Circulation Model
GED	General Economics Division
GIS	Geographic Information System
GPS	Global Positioning System
GoB	Government of Bangladesh
GHG	Green House Gas

HILIP	Haor Infrastructure and Livelihood Improvement Project
HYV	High Yielding Variety
IECs	Important Environmental Components
IWFM	Institute of Water and Flood Management
IPM	Integrated Pest Management
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
KII	Key Informant Interview
LGED	Local Government Engineering Department
MA	Medical Assistant
MoA	Ministry of Agriculture
MoEF	Ministry of Environment, Forest and Climate Change
MODIS	Moderate Resolution Imaging Spectroradiometer
NAPA	National Adaptation Programme of Action
NAP	National Agriculture Policy
NPDM	National Plan for Disaster Management
NWRD	National Water Resources Database
NGOs	Non-Governmental Organizations
PRA	Participatory Rural Appraisal
PSD	Participatory Scenerio Development
PAF	Policy Assessment Framework
PMU	Program Management Unit
PCM	Public Consultation Meeting
RCP	Representative Concentration Pathway
SIA	Social Impact Assessment
SRDI	Soil Resource Development Institute
SDSM	Statistical Downscaling Model
SGDs	Sustainable Development Goals
ToR	Terms of Reference
UKCIP	UK Climate Impacts Programme
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
WARPO	Water Resources Planning Organization
WASH	Water Sanitation and Hygiene
WHO	World Health Organization

1. Introduction

1.1 Background

The haor region of Bangladesh is a distinct landscape with a unique hydro-ecological features situated in between the natural levees of the rivers and high lands. It is a combination of different wetlands such as river, canal, stream, beel etc. has increased the diversity of this area very much. Large areas of seasonally flooded cultivated plains and beels, sporting rich ecosystem that naturally prevails and provides ecological safety net to all lives. Almost all the haors of Bangladesh are situated mostly in the north-eastern part of the country comprising of with an area of 20,000 sqkm, which is about 15% of the country and 44% of the total haor region covering the districts of Sylhet, Sunamganj, Moulvibazar, Habiganj, Netrokona, Brahmanbaria and Kishoreganj. It is source of one of the most valuable and unique type of biodiversity in the world. It also provides livelihood opportunities and the basic support to the 20 million people living in that area and by doing so; it actively supports the sustainable economic condition of the country. Fisheries and agriculture are two of the majors sector upon which the people of this area depend for their livelihood.

There has been a great change in the climatic pattern across the world. Bangladesh, due to its geographical position is one of the top victims of climate change in the world. Because of the geographical setting of the haor region, the results of climate change has made this area very much vulnerable to natural disasters. The inhabitants of the haor area has come under a great threat due to this changing phenomenon of climate. Most of the haor areas remain under water for about 6-7 months of a year and a substantial portion is perennial wetland. Flash flood is the main disaster in the haor area, which engulfs the primary production sector (e.g., agriculture) and thus threatens the lives and livelihoods of the people. Excess rainfall in the upstream hilly areas and subsequent runoff coupled with sedimentation in the rivers, improper drainage, unplanned road and water management infrastructure and the effect of climate variability can be viewed as the main reasons for the devastation caused by flash floods. In recent years, frequency of thunderstorms has been increased in haor area. A recent study indicates that climate change will affect the Haor region and will disproportionately affect subsistent farmers and women. For the affected groups, maintaining livelihoods under climate change will be a major challenge.

In this context, the Local Government Engineering Department (LGED) under the Haor Infrastructure and Livelihood Improvement Project (HILIP) has assigned CEGIS to conduct a study on assessment of impacts for hazards due to climate change in haor area and, find out possible ways to mitigate the damage with participations from the local stakeholders to the agriculture and fisheries sector brought about by these hazards.

1.2 Objectives

The main objectives of the assignment is to identify climate risk in haor areas and create awareness of the haor people about the impacts of climate change risks and align them with the adaptation of future climate change variability. Specific objectives of the project include:

- Establish a baseline climate profile for the target Haor districts (Sunamganj, Habiganj, Netrokona, Kishoreganj and Brahmanbaria) and elaborate future scenarios based on best available scientific data and through participatory scenario development involving local stakeholders.
- Climate risk assessment using appropriate tools and methods at community level focusing on fisheries and agriculture of Haor Area.
- Develop a framework for the assessment of impacts resulting from climate changes on socio-economic sectors specifically on fisheries and agriculture of Haor areas.
- Assess the socio-economic impacts of climate changes on fisheries and agricultural households particularly farmers in Haor areas.
- Develop viable adaptation options by identifying and assessing climate risk on community level and help to identify potential policy choices for the target Haor areas.
- Build capacity among local communities and departments to make them able to think strategically about current and future climate change challenges and way to tackle them, in the five Haor Districts.

1.3 Scope of Works

- Task I: Climate change forecasting for 2030, 2050 and 2100 using key climatic parameters that are best known and most easily predicted (and) such as temperature, precipitation, drought, flood etc. or which are relevant for the Haor region.
- Task II: Historical and anticipated future trends in flash flood, drought, hail storms, cold snaps, rainfall, flood waves (Afal), thunderstorms etc.
- Task III: Identify the climate risk and impacts in the community through climate data analysis agro meteorological analysis, socio economic data, production change, past impacts and future anticipated analysis using both participatory and scientific tools.
- Task IV: Develop community based climate risk mapping in terms of probability exposure and consequence (Particular considerations of the agriculture and fisheries sectors) and also indicate climate risk hotspot area in risk map.
- Task V: Matrix ranking climate risks based on frequency, vulnerabilities, capacities and potential future impacts. Prioritize current and future climate-related risks through community participatory interactions.
- Task VI: Develop participatory scenario anticipate changes and impacts over short term (up to 5 to 10 years), intermediate term (up to 20 years) and long term (up to 50 years) with the involvement of the local stakeholders to explore the future in relation with the climate change for policy and operational decisions in Haor region.
- Task VII: Assess the land-use change and estimate the Green House Gas (GHG) emissions.

- Task VIII: Identify the threshold of current and future climate risk particularly in agriculture and fisheries sector as well as other socio economic sectors in which livelihood security is affected.
- Task IX: Analyze perceived livelihood problems, causes of problem, coping mechanisms, livelihood opportunities of women and men.
- Task X: Track seasonal changes, climate related hazards, community events and other activities related to a specific month in seasonal calendar for agricultural and fishery sector.
- Task XI: Identify times of working with crops and fisheries or livestock in haor, off-farm and domestic work as well as pinpointing gender rule.
- Task XII: Identify anticipated socio-econ0mic challenges brought about by climate change
- Task XIII: Identify appropriate adaptation options in the context of future scenarios.
- Task XIV: Develop a policy synthesis and guidelines to Disaster Risk Reduction (DRR) & Climate Change Adaptation (CCA) for Haor region.
- Task XV: Develop an induction package for each of the guidelines to assist the project for providing training to the staff and make them capable to use the guidelines.
- Task XVI: Workshop with key staff from HILIP/CALIP to present and discuss the findings and to share the findings with different stakeholders.
- Task XVII: Publish the research findings taking consent of Project Director, HILIP, PMU.

1.4 Rationale

The people living in the haor region of Bangladesh have been struggling against different obstacles of nature for a very long time. With the threat of climate change in the rise, their living condition is feared to become worse in the upcoming decades. Change in different climatic parameter, especially temperature and rainfall might cause a huge change the main sources of their livelihood, i.e. agriculture and fisheries. With a view to tackling the changing climatic scenario, the Government of Bangladesh has initiated Haor Infrastructure and Livelihood Improvement Project (HILIP) including Climate Adaptation and Livelihood Protection under the Local Government Engineering Department (LGED). Under this project, the study is being executed. The study will help to understand the climate pattern of the haor region in Bangladesh. The trend of rainfall and temperature can also become handy to identify the threats and problems for the agriculture and fisheries sector of that area. As a result, the Government of Bangladesh, with the help of LGED will be able to take necessary steps to mitigate the projected threats and problems regarding this issue. Moreover, the participation of the local stakeholders is also ensured in this study. Their view to the upcoming change in climate and the threat associated with the change would help the Government to understand the public concern and the needs required by the local people. Overall, this study taken by the Haor Infrastructure and Livelihood Improvement Project (HILIP) of LGED would support the Government of Bangladesh to take timely actions in order to confront the challenges to be brought by climate change and the protection of the people and their livelihood.

Study Component

In order to complete the study conveniently, the whole process will be divided into five components. Some of these components would be completed individually and some of them would be done parallelly. All the 17 tasks assigned in this project will be divided under each of the components based on their similarity with the component.

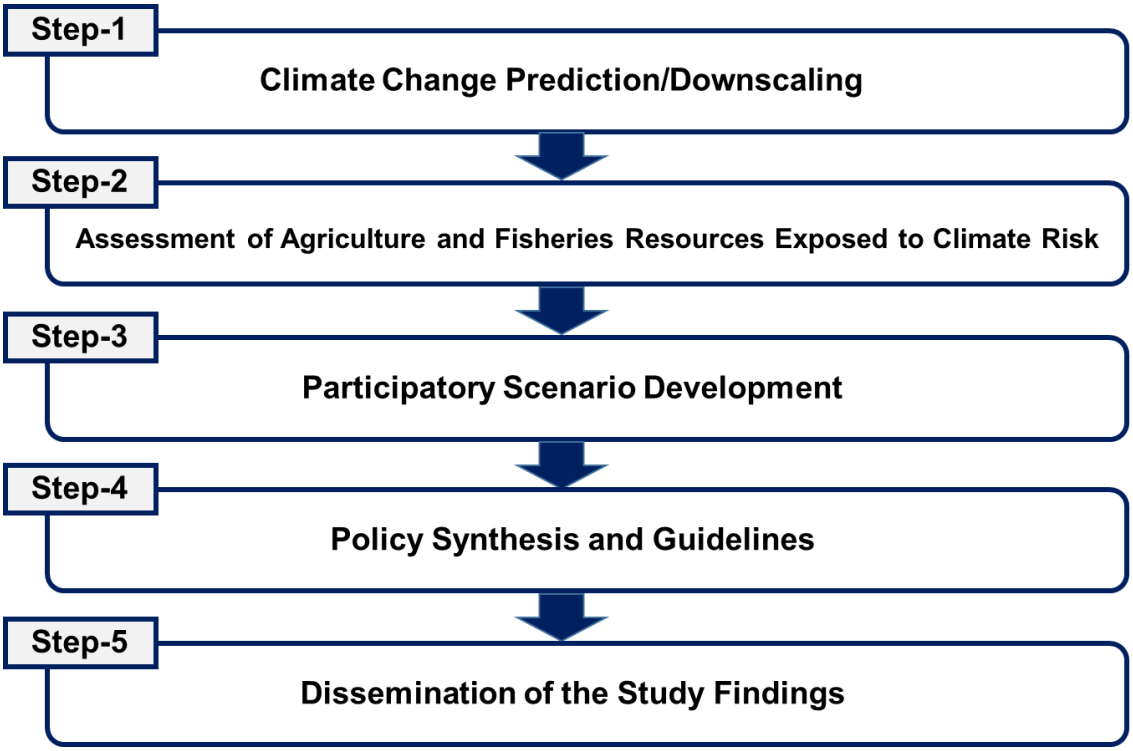


Figure 1.1: Study Component

2. Policy Synthesis and Literature Review

In order to minimize adverse effect of the natural disasters induced due to changing climatic pattern, a number of projects has already been undertaken in the Haor Region. Considering the need to mitigate the flood damage and improve the living environment through the implementation of flash flood management, improvement of the rural infrastructure, and promotion of the agriculture and fisheries; further infrastructural development in the Haor region is required. However, such development should be eco-friendly and comply with the existing policies, acts, rules and plans of the country which are relevant to the development of the Haor area. Therefore, the directives regarding haor area mentioned in different policies have been reviewed and articulated below:

2.1 Review of Policies

National Environmental Policy, 1992

The Government of Bangladesh has formulated an Environment Policy in 1992 to maintain ecological balance and overall development, increase protection against natural disasters, identify polluting agents, ensure environmentally sound development and remain associated with international environmental initiatives.

In article 3.5.5, the policy says to keep the haors, beels, free from pollution. Research in glaciology would be promoted to evaluate the impact of climate change on glaciers and ecology.

In article 2.3, 2.4 and 2.5, there is an indication to identify the key vulnerabilities of Bangladesh to climate change. Developing countries vulnerable to climate change should put emphasis on adaptation to the adverse effect of climate change.

In 3.1.1 and 3.1.2 of this policy, it says environmentally sound agricultural practices are to be encouraged and ensured for attainment of self-sufficiency in food. Among the various specific measures, use of natural fertilizers and insecticides is encouraged as opposed to the application of agro-chemicals and artificial materials exerting adverse impact on the environment

National Fisheries Policy, 1998

The National Fisheries Policy was approved in 1998 with the endorsement of the Government of Bangladesh for overall enhancement of the fisheries production.

The section 6.3 of the policy, it says a new integrated model for fish or shrimp with HYV rice culture will be initiated in the beets, haors and other flood affected areas, especially in the regions encircled by dams in flood control and irrigation projects.

In another section 6.12, it has been stated that water bodies like haor, baor and beel would be renovated for fish culture and these water bodies would not be reduced in sizes.

In the section 6.1, the policy has emphasized to conserve fish habitats from damage, appropriate care should be taken during the implementation of all developmental activities such as flood control, irrigation and drainage (FCD/1) projects, agriculture, industries, road and urban development projects.

The policy has instructed Bangladesh Agriculture University and other universities to use the ponds and other facilities of the Bangladesh Fisheries Research Institutes.

National Water Policy, 1999

The policies set forth herein are considered essential for addressing the objectives of improved water resources management and protection. There were 16 policies set forth of which, water for preservation of Haors, Baors, and Beels are directly relevant to this study as following:

Water bodies like baors, haors, beels, roadside borrow pits, etc. will, as far as possible, be reserved for fish production and development. Perennial links of these water bodies with the rivers will also be properly maintained.

Natural water bodies such as beels, haors, and baors will be preserved for maintaining the aquatic environment and facilitating drainage.

It also states that Haors, which naturally dry up during the winter, will be developed for dry season agriculture.

The policy also emphasizes to improve the efficiency of resource utilization through conjunctive use of all forms of surface water and groundwater for irrigation and urban water supply.

National Agriculture Policy, 1999

The National Agriculture Policy (NAP) was declared by the Government of Bangladesh in 1999 by the Ministry of Agriculture (MoA) to make the nation self-sufficient in food through increasing production of all crops.

The article 6.3 in the policy says that the infrastructures will be built for capturing surface water from khals, beels and small rivers and increasing availability of irrigation water by using high capacity power pumps.

It has also prescribed that, suitable projects will be taken up for building water reservoir to capture tidal water and thereby expanding mechanized irrigation facilities in the coastal areas. In this regard, participatory programs for the local beneficiaries will be undertaken.

In article 2.1, it has directed to take necessary steps to ensure environmental protection as well as environment friendly sustainable agriculture' through increased use of organic manure and strengthening of the Integrated Pest Management (IPM) programme;

Another article 4.1 has suggested the Government to pursue programs with technical support to protect crops of haor, baor and beel areas.

The policy has also stated that already introduced seed buffer stock system will continue to ensure the normal supply of seeds of major crops at the time of natural calamities or any other disaster

National Land Use Policy 2001

The main objectives of the Land Use Policy (2001) are preventing excessive land use due to demand for crop production, maximum utilization of lands, preservation of ‘Khas Lands’ and helping to reduce the number of landless people in Bangladesh. The statements which are relevant to haor and climate change are stated below:

National land use policy states that, Government will be responsible for reservation of large

water bodies like haor, baor etc. Ensuring proper use of land, water bodies and water cultivation of crops should be used in a way not to contradict with fisheries policy but still contributing in agricultural irrigation policy.

The policy has given instruction to the Ministry of Land to conduct a range of activities to protect agricultural land and ensure the planned use of land considering dependency of poor and underprivileged families on land.

National Jalmohal Management Policy 2009

The government adopted the Jalmohal Management Policy in 2009 for increased production and biodiversity conservation of fisheries resources .The Policy defines jalmohals as "the water body where water remains sometimes or throughout the year and is known as jalmohal. Some statements are made in the policy as below which could be related to haor:

Irrigation facility is provided by some of the jalmohals (i.e. River, Haor, Khal) to the agricultural land. Irrigation from those jalmohals cannot be hampered during the season of irrigation.

Optimal irrigation activity can be directed without hampering the "Fish Farming" in the closed jalmohals which will go for lease. "District Jalmohal Management Committee" will take decision in case of the government jalmohals having an area of 20acres. On the other hand, "Upazilla Management Committee" will take decision in case of the government jalmohals having an area of more than 20acres.

When the leased water bodies will mix up with the inundated land and consequently become single water-body during the monsoon, then the leaseholders' right will be limited inside the leased water bodies. In case of open and closed water-bodies, cultivation of "Gourmet Fish" is strictly prohibited.

Specified "Restricted Area" has to be established in open water-bodies with the help of 'District Administration' to prohibit fishing for the protection of fisheries.

National Agriculture Extension Policy, 2012

The National Agricultural Policy 2013 was enacted for the overall development of Bangladesh agriculture and farmers focusing on different development strategies, especially the Sustainable Development Goals. The act has mentioned several directives which is relevant to agriculture development in haor area are given below:

The policy has signified on the invention and popularization of different varieties of crops which are high yielding, tolerant to adversity and suitable for different agricultural climate, spatially for the haor region, water logged and coastal area.

The policy also states that advanced agro-technologies should be introduced to tackle adverse climate condition like flooding, drought, storm, salinity, erosion, disease, insect onslaught etc.

2.2 Review of Act and Rules

Embankment and Drainage Act 1952

An Act to consolidate the laws relating to embankment and drainage and to make better provision for the construction, maintenance, management, removal and control of embankments and water courses for the better drainage of lands and for their protection from floods, erosion or other damage by water.

In section 28 of this act it is said that, whenever any land other than land required or taken by the engineer, or any right of fishery, right of drainage, right to the use of water or other right of property, would be injuriously affected by any act done or any work executed under the due exercise of the powers or provisions of this Act, the person in whom such property or right is vested may prefer a claim by petition to the Deputy Commissioner for compensation:

In section 27 it says, different sections of this act outlined provision of land acquisition in case of emergency as well as provisions of compensation of damages of any land or any right of fishery resulting from completion of the water works.

Bangladesh Environmental Conservation Act 1995

This act introduced some regulatory clauses for protection and conservation of fish in water body, natural or artificial, open or closed, flowing or stagnant (such as river, haor, baor, beel, floodplain, canal etc.). Few sections of this policy which are directly, indirectly are relevant to haor areas are stated below:

- Government may make rules for the purposes hereinafter in this section mentioned Such rules may- prohibit the destruction of, or any attempt to destroy, fishes by explosives, gun, bow and arrow in inland water or within coastal territorial waters;
- Protection and conservation of fishes by prohibiting/regulating the construction of weirs, dams, bunds, embankments and other structures which destroy fishes/ cause depletion of fisheries.
- Safety measures or remedial measures should be undertaken to prevent portable accident which may cause degradation and pollution of environment
- Research and capacity development are emphasized for conservation, improvement and pollution of the environment
- Collection and publication of information regarding environmental pollution should be performed
- Inter-agency co-ordination should be established
- Ecologically Critical Area should be declared if any ecosystem is in the state of critical situation and no interventions should be undertaken in this designated area
- Industrial development on any kind of environment or ecosystem is matter of approval of authority
- Therefore, this act portrays some strict features regarding conservation of environment as well as ecosystem preventing pollution. This act also states to formulate environmental guideline to conserve the environment.

Environmental Conservation Rules 1997

This rules promulgated to implement the Environment Conservation Act, 1995 which is particularly relevant for controlling pollution in Environment. The rules which are directly or indirectly related to haor and climate change are stated below:

The section 7 of Environmental Conservation Rules (ECR) focuses on enforcement of laws for clearance of different categories of industry (i.e. Green, Orange-A, Orange-B and Red) on different location of environment.

Necessity of Environmental Impact Assessment (EIA) followed by Environmental

Management Plan (EMP) before any kind of development was prescribed to be done.

National committee and co-management team to ensure engagement from root level like village protection team should be formed for designating an Ecologically Critical Area

The Rules prohibits some activities or processes, which cannot be initiated or continued in an ECA like polluting water by discharging waste or any other activities that could destroy or change the natural characteristics like biodiversity or other habitats of an ECA.

Bangladesh Water Act 2013

Bangladesh Water Act, 2013 is the latest and most important legal document which was prepared. To make provision of integrated development, management, abstraction, distribution, use, protection and conservation of water resources. In relevant to haor area, this act specifically stated legal bindings on conservation of haor, baor or any other water source and management thereof for conservation of biodiversity dependent on it, in section 22 (b). Other directives of this act are as following:

- Delineation of water stress area and preferential use of water from sources for different purposes like for agriculture, fisheries, drinking water, industry etc.
- Ensuring normal flow in water course prohibiting any kind of diversion through construction of structures without feasibility study
- Protection of flood control embankment, especially which protects property, life and crops by restricting construction any house, establishment or any other structure on or on the slope of such embankment.
- Demarcation of flood control zone in wetlands to ensure smooth passage of flood water.

This act also emphasized preparation of National Water Resources Plan which will provide guideline to assess impact of different development on water resources.

Bangladesh Water Rule 2018

Bangladesh Water Rule, 2018 is prepared by Water Resources Planning Organization (WARPO) with a view to implement Bangladesh Water Act, 2013. The main purpose of this rule is to ensure the water right of every citizen of Bangladesh. The rule has described the laws regarding the extraction and proper use of surface and ground water.

This rule has given WARPO the authority to give clearance to any agency or owner for development projects in or near a water body under the condition that it would not cause any adverse impact to it, specifically for:

- flood control and management project
- water supply and sanitation project
- surface water irrigation project
- hydraulic intervention project
- water extraction or storage project
- floodplain or haor development project
- Project on surface water use for industry

- river training works or river bank protection project
- river or canal dredging project
- fishery development project in surface water

Increasing public awareness thus in terms of water consumption and usage is another priority of this rule. Emphasis has been given on delineation of water stress area in a scientific way and considering socio-economic perspective. Participatory approach is given priority in this rule to overcome such water stressed situation. Water rule has instructed to identify 'Flood Flow Zone' or 'Sub Flood Flow Zone' analyzing flood model and RS-GIS techniques, and restriction has been outlined to do any development like construction of embankment, infrastructure development for agriculture and fisheries etc. inside the 'Flood Flow Zone'. Activation of this rule will ensure efficient use of water over the country.

Bangladesh Biodiversity Act, 2017

Bangladesh Biodiversity Act 2017 is the latest legislative document to ensure conservation of biodiversity and sustainable use of its relevant elements. This act is prepared followed by Convention on Biological Diversity of United Nations. Following directive of this act is relevant to this study:

- This act has instructed to form Biodiversity Conservation and Management Committee from national to root level for ensuring sustainable use of services provided by different species diversity
- Identification of biodiversity rich area is encouraged and declaration of any area as world heritage depending on the importance of the biological diversity is mentioned, specially Ramsar designated site or wetlands
- Any development works which may interrupt safe living of bio-diversity or impose adverse impact should be prohibited
- Monitoring and reducing extraction of excessive resources in biologically diversified area has been discouraged
- Emphasis has been given on strategic and action plan preparation for conservation of biodiversity and sustainable use of their resources
- The breeding ground of any species can declared protected and the government can take necessary steps to protect the breeding ground.
- It also refers to the conservation of existing biodiversity and genetic resources in in-situ or ex-situ environment
- Protection of endangered species is encouraged
- Research and awareness building program should be taken for raising awareness among communities for conservation of biodiversity

2.3 Review of Plans, Strategies and Studies

National Adaptation Programme of Action (NAPA)

The National Adaptation Programme of Action (NAPA) for Bangladesh has been prepared by the Ministry of Environment and Forest (MOEF), Government of the People's Republic of Bangladesh. The strategic goals and objectives of future coping mechanisms are to reduce

adverse effects of climate change including variability and extreme events and promote sustainable development. The Actions related to haor area and climate change are stated below:

The suggested future adaptation strategies are:

- In executive summary 4 it says, Climate change and adaptation information dissemination to vulnerable community for emergency preparedness measures and awareness raising on enhanced climatic disasters.
- In executive summary 5, Construction of flood shelter, and information and assistance center to cope with enhanced recurrent floods in major floodplains.
- In 10 it says, Promotion of research on drought, flood and saline tolerant varieties of crops to facilitate adaptation in future.
- In 12 it says, Adaptation to fisheries in areas prone to enhanced flooding in North East and Central Region through adaptive and diversified fish culture practices.
- The final prioritization of the list was done through the national consultative workshop held on 15 September 2005 in Dhaka with over 100 stakeholders from different sectors and groups, including both government as well as nongovernment.
- Reduction of climate change hazards through coastal afforestation with community participation.
- Capacity building for integrating Climate Change in planning, designing of infrastructure, conflict management and land-water zoning for water management institutions.
- Enhancing resilience of urban infrastructure and industries to impacts of climate change
- Development of eco-specific adaptive knowledge (including indigenous knowledge) on adaptation to climate variability to enhance adaptive capacity for future climate change.
- In executive summary 6 it says, Adaptation to agriculture systems in areas prone to enhanced flash flooding–North East and Central Region.

Bangladesh Climate Change Strategy and Action Plan, 2009

The Bangladesh Climate Change Strategy and Action Plan, 2009 was adopted as a 10-year programme (2009-2018) to build the capacity and resilience of the country to meet the challenges of climate change in different sectors. The BCCSAP established programmes of action on six main pillars for the first five year period (2009-2013). Programmes relevant to haor under these six pillars are stated below:

Theme No.	Theme Name	Programmes
1	Food security, social protection and health	Development of climate resilient cropping system appropriate for different agro-climatic regions and sub-regions Adaptation in fisheries and livestock systems to ensure local and national food security. Livelihood protection in ecologically fragile areas

Theme No.	Theme Name	Programmes
2	Comprehensive Disaster Management	Improvement of flood forecasting and warning system
3	Infrastructure	Repair and maintenance of existing flood embankments and ensuring continued flood protection by repairing and rehabilitating existing flood embankments and ancillary infrastructure. Adaptation against floods to make flood prone areas more resilient by flood zoning and management. Planning, design and implementation of resuscitation of the network of rivers and khals through dredging and de-siltation work.
4	Research and knowledge management	Modelling of climate change scenarios by applying global climate change models
5	Mitigation and low carbon development	Raising productivity of agricultural land and lowering emissions of methane by efficient use of water Increase water efficiency in built environments with further mention to groundwater lowering in major cities including Sylhet Improving energy consumption pattern in the transport sector, which is related to the navigational facilities in the Haor area without much use of fuel

Haor Master Plan 2012

The haor region has long been lagging behind mainstream national development although the economic development of Bangladesh is moving steadily at a moderate pace. The government has taken many initiatives including the preparation of national and regional strategies to steer economic growth and has accordingly prepared plans over the years to boost the country's development.

In Chapter 6, The principles followed for developing the Master Plan strategy are:

- Pursuing the integrated policy directives of the government for sustainable development of the haor area
- Maximization of resources utilization with minimum degradation of the haor wetlands and ecosystem
- Based on the above principles, the strategies have been formulated under the umbrella of six broad thematic areas, which are:
- Agricultural development for food security -improvement in agricultural sector performance and acceleration in its growth are critical for reducing rural poverty. Pearl culture can open up a new-dimension of economic activity in the haor areas.
- Biodiversity enhancement and Wetland management-strategic options on conservation and sustainable management are required to protect the country's wetlands and biodiversity.
- Social safety net and improved standard of living -Social safety nets or "socio-economic safety nets" are non-contributory transfer programmes seeking to protect

the poor and those who are vulnerable to shocks and poverty from falling below a certain poverty level.

- Improved physical infrastructure- building infrastructures like road, railway, and inland waterway, tourism facilities etc. will help in economic development, enhance tourism, employment generation and help in poverty reduction.
- Enterprise and technology development-SME development for haor areas will contribute to regional economic growth in general and pro-poor growth in particular. Development of agro-based industry and sustainable use of mineral resources will be carried out for economic development of the area as well as of the whole country.

7th Five Year Plan (2016-2020), 2016

Planning Commission of Bangladesh launched the 7th Five Year Plan for the financial year 2015-16 to 2019-20 to achieve the targets envisaged in Bangladesh Perspective Plan 2010-21 with a vision 'Accelerating Growth, Empowering Citizens'. Several strategic directions and policy framework have been outlined in this five year plan, where agriculture, fisheries, watershed management and resilience against climate change got special emphasis in relation to haor area are given below:

Agriculture

Priority has been given to address the problem areas (like hills, coastal, haor and barind areas) that are more prone to weather vagaries and that have proportionately higher populations of poor and vulnerable people.

Development and refinement of technologies which may bridge yield gaps and promote diversification, sustainable natural resources management i.e. rain water and river water harvesting for agricultural production, disease and pest management, development of varieties/species with post-harvest technology of high value agricultural commodities, mechanization, etc.

Breeding and introducing saline or drought tolerant, short duration or submergence varieties to withstand with climate change.

Fisheries

Prevent deterioration of water logging, blockade of water-flows and shrinkage of water-bodies by infrastructures like embankment, roads, urban housing projects and industrialization. Such projects must follow the environmental rules and regulations (including EIA, SIA, etc.) and incorporate adequate mitigation measures in consultation with the Ministry of Fisheries and Livestock.

Projects and programmes should be implemented to construct and maintain fish-passes, fish-friendly regulators, re-excavate canals, rivers restoring, and conserving productivity as much as possible

Establish and maintain fish and wetland sanctuaries, which would comprise complete ban on fishing in certain eco-sensitive areas like Sundarbans, parts of Kaptai Lake, and several sections of the river Halda, selected beels and haor areas.

The fishermen would be organized in sustainable community based organizations and such organizations would be given management responsibility of khals jalmohal on long term basis so that they conserve rather than just exploit resources.

Present short term leasing system, often benefiting the influential elite and the leaseholder not taking any effort to conserve, would gradually be replaced by the long-term lease to organizations of genuine fishermen who will be trained in sustainable management and provided other support

Daudkandi model of seasonal floodplain aquaculture should be further promoted to expand all over the country but with added emphasis to combine maintaining sanctuaries in the important beel and haor areas.

Watershed Management

Watershed management and wetland conservation should be initiated in the haor regions and hills districts and also would be intensified in the old areas for better conservation of nature during the plan period

Integrated Haor Management Programme for Haor Region has suggested by BDP2100, which is also recommended by Seventh Five Year Plan (2016-2020).

Climate Change

In respect to climate change, the country is not an actor but the worst sufferer. BWDB/LGED coastal FCD/FCDI projects and submersible embankment projects in Haor area are the first stage defense in case of climate change

In addition, this plan stated that, Bangladesh has enormous potential for wind energy, mainly in the coastal areas, haors and offshore islands. Government has a plan to generate electricity from wind power under public & private initiatives

In essence, the Five Year Plan (2016-2020) has shown a way to conservation of wetlands including Jalmohals and rivers in dry season.

To attain good governance in environmental sustainability, the following measures can be takes under consideration:

- Ensure appropriate environment management system for sustainable development
- Enhance enforcement for pollution control
- Enhance, preserve, conservation of natural resources
- Develop ‘climate-smart food systems’, ensuring that climate threats to other elements of food systems beyond agriculture, such as storage, distribution and access are taken into consideration.
- Mainstream poverty-environment-climate-disaster nexus in the project design phase, budgetary process, project implementation and monitoring processes.
- To hold water of wetlands including jalmohals and rivers in dry season the following measures are being suggested in the plan:
- Preserve, protect and develop the natural wetlands and water bodies
- Conserve and protect the eco-system for bio-diversity of wetlands
- Half/reduce rate of salinity intrusion and mitigate impacts of salinity on human health and agro-ecosystem production.
- Ensure that dry season groundwater levels do not fall below 2005 levels.

- Promote appropriate environment management system for mitigation and adaptation to climate change and climate vulnerability
- The following activities under the 7th five year plan can be taken under consideration for climate change adaptation
- Promote a whole-of government approach for climate change readiness
- Promote a whole-of government approach for climate change readiness
- Improved Implementation, Monitoring and Shared learning
- Integrate Gender Sensitivity in project design:
- Managing hazards and disasters
- Curbing internal migration and displacement

National Plan for Disaster Management, 2016-20

Considering all the changes occurring in the interim and recognizing the need for continual development, GoB has decided to take stock of the progress made in the implementation of the NPDM (2010-2015) and draw lessons from the past five years to feedback into the plan for 2016-2020.

Disaster and development linkage

Since poverty, sustainable development, disasters and climate change are closely interlinked, it is crucial to integrate DM measures in development initiatives where people's livelihoods are at risk

- Accountability framework for disaster management
- Ministry, department and agency focal point
- Links between policy and operations
- Expanding the scope of planning
- Political consensus and allocation of resources
- Contingency / Preparedness plan
- Periodic review of the implementation of the plan
- Funding requirement and resource mobilization
- Coordination, Communication and Cooperation

Priority level action plans: This plan follows an 'all-hazards' or multi-hazard approach; hazard-specific activities where suggested are linked to broader priority level action plans.

Priority 1: Understanding disaster risk

- To upgrade and strengthen national awareness raising initiatives on hazards and DM through community, institutions and media.
- Special attention to be given to awareness raising and data products on earthquakes, particularly in the rapidly urbanizing context.
- To continue to support and engage in DM-related research and development activities.

- To invest in creation of a risk repository which is accessible to public sector planners to ensure that major investment of the government is planned and designed with systemic risk information.
- To strengthen regional and international DM networks and establish new ones to share and learn from experiences elsewhere.
- To develop information products and management strategies for a range of less prominent but nonetheless devastating hazards.

Priority 2: Strengthening disaster risk governance to manage disaster risk

- To risk-proof public investments and inclusion of Disaster Impact Assessment in the EIA and SIA processes
- To undertake inter-ministerial coordination to develop sectorial policies and capacity building, and to review and carry out risk-informed updating and implementation of relevant policies,
- To strengthen formal institutional capacities
- Invest in risk reduction of private sector for resilience
- To close gaps in institutional policies and programs regarding drought and cold wave hazards by ensuring the implementation of the National Water Policy and supporting a range of measures.
- To strengthen at the national and ministerial level international and regional cooperation and knowledge/information sharing with key DM-related bodies and other ministries.

Priority 3: Investing in disaster risk reduction for resilience

- To undertake nationwide capacity building for resilience, including dealing with new human-induced and chemical hazards, through training workshops, seminars, drills and simulation exercises and equipment support
- To carry out physical works and structural measures for resilience including construction of fire stations in all towns and commercially important areas.
- To investigate DM financial options such as private sector investment for resilience, insurance for disaster risk reduction and funding to support resilient and alternative livelihoods, skill development training and initiation of employment for social protection.
- To invest in resilience institutions including a Research & Development Center
- To strengthen flood management through existing and new policies and programs
- To strengthen cyclone management by upgrading and extending of the Cyclone Preparedness Programme (CPP) in all coastal areas.
- Priority 4: Enhancing disaster preparedness for effective response and to “Build Back Better” in recovery, rehabilitation and reconstruction
- To strengthen the national forecasting and early warning system

- To build capacity of relevant services personnel and volunteers on emergency response
- To formulate and strengthen sector wise preparedness measures
- To develop an early/medium/long-term recovery and rehabilitation strategy
- To strengthen preparedness and response measures for slow-onset hazards

Bangladesh Environment, Forestry and Climate Change Country Investment Plan, 2016

In the country, there are more than 200 laws and by-laws exist to tackle these challenges related to environmental issues. The EFCC investment plan provides a strategic framework for national and international investments for the environment, forestry and climate change sectors in Bangladesh, and to coordinate implementation with all of the sector's stakeholders.

In Article 3.4 of the plan it says, the Government of Bangladesh recognizes that tackling climate change requires an integrated approach involving a number of different ministries and agencies, civil society and the private sector. Under the leadership of Ministry of Environment, Forest and Climate Change (MoEF), the GoB prepared a National Adaptation Programme of Action (NAPA) which was launched in 2005 and updated in 2009. The plan identifies priority activities to provide a response to urgent and immediate adaptation needs.

The plan has emphasized on climate change mitigation with a focus on sustainable forests management for carbon sequestration, establishment and implementation of climate smart technologies and the promotion of low emission practices from the agricultural sector

In Article 3.4 the plan focuses on strengthening climate change resilient buildings, roads and storage facilities, strengthening coastal and inland embankments and improve drainage capacity, Increased resilience at community level by scaling-up local innovations on adaptation

Bangladesh Delta Plan 2100

Bangladesh Delta Plan 2100 was formulated by General Economics Division of Bangladesh (GED) with the help of the Government of Netherlands. It has been idolized with a same type of Delta Plan that the Netherlands had initiated. The main purpose of this plan is to set a guideline for the water resource management in Bangladesh for the next hundred years. Some strategies and measures specifically for haor area articulated in BDP2100 are given below:

- Assigning data to the six Delta Hotspots involves extensive mapping exercises using the lowest administrative units of the surveys and definitions/maps of the six Delta Hotspots. The Haor area is one of these hotspots.
- Protect Boro Crops from Flash Flood in Low Lying Areas Pre-monsoon flash flood
- From the neighboring hilly region is a common phenomenon in this hotspot.
- Protect Aush and Aman Crops from Monsoon Floods in High Lands
- Protect the Post-Harvest Crop from Rotting
- Sub-strategies and measures of achieving water security for haor and flash flood area
- Providing irrigation facilities utilizing surface water

- Achieve equitable access to adequate and affordable drinking water and safe sanitation
- Sub-strategies and measures of river management for haor and flash flood area
- Increasing the conveyance capacity of rivers
- Maintaining navigability of the medium and minor rivers
- Stabilizing the river courses in strategic locations for protecting urban and rural areas
- Sub-strategies and measures of haor wetland and biodiversity management for haor and flash flood area
- Improve water quality
- Protect and restore haor and river ecosystems, fish breeding and grazing grounds
- Manage wetland in order to protect biodiversity
- Adaptation pathways, where uncertainty is important, adaptation or strategic pathways help for understanding, scheduling measures and developing optimal combinations of measures to meet the policy goals.
- Strategies for Development of Agriculture in the Haor and flash flood areas
- Improved water and disaster management
- Agricultural development for food security
- Biodiversity enhancement and wet land management
- Social safety nets and improvement of living conditions
- Improved physical infrastructure, and
- Specialized enterprise and technology development for alternative sources of rural livelihood including eco-tourism based on wetland development, development of river transport, small manufacturing enterprises, and strengthening of forestry resources.
- Quick growing suitable verities of vegetables, mustard, chickpea, kheshari seed to be made available before Boro rice varieties are transplanted where late Aman plantation not feasible.
- Construction of buffer stock go down to be made in the areas encouraging private sectors.
- Mechanization for quick land preparation, planting, harvesting, seed drying and processing need to be promoted by the agricultural extension services.
- Plant breeding programme need to be encouraged crossing with the local varieties like kasalath, chengri, baorash, dumain for development of short duration quick maturing Boro rice varieties which would help cope with the flash floods.

Study on Livelihood System Assessment, Vulnerable Group Profiling and Livelihood Adaptation to Climate Hazard and Long Term Climate Change in Bangladesh, 2006

In order to increase resilience at all levels, from the national to community level and to reduce damage and losses from natural disasters and the impacts of climate change, the Government of Bangladesh has launched the Comprehensive Disaster Management Programme (CDMP), which started field implementation in 2004. Within this framework, the Food and Agriculture

Organization of the United Nations (FAO) has been assisting the Government of Bangladesh and other key stakeholders in designing and promoting livelihood adaptation strategies in the agricultural sector, which is expected to help in devising strategies to reduce vulnerability to climate change, particularly amongst women and poor communities who have the lowest capacity to adapt.

The study has outlined an excellent method of identifying the venerable groups where the study would be carried out evaluating the assets of livelihood of people living around that area and identifying the climate variations and gender specific vulnerabilities. A few adaptive responses and coping strategies to tackle the impacts, which are caused by climate change, are discussed in this study. They include:

- Traditional responses
- State supported responses
- Alternative responses
- Domestic responses
- Socio-economic adaptive responses
- Adaptive responses by livelihood groups

Study on Strengthening Disaster Risk Management in Agricultural Sector in Bangladesh

In collaboration with Food and Agriculture Organization of the United Nations (FAO), the Government of Bangladesh is providing assistance in reinforcing and operationalizing the shift from disaster relief to prevention/preparedness in the agricultural sector. This study has set a guideline to strengthen the capacity of the people living in the disaster prone area of Bangladesh as well as the Government to face the challenges brought by the varieties of natural disasters in agricultural sector. The study has set a methodology for flood hazard mapping which focuses on the reduction of losses due to flood. The study has also set a method for vulnerability group profiling. This profiling can be useful to make a full vulnerability analysis of the study area. In addition, institutional analysis can be also completed with the help of this study.

Sustainable Development Goals

As a successor of Millennium Development Goals, the United Nations have initiated a new set of goals, referred to as Sustainable Development Goals or the SGDs to transform the world to make it a better place to live in emphasizing on the environment. There are 17 goals and 169 targets in-between them in SDGs. Among these 17 goals, Goal 6 and Goal 15 represent the themes of water and ecosystem.

It is narrated in Target 6.6 of Goal 6 that by 2030, the water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes will be protected and restored. Ensuring the availability of fresh water across the world is another target of this goal.

Goal 15 of SDG signifies on protection, restoration and promotion of terrestrial and inland freshwater ecosystems and halt biodiversity loss. It is also mentioned in Target 15.1.2 that by 2030, important sites for terrestrial and freshwater biodiversity that are covered by protected areas shall also be prompted, by ecosystem type.

The Haor region of Bangladesh is loaded with different species of biodiversity, which has created a very complex ecosystem in that area. Sustainable management of these complex ecosystem thus very important issues to achieve targets stated in Sustainable Development Goals by 2030.

3. Study Area

3.1 Geography

The haor region of Bangladesh is a saucer shaped shallow depression which is an internationally recognized important wetland ecosystem, spread over Sunamganj, Habiganj, Moulvibazar, Kishoreganj and Netrokona districts along with some portion of Sylhet Sadar Upazilla. Brahmanbaria also has 29616 hectares of Haor area and the district has a total of 7 haors. The haors in the north-east part of the country covers an area estimated about 20,000 square kilometers which is about 15% of the country. It is further estimated that the total area of haor-type wetlands throughout Bangladesh exceeds 8 million hectares. The Haor Basin is surrounded by the mountain ranges of India, with Meghalaya to the north, Tripura and Mizoram to the south, and Manipur and Assam to the east. It is a mosaic of wetland habitats, which includes rivers, streams, irrigation canals, large areas of seasonally flooded cultivated plains and hundreds of haors and beels. The study area includes about 47 haors and some 6,300 beels of varying size, out of which about 3,500 are permanent and 2,800 are seasonal. The entire Sunamganj district, major portion of Habiganj district, some parts of Sylhet Sadar Upazilla and Moulvibazar district are covered by many haors. In greater Sylhet the most prominent haors are Shanir haor, Hail haor, Hakaluki haor, Dekar haor, Maker haor, Chayer haor, Tanguar haor, and Kawadighi haor. This report focuses on the major haor systems like Patharchuli Haor, Pagnar Haor, Kalikota Haor, Dekar Haor, Gungiajuri Haor, Shanir Haor, Matian Haor, Kalikota Haor.

3.2 Topography

The evolution of the Indian sub-continent has been the result of a collision between the northward moving Indian plate and the Stationary Eurasian Plate since the Cretaceous times. Part of the north-east Indian plate has fractured and sank below the sea-level during the Oligocene times. Since then the Bengal Basin has started to form, filling up with sediment by a process of deltaic sedimentation into a slowly subsiding tectonic basin. Bangladesh constitutes the eastern continuation of the central broad Indo–Gangetic plains of India, which serve to physiographical divide the Peninsular (shield) area to the south from the extra-Peninsular region (Himalayan mountain ranges) to the north and northeast. The Bengal Basin is located primarily in Bangladesh, with a lesser part in the West Bengal State of India. The basin is surrounded by India on three sides. The Sylhet Trough is a sub-basin of the Bengal Basin and consists of 13-20 km thick alluvial and deltaic sediments underlain by much older gneiss and granite rocks. The basin is bounded by the Shillong Plateau in the north, by the Indian Burmese ranges in the east and by the Indian Shield in the west. The southern and eastern parts of the Sylhet Trough are characterized by a series of north trending folds which have formed as a result of deformation from the Indo-Burmese ranges. The anticlines constitute the Tripura Hills along the southern border of the region. The Sylhet Basin has subsided 30-40 feet (10-12 m) in the last several hundred years. A subsidence rate of 21 mm/y in the Surma Basin has been reported by the Master Plan Organization (1985) and FEC (1989). This value appears to be arrived at by using Morgan and McIntire's estimate of 10 m subsidence in 500 years. Therefore, if it is considered that the Sylhet Basin is subsiding at a rate of 2-4 mm every year and that the soil compaction rate is 1-2 mm/yr, then the actual subsidence rate of the Sylhet Basin might be 3-6 mm/yr.

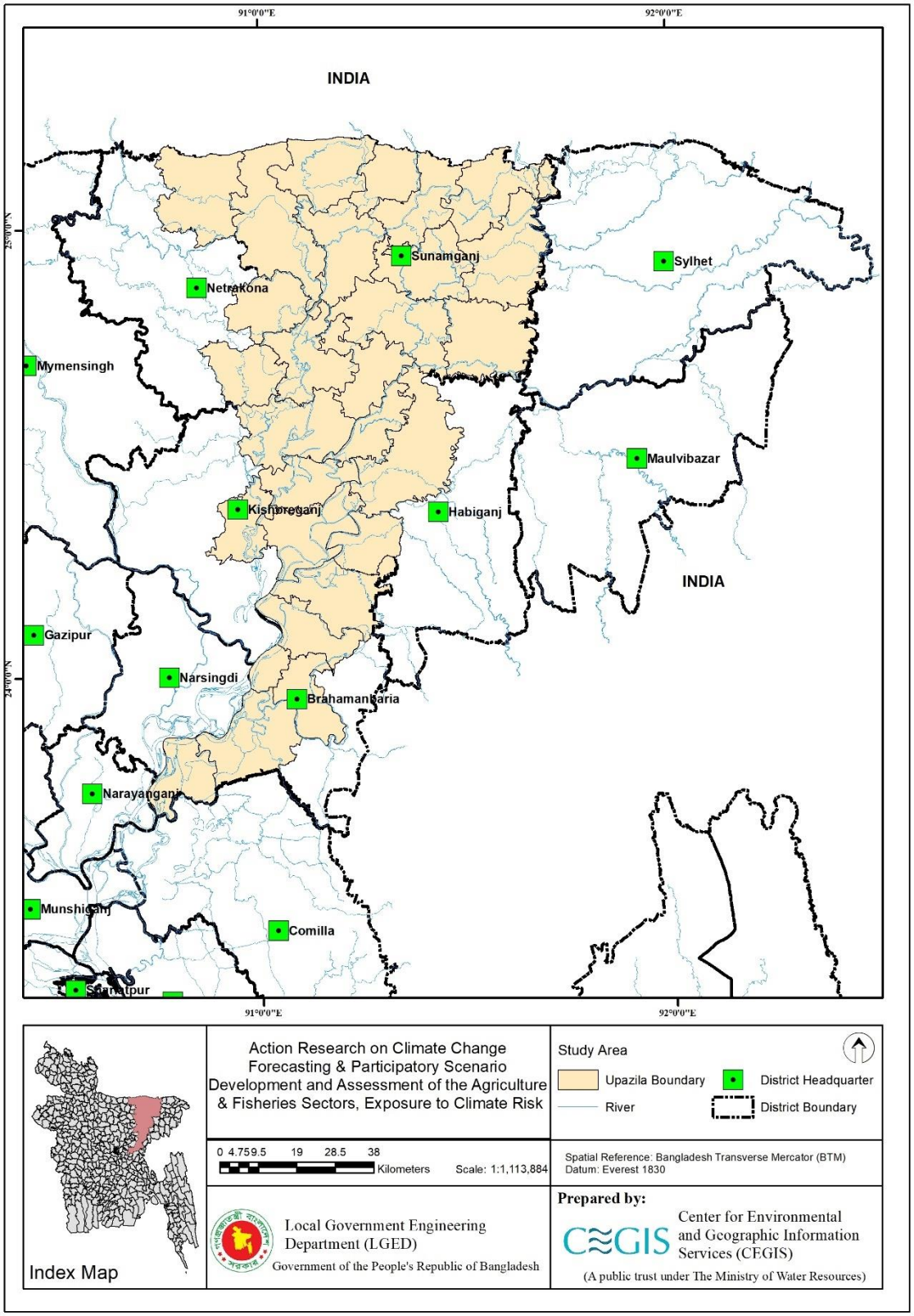


Figure 3.1: Geographic Location of the Study Area

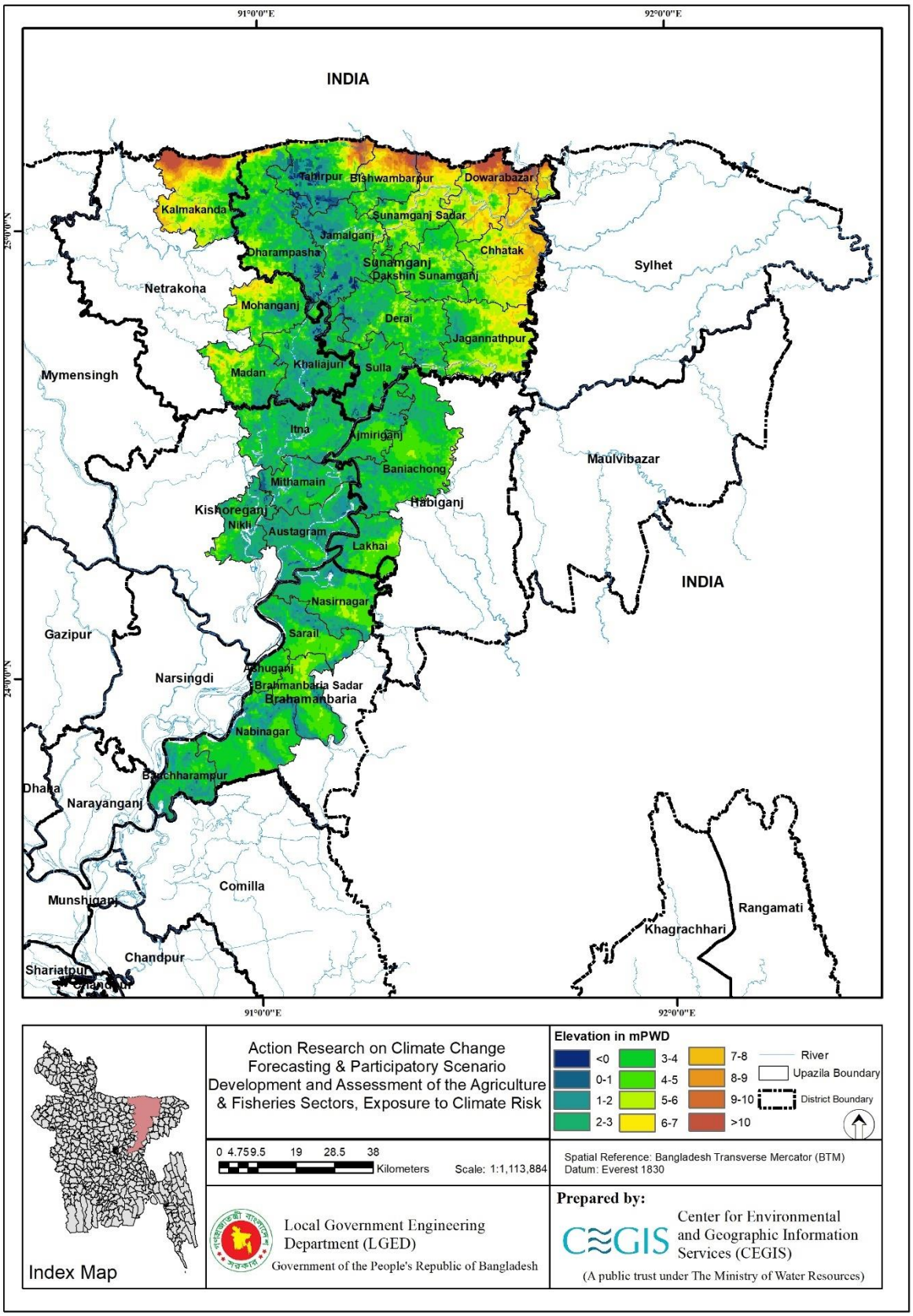


Figure 3.2: Digital Elevation Map (DEM) of the Study Area

3.3 Land Use

The analysis of the land use data of the study area shows that most of the area, about 83.58% is herbaceous crops, which is about 924645 hectares. About 8.22% of the area which is 90976.17 hectares, is rural settlement. Rivers and khals dominate on 4.41% of the study area, which is 48757 hectares in reality. Perennial Beels and Haors form 14511 hectares of the area which is 1.31% of the study area. Rest of the area consists of baor, brickfield, extraction sites, forest planted area, herb dominated area, lakes, pond, sand, shrub dominated area, swamp reed land.

Table 3.1: Total Land Use of the Study Area

Land Type	Land Area	Percentage
Baor	2711.91	0.25
Brickfield	534.86	0.05
Dump Sites / Extraction Sites	137.19	0.01
Forest Plantation	176.00	0.02
Herb Dominated Area	19892.63	1.80
Herbaceous Crops	924645	83.58
Lake	0.83	0.00
Perennial Beels/Haors	14510.78	1.31
Ponds	435.75	0.04
Rivers and Khals	48757.32	4.41
Rural Settlement	90976.17	8.22
Sand	974.24	0.09
Shrub Dominated Area	389.98	0.04
Swamp Reed Land	2176.67	0.20

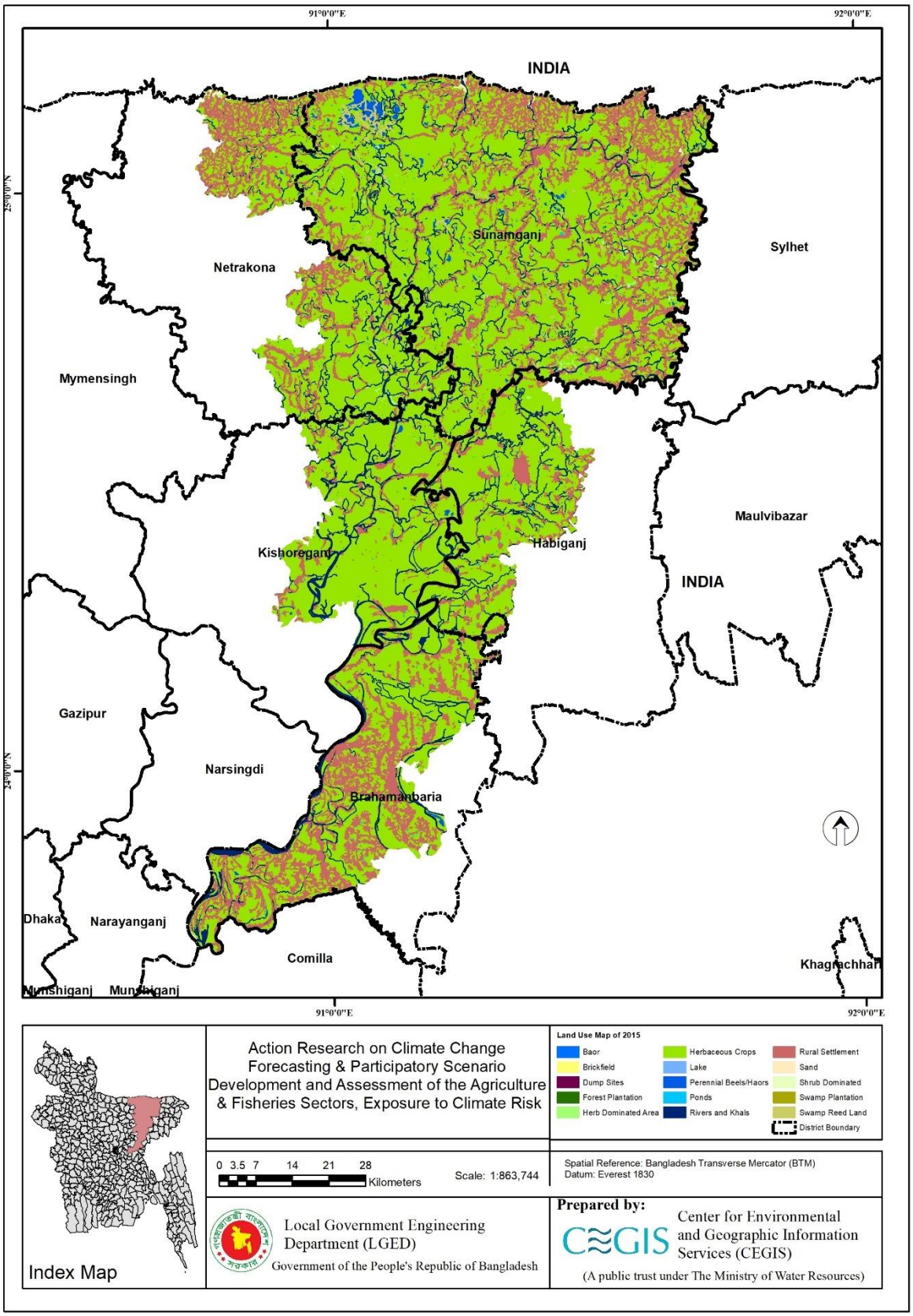


Figure 3.3: Land Use Map of the Study Area

3.4 River System

Situated just below the hilly regions of the states of Assam, Meghalaya and Tripura of India, the haor area has some of the most severe hydrological conditions like extreme rainfall and subsequent flooding. The area receives water from the catchment slopes of the Shillong Plateau across the borders in India to the north and the Tripura Hills in India to the southeast. The principal rivers of the area include the Surma, the Kushiyara, the Manu, the Kalni, the Baulai, the Kangsha, the Someswari, the Jadukata and the Khowai. Haor are connected with the main rivers by numerous small rivers and khals. A large number of Transboundary rivers enter into Bangladesh in the Northeast region. The major parts of the catchments of these rivers are outside of the country. Out of 54 Transboundary rivers between Bangladesh and India, Twenty-three enter into Bangladesh in the North East Region. The major parts of the catchments of these rivers are outside the country (in India). In the haor area, three major Transboundary river systems are the Meghalay, Barak and Tripura systems.

Three major river systems govern our study area: The Kushiyara-Kalni-Dhaleswari-Upper Meghna River System, The Surma-Baulai River System and the Bhugai-Kangsha-Dhanu River System. The Barak River (Indian River) feeds the Surma and the Kushiyara. Consequently it plays an important role in the two major systems, the Surma-Baulai and the Kalni-Kushiyara. The rivers contributing in these systems are described below:

Kushiyara-Kalni-Dhaleswari-Upper Meghna River System

The Barak River has been bifurcated at Amalshid into Kushiyara and Surma rivers. Starting at the bifurcation point, the Kushiyara River has a higher bed slope and is much deeper than the Surma River. The distribution of the Barak flow into the Kushiyara ranges from about 60% during high stages to about 100% during low river stages (FAP6, April 1993). The Kushiyara River has two major left bank tributaries, the Juri-Sonaibardal River and Manu-Dhalai River. These rivers, with hilly catchments in India, contribute flash floods.

Downstream of Markuli, the Kalni River flows through the low-lying Sylhet Basin. It is controlled by backwater flow of the Meghna River during monsoon season. Spills occur at several locations along the river in monsoon. These spills divert water from the Kalni River into the north and south floodplain.

The Kalni River splits near Issapur, with the western branch (the Baida River) flowing through the Meghna Estuarine floodplain and the eastern branch takes the name as Dhaleswari River (named as Dhaleswari-NE in the model). The Ratnasatai and Khowai River falls into Dhaleswari River near Madna. This river has an irregular, split channel pattern with abandoned channels and ox-bows adjacent to the main channel (FAP6, May 1997). The river is tidal at low flows, and water levels are controlled by backwater from the Meghna River.

Surma Baulai River System

This system carries the flow of the Surma and a large number of transboundary rivers flowing from the north to south.The Surma River conveys a part of the Barak river discharge and the discharges of its right bank tributaries. At the bifurcation near Amalshid, the channel bed of the Surma is higher than that of the Kushiyara; as a result the inflow from the Barak River into the Surma is less. It varies from about 40% of the Barak discharge at high stages to zero at the low stages (FAP6, April 1993). The dry season flows in the Surma River measured at Kanairghat originate mostly from the Lubhachara River. Major tributaries of this river system

are Sarigowain, Piyan, Dhalagang, Chela, Jhalukhali, Jadukata, Rakti and Someswari rivers.

Bhugai-Kangsha-Dhanu River System

The Bhugai River originates in the Tura Range of the Meghalaya Hills and enters Bangladesh at Nakuagaon. Above Nakuagaon, the river has a catchment area of 457 km2 within India. Within Bangladesh, the river flows in a southernly course for 28 km from Nakuagaon to its confluence with the Malijhee river, five kilometers south of Nalitabari. The Bhugai River has steep longitudinal slope, transports huge sediments during floods.

The Kangsha River originates from the confluence of the Bhugai and Malijhee, just upstream of Sarchapur, from where it follows an easterly course until it joins the Baulai just south of Sukdevpur. The Kangsha River receives cross-boundary inflows coming from the north via the Malijhee, Chillakhali, Bhugai, Nitai, Shibganjdhala and other hilly streams. The river also receives rainfall-runoff from the local area within Bangladesh, which is mostly located to the north of the Kangsha. The river divides into three channels at Thakurakona; Ghulamkhal, the Lower Kangsha and Dhonaikhali khal. The Kangsha river below its trifurcation has infilled with sediment thereby virtually blocked the original channel there. At present, about 70% of the monsoon flow of the Kangsha river is conveyed through the Ghulamkhal, 10% through the lower Kangsha and 20% through the Dhonaikhal River. However, the entire dry season flow is conveyed by the Dhonaikhal River (FAP6, September 1994).

Dhanu river carry the combined flow of Mogra river and Dhonaikhal and finally drains to the Ghorautra river.

3.5 Haor system

Almost all the haors of Bangladesh are scattered across the north-east part of the country. Depending on their position and characteristics, haors can be classified into three types.

- Foothill and near hill haor
- Floodplain haor
- Deeply flooded haor

The haor area of Sylhet and Moulvibazar districts are situated near hills or at foothills. The haor areas of Kishoreganj, Brahmanbaria and a part of Netrokona district are floodplain haor while those of Sunamganj, Habiganj and rest of Netrokona are deeply flooded haor. The haors in the study area of this project mainly lies within the deeply flooded category. The deeply flooded haor area is defined by the region fed mainly by the Meghalaya catchment of India. The upstream catchments of India receive heavy rainfall. The place with highest rainfall in the world, Mawsynram-Cherrapunji is just on the north of this deeply flooded area. Because of the intense rainfall in the upper catchment area which includes a hilly topography also, flood water is carried by the rivers very quickly to the downstream leading to flooding rapidly in this region. The Surma-Kushiyara river system in this area carry the flood water from the upstream.

There are at least 203 haor systems within the study area. The major haors which are located within this area are Pagner Haor, Patharchuli Haor, Kalikota Haor, Dekar Haor, Gunjaijuri Haor, Shanir Haor, Matian Haor, Tanguar Haor, Halir Haor, Chayer Haor, etc. Tanguar Haor Shanir Haor and Matian Haor are located in the north most part of the study area while Humaipur, Katiajuri and Dattakhola Haor are in the south most part of it. Gungiajuri Haor, Dekar Haor, Kalitkota Haor, Pagner Haor etc. are some of the biggest haors located in this

area. These haors mainly receive water from the Surma-Kushiyara river system and the surrounding Jadukata, Dhanu, Kalni, Baulai, Updakhali, Titas, Upper Meghna, Ghorautra etc.

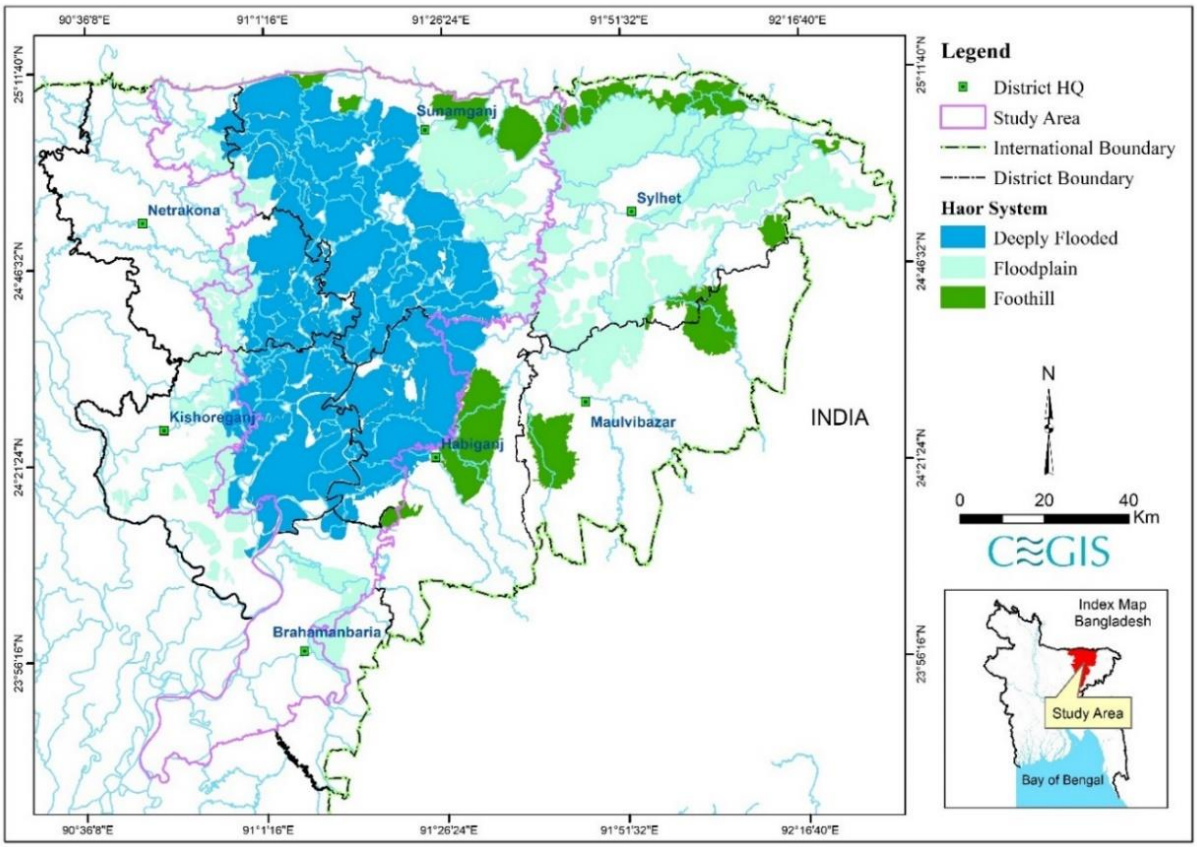


Figure 3.4: Location of the Haors in the Study Area

3.6 Climate

The Northeast Region has a typical tropical monsoon climate characterized by the twice-yearly reversal of air movement over the region. For about four months in winter (December through March) air flows to the region from northeast, while for about four months in summer (June through September) it flows to the region from the southwest. These airflows or winds are called monsoons; that of winter called the northeast monsoon while that of summer is called the southwest monsoon. A reversal of the monsoons takes about two months, the first occurring in spring (April-May) when the change of wind direction is from northeast to southwest via northwest, and the second occurring in autumn (October-November) when the change is from southwest to northeast via southeast. These periods of changing wind direction are called the spring and autumn reversals.

The southwest monsoon brings moist air into the region from the Bay of Bengal. Rainfall in this season is abundant and it is often referred to as "the monsoon", meaning the rainy season. Typically, the rainfall in this season increases, northeastwards across the region and reaches a maximum on the southward-facing slopes of the Shillong Plateau in Meghalaya; Cherrapunji, on these slopes, is well known as the wettest place on Earth, its mean annual rainfall being over 12000 mm.

3.7 Rainfall

Rainfall is the most distinctive component of climate in the haor region. Climate is dominated by distinctive geographical characteristics of the region which ultimately plays a major role in determining the spatial and temporal distribution of rainfall, evapotranspiration and hydrology of surface and groundwater. The region is located entirely to the north of the tropic of cancer; hence its monsoon climate is known as sub-tropical. The sub-tropical monsoon climate tends to have more sharply defined seasons than the tropical climate.

Since rainfall in the adjacent Indian side largely affects flooding in the haor area, the rainfall pattern of the upstream catchment has great influence. There is a huge variation in rainfall in different catchment of the river systems of the upstream area in India. Annual average rainfall in the haor districts are huge and found to have huge variation over the area from observed data.

Like all other part of Bangladesh, the hydrological year in the region is defined as beginning on 1st of April and ending on 31st of March, and it comprises four more or less distinct seasons:

- Pre-Monsoon: April and May
- Monsoon: June to September
- Post-Monsoon: October and November
- Dry Season: December to March

The pre-monsoon season is characterized by increasing rainfall and flash floods. The bulk of the annual rainfall occurs during the monsoon season when flash floods are regular and frequent and the central part of the Northeast Region is flooded over to a depth of several meters. The post-monsoon is characterized by decreasing rainfall and by the draining out of flood water which is usually accumulated in the monsoon season. The dry season is one of little or no rain, and river discharges are greatly reduced.

The available recent climate data of the two stations in the study area show that the yearly average rainfall in the study area is 3200mm. The maximum rainfall recorded in Sreemangal Station is 258 mm on 20 July, 2004 and that in Sylhet Station is 362 mm on 13 June, 2000. Usually, most precipitation is recorded in the month of June and the minimum in the month in January. Among the locations of the study area the highest rainfall was recorded in Sunamganj closest to Cherapunji, which is the highest precipitation area in the world.

3.8 Temperature

The available data on temperature of the two stations situated in the study area shows that the average maximum temperature in that area is 30.55°C and the average minimum temperature is 20.19°C. January is considered to be the coolest month of the year having a temperature of 11.4°C and August is warmest month in this region with a temperature of 32.55°C. In the recent time (1991-2017), the year 1999 was considered to be the warmest year having an annual maximum temperate of 31.4°C and 1997 was the coolest having a record of annual minimum temperature of 18.92°C.

4. Data Collection

4.1 Secondary Data

4.1.1 Hydrological Data

A number of both tidal and non-tidal water level stations of Bangladesh Water Development Board (BWDB) are located in the study area. The available water level data of these station was collected for the analysis of flood frequency and consequently for the determination of the probability of the return period of floods of heavy intensity in the study area. The list of the water level stations, both tidal and non-tidal in the study area is tabulated below:

List of Tidal and Non-Tidal Stations in the Study Area

Non-Tidal Rivers		
Station ID	**Station Name**	**River Name**
33	Gobindaganj	Bhattakhal
72B	Sukdebpur	Dhanu-Boulai
131.5	Laurergarh Saktiarkhola	Jadukata
333	Muslimpur	Julakhali
333A	Dulura	Jhalu Khali
337	Urargaon	Noyagang
268	Chhatak	Surma-Meghna
269	Sunamganj	Surma-Meghna
345	Durlavpur	Dhanu
Tidal Rivers		
Station ID	**Station Name**	**River Name**
3A	Brahmanbaria	Anderson Khal
72	Khaliajuri	Dhanu-Boulai Ghorutrautra
73	Itna	Dhanu-Boulai Ghorutrautra
270	Markuli	Lower Meghna
271	Azmiriganj	Upper Meghna
272.1	Austagram	Upper Meghna
272	Madna	Lower Meghna
295	Ajabpur	Titas
297	Gokarnaghat	Titas
298	Nabinagar	Titas

4.1.2 Meteorological Data

Available data related to the climate such as rainfall, maximum temperature and minimum temperature was collected from the two weather stations of Bangladesh Meteorological Department (BMD), Sylhet and Sreemangal situated in the study area. The timeline of the collected data was from 1991 to 2015.

Table 4.1: BMD Stations in the Study Area and Respective ID

BMD Station Name	BMD Station ID
Sylhet	10705
Sreemangal	10724

4.1.3 Land Use Data

The assessment of land use change was carried out using satellite image analysis of two distinctive years, although land use change is so insignificant in Haor areas. Green House Gas emissions will be assessed mainly from agriculture sector and significant land use change. Agriculture and Land Use National Greenhouse Gas Inventory Software will be used to assess GHG emission. IPCC guideline, 1996 will be followed for GHG emission inventory preparation.

4.1.4 Hazard Data

Hazard data was collected from a number of number of organizations. These organizations have been collecting these data for years. The source of flash flood data was National Water Resources Database (NWRD), Soil Resource Development Institute (SRDI), National Water Resources Database (NWRD) and Bangladesh Meteorological Department (BMD) provided the drought data and lastly data on thunderstorm, hail storm and cold snaps was collected from Bangladesh Meteorological Department (BMD) and Comprehensive Disaster Management Programme (CDMP-II) and from other available published literatures.

Table 4.2: Hazard Data Collected from Different Sources

Data Source	Type of Data
National Water Resources Database (NWRD)	Flash Flood Data, Drought Data, Production Data
Soil Resource Development Institute (SRDI)	Drought Data
Comprehensive Disaster Management Programme (CDMP-II)	Thunder Storm, Hail Storm, Cold Snap Data

4.1.5 Green House Gas (GHG) Data

Green House Gas (GHG) emissions has been assessed mainly from agriculture sector. Four major sources of GHG emission from agriculture sector are (i) CH4 emission from cultivated rice fields, (ii) N2O and CO2 emission from N-based fertilizer, (iii) Enteric fermentation, and (iv) CH4 and N2O emission from manure management. The dominant sources of emissions are CH4 from rice field and enteric fermentation from the livestock subsector. The next important sources are N2O emission from fertilizer application and direct N2O emissions from manure system.

To facilitate the estimation of emissions following data from both secondary sources and field levels habve been collected:

- Cropped Area from Bangaladesh Bureau of Statistics
- Cropping Pattern from Field Survey
- Fertilizer Data from Department of Agriculture Extension
- Livstock Information from Depatrment of Livestock Services

4.2 Primary Data

4.2.1 Scoio-economic, Climate Risk and Participatory Scenario Related Data

For socio-economic and climate change risk assessment and participatory scenario development process, different data has been collected from field level through using different social techniques like Key Informant Interview (KII), Sample based Household Survey and Focused Group Discussions (FGDs). Rigorous field level investigation has been performed with relevant keystakeholders to facilitate the analysis.

Key Informant Interview (KII)

Total 56 Key Informants Interview have been conducted, which comprises of concerned actors who have stake/influence on the objective of this project. Thus, it include: LGED officials, officials from relevant government departments, NGOs, local knowledgeable person and community people etc.

Sample based Household Survey

A sample basis survey among the beneficiary household has been carried out for getting out field level quantitative data. About 392 sample household surveys have been carried out from 56 unions of 28 upazilas of the study area. It is a non-probability purposive sampling technique, which covers 14 numbers of household surveys (7 for fishers and 7 for agriculture) for each upazila. In this method, sample population was identified from the most climate-vulnerable areas based on occurrence of climatic hazards. Thus, for example, one area will be selected for hailstorm, flash flood etc. The questionnaire was semi-structured considering issues mentioned in ToR based Task.

Focused Group Discussions (FGDs)

A total of 56 FGDs have been conducted in the most vulnerable areas of the study area. Here, preliminary vulnerable areas refer to unions have been identified through preliminary field visit and conducting KII with relevant personnel. The participants of FGDs were two occupational groups (agriculture and fishery) separately; and they are most climate-vulnerable parson in terms of their geographical living locations. The sessions were pre-arranged following standard participatory norms of FGDs. Checklists prepared for FGDs and KII are attached in Appendixes and Table 4.3 shows the identified most climate vulnerable unions for conducting KIIs, FGDs and Household Surveys in the study area.

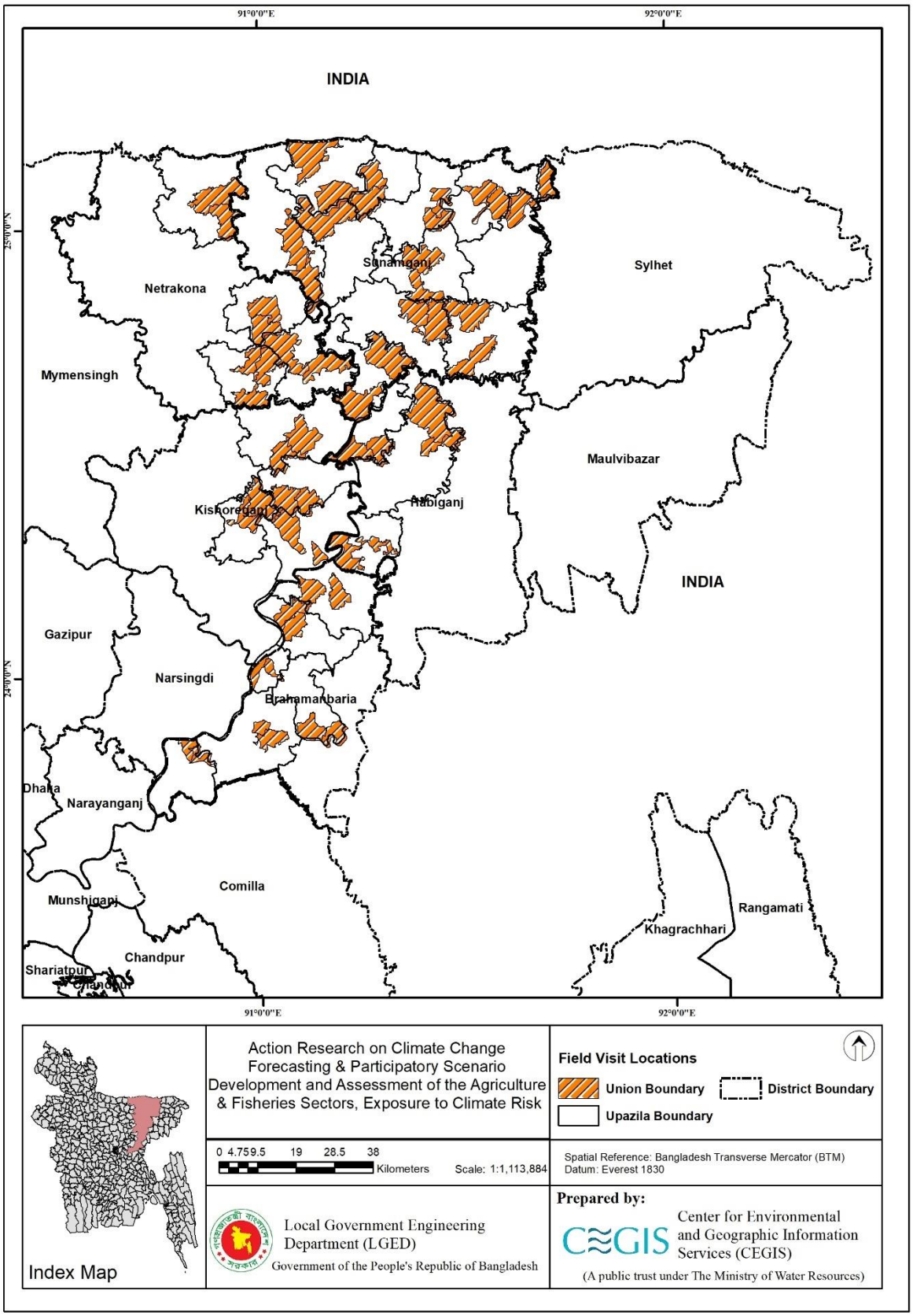


Figure 4.1: Location of FGDs and KII

Table 4.3: Most Climate Vulnerable Unions of the Study Area

SL	Districts	Upazilas	Vulnerable unions
01	Sunamgonj	Sunamganj Sadar	Molla Para
			Korban Nagar
02		Bishwamvarpur	Fatehpur
			Badhaghat
03		Tahirpur	Sreepur
			Tahirpur Sadar
04		Dowarabazar	Dowarabazar Sadar
			Surma
05		Chatok	Islampur
			Noarai
06		Jamalganj	Beheli
			Jamalganj Uttar
07		Jaghannathpur	Kalkalia
			Raniganj
08		Derai	Jagdal
			Karimpur
09		Dakkhin Sunamganj	Joykalas
			Pashchim Birgaon
10		Sullah	Habibpur
			Sullah Sadar
11		Dharampasha	Uttar Sukhair Rajapur
			Dakkhin Sukhair
12	Netrakona	Mohonganj	Magan Siadhar
			Suair
13		Madan	Govindasree
			Kaitaeel
14		Khaliajuri	Mendipur
			Khaliajuri Sadar
15		Kalmakanda	Kalmakanda Sadar
			Barkafan
16	Habiganj	Lakhai	Lakhai Sadar
			Bamoi
17		Baniachang	Kagapasha
			Boroiuri
18		Ajmiriganj	Sibpasha
			Kakailseo
19	Kishoreganj	Itna	Elongjuri

SL	Districts	Upazilas	Vulnerable unions
			Itna Sadar
20		Nikli	Shingpur
			Dampara
21		Aushtagram	Kastul
			Purba Aushtagram
22		Mithamain	Ghagra
			Mithamain Sadar
23	Brahmanbaria	Nabinagar	Nabinagar purba
			Shibpur
24		Bancharampur	Pahariakandi
			Tejkhali
25		Brahmanbaria Sadar	Basudev
			Sultanpur
26		Sirail	Pakshimul
			Chunta
27		Nasirnagar	Volakut
			Nasirnagar Sadar
28		Ashuganj	Ashuganj Sadar
			Char Car Tola

4.2.2 Database Preparation, Data Entry, Processing and Analysis

Finally, all generated data from the quiestionnaire have been digitized into access database, checked the quality and processed accordingly for further analysis.

5. Trend Analysis and Future Projections

5.1 Trend Analysis

5.1.1 Temperature

To perceive the annual trend of the maximum and minimum temperature variations over three decades, trend analysis of rainfall data of two stations (Sreemangal and Sylhet) were performed. It has been seen that, the mean maximum annual temperature varies between **31.62°C to 29.88°C** at Sreemangal while the range at Sylhet is between **31.47°C to 29.12°C**. Available temperature datasets were collected from the Bangladesh Meteorological Department. The mean maximum annual temperature varies between **31.62°C and 29.88°C** at Sreemangal whereas values ranged between **31.47°C** and **29.12°C** at Sylhet. Both maximum and minimum temperature at Sylhet shows relatively higher variability than at Sreemangal.

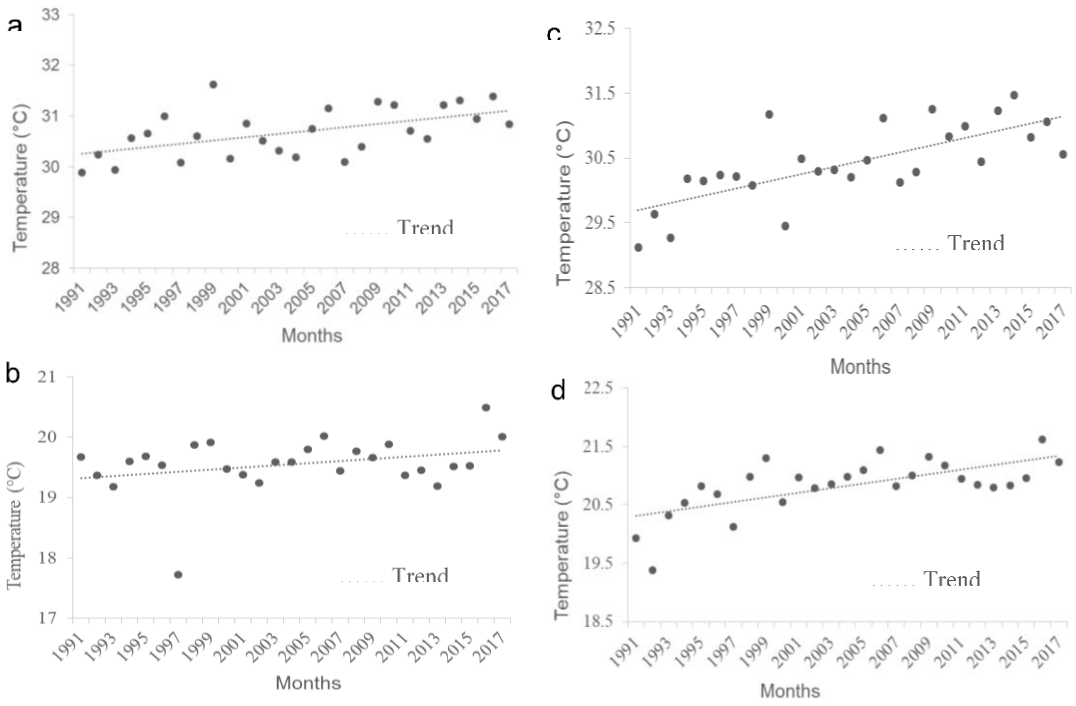


Figure 5.1: Annual Average Maximum and Minimum temperature from 1991 to 2017 at station(s) Sreemangal (a & b) and Sylhet (c & d) respectively

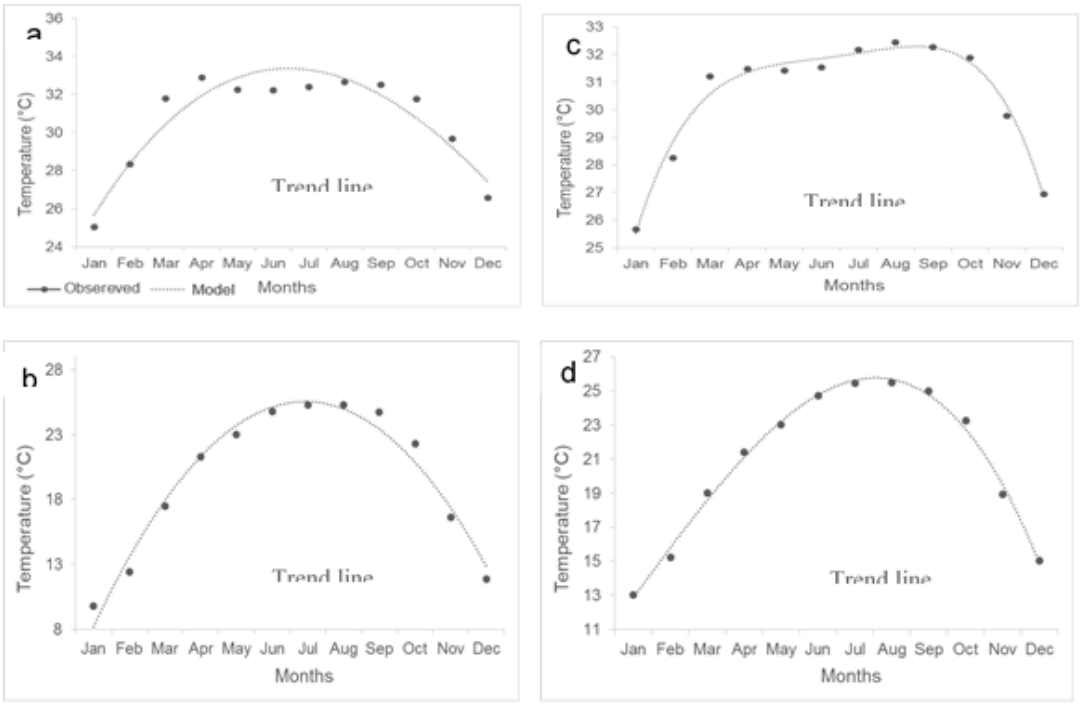


Figure 5.2: Monthly average maximum and minimum temperature from 1991 to 2017 at station(s) Sreemangal (a & b) and Sylhet (c & d) respectively

5.1.2 Rainfall

Haor region carries huge volume of flow every year through its three main catchments Barak (50%), Meghalaya (36%) and Tripura (14%). Major portions of this flow are generated from significant rainfall in Meghalaya and Barak basins in addition to the local contribution of Sylhet region of Bangladesh.

Available rainfall data for Sreemangal and Sylhet were collected from Bangladesh Meteorological Department. Cumulative annual rainfall data from 1991 to 2017 were examined to conduct the trend analysis for those locations.

Annual cumulative rainfall at Sylhet station showes a higher variability compared to Sreemangal station. The minimum and maximum rainfall varies between 1741mm and 3813mm, and 3100 mm and 5944 mm at Sreemangal and Sylhet stations respectively. Median annual rainfall at Sylhet station (3891mm) was found considerably higher than Sreemangal station (2266mm). A moderately strong positive correlation was noticed (correlation co-efficient 0.62) between the cumulative annual rainfalls at those two locations.

A slight increase in annual rainfall were noticed in both stations. The regression model shows an average of 4.1% increase of the annual rainfall at every decadal scale time periods. On the other hand, an approximately 2.28% increase of the annual rainfall were predicted at Sylhet station for the similar time frames.

In addition to the cumulative annual rainfall, an increase of pre-monsoon rainfall were reported in last few decades which might increase the chances of extreme flash flood events during the pre-monsoon periods. Evidence has been found from analysis of pre-monsoon rainfall that, pre-monsoon rainfall has increased from 18%-24% (from the period 1691-1990) to 25%-27% in recent years (1991-onwards) due to climate change (CEGIS, 2017).

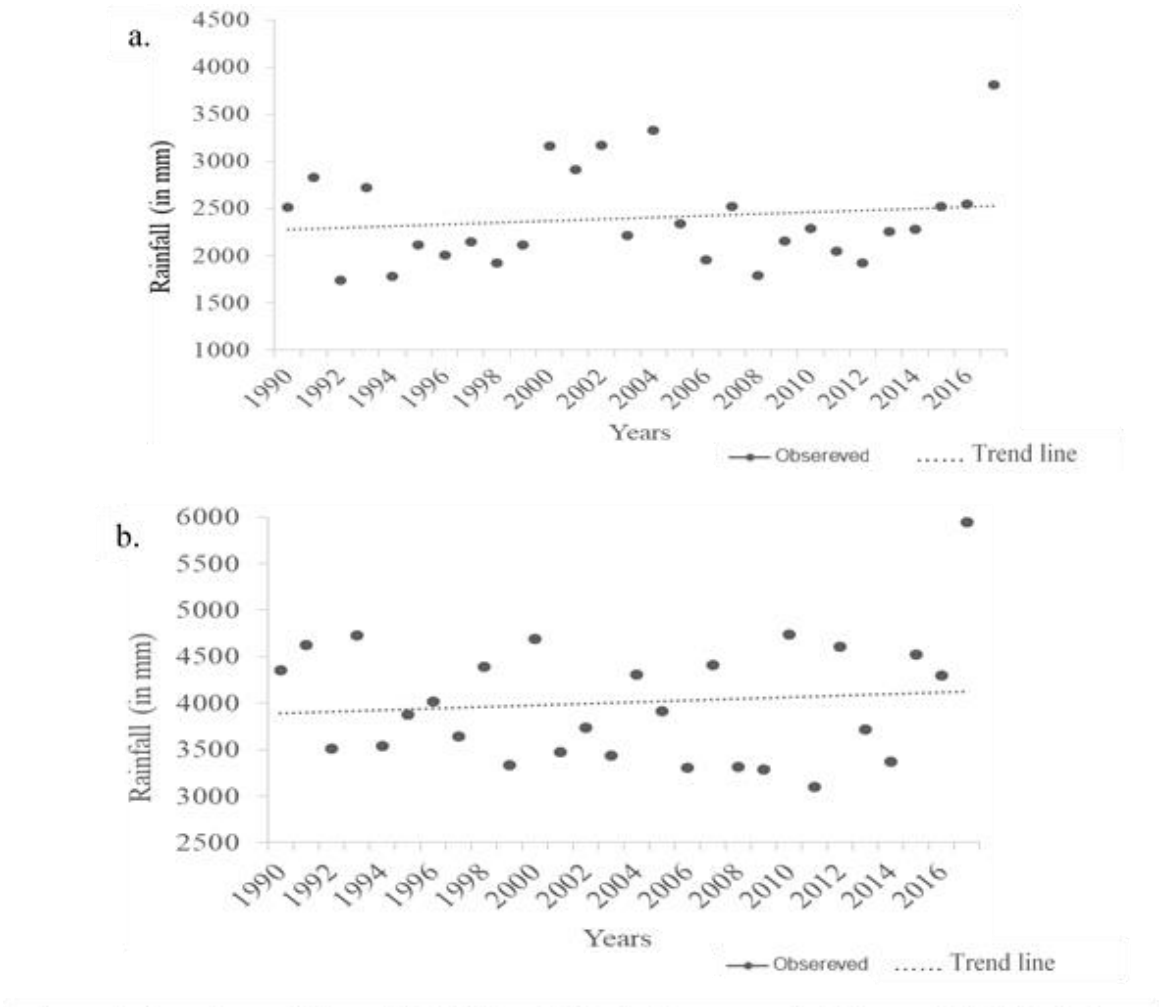


Figure 5.3: Annual Cumulative rainfall (1991-2017) at a) Sreemangal station and b) Sylhet station

5.1.3 Flash Floods

Available MODIS satellite images for the peak flood months (March to May) from 2005 to 2017 were studied to evaluate the flash flood extents at the N-E haor region and understand the trend of flash floods. In general, the largest land area inundated with water were found in May. However, analysis results showed a time dependent variations of peak flood extents at different locations. In March, Brahmanbaria and Habiganj districts were found to be most and least inundated among the five haor districts. On the other hand, Sunamganj areas became highly flooded in the month of April. Most importantly, the majority of the extreme flood events were found to be taken place in May. In Mays' of 2006, 2007, 2010 and 2015, more than 15% of the lands were flooded with water at several haor districts (Figure 5.4). In May 2010, about 60%, 39%, 35%, and 15% land areas were flooded at Kishoreganj, Sunamganj, Netrokona and Habiganj respectively.

Table 5.1: Summary statistics of the flood extents (% area inundated) at five haor districts in pre-monsoon period (Year 2005 – 2017)

Months / Districts	March				April				May			
	Minimum	Maximum	Median	Std. Deviation	Minimum	Maximum	Median	Std. Deviation	Minimum	Maximum	Median	Std. Deviation
Brahamanbaria	5.47	17.49	9.32	3.53	0.07	8.31	4.38	2.92	0.36	10.28	6.07	3.17
Habiganj	0.55	8.27	1.09	2.69	0.19	10.41	2.03	4.47	0.32	15.23	3.83	5.01
Kishoreganj	1.31	5.95	3.21	1.34	0.91	11.55	4.82	4.15	0.44	60.82	7.72	17.52
Netrakona	0.079	8.45	2.70	2.7	1.15	5.17	2.05	1.39	0.98	35.15	4.02	10.71
Sunamganj	2.73	6.19	4.37	1.19	4.87	12.34	7.52	2.49	2.12	39.8	10.75	10.86

Note: Stranded deviation denotes a quantity expressing by how much the values of a dataset differ from the mean value

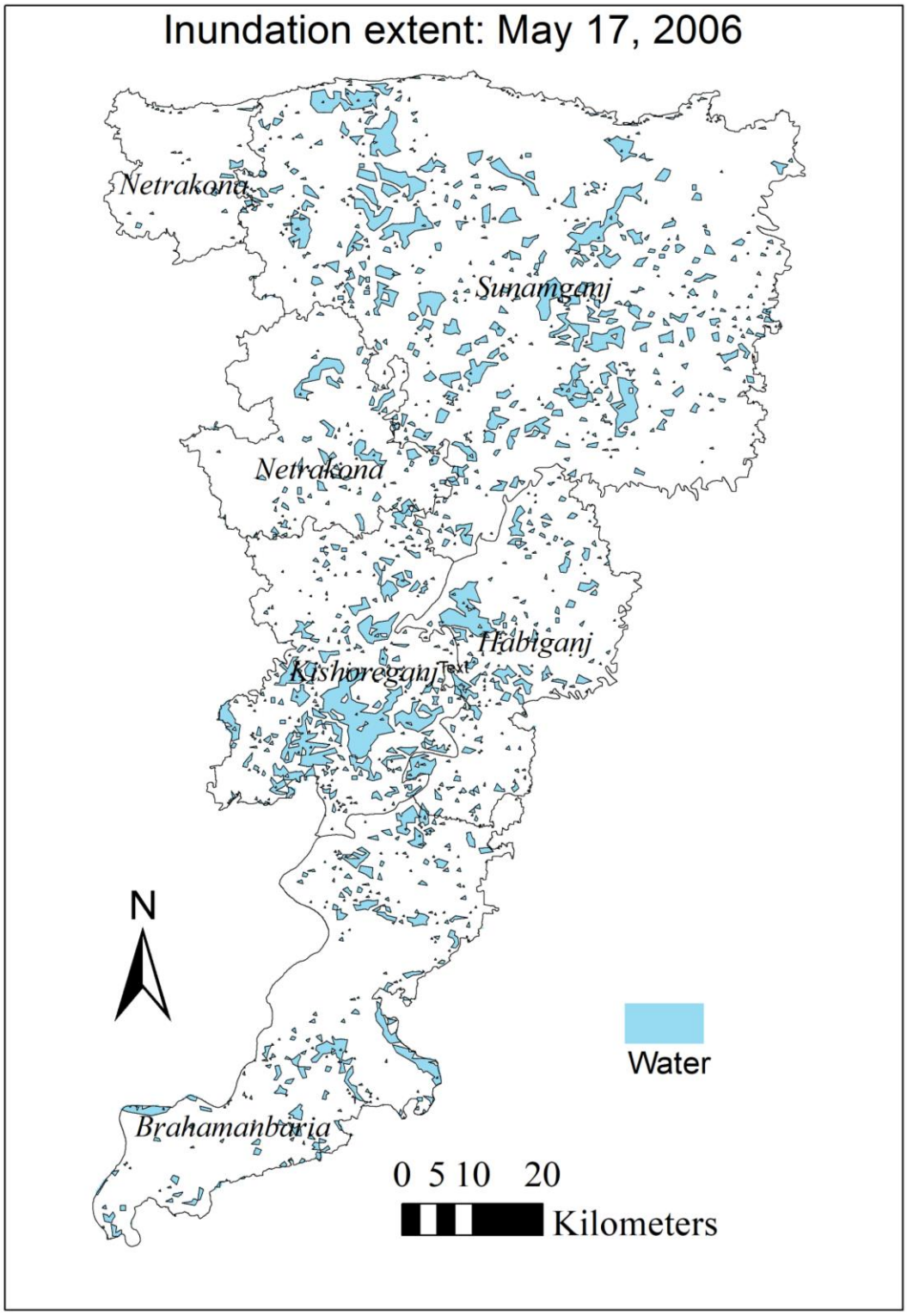


Figure 5.4: Flash flood extents (% area inundated) at five haor districts in 2006

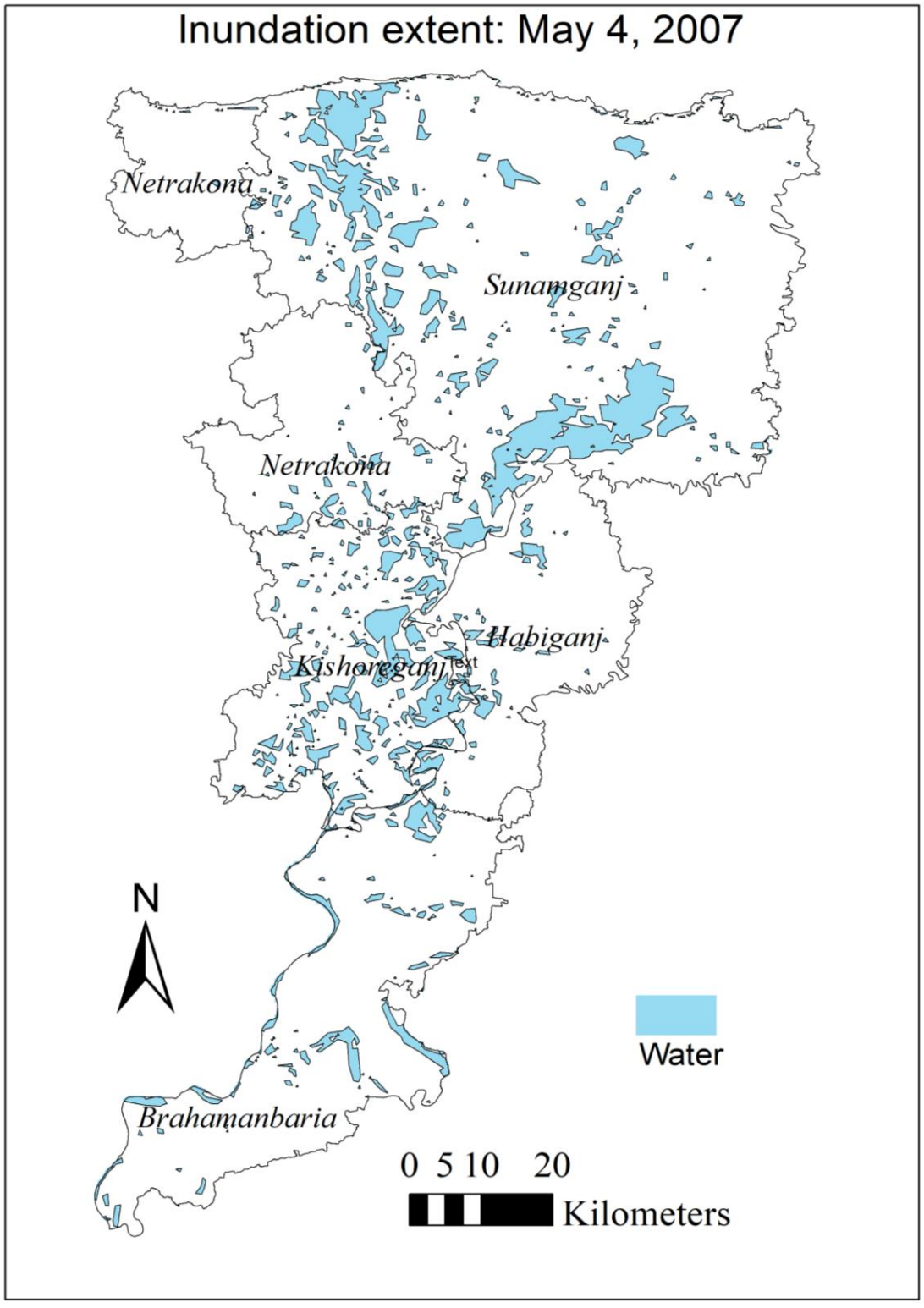


Figure 5.5: Flash flood extents (% area inundated) at five haor districts in 2007

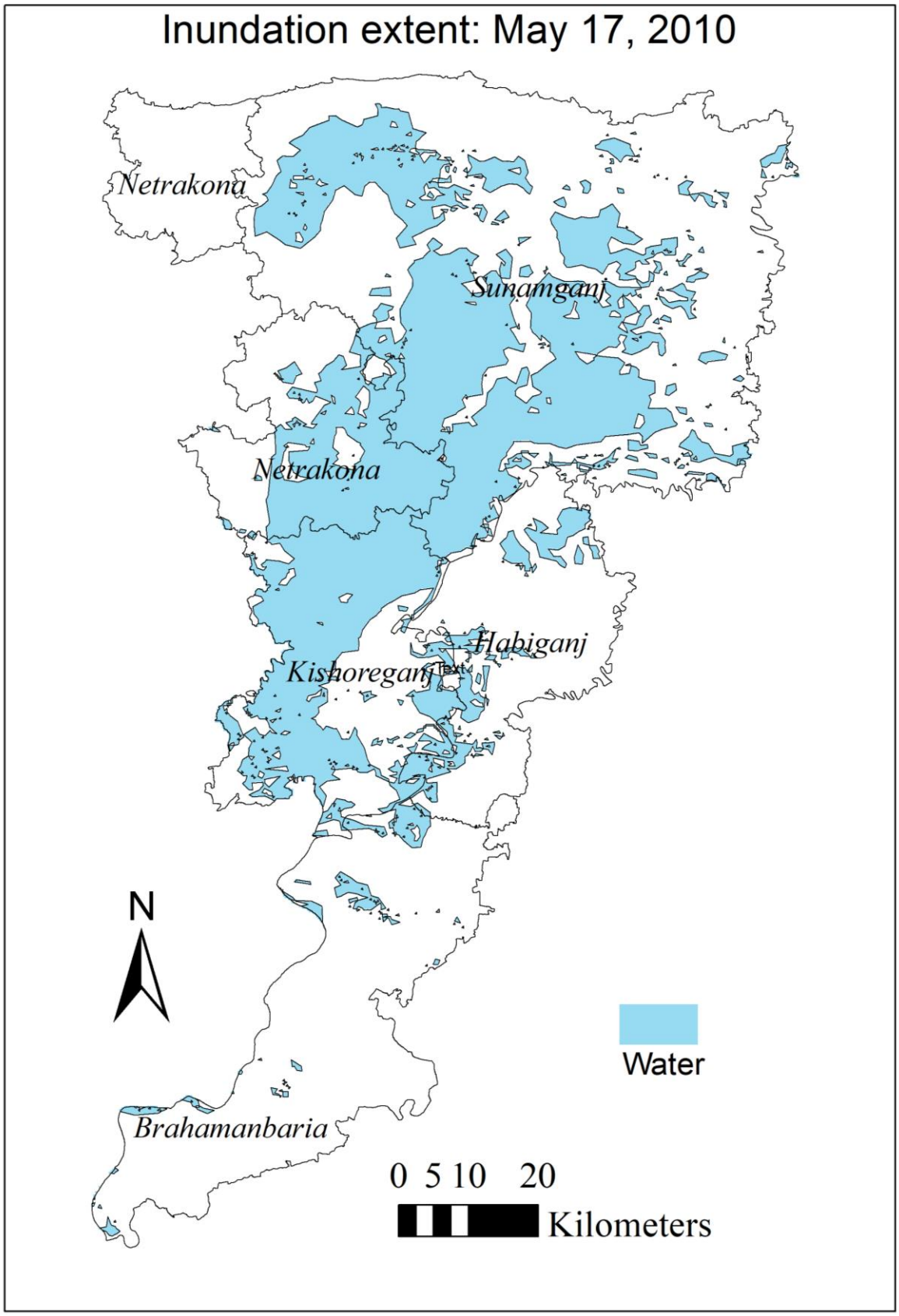


Figure 5.6: Flash flood extents (% area inundated) at five haor districts in 2007

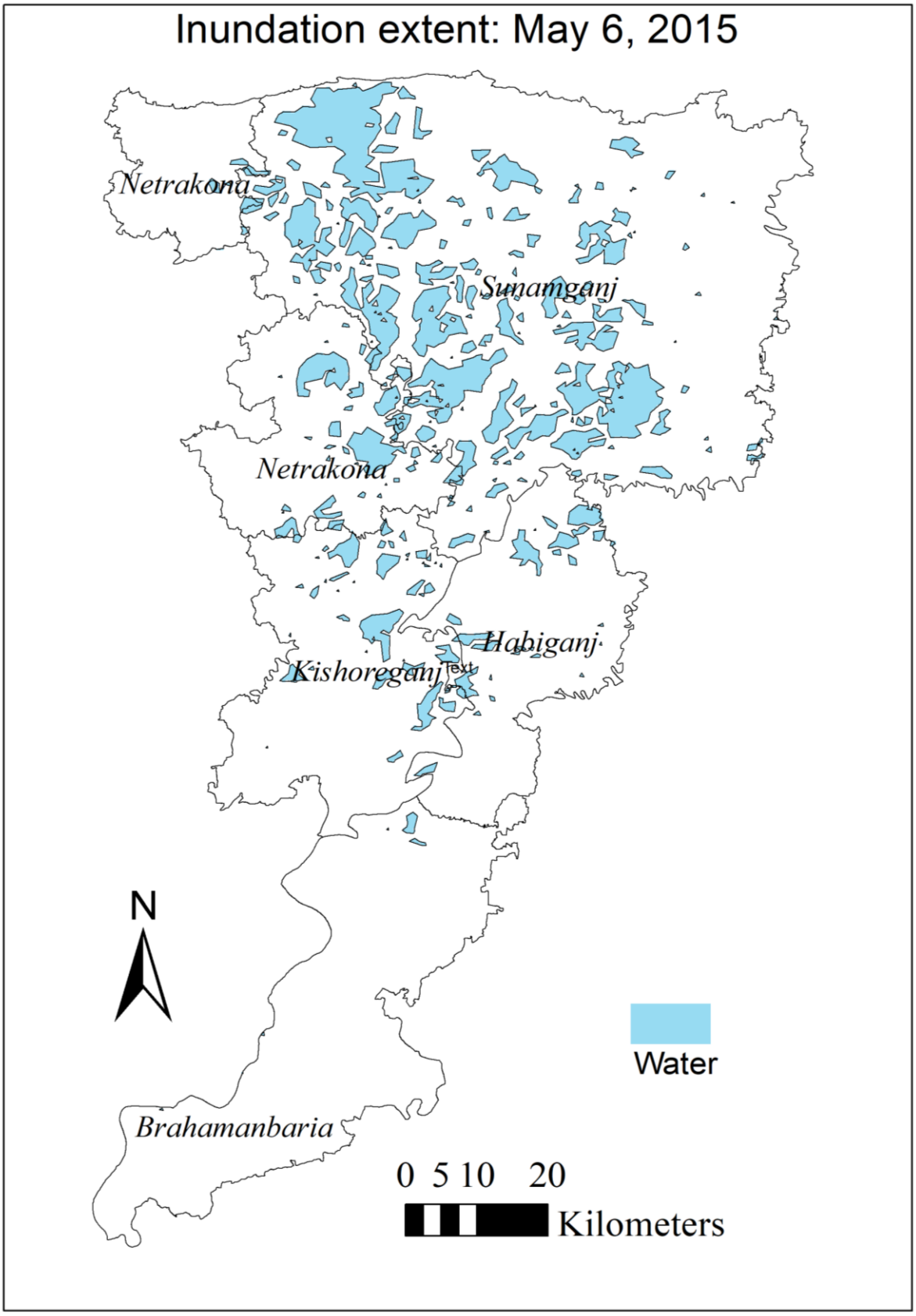


Figure 5.7: Flash flood extents (% area inundated) at five Haor districts in 2015

Although the flood flood trends were not significantly increased over the past thirteen years' time period in the N-E haor areas, the frequency of high magnitude extreme flash flood events have been increased based on a recent study by CEGIS (2017) (Figure 5.8). Increase of the pre-monsoon rainfall as stated in the earlier rainfall section, might be the most possible reason for such an increase of extreme flash floods in those areas, which comes early than usual time and hampers crop production. Figure shows that more than 10 years return period flash floods is increasing in recent years, whereas 5 year return period flash floods occurred in regular basis before 2010. These phenomena state that intensity and frequency both are increasing in case of early flash floods.

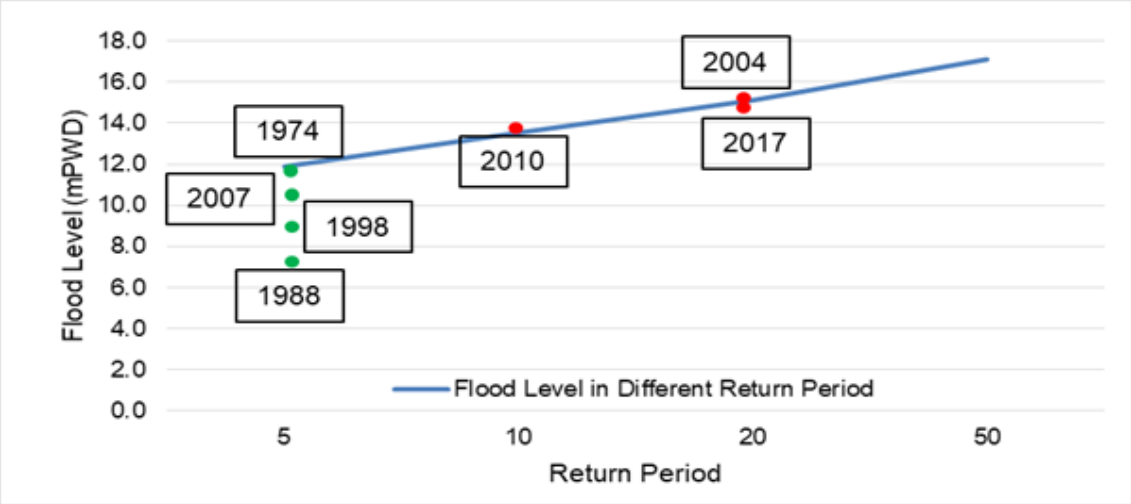


Figure 5.8: Peak flood level of a nearby station at Sylhet near the study area during April against different return periods (CEGIS, 2017)

5.1.4 Thunderstorm

Several literatures have been reviewed to understand the occurrence level of thunderstorm throughout the nation; but no specific data or information has been found on thunderstorm except one, where the year wise fatality rate and percentage of fatality occurrence with respect to each district was found. That percentage was applied to calculate fatality occurrence in each district; Relation between fatality rate and occurrence of Lightning was found out by dividing total known lightning occurrence by total fatality occurrence.

Rate of Fatalities from 1990-mid 2017

As per the database collected on fatalities and injuries due to lightening for timespan 1990 to mid-2017collected from disastrous weather events of the Department of Disaster Management Bangladesh it has been observed that, number of death tolls was about **3056 (Approximately)** during last 28 years; From the below Figure, it is evident that, fatality rate due to lightening are highest during pre-monsoon (62%) and lowest during winter (2%); Same thing has been observed in case of number of injuries. Injury rate due to lightening are highest during pre-monsoon (59%) and lowest during winter (1%); Figure 5.9 and Figure 5.10 shows the bar chart representing number of fatalities and injuries respectively for the time period 1990 to mid-2017. Figure 5.11 contains the pie bar representing the percent of fatalities and injuries during monsoon, pre-monsoon, post monsoon and winter.

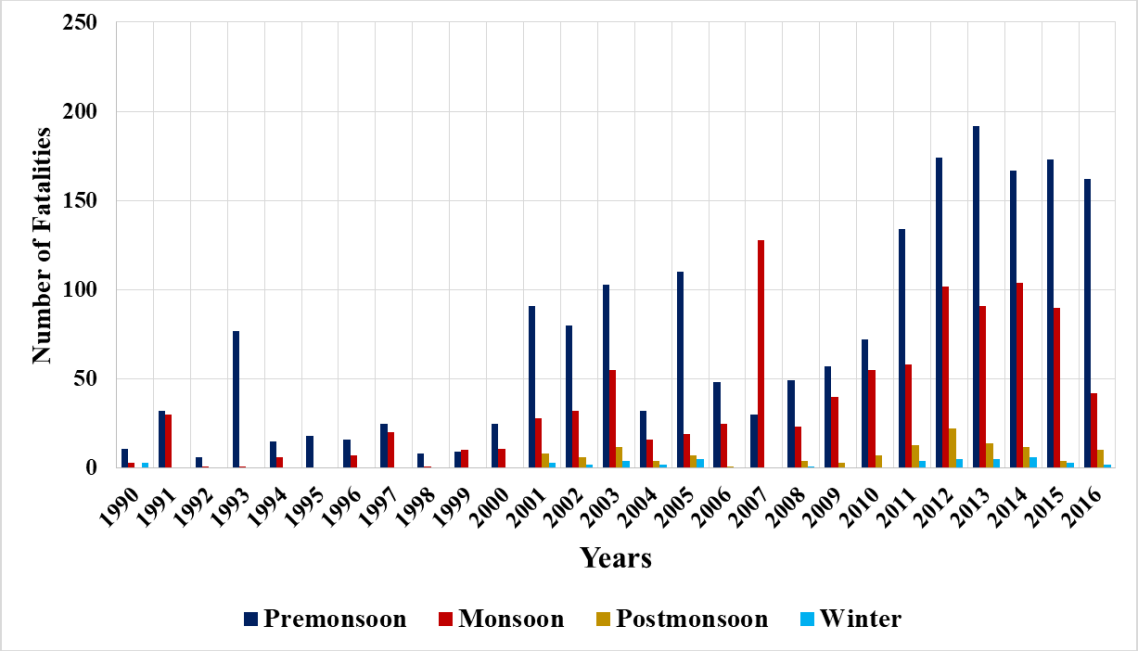


Figure 5.9: Number of Fatalities from 1990 to mid-2017

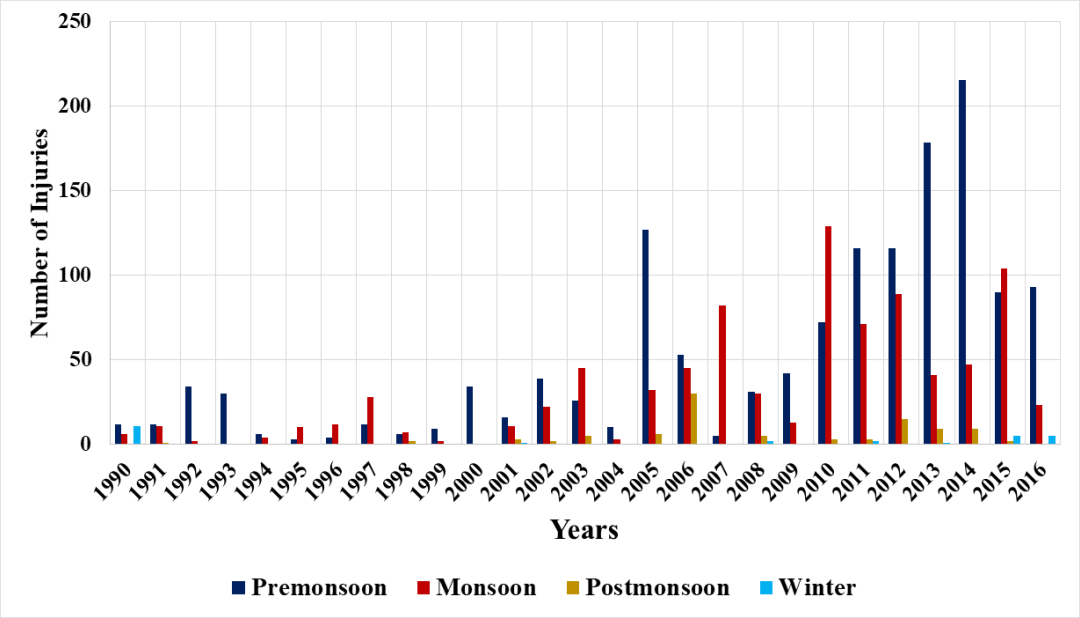
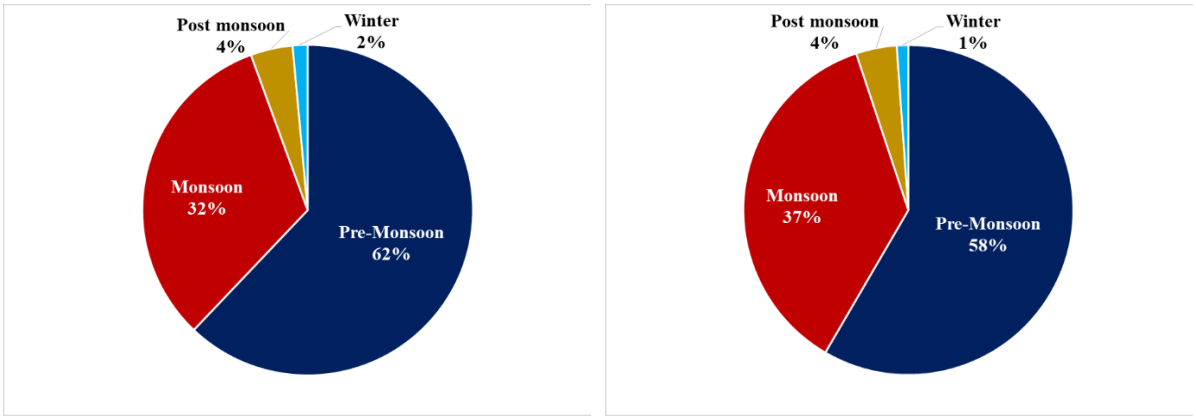


Figure 5.10: Number of Injuries from 1990 to mid-2017



(a) (b)

Figure 5.11: Pie Diagram Showing the Rate of Fatalities and Injuries both are high during Pre-monsoon

The trend analysis from 1990 to 2017 shows an increasing trend of both fatalities and injuries. Also, comparing between both of fatalities and injuries rate it has been seen that, fatality has more increasing trend than the injuries. Figure 5.12 below represents the trend of fatality and injuries for the time span 1990-2017:

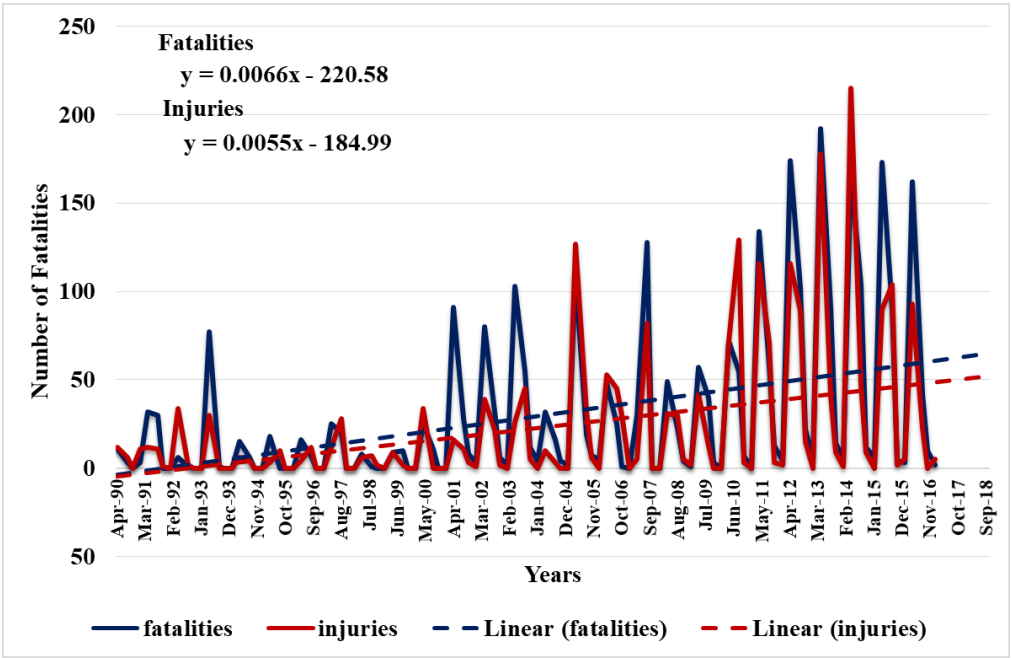


Figure 5.12: Diagram Showing Rate of Fatalities and Injuries Due to Thunderstorm

Trying the relate the “number of fatalities” with “number of lightening events” it has been observed that, fatality numbers were between one to three in case of 91% of total thunderstorm;

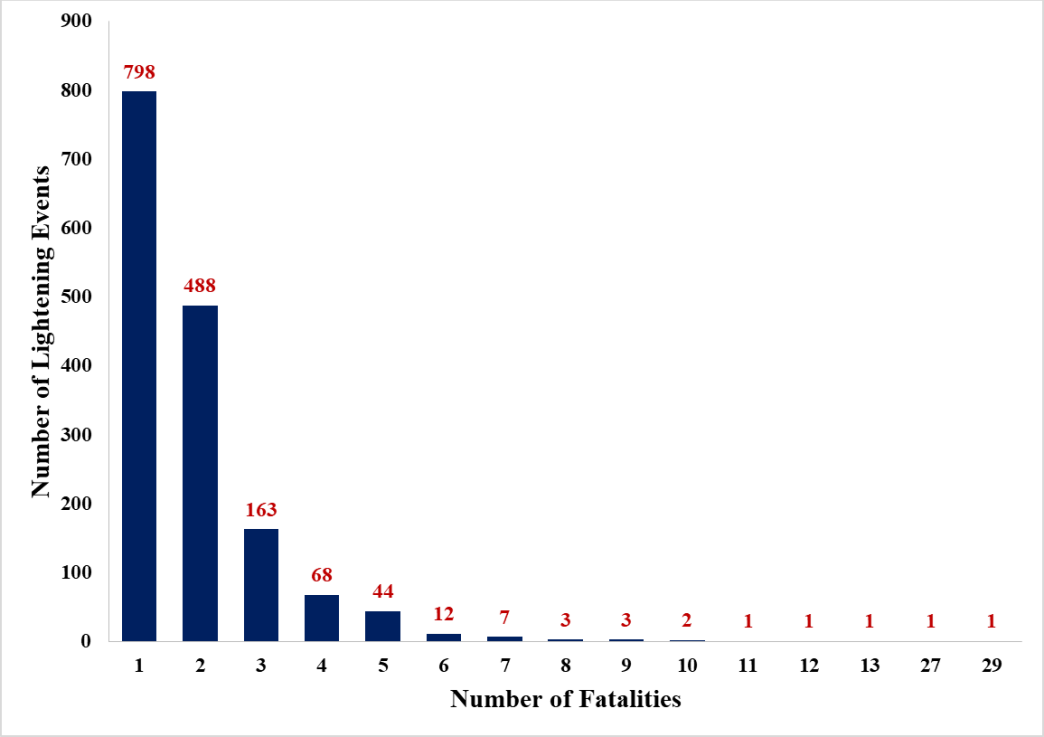


Figure 5.13: Number of Lightening Events against Number of Fatalities

District wise Lightening Trend

The total Haor area consists of 16.72% of the whole fatality of Bangladesh. From available data analysis it has been observed that, Sunamganj holds the third position in Bangladesh in terms of fatalities whereas holds the first position in terms of injuries due to thunderstorm. Also, it can also be seen that, in most of the districts of Haor regions, death toll due to thunderstorm is more than the number of injuries.

Table 5.2: Fatality and Injury Rate in Haor Regions Due to Thunderstorm (1990-2017)

District name	Average population (m)	Area (km^2)	Fatality		Injuries		Fatality number	% of Fatality with respect to Bangladesh
			Number	Rank	Number	Rank		
Sunamganj	2.1	3706.8	132	**3**	126	**1**	132	4.28
Kishoregonj	2.6	2513.3	109	**4**	68	**14**	109	3.53
Brahmanbaria	2.5	1918.6	104	**5**	75	**8**	104	3.37
Netrakona	2	2869.3	91	**6**	115	**2**	91	2.95
Habiganj	1.8	2585.7	80	**7**	35	**26**	80	2.59

From below figure it can be observed that, number of lightening is following an increasing trend in Haro regions. Significant increment in occurrence of lightening has been noted, in last 6 years (2011-2017); Also, death toll is also increasing with the increment in lightening occurrence number.

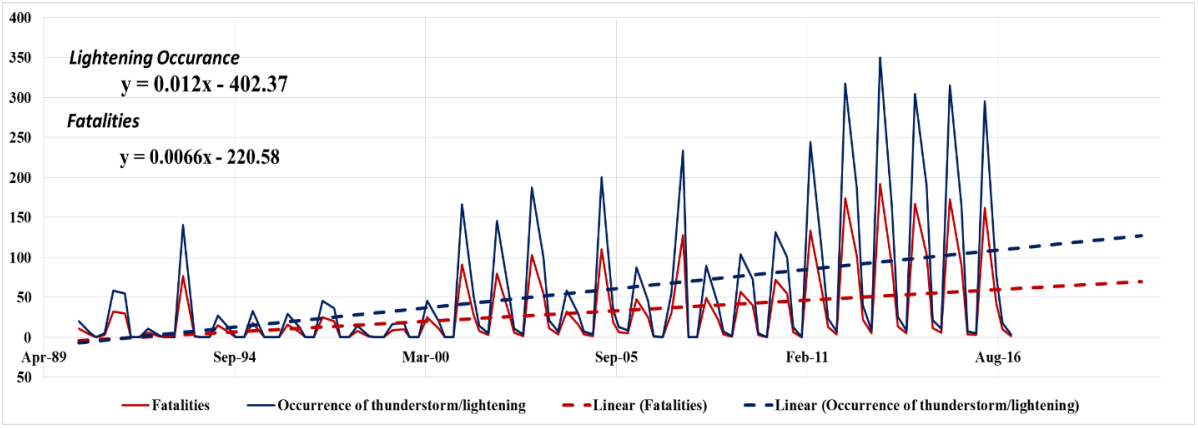


Figure 5.14: Diagram Showing Rate of Fatalities and Injuries in Haor Area Due to Thunderstorm

Sunamganj

As stated Sunamganj holds the third position in terms of causality and first position in terms of injuries occurs sue to thunderstorm in Bangladesh. 4.28% of total fatality of Bangladesh due to thunderstorm occurs in Sunamganj. With passage of time, intensity of lightening is increasing as evident from the graph given in Figure 5.15; Also, from Figure 5.16 it can also be noted that, almost 61% of total lightening in Sunamganj happened during pre-monsoon;

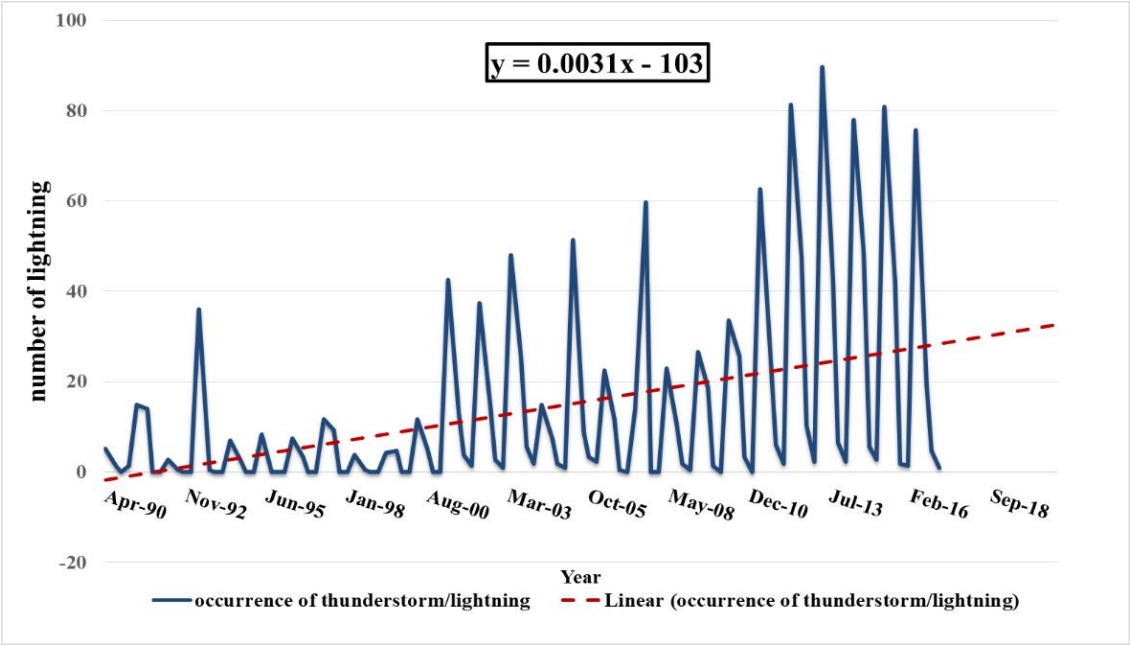


Figure 5.15: lightning occurrence from 1990-2017 in Sunamganj

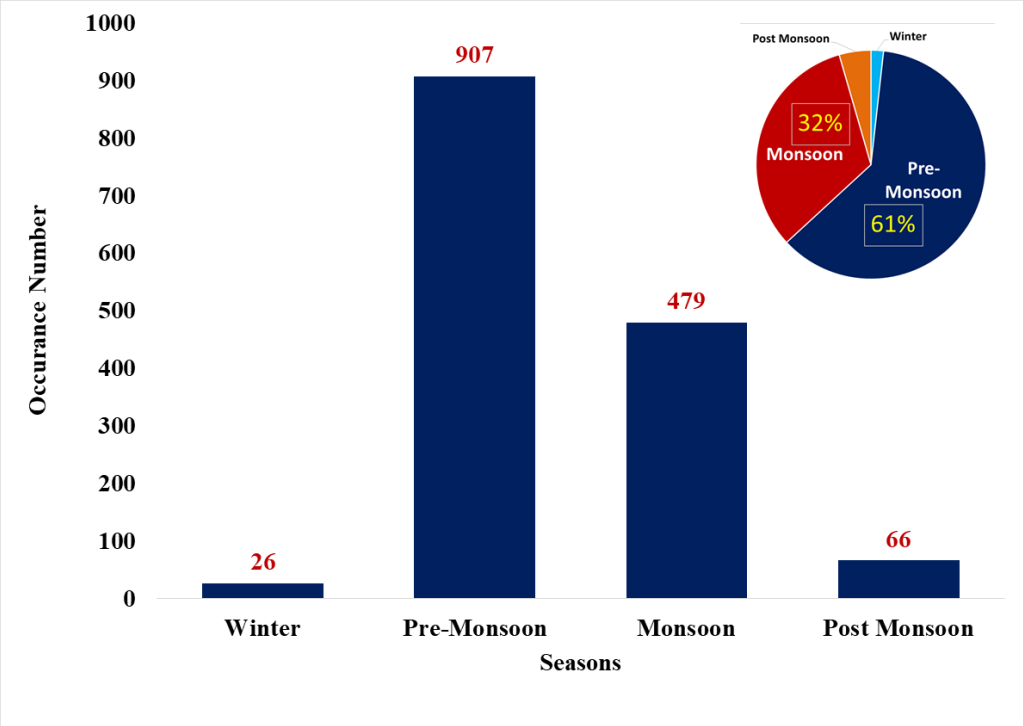
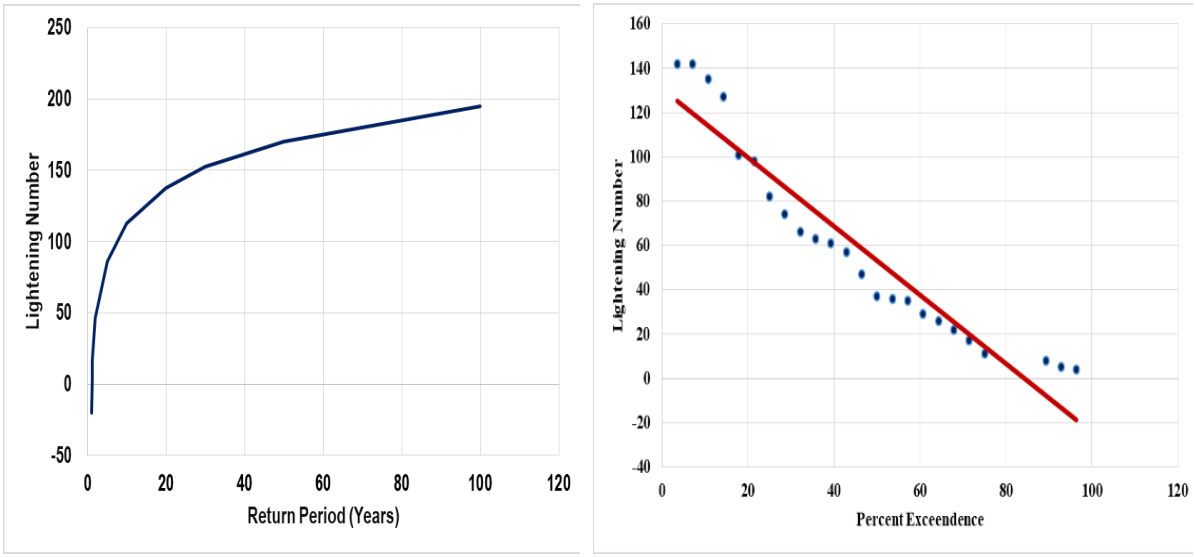


Figure 5.16: Number of Lightening at Sunamganj from 1990-2017

Frequency analysis by Gumble method has also been performed to predict the future scenario of lightning event number following the time series trend (1990-2017); Result shows that the lightening number will be within 200 in next 100 years with maximum possibility of occurrence of 4 events per year. Figure 5.17 represents the result of frequency analysis:



(a) **(b)**

Figure 5.17: (a) Lightning Number vs Return period analysis (b) Percent Exceedance of Lightning of Sunamganj

Habiganj

Habiganj holds the seventh position in terms of causality and twenty sixth position in terms of injuries occurs sue to thunderstorm in Bangladesh. 2.59% of total fatality of Bangladesh due to thunderstorm occurs in Habiganj. With passage of time, intensity of lightening is increasing as evident from the graph given in Figure 5.18; Also, from Figure 5.19 it can also be noted that, almost 62% of total lightening in Habiganj happened during pre-monsoon;

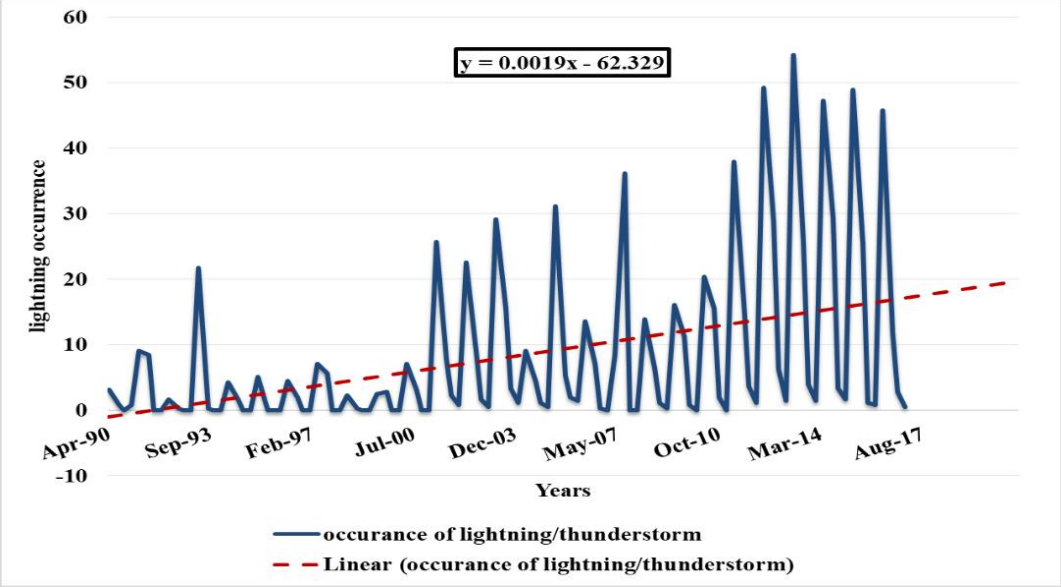


Figure 5.18: lightning occurrence from 1990-2017 in Habiganj

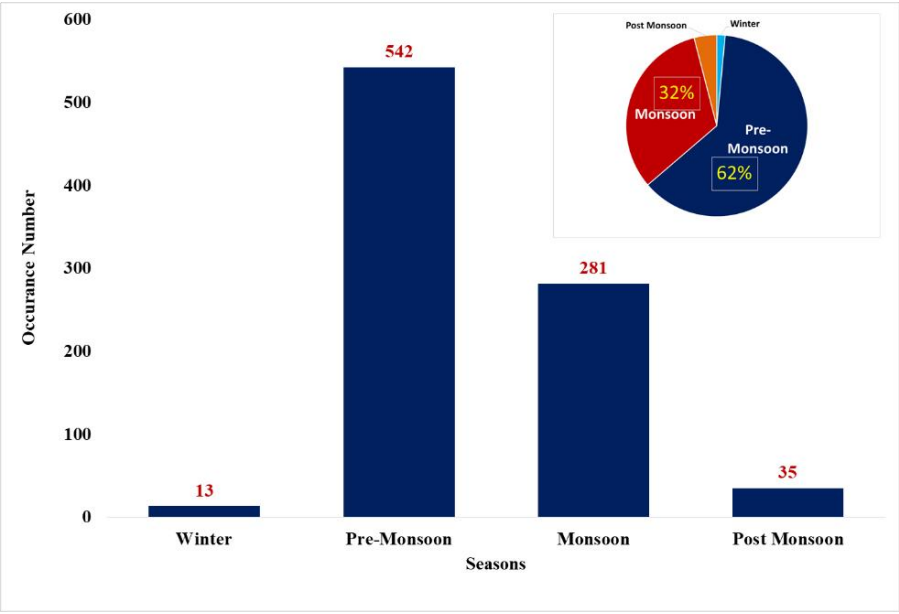
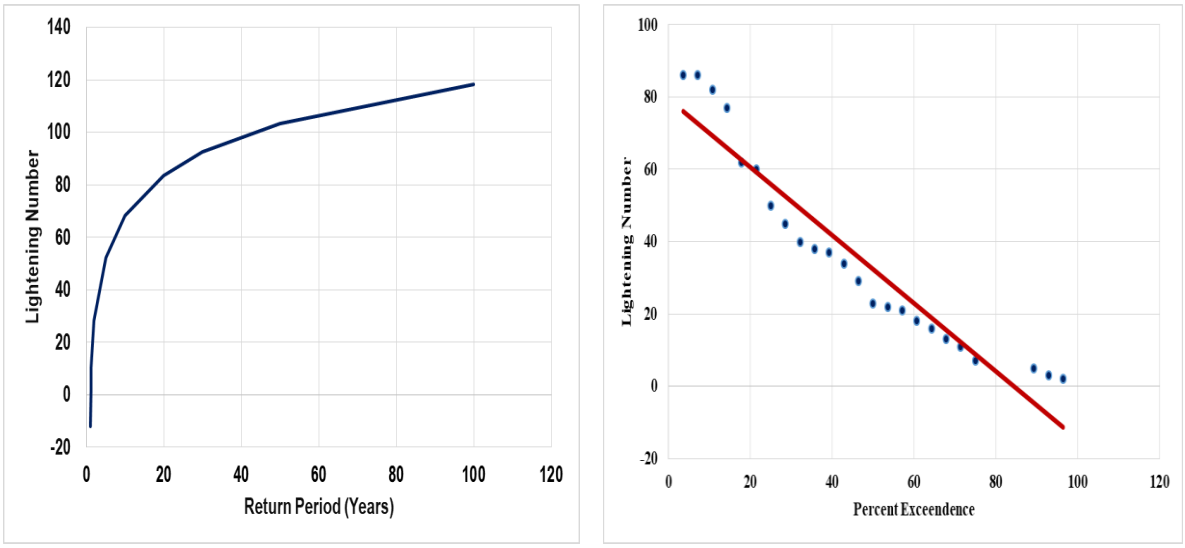


Figure 5.19: Number of Lightening at Habiganj from 1990-2017

Frequency analysis by Gumble method has also been performed to predict the future scenario of lightning event number following the time series trend (1990-2017); Result shows that the lightening number will be within 120 in next 100 years with maximum possibility of occurrence of 2 events per year. Figure 5.20 represents the result of frequency analysis:



(a) (b)

Figure 5.20: (a) Lightning Number vs Return period analysis (b) Percent Exceedance of Lightning of Habiganj

Kishorganj

Kishorganj holds the fourth position in terms of causality and four-tenth position in terms of injuries occurs sue to thunderstorm in Bangladesh. 3.53% of total fatality of Bangladesh due to thunderstorm occurs in Kishorganj. With passage of time, intensity of lightening is increasing as evident from the graph given in Figure 5.21; Also, from Figure 5.22 it can also be noted that, almost 62% of total lightening in Habiganj happened during pre-monsoon;

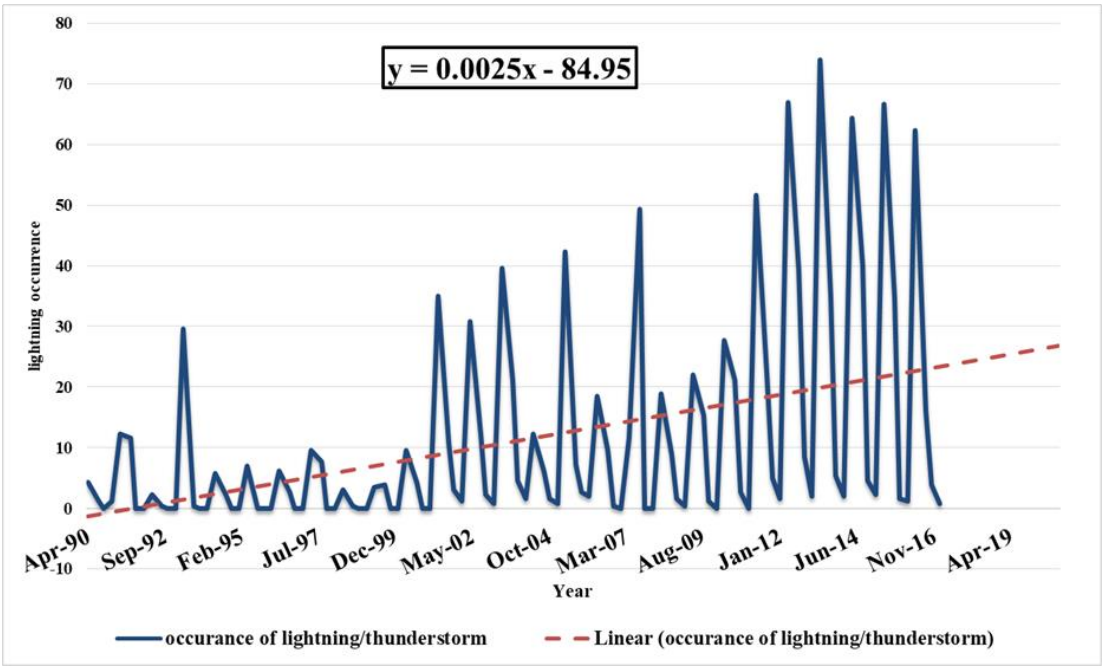


Figure 5.21: Lightning occurrence from 1990-2017 in Kishorganj

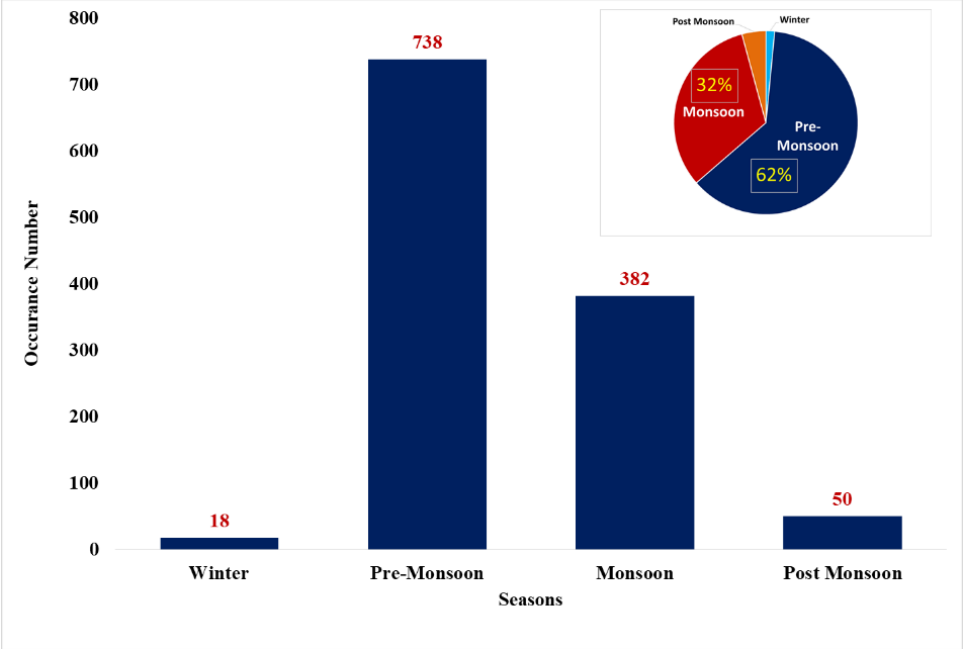
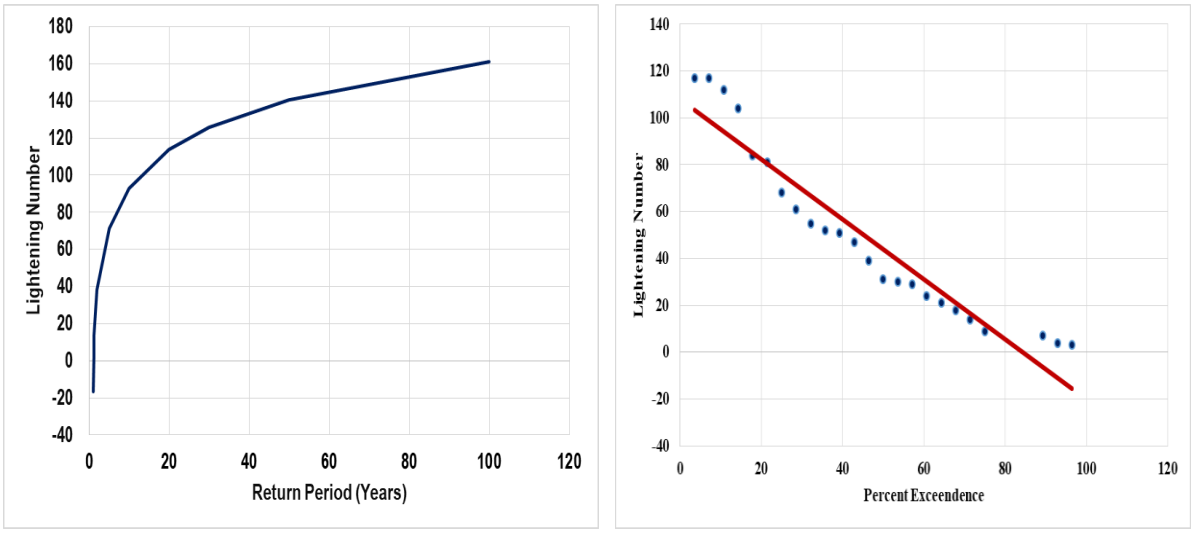


Figure 5.22: Number of Lightening at Kishorganj from 1990-2017

Frequency analysis by Gumble method has also been performed to predict the future scenario of lightning event number following the time series trend (1990-2017); Result shows that the lightening number will be within 161 in next 100 years with maximum possibility of occurrence of 2 events per year. Figure 5.23 represents the result of frequency analysis:



(a) **(b)**

Figure 5.23: (a) Lightning Number vs Return period analysis (b) Percent Exceedance of Lightning of Habiganj

Netrokona

Netrokona holds the sixth position in terms of causality and second position in terms of injuries occurs sue to thunderstorm in Bangladesh. 2.95% of total fatality of Bangladesh due to thunderstorm occurs in Netrokona. With passage of time, intensity of lightening is increasing

as evident from the graph given in Figure 5.24; Also, from Figure 5.25 it can also be noted that, almost 62% of total lightening in Habiganj happened during pre-monsoon;

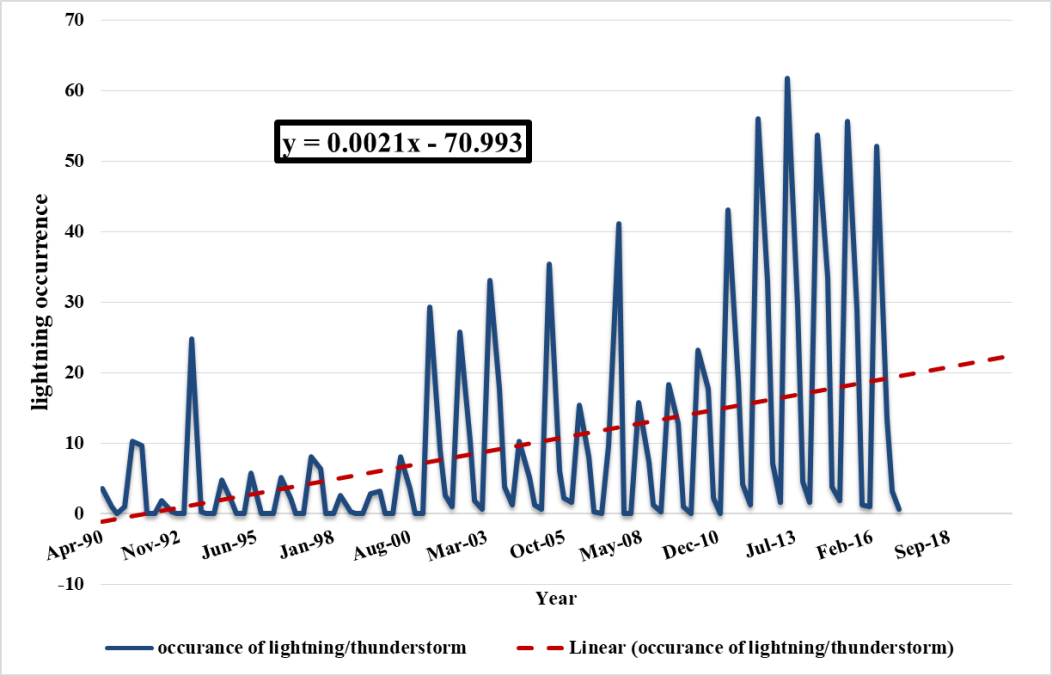


Figure 5.24: Lightning occurrence from 1990-2017 in Netrokona

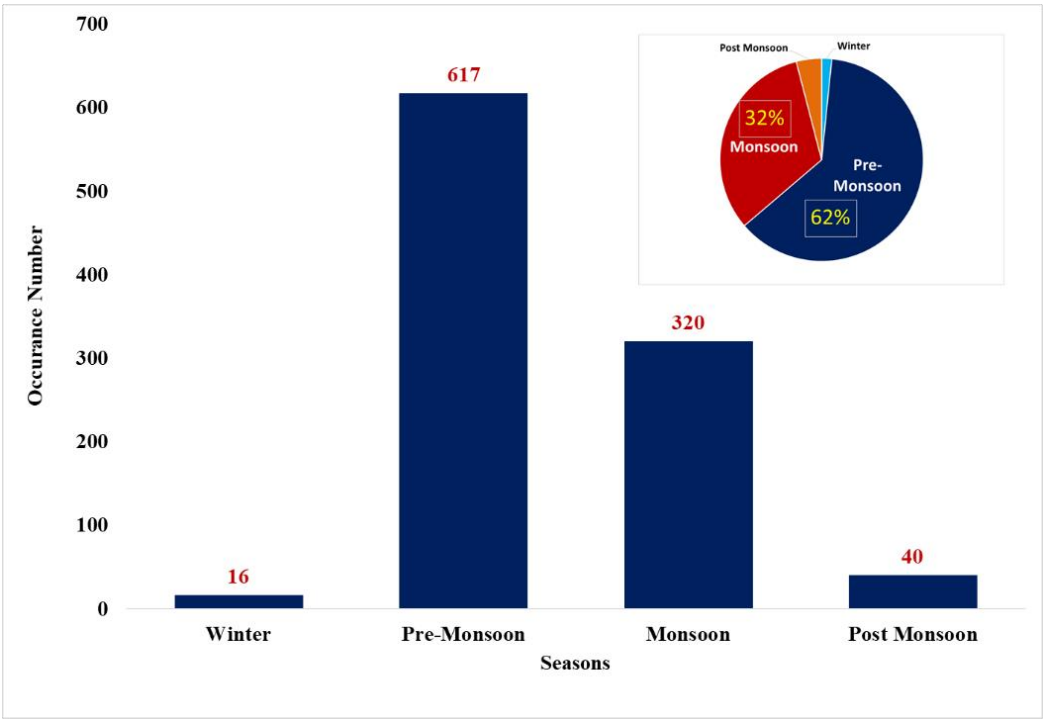
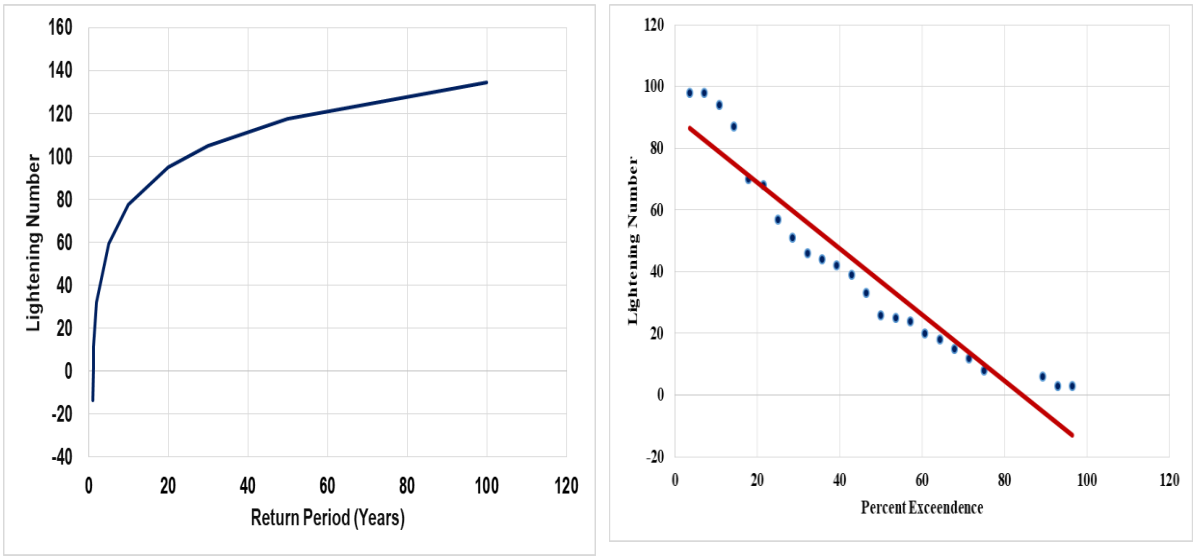


Figure 5.25: Number of Lightening at Netrokona from 1990-2017

Frequency analysis by Gumble method has also been performed to predict the future scenario of lightning event number following the time series trend (1990-2017); Result shows that the lightening number will be within 138 in next 100 years with maximum possibility of occurrence of 2 events per year. Figure 5.26 represents the result of frequency analysis:



(a) (b)

Figure 5.26: (a) Lightning Number vs Return period analysis (b) Percent Exceedance of Lightning of Netrokona

Bhrahmanbaria

Bhrahmanbaria holds the fifth position in terms of causality and eighth position in terms of injuries occurs sue to thunderstorm in Bangladesh. 3.37% of total fatality of Bangladesh due to thunderstorm occurs in Bhrahmanbaria. With passage of time, intensity of lightening is increasing as evident from the graph given in Figure 5.27; Also, from Figure 5.28 it can also be noted that, almost 62% of total lightening in Habiganj happened during pre-monsoon;

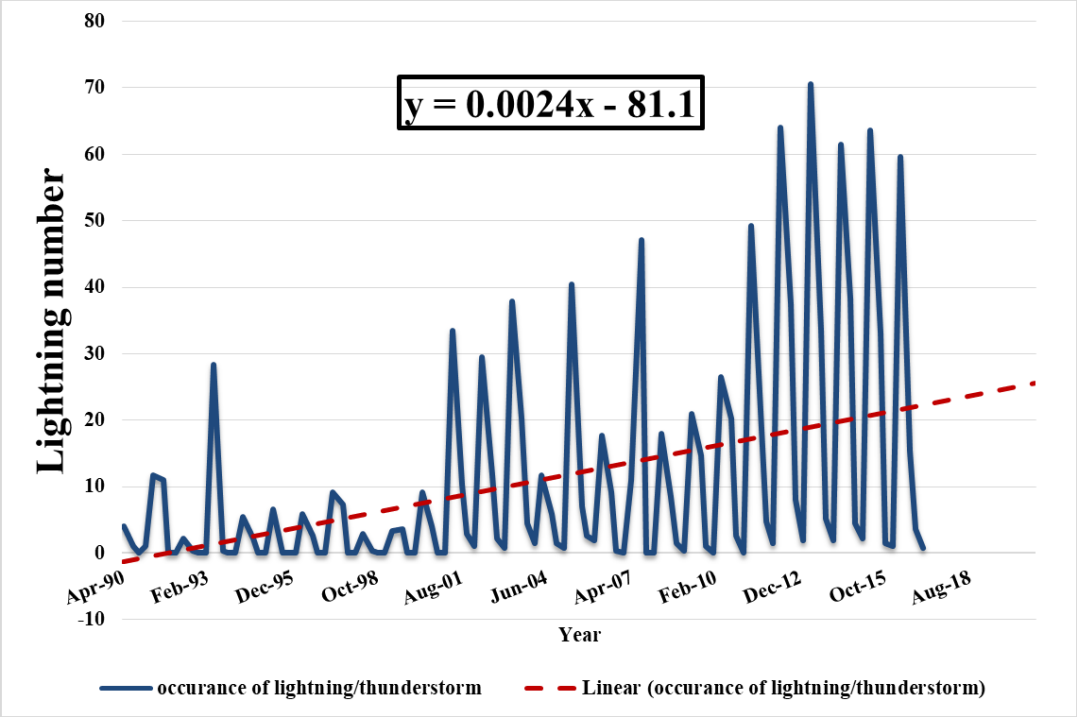


Figure 5.27: Lightning occurrence from 1990-2017 in BrahmanBaria

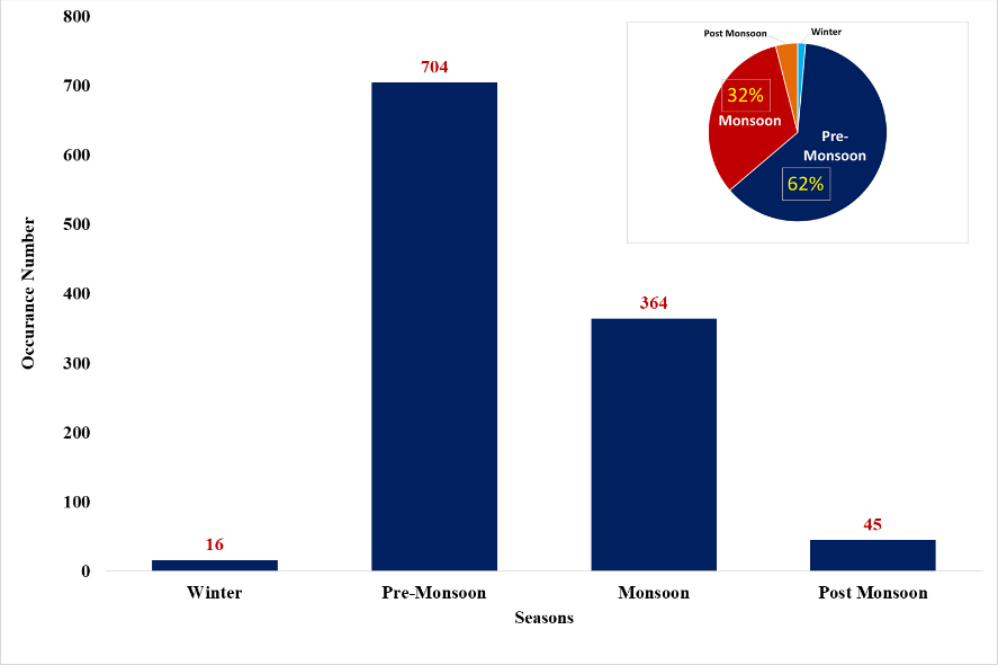
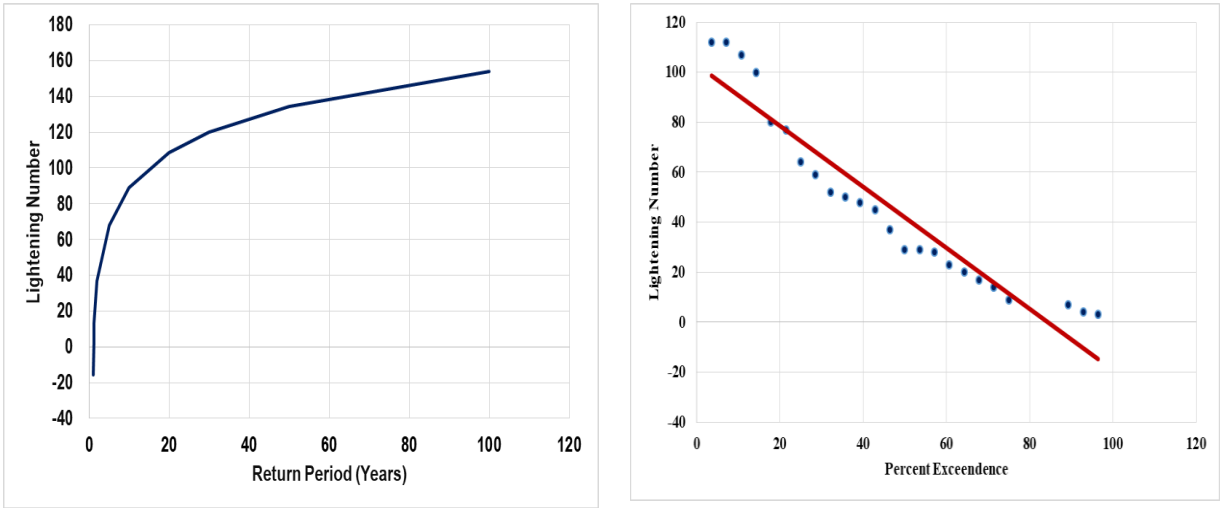


Figure 5.28: Number of Lightening at Brahmanbaria from 1990-2017

Frequency analysis by Gumble method has also been performed to predict the future scenario of lightning event number following the time series trend (1990-2017); Result shows that the lightening number will be within 150 in next 100 years with maximum possibility of occurrence of 2 events per year. Figure 5.29 represents the result of frequency analysis:



(a) **(b)**

Figure 5.29: (a) Lightning Number vs Return period analysis (b) Percent Exceedence of Lightning of BrahmanBaria

In a nutshell, maximum number of thunderstorm is happens in Sunamganj while minimum number of thunderstorm happens in Habiganj.

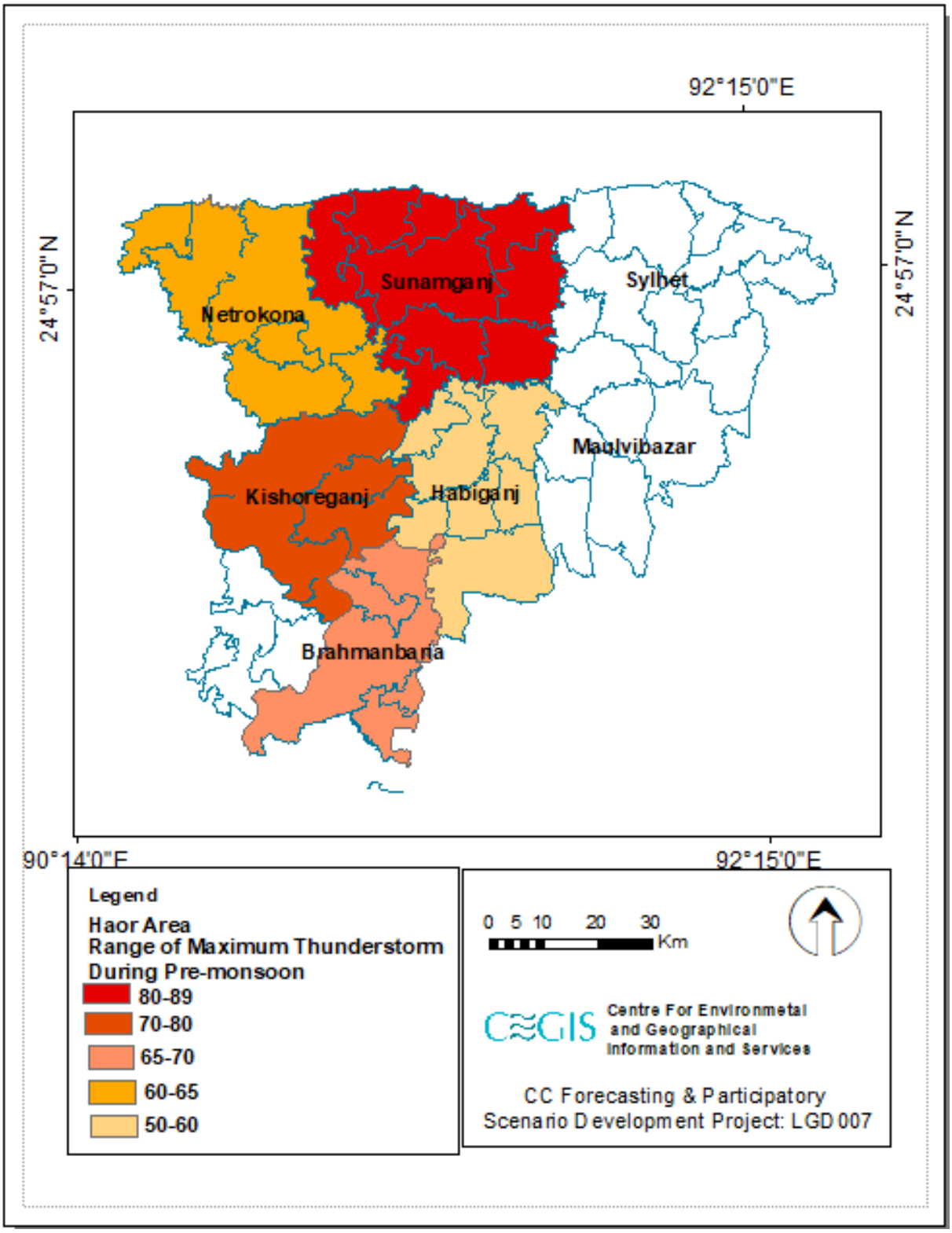


Figure 5.30: Map of maximum thunderstorm during pre-monsoon period for each district in Haor area

5.1.5 Wave Action

Wave action in haor areas is very common phenomena during monsoon (June-November) which trigger soil erosion making house or settlements vulnerable. Typically during monsoon, water surface wind blows predominantly with South East and East direction with high speed and produces damaging waves with high depth of wave (Khan, S.M., 2010).

As wave action is triggered by wind speed, trend analysis of wind speed has been performed for four Bangladesh Meteorological (BMD) stations i.e. Sylhet, Sreemangal, Mymensingh and Comilla. Available annual maximum wind speed data of 1981-2017 has been taken for trend analysis. Results of trend analysis shows that, annual maximum wind speed is increasing at a rate of 0.01 m/s per year and 0.14 m/s per year for Sylhet and Sreemangal stations respectively. On the other hand, annual maximum wind speed is decreasing at a rate of 0.33 m/s per year and 0.15 m/s per year for Mymensingh and Comilla stations respectively. As, Sylhet and Sreemangal stations are most influential stations than Mymensingh and Comilla stations, it can be concluded that overall trend of annual maximum wind speed is increasing in and around the study area, which indicates chances of increasing trend of wave action in the study area.

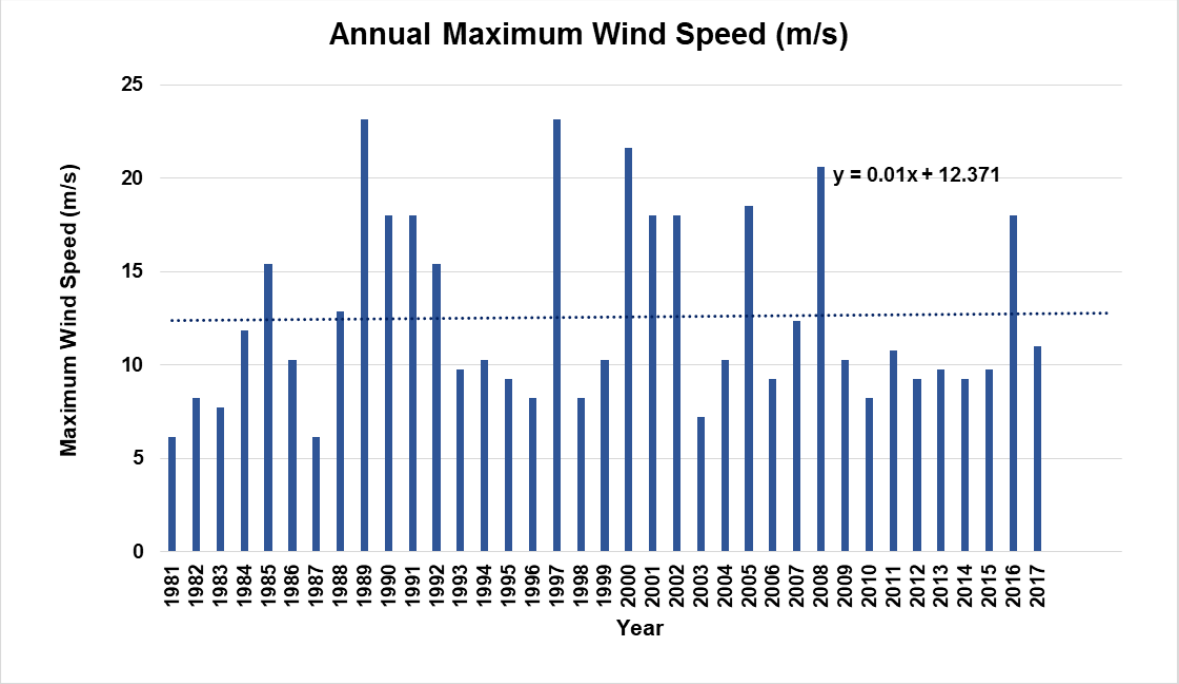


Figure 5.31: Annual maximum wind speed of Sylhet station

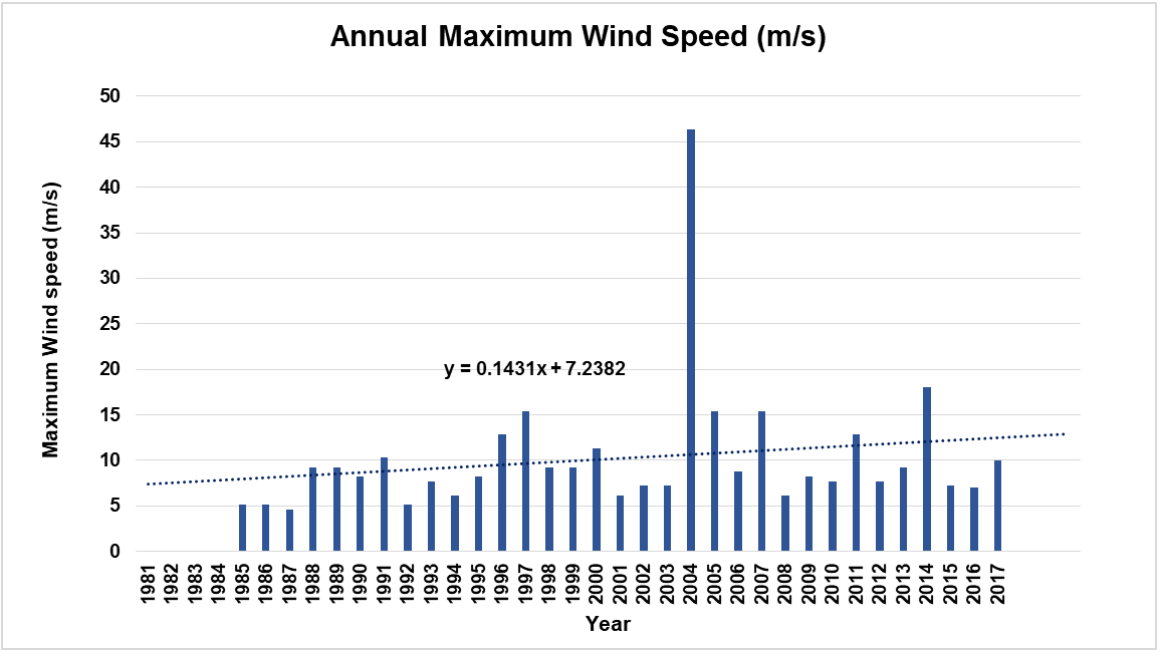


Figure 5.32: Annual maximum wind speed of Sreemangal station

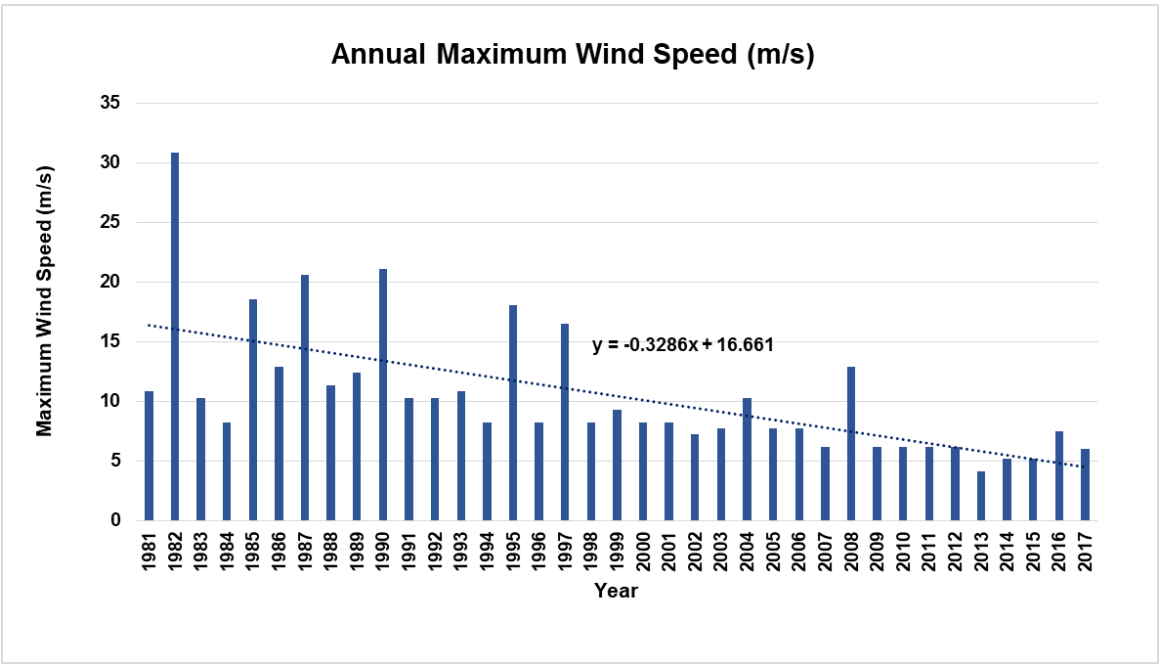


Figure 5.33: Annual maximum wind speed of Mymensingh station

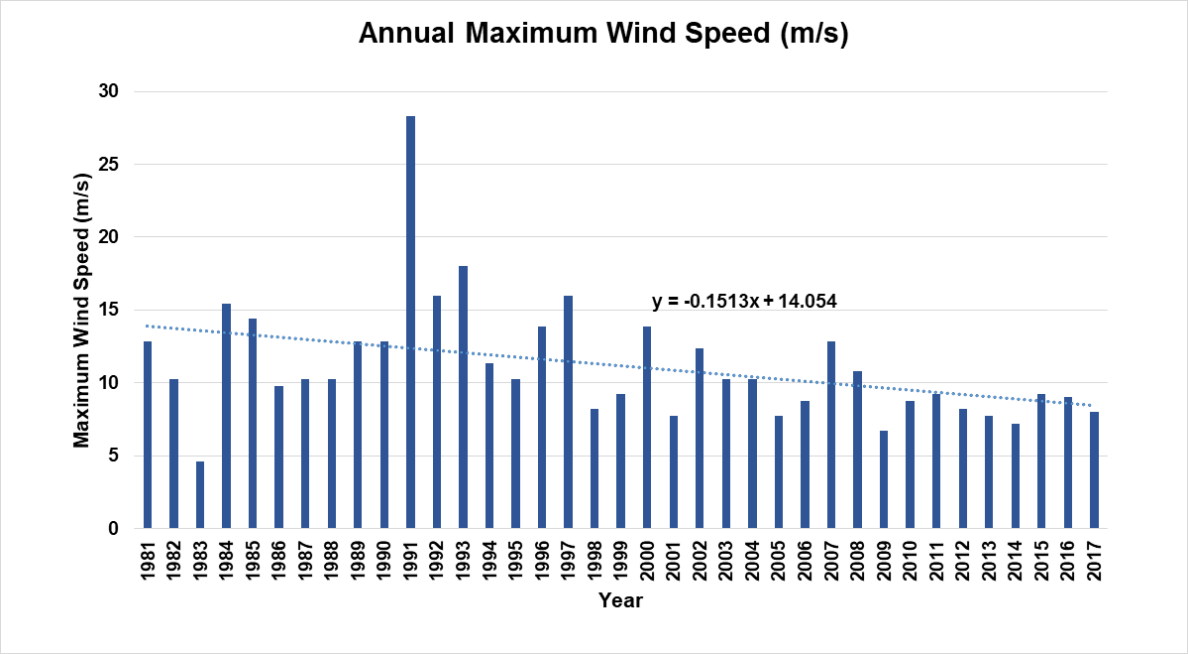


Figure 5.34: Annual maximum wind speed of Comilla station

Traditionally, people in haor areas built their settlements on earthen mounds or raised platforms and live in a very isolated way. Boats are the only means of transportation for them during the monsoon. Extensive de-plantation has been occurred to reclaim the agricultural land. The cropping pattern has also significantly changed over last three decades. These alterations have increased wave attacks in the haor areas.

A decade ago, wave actions were not a serious threat to the existence of settlements. In the past, the farmers cultivated long stem paddy during monsoon that could absorb wave impacts. Presently, the land is vacant during the monsoon season and the wave height has thus increased two fold from 0.6 meter to 1.5 meter, threatening the settlement. Therefore, trend of wave action has drastically been increased in recent years (Alam et al., 2010).

5.1.6 Cold Snap

Cold wave in Haor area can be severe for the livelihood of people and also hampers daily life and health. In winter season (December – February) when minimum temperature goes below 10°C over a wide area then cold wave situation occurs. In these case, Bangladesh Meteorological Department (BMD) issues cold wave warnings depending upon its intensity and duration. Cold waves are categorized as:

Table 5.3: Category of Clod Wave

Cold Wave	Minimum Temperature Range
Mild cold wave	08-10°C
Moderate cold wave	06-08°C
Severe cold wave	06-04°C
Very severe cold wave	< 04°C

Total Cold Wave Trend in Srimangal and Sylhet

From the available cold wave data, it has been analyzed that, total cold wave days at Srimangal was 763 from 1990-2017, with maximum **52 cold wave days** in **2010** and minimum **15 cold wave days** in **2004**. Analysis of tine series cold wave data shows a slow increasing trend.

Sylhet has faced, maximum **6 cold wave days** in **1993** and minimum **3 cold wave days** in **2003**. Analysis of tine series cold wave data shows a slowly decreasing trend. Figure 5.35 and Figure 5.36 contains the trend of cold wave days in Sylhet.

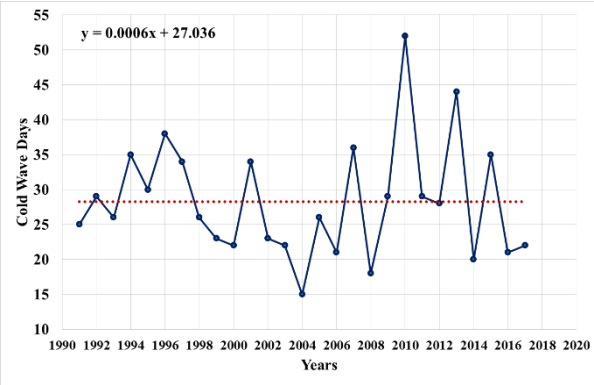


Figure 5.35: Cold Wave Days in Srimangal from 1990-2017

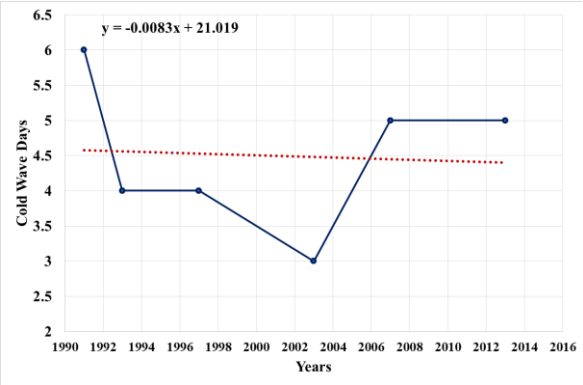


Figure 5.36: Cold Wave Days in Sylhet from 1990-2017

Mild Cold Wave Trend

From the available mild cold wave data, it has been analyzed that, in srimangal maximum **42 mild cold wave days** in **1992** and minimum **2 mild cold wave days** in **2002**. Analysis of tine series cold wave data shows a slow increasing trend. Forecast shows that the mild cold wave day's number will be between 20-23 for next 7 years.

in Sylhet maximum **10 mild cold wave days** in **1989** with no mild cold wave days several years/ Analysis of tine series cold wave data shows a slow decreasing trend. Forecast shows that the mild cold wave day's number will be between 0 to 1 for next 7 years.

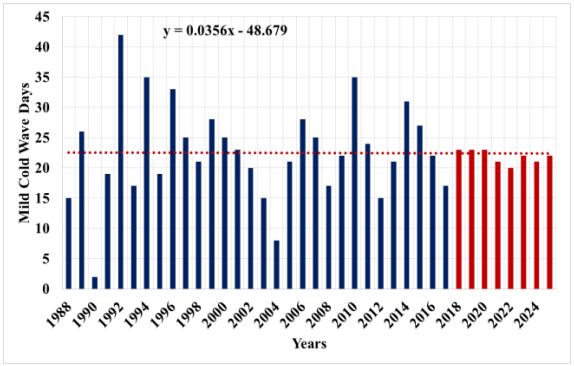


Figure 5.37: Mild Cold Wave Days in Srimangal from 1990-2017

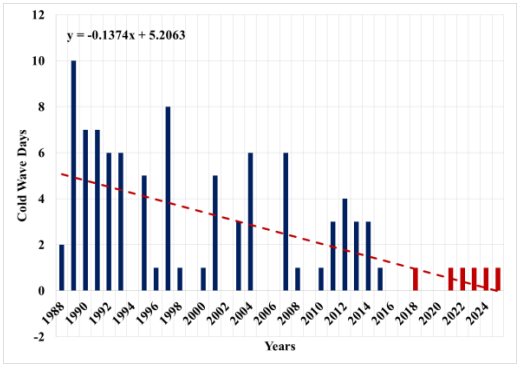


Figure 5.38: Mild Cold Wave Days in Sylhet from 1990-2017

**Red Bar Signifies the Forecasted Value*

Moderate Cold Wave Trend

From the available mild cold wave data, it has been analyzed that, in srim angal maximum **18 moderate cold wave days** in **several years** and minimum **2 mild cold wave days** in **several years**. Analysis of tine series cold wave data shows a slow increasing trend. Forecast shows that the mild cold wave day's number will be between 9-11 for next 7 years.

In Sylhet the number of moderate cold wave days ranges between 0 to 1 which means that occrance of moderate cold wave in Sylhet is too low. Analysis of tine series cold wave data shows a slow decreasing trend. Forecast shows that the mild cold wave day's number will be between 0 to 1 for next 7 years.

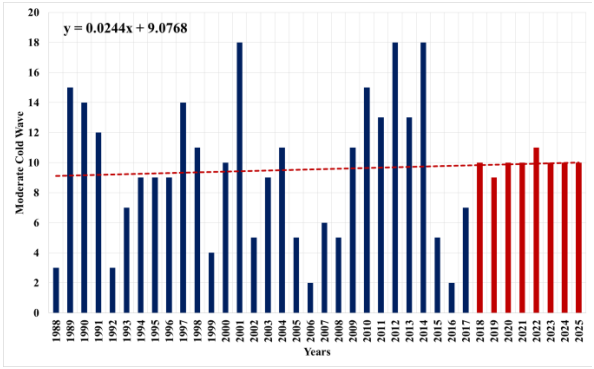


Figure 5.39: Moderate Cold Wave Days in Srimangal from 1990-2017

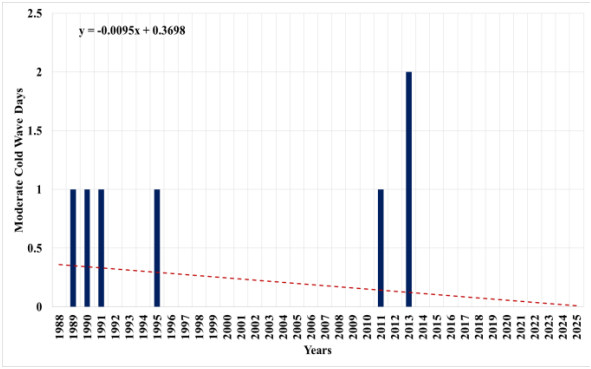


Figure 5.40: Moderate Cold Wave Days in Sylhet from 1990-2017

**Red Bar Signifies the Forecasted Value*

Severe Cold Wave Trend

From the available mild cold wave data, it has been seen that, maximum 46 severe cold wave days have been noted in 1997. After that, the number increased significantly for next 20 years (2017); Data forecast alsow shows that, the number will vary between 1 to 2 for next seven years.

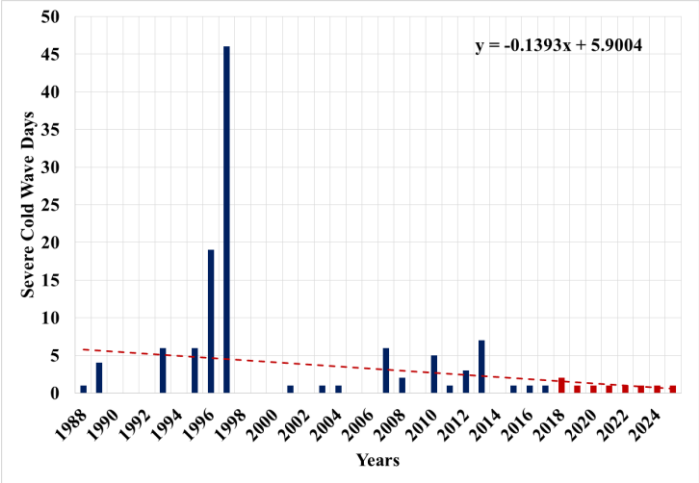


Figure 5.41: Moderate Cold Wave Days in Srimangal from 1990-2017

**Red Bar Signifies the Forecasted Value*

Very Severe Cold Wave

Very severe cold means the temperature drops below 4°C and life comes to a stop for most poor people living in marginal conditions in Haor area. Fortunately, Srimangal faced only one day with very severe cold wave in 1995, 2007 and 2013. On the other hand, Sylhet faced only one day with severe cold wave in 2013;

Table 5.4: Very Severe Cold Wave Days in Sylhet and Srimangal

Station	year	Number of Very Severe cold wave days
Srimangal	1995	1
Srimangal	2007	1
Srimangal	2013	1
Sylhet	2013	1

5.1.7 Hailstorm

Hail is a form of solid precipitation. It is distinct from ice pellets, though the two are often confused. It consists of balls or irregular lumps of ice, each of which is called a hailstone. Any thunderstorm which produces hail that reaches the ground is known as a hailstorm.

From the available data it is observed that, in Sylhet, a total of 50 hailstorm occurred from 1988-2012 with maximum 8 hailstorms in 1988 and minimum single hailstorm in1997, 2001, and 2012; The table below contains the number of hailstorm occurred from 1988-2012:

Table 5.5: Hailstorm in Sylhet

Year	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1988	1	1	2	4					**8**
1989					2	1	1	1	**5**
1992			2						**2**
1993				1	1	2			**4**
1994		2		1		2			**5**
1995					1		1		**2**
1996		2		1			1		**4**
1997							1		**1**
2000			1				3	3	**7**
2001				1					**1**
2003			1			1			**2**
2004			1			2	1		**4**
2005		4							**4**
2012			1						**1**

Also, it has been noted that, hailstorm in Sylhet occurs mostly during monsoon (61%) and pre-monsoon (31%). Between 1988 to 2012 , total 28 hailstorm events happened during monsoon, whereas 17 hailstorm event happened during pre-monsoon.

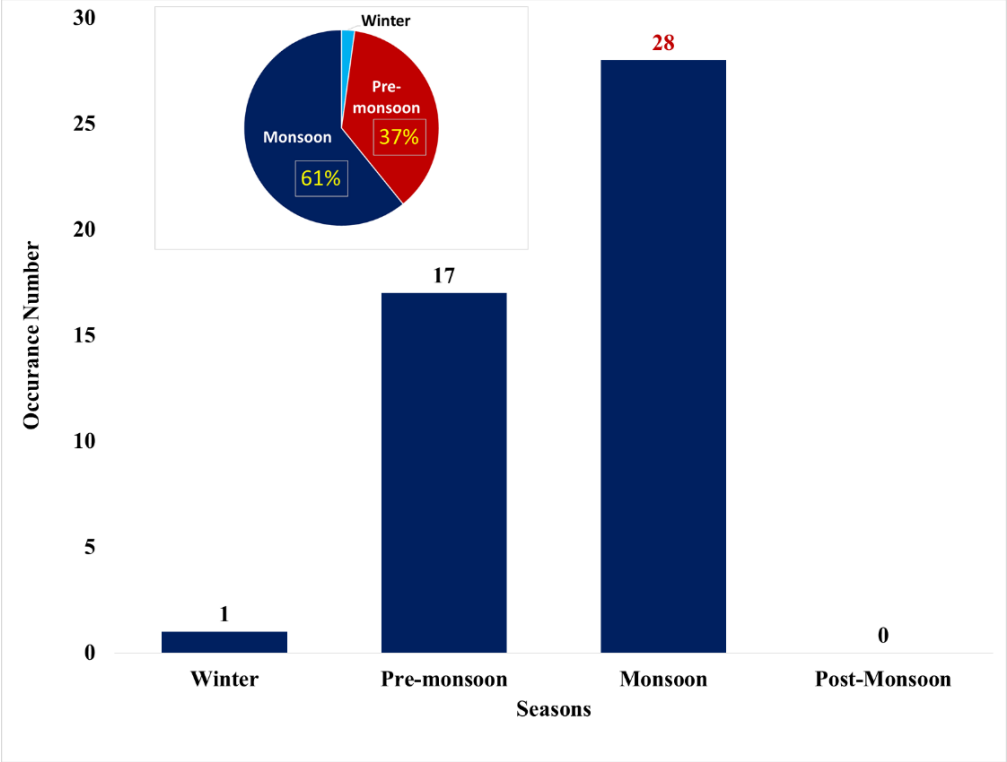


Figure 5.42: Season wise Intensity of Hailstorm in Sylhet

Intensity of Hailstorm in Srimangal is less than Sylhet. From the available data it is observed that, in Srimangal, a total of 25 hailstorms occurred from 1987-2015 with maximum 5 hailstorms in 1991 and minimum single hailstorm in several years. The table below contains the number of hailstorm occurred from 1987-2015:

Table 5.6: Hailstorm in Srimangal

Year	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1987					1					**1**
1989							1	1		**2**
1991	2		1	2						**5**
1995	1									**1**
1997					1					**1**
1998					1					**1**
1999					1				1	**2**
2000							1			**1**
2001		1								**1**
2002					1		2	1		**4**
2003								1		**1**
2004				1		1				**2**
2005		1								**1**
2010				1						**1**
2015		1								**1**

Also, it has been noted that, hailstorm in Srimangal hailstorm occurs mostly during monsoon (52%) and pre-monsoon (32%). Between 1987 to 2015 , total 13 hailstorm+ events happened during monsoon, whereas 8 hailstorm events happened during pre-monsoon.

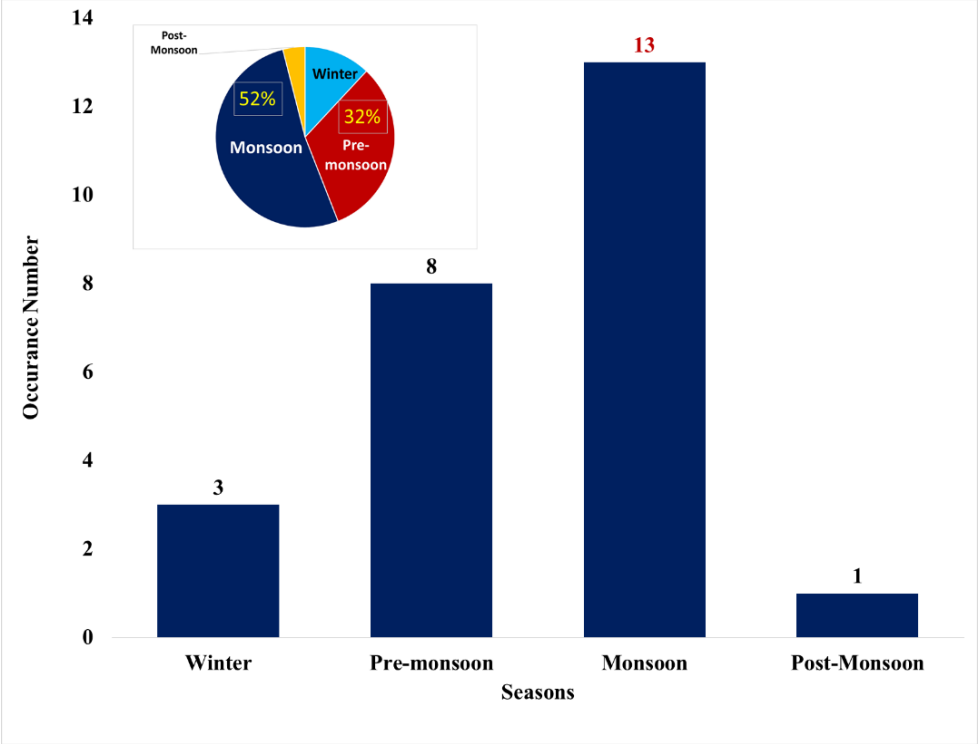


Figure 5.43: Season wise Intensity of Hailstorm in Srimangal

Damages due to hailstorm has been financial and have cause casualties in human and livestock. The hailstorm in 2018 damaged the Boro crops in northern districts while thundershower damaged many makeshift houses in Sylhet Division. According to the preliminary estimates, the loss in term of crop has been estimated to be 11089 tonnes of rice worth Tk 263.2 million. Highest damage worth Tk 115.19 million has been estimated in Sylhet district while Tk 62.45 million was in Moulvibazar district, while and it was worth Tk 76.5 million in Habiganj. The damage in Sunamganj district was worth over Tk over 9.05 million.

5.2 Future Projections through Statistical downscaling using SDSM

This Statistical Downscaling Model (SDSM) which is software package designed to implement statistical downscaling methods to produce high-resolution monthly climate information from coarse-resolution climate model (GCM) simulations was used to make the prediction of the climatic scenario for the year 2030s, 2050s and 2080s under both RCP4.5 and RCP8.5 climate change scenarios. In order to make the prediction for this time series, the base period was considered from 1971 to 2000. Table 5.7 show future projections for annual average maximum and minimum temperatures. According to projections, mean aanual maximum temperature may increase up to 1.6°C and minimum temperature may increase up to 2.3°C in 2080s considering extreme climate change scenario RCP8.5. The rate of increase of minimum temperature would be higher than maximum temperature, which depict higher range of climate variability over the study area.

Table 5.7: Annual Average Temperature Anomalies over Bangladesh

Region	Change in Temperature, ºC (Mean [Min-Max])								
	RCP2.6			RCP4.5			RCP8.5		
	2030s	2050s	2080s	2030s	2050s	2080s	2030s	2050s	2080s
MaxT	0.5 [no variation]	0.6 [no variation]	0.6 [0.6-0.7]	0.6 [no variation]	0.8 [no variation]	1.0 [0.9-1.0]	0.6 [no variation]	1.0 [0.9-1.0]	1.6 [1.5-1.7]
MinT	0.9 [no variation]	1.1 [1.0-1.1]	1.1 [no variation]	0.9 [no variation]	1.2 [1.1-1.2]	1.4 [1.4-1.5]	1.0 [no variation]	1.5 [1.4-1.5]	2.3 [2.3-2.4]

Table 5.8: Prediction for Change in Maximum and Minimum Temperature for 2030, 2050 and 2080 under RCP 4.5 and 8.5

Maximum Temperature							Minimum Temperature						
Season	RCP 4.5			RCP 8.5			Season	RCP 4.5			RCP 8.5		
	2030	2050	2080	2030	2050	2080		2030	2050	2080	2030	2050	2080
DJF	0.3	0.7	0.8	0.9	0.9	1.7	DJF	1.0	1.1	1.3	1.1	1.4	2.0
MAM	0.9	1.1	1.3	0.9	1.4	2.2	MAM	1.1	1.4	1.5	1.2	1.8	2.7
JJAS	0.5	0.6	0.6	0.6	0.7	1.0	JJAS	0.8	1.0	1.2	0.8	1.3	2.1
ON	0.8	1.1	1.6	0.9	1.5	2.6	ON	0.8	1.1	1.6	1.0	1.8	3.0

On the other hand, rainfall occurrence would increase in pre-monsoon season i.e. March-April-May (MAM) decreasing rainfall occurrence in post-monsoon i.e. October-November (ON). Specially, pre-monsoon rainfall occurrence will be increased around 5%-6% increase in north-eastern region than base period, which clearly depicts that study area of Bangladesh will be more prone to early rainfall as well as early flash floods in future periods.

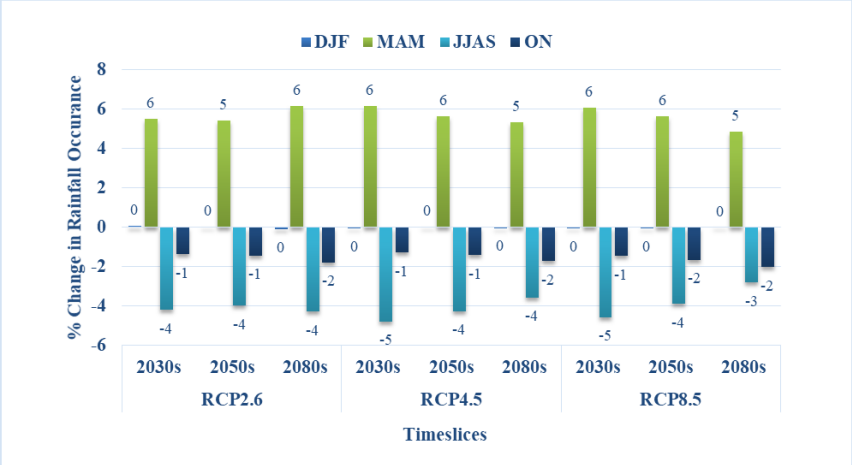


Figure 5.44: Increase of Pre-monsoon rainfall occurrence in the study area

Annual average rainfall anomnalies reveal that total annual rainfall over the study area will be increased up to 11%-12% by 2080s considering both RCP4.5 and RCP8.5. Table 5.9 shows pvariations of future rainfall changes in different seasons.

Table 5.9: Annual Average Rainfall Anomalies over Bangladesh

Region	Change in Rainfall, % (Mean [Min-Max])					
	RCP4.5			RCP8.5		
	2030s	2050s	2080s	2030s	2050s	2080s
North East	8.0 [7.0-9.0]	10.0 [9.0-10.]	12.0 [10.0-13.0]	8.0 [7.0-9.0]	8.0 [7.0-9.0]	11.0 [9.0-14.0]

Table 5.10: Prediction for Change in Seasonal Rainfall for 2030, 2050 and 2080 under RCP 4.5 and 8.5

Rainfall						
Season	**RCP 4.5**			**RCP 8.5**		
	2030	**2050**	**2080**	**2030**	**2050**	**2080**
DJF	4	13	12	7	4	14
MAM	35	29	29	36	33	35
JJAS	35	35	36	2	3	9
ON	-14	-15	-18	-16	-20	-23

5.3 Land Use Change Assessment

Over the past few decades, the land pattern of land use has changed by a huge margin. Comparing the land use data of 1989 and 2015, it is evident that the pond area has increased most, about 3.5 times in 26 years, while the perennial beel and haor area has decreased the most. Remarkably, the area of forest plantation has increased almost double and shrub dominated area has decreased to half.

Table 5.11: Land Use Change Comparison of the Year 1989 and 2015

Land Type	**Area (Ha)**		**Percentage of Change**
	1989	**2015**	
Baor	3949.74	2711.91	-31.34
Brickfield	194.15	534.86	175.50
Dump Sites / Extraction Sites	N/A	137.19	
Forest Plantation	99.00	176.01	77.79
Herb Dominated Area	17017.83	19892.63	16.89
Herbaceous Crops	935504.14	924645.01	-1.16
Lake	1.32	0.83	-37.29
Perennial Beels/Haors	22368.29	14510.77	-35.13
Ponds	93.76	435.75	364.78
Rivers and Khals	51562.40	48757.32	-5.44
Rural Settlement	81550.88	90976.17	11.56
Sand	1449.00	974.24	-32.76
Shrub Dominated Area	595.98	389.99	-34.56
Swamp Reed Land	1743.08	2176.67	24.87

**Positive values indicate increase and negative values indicate decrease*

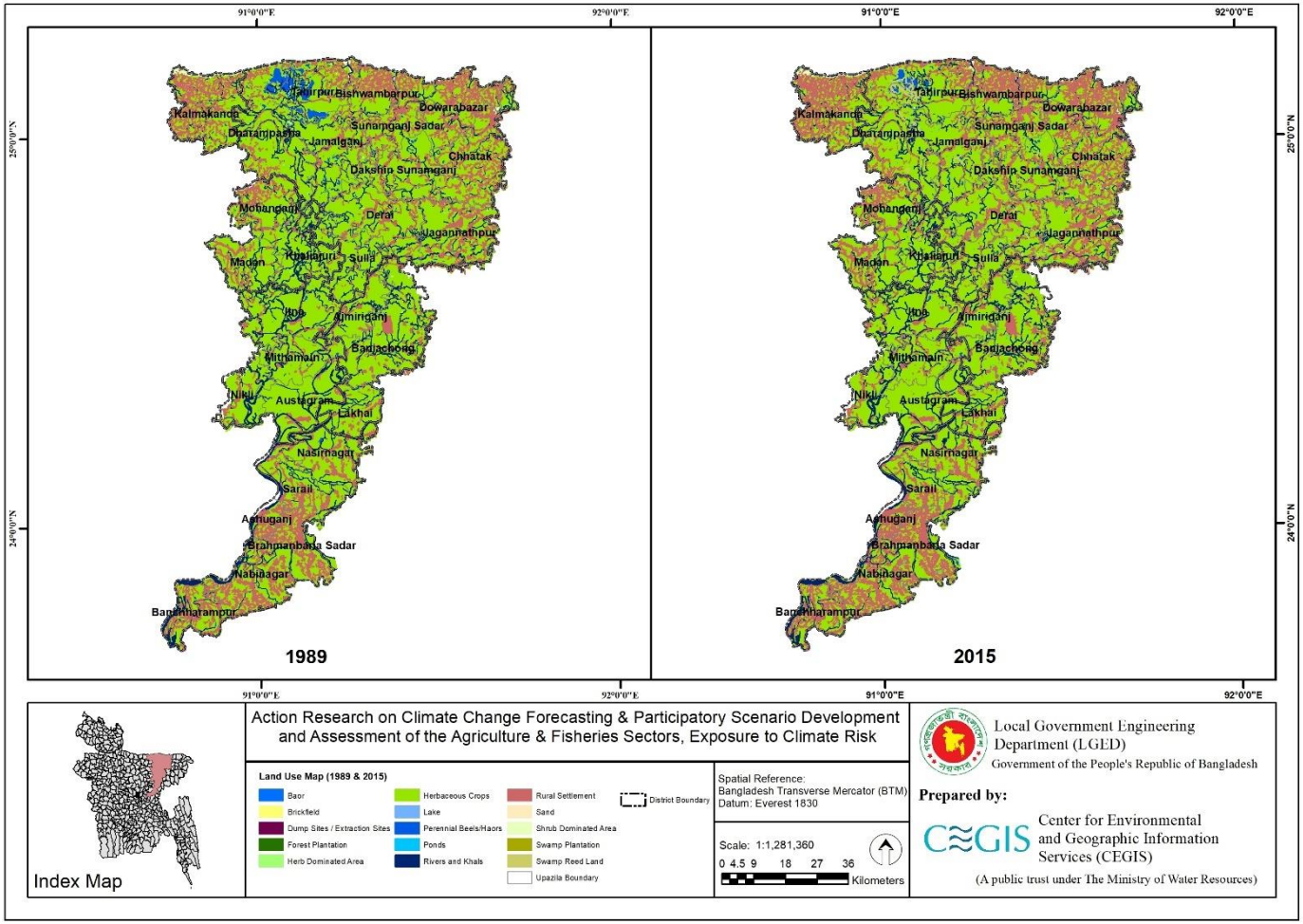


Figure 5.45: Land Use Change Comparison of the Year 1989 and 2015

6. Green House Gas Emission Inventory from Agriculture Sectors

6.1 Introduction

Green House Gas (GHG) emissions have been assessed mainly from agriculture sector. Four major sources of GHG emission from agriculture sector are (i) CH4 emission from cultivated rice fields, (ii) N2O and CO2 emission from N-based fertilizer, (iii) Enteric fermentation, and (iv) CH4 and N2O emission from manure management. The dominant sources of emissions are CH4 from rice field and enteric fermentation from the livestock subsector. The next important sources are N2O emission from fertilizer application and direct N2O emissions from manure system.

Agriculture and Land Use National Greenhouse Gas Inventory Software version 6.1.0.3 has been used for estimation of methane emission from rice fields. This software was developed at Colorado State University. The program can be used to estimate emissions and removals associated with biomass carbon stocks, soil carbon stocks, soil nitrous oxide emissions, rice methane emissions, enteric methane emissions, manure methane and nitrous oxide emissions, as well as non-CO2 GHG emissions from biomass burning. Methods of GHG emission estimations in this software are based on 2006 IPCC (Intergovernmental Panel on Climate Change) Guidelines for National Greenhouse Gas Inventories.

The software has several innovative features:

- Accommodates Tier 1 and 2 methods as defined by the IPCC
- Allows compilers to integrate GIS spatial data along with national statistics on agriculture and forestry
- Designed to produce a consistent and complete representation of land use for inventory assessment
- Can develop an enhanced characterization for livestock
- Has explicit quality control and quality assurance steps
- Provides a long-term archive of data and results in digital format
- Generates emission reports that can be included in communications with interested parties.

6.2 Sub-sector: Methane Emission from Cultivated Rice Fields

Anaerobic decomposition of organic material in flooded rice fields produces CH4 which escapes to the atmosphere. Upland fields, which are not flooded, produce insignificant amounts of CH4. Other cultivated areas consisting of irrigated, rain-fed and deep-water lands produce CH4. The parameters that influence CH4 emission vary widely both spatially and temporally. Moreover, CH4 flux from a paddy field is critically dependent on several factors including climate, characteristics of soil and paddy and agricultural practices particularly water regime.

The following equations and factors were used for estimating CH4 emission from rice

cultivation. The values of different factors has been considered for different climate, ecological zones, cropping pattern, water regime before and during cultivation etc. are presented in Appendix A.

CH4rice = A * t * EFrice * 0.000001

EFrice = EFc * SFw * SFp * SFo * SFs * SFr

SFo = (1 + SUM(ROA * CFOA))^0.59

Where,

Abbreviation	Description	Units	Type (Factor Value)
CH4 rice	Methane Emissions from Rice Cultivation	(Gg CH4 yr-1)	Equation Result
A	Annual Harvested Area for Rice	(ha)	Quantity Value (Table 1.1)
t	Cultivation Period for Rice	(days)	Quantity Value (Table 1.1)
EFrice	Adjusted Daily CH4 Emission Factor for Rice Cultivation	(kg CH4 ha-1 day-1)	Calculated Factor (Appendix A)
EFc	Default CH4 Baseline Emission Factor	(kg CH4 ha-1 day-1)	Factor Value (Appendix A)
SFw	Scaling Factor for Cultivation Period Water Regime	(unitless)	Factor Value (Appendix A)
SFp	Scaling Factor for Pre-Season Water Regime	(unitless)	Factor Value (Appendix A)
SFs	Scaling Factor for Soil Type	(unitless)	Factor Value (Appendix A)
SFr	Scaling Factor for Rice Cultivar	(unitless)	Factor Value (Appendix A)
SFo	Methane Scaling Factor for Organic Amendment	(unitless)	Equation Result (Appendix A)
ROA	Application Rate of Organic Amendment	(tonnes ha-1)	Quantity Value (Appendix A)
CFOA	Conversion Factor for Organic Amendment	(fraction)	Factor Value (Appendix A)

6.2.1 Methane estimation

In the year 2018 (2017-18) total 1.32 million ha of land was under rice cultivation of which 6.8%, 5.2%, 30.4% and 57.5% were Aus, Broadcast (B) Aman, Transplanted (T) Aman and Boro respectively. The rice cultivated area was highest in Sunamganj (23%) but lowest in Brahmmanbaria (16%) district. Cultivated rice area by district and cultivation period of different rice crops is presented in Table 6.1.

Table 6.1: Cultivated Area and Cultivation (ha) Period of Different Rice Crops

Crop Name	Brahmmanbaria	Kishoreganj	Netrokona	Habiganj	Sunamganj	Cultivation Period (days)
Aus	8,115	24,135	490	45,120	12,452	90
B Aman	21,250	-	-	27,000	21,250	180
T Aman	54,360	77,020	122,395	75,000	74,270	110
Boro	121,852	158,184	171,875	108,125	201,037	120
Total Rice	205,577	259,339	294,760	255,245	309,009	

Source: Yearbook of Agricultural Statistics-2018 (BBS 2019)

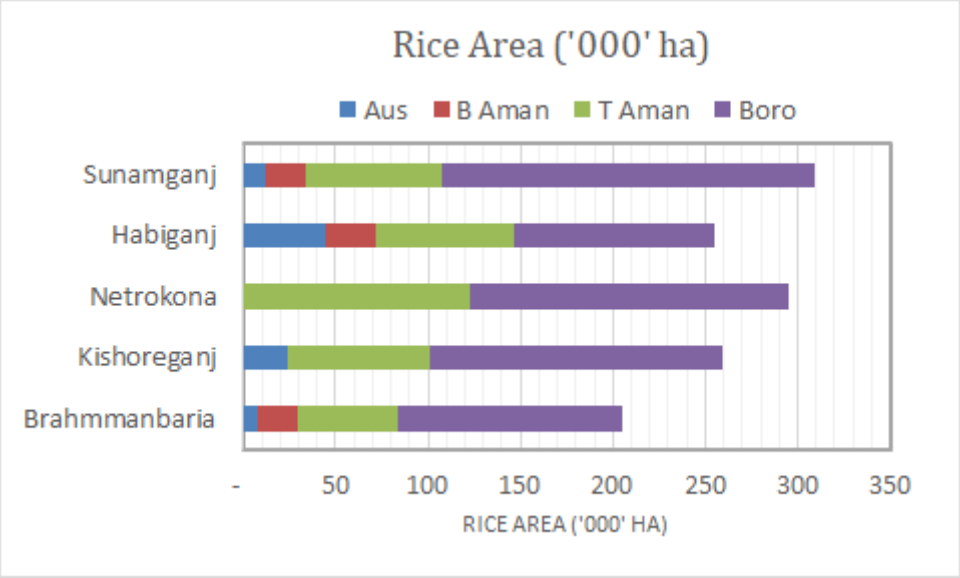


Figure 6.1: Different Rice Cultivated Area

Total methane emission from rice cultivation was estimated at about 94.134 Gg. The methane emission from rice cultivation was observed highest in Sunamaganj (29.219 Gg CH4) and lowest in Brahmanbaria (14.626 Gg CH4) district. However, the methane emission from rice cultivation in Kishoreganj, Netrokona, Habiganj districts were 17.651, 16.006 and 16.632 Gg CH4 respectively. Year-wise total methane emission from rice cultivation is presented in Table 6.2.

Table 6.2: Total Methane Emissions from Rice Cultivation

District Name	Gg CH4	(Gg CO2eq)
Brahmanbaria	14.626	410
Kishoreganj	17.651	494
Netrokona	16.006	448
Habiganj	16.632	466
Sunamganj	29.219	818
Total	94.134	2636

6.3 Sub-sector: Nitrous Oxide and Carbon Dioxide Emission from N-based Fertilizer

Nitrogen-based fertilizer and other N-containing amendments, when applied to agricultural soils, are the sources of direct and indirect N2O emissions. In Bangladesh, urea (CH4N2O) and diammonium Phosphate (DAP, (NH4)2HPO4)) are the most commonly used N-based fertilizers. The N-based fertilizers produced N2O. Nitrous oxide is produced naturally in soils through the processes of nitrification and denitrification. Nitrification is the aerobic microbial oxidation of ammonium to nitrate, and denitrification is the anaerobic microbial reduction of nitrate to nitrogen gas (N2). Nitrous oxide is a gaseous intermediate in the reaction sequence of denitrification and a by-product of nitrification that leaks from microbial cells into the soil and ultimately into the atmosphere. One of the main controlling factors in this reaction is the availability of inorganic N in the soil.

According to Van der Gon and Bleeker (2005) the emissions of N2O that result from anthropogenic N inputs occur through both-a direct pathway (i.e. directly from the soils to which the N is added), and through two indirect pathways (i.e. through volatilization as NH3 and NOx and subsequent redeposition, and through leaching and runoff).

For estimation of direct and indirect N2O emissions from N-based fertilizers the ALU software version 6.1.0.3 was used (described in subsection below).

Direct N2O Emissions from N Fertilizers

The following equations and factors were used for estimating direct nitrous oxide emission from N-based fertilizers.

N2O(D)sn = Sum(N2Osn)

N2Osn = Fsn * EFsn * (44/28)

Where,

Abbreviation	Description	Units	Type (Factor Value)
N2O(D)sn	Total Direct N2O Emissions from N Fertilizers	(kg N2O yr-1)	Equation Result
N2Osn	Direct N2O Emissions from N Fertilizers	(kg N2O yr-1)	Equation Result
Fsn	Annual Amount of Synthetic Fertilizer N Applied to Soils	(kg N yr-1)	Quantity Value (Appendix B)
EFsn	Direct N2O Emission Factor	[(kg N2O -N (kg N Input) -1]	Factor Value (0.01)

6.3.1 Total Urea CO2 Emissions

Adding urea to soils during fertilization leads to a loss of CO2 that was fixed in the industrial production process. Urea is converted to ammonium (NH4+), hydroxyl ion (OH-), and bicarbonate (HCO3-), in the presence of water and urease enzymes. The following formulas have been used for estimating CO2 emission from urea fertilizer.

Ctotal = Sum(CO2urea)

CO_2 urea = Murea * EFurea * (44/12)

Murea = (Domestic + Imports - Exports) * pUrea

Where,

Abbreviation	Description	Units	Type (Factor Value)
CO_2total	Total Urea CO2 Emissions	(tonnes CO2 yr-1)	Equation Result
CO_2urea	Urea CO2 Emissions	(tonnes CO2 yr-1)	Equation Result
Murea	Annual Urea Fertilizer Applied to Soils	(tonnes urea yr-1)	Equation Result
EFurea	Urea Carbon Emission Factor	[tonnes C (tonnes urea-1)]	Factor Value (0.2)
Domestic	Annual Urea Fertilizer from Domestic Production	(tonnes urea fertilizer yr-1)	Quantity Value (Appendix B)
Imports	Annual Urea Fertilizer Imported	(tonnes urea fertilizer yr-1)	Quantity Value (Appendix B)
Exports	Annual Urea Fertilizer Exported	(tonnes urea fertilizer yr-1)	Quantity Value (Appendix B)
pUrea	Percent of Fertilizer that is Urea	(tonnes urea fertilizer yr-1)	Quantity Value

6.3.2 Total Indirect N2O Emissions - Atmospheric N Deposition

The following equations and factors were used for estimating indirect N2O emission from N-based fertilizers.

N2O(ATDtot)sn = Sum(N2O(ATD)sn)

N2O(ATD)sn = Fsn * FracGASF * EFv * (44/28)

Where,

Abbreviation	Description	Units	Type (Factor Value)
N2O(ATDtot)sn	Total Indirect N2O Emissions - Atmospheric N Deposition	(kg N2O yr-1)	Equation Result
N2O(ATD)sn	Indirect N2O from N Fertilizer - Atmospheric N Deposition	(kg N2O yr-1)	Equation Result
Fsn	Annual Amount of Synthetic Fertilizer N Applied to Soils	(kg N yr-1)	Quantity Value (Appendix B)
FracGASF	Fraction of N Fertilizer that Volatilizes	(fraction)	Factor Value (0.1)
EFv	Indirect N2O Emission Factor - Volatilization	[kg N2O-N (kg N volatilized) -1]	Factor Value (0.01)

6.3.3 Total Indirect N2O Emissions - Leaching/Runoff

For estimating indirect nitrous oxide emission from N based fertilizer the following equations and factors were used.

N2O(Ltot)sn = Sum(N2O(L)sn)

N2O(L)sn = Fsn * FracLEACH * EFlr * (44/28)

Where,

Abbreviation	Description	Units	Type (Factor Value)
N2O(Ltot)sn	Total Indirect N2O Emissions - Leaching/Runoff	(kg N2O yr-1)	Equation Result
N2O(L)sn	Indirect N2O from N Fertilizer - Leaching/Runoff	(kg N2O yr-1)	Equation Result
Fsn	Annual Amount of Synthetic Fertilizer N Applied to Soils	(kg N yr-1)	Quantity Value (Appendix B)
FracLEACH	Fraction of N Fertilizer lost - Leaching/Runoff	(fraction)	Factor Value (0.3)
EFlr	Indirect N2O Emission Factor - Leaching/Runoff	[(kg N2O-N (kg N leached) -1]	Factor Value (0.0075)

6.3.4 Direct Nitrous Oxide (N2O) and Carbon Dioxide (CO2) estimation

The amount of direct N2O emissions and CO2 emissions from N-based fertilizer were estimated to be 1.364 Gg N2O and 132 Gg CO2eq respectively. Direct N2O emissions and CO2 emissions from N-based fertilizer by districts is presented in Table 6.3.

Table 6.3: Direct Nitrous Oxide emissions and Carbon Dioxide emissions from N based fertilizer

Year	N2O Emissions (Gg N2O)	N2O Emissions (Gg CO2eq)	CO2 Emissions (Gg CO2eq)
Brahmanbaria	0.210	56	19
Kishoreganj	0.525	139	16
Netrokona	0.261	69	52
Habiganj	0.174	46	25
Sunamganj	0.194	51	19
Total	1.364	361	132

Source: CEGIS estimation, 2019

In Table 6.4 the indirect N2O emissions from N-based fertilizer is presented. From the table, it is evident that the indirect N2O emissions from as Atmospheric N Deposition and from Leaching/Runoff showed 0.135 and 0.307 Gg N2O respectively.

Table 6.4: Indirect Nitrous Oxide (N2O) emissions from N based fertilizer

Year	Gg N2O			(Gg CO2eq)
	Atmospheric N Deposition	Leaching/Runoff	Total	Total
Brahmanbaria	0.021	0.047	0.068	18
Kishoreganj	0.052	0.118	0.170	45
Netrokona	0.026	0.059	0.085	23
Habiganj	0.017	0.039	0.056	15
Sunamganj	0.019	0.044	0.063	17
Total	0.135	0.307	0.442	118

Source: CEGIS estimation, 2019

6.4 Sub-sector: Enteric Fermentation

During animal digestion, methane is produced through enteric fermentation, a process in which methane is produced as a by-product in the rumen by microbes that reside in animal digestive systems that breakdown the feed consumed by the animal. Ruminants, which include cattle, buffalo, sheep, and goats, have the highest methane emissions among all animal types because they have a rumen, or large "fore-stomach," in which a significant amount of methane-producing fermentation occurs. The amount of methane produced and excreted by an individual animal also depends upon the amount and type of feed it consumes (EPA, 1995). Non-ruminant domestic animals, such as pigs and horses, have much lower methane emissions than ruminants because much less methane-producing fermentation takes place in their digestive systems. The number of pigs and horses is insignificant in Bangladesh, therefore, these were not considered for the reporting.

Methane emission from enteric fermentation was estimated using the ALU software version 6.1.0.3. (described in sub-sub-section 1.2.1). The following factors and equations were used for estimating enteric methane emissions.

CH4ent = Sum(CH4ent(b))

CH4ent(b) = (Nt * EFt(b)) / 1000000

Where,

Abbreviation	Description	Units	Type (Factor Value)
CH4ent	Total Enteric CH4 Emissions	(Gg CH4 yr-1)	Equation Result
CH4ent(b)	Enteric CH4 Emissions: Basic Characterization	(Gg CH4 yr-1)	Equation Result
Nt	Number of Livestock (Average Annual Population)	(head)	Quantity Value (Table 3.1)
EFt(b)	Enteric CH4 Emission Factor: Basic Characterization	(kg CH4 head-1 yr-1)	Factor Value (Appendix C)

6.4.1 Methane estimation

The data on livestock population has been collected from the Department of Livestock Services (DLS). The total number of livestock population by different district is presented in Table 6.5. In the year 2018, livestock population has been estimated to comprise 1.96 million dairy cows, 0.74 million non-dairy cows, 0.05 million buffaloes, 1.00 million goats, 0.14 million sheep and 19.08 million poultry birds.

Table 6.5: Total Livestock Population (number)

Livestock Category	District Name				
	Brahmanbaria	Kishoreganj	Netrokona	Habiganj	Sunamganj
Dairy Cows[1]	209580	461710	425340	246830	614830
Non Dairy Cows	79640	175450	161630	93800	233630

[1] *Dairy cow is 62% of the total cattle. This factor is derived in FAO – BLRI Joint workshop on data validation held during 23-24 January 2016 in Dhaka.*

Livestock Category	District Name				
	Brahmanbaria	Kishoreganj	Netrokona	Habiganj	Sunamganj
Buffalo	4250	5950	7740	21910	8500
Goat	100520	196910	387680	130780	179600
Sheep	13000	21160	7230	22570	79610
Poultry	2284460	7656770	5186150	1781790	2166910

Source: Department of Livestock Services (DLS), 2019.

The total enteric methane emission was estimated from selected districts of Haor areas at 49.141 Gg CH4 for the year 2018. The total enteric CH4 emission by different livestock categories and by districts is presented in Table 6.6.

Table 6.6: Total Enteric CH4 Emissions by different livestock categories

Year	Gg CH4						(Gg CO2eq)
	Dairy Cows	Non Dairy Cows	Buffalo	Goat	Sheep	Total	Total
Brahmanbaria	3.353	1.195	0.157	0.452	0.034	5.191	145
Kishoreganj	7.387	2.632	0.220	0.886	0.056	11.181	313
Netrokona	6.805	2.424	0.286	1.745	0.019	11.279	316
Habiganj	3.949	1.407	0.811	0.589	0.060	6.816	191
Sunamganj	9.837	3.504	0.315	0.808	0.210	14.674	411
Total	31.331	11.162	1.789	4.480	0.379	49.141	1376

6.5 Sub-sector: Methane (CH4) and Nitrous Oxide (N2O) emission from manure management

Manure management is a major source of Methane and Nitrous Oxide emission from the agriculture sector. The main factors affecting CH4 emissions are the amount of manure produced and the portion of the manure that decomposes anaerobically. The former depends on the rate of waste production per animal and the number of animals, while the latter on how the manure is managed. When manure is stored or treated as a liquid (e.g., in lagoons, ponds, tanks, or pits), it decomposes anaerobically and can produce a significant quantity of CH4. The temperature and the retention time of the storage unit greatly affect the amount of methane produced. When manure is handled as a solid (i.e., in stacks or piles) or when it is deposited under aerobic conditions, it tends to produce more CO2 and less CH4.

Direct N2O emissions occur via combined nitrification and denitrification of nitrogen contained in the manure. The production and emission of N2O from managed manures requires the presence of either nitrites or nitrates in an anaerobic environment preceded by aerobic conditions necessary for the formation of these oxidized forms of nitrogen.

The total methane and nitrous oxide emissions from manure management were estimated at 14.109 Gg CH4 and 1.820 Gg N2O respectively for the year 2018. The total emission from this source is presented in Table 6.7.

Table 6.7: Total Manure CH4 and N2O Emissions by year from Manure Management

Year	CH4 (Gg CH4)	N2O (Gg N2O)	Total (Gg CO2eq)
Brahmanbaria	1.508	0.193	93
Kishoreganj	3.352	0.420	205
Netrokona	3.104	0.412	196
Habiganj	1.847	0.240	115
Sunamganj	4.298	0.555	267
Total	14.109	1.820	876

The ALU (Agriculture and Land Use) software version 6.1.0.3 was used for estimation of methane emission from manure management.

6.5.1 Direct Methane (CH4) estimation

The following equations and factors were used for estimating total CH4 emissions from manure.

CH4man = Sum(CH4man(b))

CH4man(b) = (Nt * EFt(b)) / 1000000

Where,

Abbreviation	Description	Units	Type (Factor Value)
CH4man	Total Manure CH4 Emissions	(Gg CH4 yr-1)	Equation Result
CH4man(b)	Manure CH4 Emissions: Basic Characterization	(Gg CH4 yr-1)	Equation Result
Nt	Number Head of Livestock (Average Annual Population)	(head)	Quantity Value (Table 3.1)
EFt(b)	Manure CH4 Emission Factor: Basic Characterization	(kg CH4 head-1/yr-1)	Factor Value (Appendix D)

6.5.2 Direct Nitrous Oxide (N2O) estimation

The following equations and factors were used for estimating direct nitrous oxide emissions from manure system.

N2ODmm = Sum(N2ODmm(b))

N2ODmm(b) = Nt * Nex(b) * MS * EF3 * (44/28)

Nex(b) = Nrate * (TAM / 1000) * 365

Where,

Abbreviation	Description	Units	Type (Factor Value)
N2ODmm	Total Direct N2O Emissions from Manure System	(kg N2O yr-1)	Equation Result
N2ODmm(b)	Direct N2O from Manure System: Basic Characterization	(kg N2O yr-1)	Equation Result

Abbreviation	Description	Units	Type (Factor Value)
Nt	Number Head of Livestock (Average Annual Population)	(head)	Quantity Value (Table 3.1)
MS	Fraction Livestock Manure in Manure System	(fraction)	Quantity Value (Appendix D)
EF3	Direct N2O Emission Factor for Manure System	(kg N2O-N kg-1 N)	Factor Value (Appendix D)
Nex(b)	Annual N Excretion Rate: Basic Characterization	(kg N animal-1 yr-1)	Equation Result
Nrate	Daily N Excretion Rate: Basic Characterization	[kg N (1000 kg animal) -1 day-1]	Factor Value (Appendix D)
TAM	Typical Animal Mass: Basic Characterization	(kg animal-1)	Factor Value (Appendix D)

6.5.3 Indirect Nitrous Oxide (N2O) estimation from volatilization

The following equations and factors were used for estimating indirect nitrous oxide emissions from volatilization.

N2OGmm = Sum(N2OGmm(b))

Nvol(b) = Nt * Nex(b) * MS * FracGASM

N2OGmm(b) = Nvol(b) * EFv * (44/28)

Nex(b) = Nrate * (TAM / 1000) * 365

Where,

Abbreviation	Description	Units	Type (Factor Value)
N2OGmm	Total Indirect N2O Emissions - Volatilization	(kg N2O yr-1)	Equation Result
Nvol(b)	N Volatilization from Manure System: Basic Characterization	(kg N yr-1)	Equation Result
Nt	Number Head of Livestock (Average Annual Population)	(head)	Quantity Value (Table 3.1)
MS	Fraction Livestock Manure in Manure System	(fraction)	Quantity Value (Appendix D)
FracGASM	Fraction of Manure N Volitization	(fraction)	Factor Value (Appendix D)
N2OGmm(b)	Indirect N2O Emissions - Volatilization: Basic Characterization	(kg N2O yr-1)	Equation Result
EFv	Indirect N2O Emission Factor - Atmospheric N Deposition	(kg N2O-N kg-1 N volatilized)	Factor Value (Appendix D)
Nex(b)	Annual N Excretion Rate: Basic Characterization	(kg N animal-1yr-1)	Equation Result
Nrate	Daily N Excretion Rate: Basic Characterization	[kg N (1000 kg animal) -1 day-1]	Factor Value (Appendix D)
TAM	Typical Animal Mass: Basic Characterization	(kg animal-1)	Factor Value (Appendix D)

6.5.4 Indirect Nitrous Oxide (N2O) estimation from leaching/runoff

The following equations and factors were used for estimating indirect nitrous oxide emissions from leaching/runoff.

N2OLmm = Sum(N2OLmm(b))

Nleach(b) = Nt * Nex(b) * MS * FracLEACH

N2OLmm(b) = Nleach(b) * EFlr * (44/28)

Nex(b) = Nrate * (TAM / 1000) * 365

Where,

Abbreviation	Description	Units	Type (Factor Value)
N2OLmm	Total Indirect N2O Emissions - Leaching/Runoff	(kg N2O yr-1)	Equation Result
Nleach(b)	N Leached from Manure System: Basic Characterization	(kg N yr-1)	Equation Result
Nt	Number Head of Livestock (Average Annual Population)	(head)	Quantity Value (Table 3.1)
MS	Fraction Livestock Manure in Manure System	(fraction)	Quantity Value (Appendix D)
FracLEACH	Fraction of N Lost from Manure System by Leaching/Runoff	(fraction)	Factor Value (0.1)
N2OLmm(b)	Indirect N2O Emissions - Leaching: Basic Characterization	(kg N2O yr-1)	Equation Result
EFlr	Indirect N2O Emission Factor - Leaching/Runoff	(kg N2O-N kg-1 N leached)	Factor Value (0.0075)
Nex(b)	Annual N Excretion Rate: Basic Characterization	(kg N animal yr-1)	Equation Result
Nrate	Daily N Excretion Rate: Basic Characterization	[kg N (1000 kg animal)-1 day-1]	Factor Value (Appendix D)
TAM	Typical Animal Mass: Basic Characterization	(kg animal-1)	Factor Value (Appendix D)

6.5.5 Methane (CH4) and Direct Nitrous Oxide (N2O) estimation

Total manure CH4 and direct nitrous oxide (N2O) emissions from selected districts of Haor areas were estimated at 14.110 Gg CH4 and 1.820 Gg N2O for the year 2018. Detailed estimated Methane (CH4) and Direct Nitrous Oxide (N2O) from manure management by different district and livestock categories are presented in Table 6.8 and Table 6.9.

Table 6.8: Total Manure CH4 Emissions by year by different livestock categories

Year	Gg CH4							(Gg CO2eq)
	Dairy Cows	Non Dairy Cows	Buffalo	Goat	Sheep	Poultry	Total	Total
Brahmanbaria	1.257	0.159	0.021	0.022	0.003	0.046	1.508	42
Kishoreganj	2.770	0.351	0.030	0.043	0.004	0.153	3.351	94

Year	Gg CH4							(Gg CO2eq)
	Dairy Cows	Non Dairy Cows	Buffalo	Goat	Sheep	Poultry	Total	Total
Netrokona	2.552	0.323	0.039	0.085	0.001	0.104	3.104	87
Habiganj	1.481	0.188	0.110	0.029	0.005	0.036	1.849	52
Sunamganj	3.689	0.467	0.043	0.040	0.016	0.043	4.298	120
Total	11.750	0.219	0.242	1.488	0.382	0.029	14.110	395

Table 6.9: Total Direct N2O Emissions from Manure System by year by different livestock categories

Year	Gg N2O							(Gg CO2eq)
	Dairy Cows	Non Dairy Cows	Buffalo	Goat	Sheep	Poultry	Total	Total
Brahmanbaria	0.160	0.018	0.003	0.012	0.001	-	0.193	51
Kishoreganj	0.353	0.039	0.004	0.023	0.002	-	0.420	111
Netrokona	0.325	0.036	0.005	0.046	0.001	-	0.412	109
Habiganj	0.188	0.021	0.014	0.015	0.002	-	0.240	64
Sunamganj	0.469	0.052	0.005	0.021	0.007	-	0.555	147
Total	1.495	0.166	0.031	0.117	0.013	-	1.820	482

6.5.6 Indirect Nitrous Oxide (N2O) estimation

It is observed from Table 6.10 that emissions through volatilization from livestock subsector was estimated at 0.579 Gg N2O for the year 2018. For the same period, the contributions to the total indirect N2O emission from leaching or runoff was estimated at 0.155 Gg N2O (Table 6.11).

Table 6.10: Total Indirect N2O Emissions - Volatilization

Year	Gg N2O							(Gg CO2eq)
	Dairy Cows	Non Dairy Cows	Buffalo	Goat	Sheep	Poultry	Total	Total
Brahmanbaria	0.005	0.047	0.001	0.003	0.000	0.006	0.062	16
Kishoreganj	0.011	0.104	0.001	0.006	0.000	0.019	0.142	38
Netrokona	0.011	0.096	0.002	0.011	0.000	0.013	0.132	35
Habiganj	0.006	0.056	0.005	0.004	0.001	0.005	0.075	20
Sunamganj	0.015	0.139	0.002	0.005	0.002	0.006	0.168	45
Total	0.048	0.442	0.011	0.029	0.003	0.049	0.579	153

Table 6.11: Total Indirect N2O Emissions - Leaching/Runoff

Year	Gg N2O							(Gg CO2eq)
	Dairy Cows	Non Dairy Cows	Buffalo	Goat	Sheep	Poultry	Total	Total
Brahmanbaria	0.012	0.001	0.000	0.002	0.000	0.001	0.017	5
Kishoreganj	0.026	0.003	0.000	0.003	0.000	0.005	0.037	10
Netrokona	0.024	0.003	0.000	0.007	0.000	0.003	0.037	10
Habiganj	0.014	0.002	0.001	0.002	0.000	0.001	0.020	5
Sunamganj	0.034	0.004	0.000	0.003	0.001	0.001	0.044	12
Total	0.110	0.013	0.001	0.017	0.001	0.011	0.155	41

6.6 Summary of GHGs Emissions from Agriculture Sectors

A significant amount of greenhouse gases (GHGs), such as Carbon dioxide (CO2), Methane (CH4) and (Nitrous oxide) N2O are released into the atmosphere through agricultural activities (Smith et al. 2007). Carbon dioxide, which is emitted mostly from microbial decomposition or burning of plant residues and soil organic matter (Janzen 2004; Smith 2004). Methane is produced when organic materials decompose under reduced or oxygen-deprived conditions, notably from enteric fermentation by ruminant livestock, stored manures and paddy rice cultivation under flooded conditions (Mosier et al. 1998). Nitrous oxide is produced by transformation of nitrogen in soils and manures by microbial activities and is often enhanced where available N exceeds plant requirements, especially under water saturated conditions (Smith & Conen 2004; Oenema et al. 2005). The agricultural sector is one of the major contributors, emitting about 60% of total anthropogenic N2O (Smith et al. 2007). Emissions of N2O and NO are mainly associated with N fertilizer use (or soil N content) and water regime. Agricultural greenhouse gas fluxes are complex and heterogeneous, but the amount of emission depends on the management of agricultural systems.

Four major sources of GHG emission from agriculture sector have been identified in Haor area i.e; (i) CH4 emission from cultivated rice fields, (ii) N2O and CO2 emission from N-based fertilizer, (iii) Enteric fermentation, and (iv) CH4 and N2O emission from manure management. It should be mentioned here that biomass burning and liming are sporadically practiced in the Haor area. Therefore, in this study only the dominant sources of GHG emissions have been considered. The dominant sources of emissions are CH4 from rice field and enteric fermentation from the livestock subsector. The next important sources are N2O emission from fertilizer application and direct N2O emissions from manure system. A summary of GHG emission by district is presented in Table 6.12.

Table 6.12: Summary of Emission of Agriculture Sector (Gg CO2eq)

Source of Emission	Brahmanbaria	Kishoreganj	Netrokona	Habiganj	Sunamganj	Total
Total CH4 Emissions from Rice Field	410	494	448	466	818	2636
Direct Nitrous Oxide (N2O) from Fertilizer application	56	139	69	46	51	361
Indirect Nitrous Oxide (N2O) emissions from N based fertilizer	18	45	23	15	17	118
Total Enteric CH4 Emissions	145	313	316	191	411	1376
Total Manure CH4 Emissions	42	94	87	52	120	395
Total Direct N2O Emissions from Manure System	51	111	109	64	147	482
Total Indirect N2O Emissions - Volatilization	16	38	35	20	45	154
Total Indirect N2O Emissions - Leaching/Runoff	5	10	10	5	12	42
Total	743	1244	1097	859	1621	5564

Source: CEGIS estimation, 2019

In the Third National Communication (MoEF, 2018), the total GHG emission from agriculture sector was estimated at about 45877 Gg (CO2eq). However, the estimated total GHG emission from agriculture sector in the selected districts of Haor areas at about 5564 Gg (CO2eq) which is 12% of Bangladesh. Among the selected district highest emission is observed in Sunamganj district (29%) and lowest in Brahmanbaria (13%).

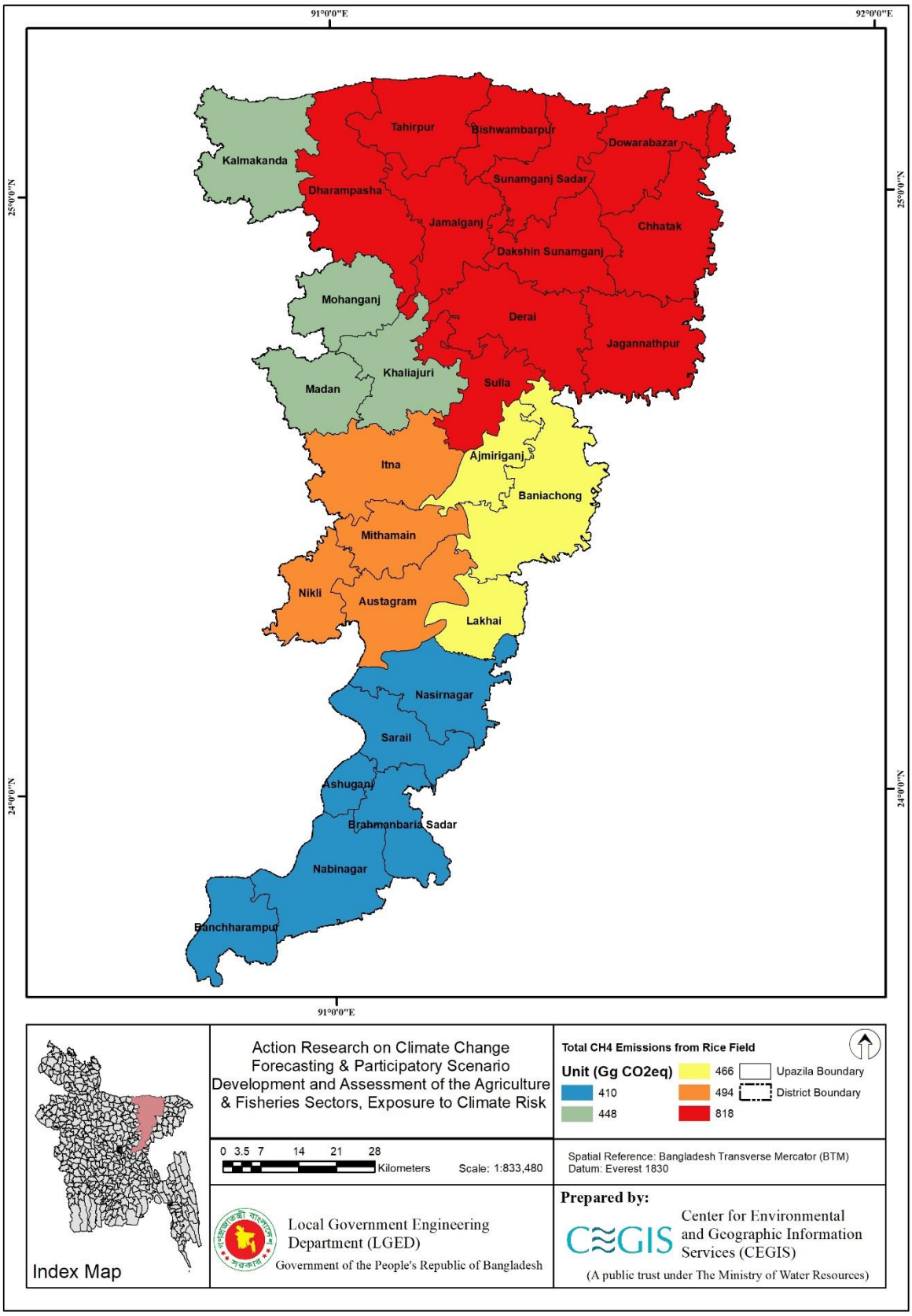


Figure 6.2: Total CH_4 Emissions from Rice Field

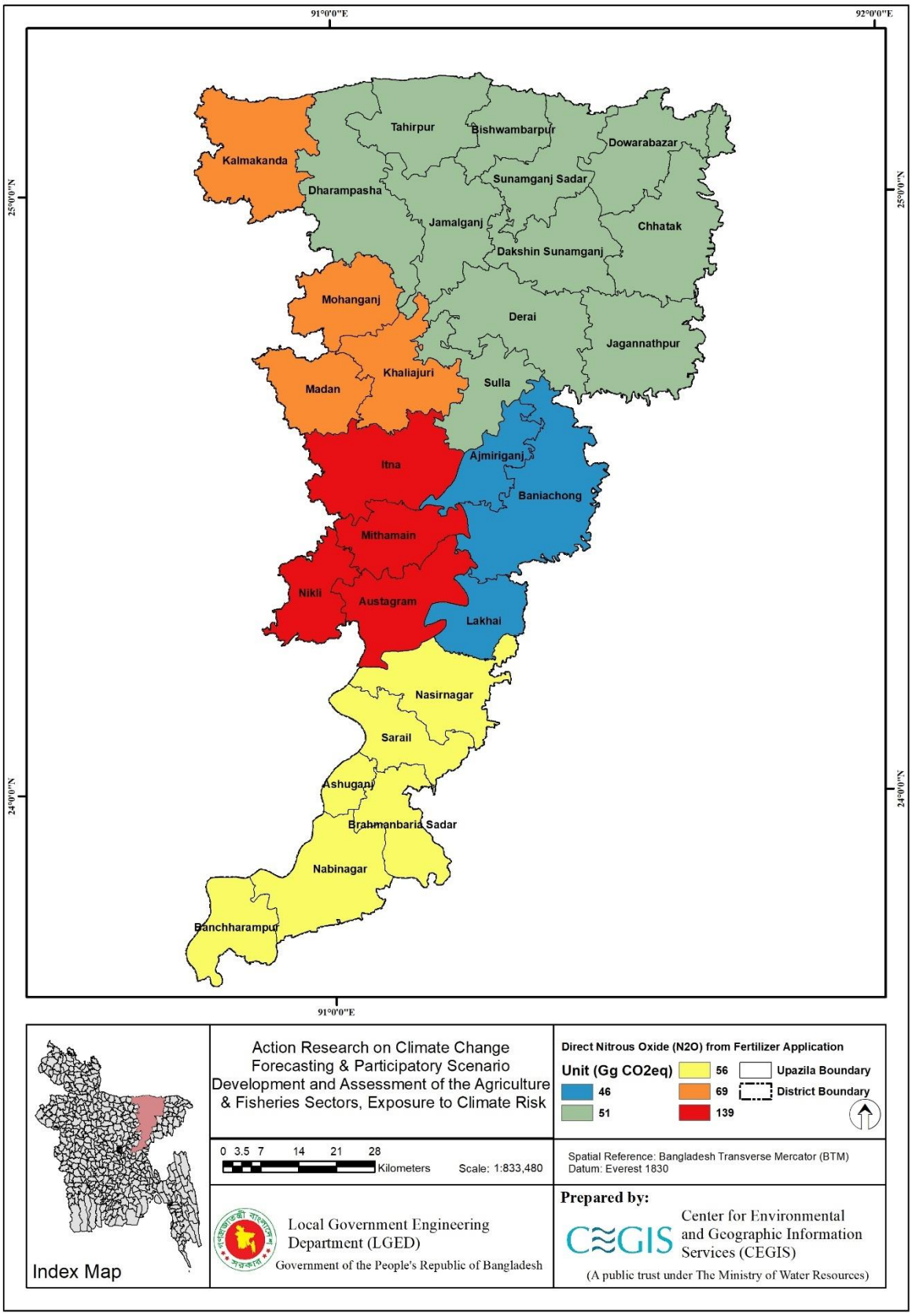


Figure 6.3: Direct Nitrous Oxide (N_2O) from Fertilizer application

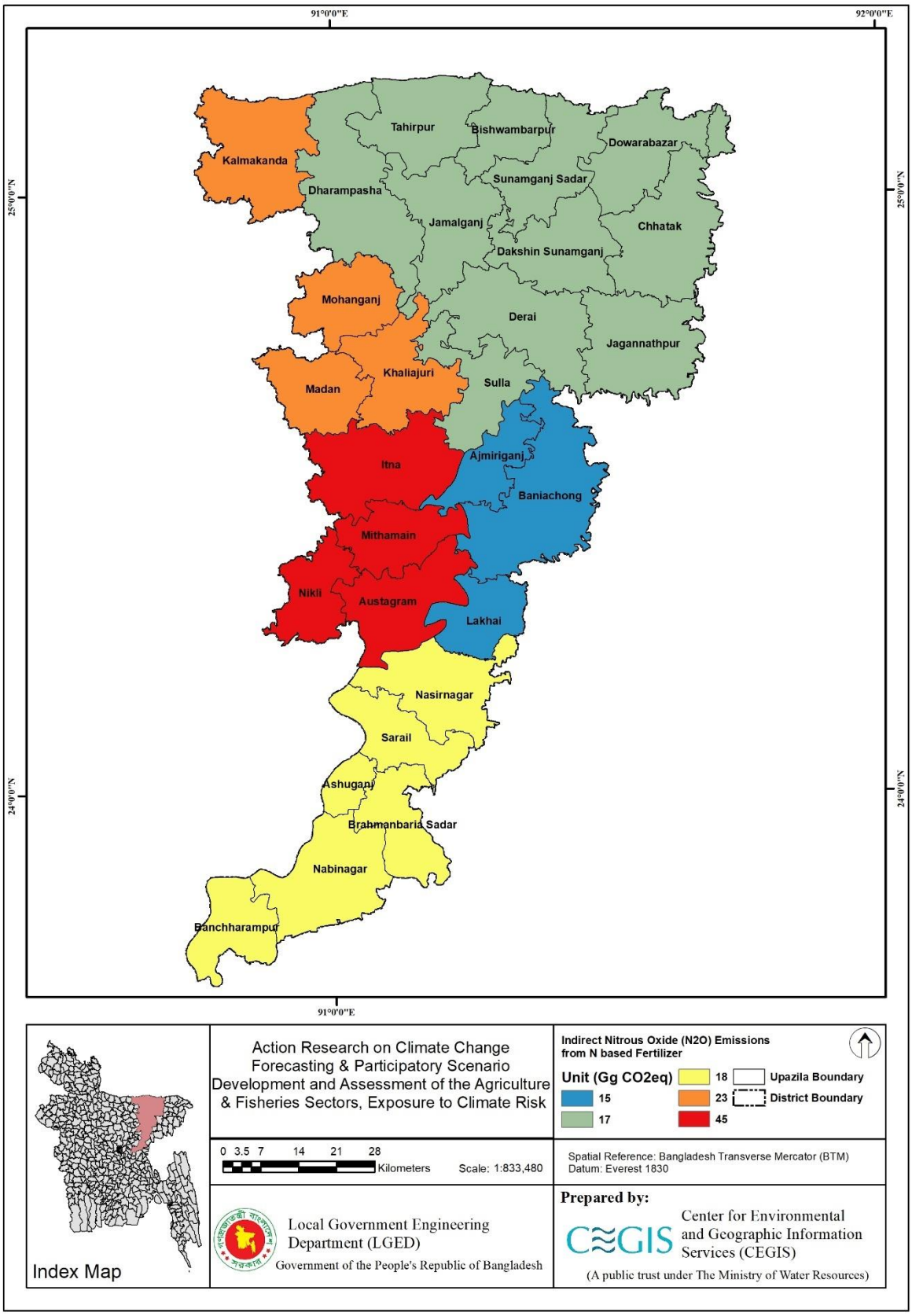


Figure 6.4: Indirect Nitrous Oxide (N_2O) emissions from N based fertilizer

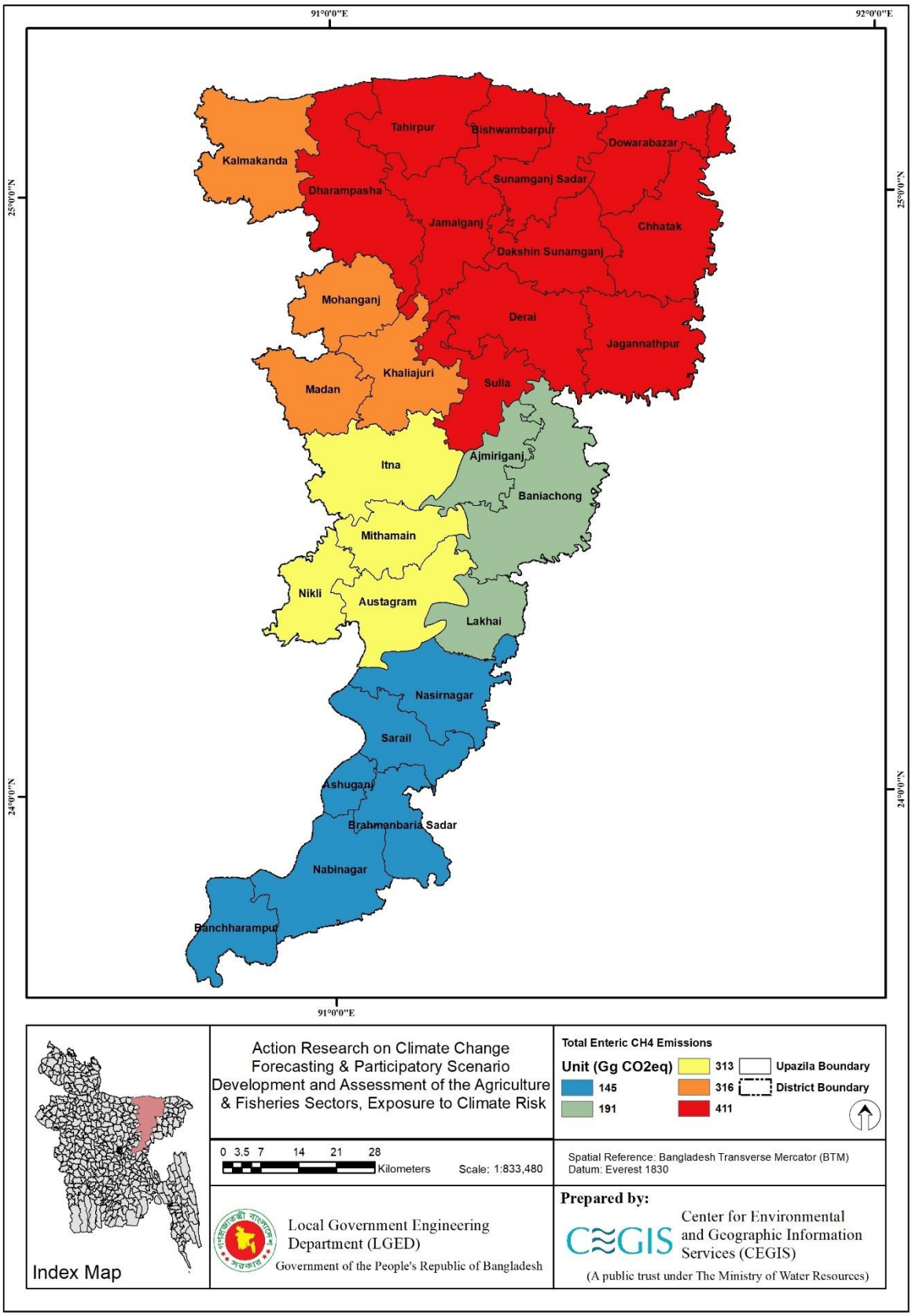


Figure 6.5: Total Enteric CH_4 Emissions

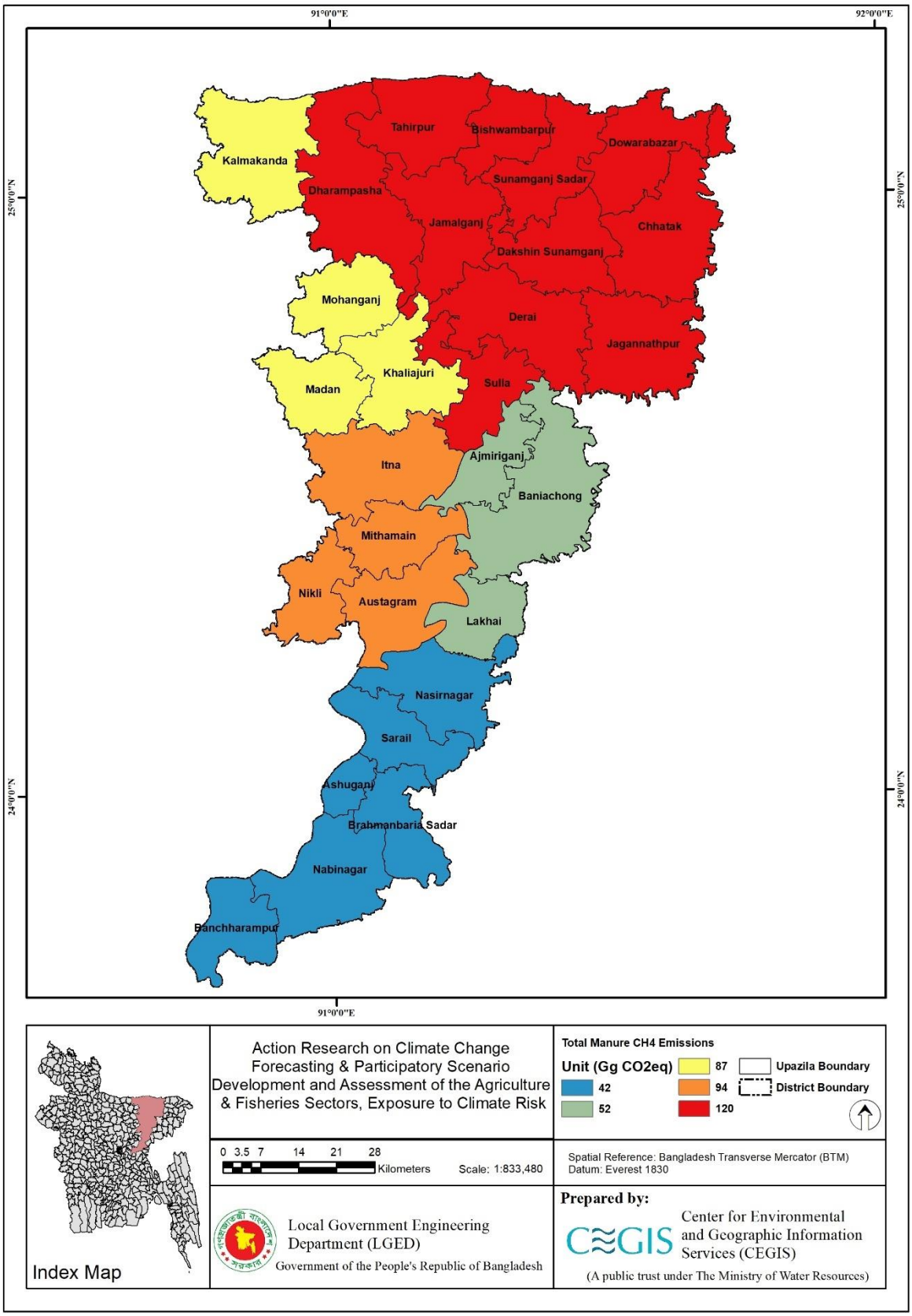


Figure 6.6: Total Manure CH_4 Emissions

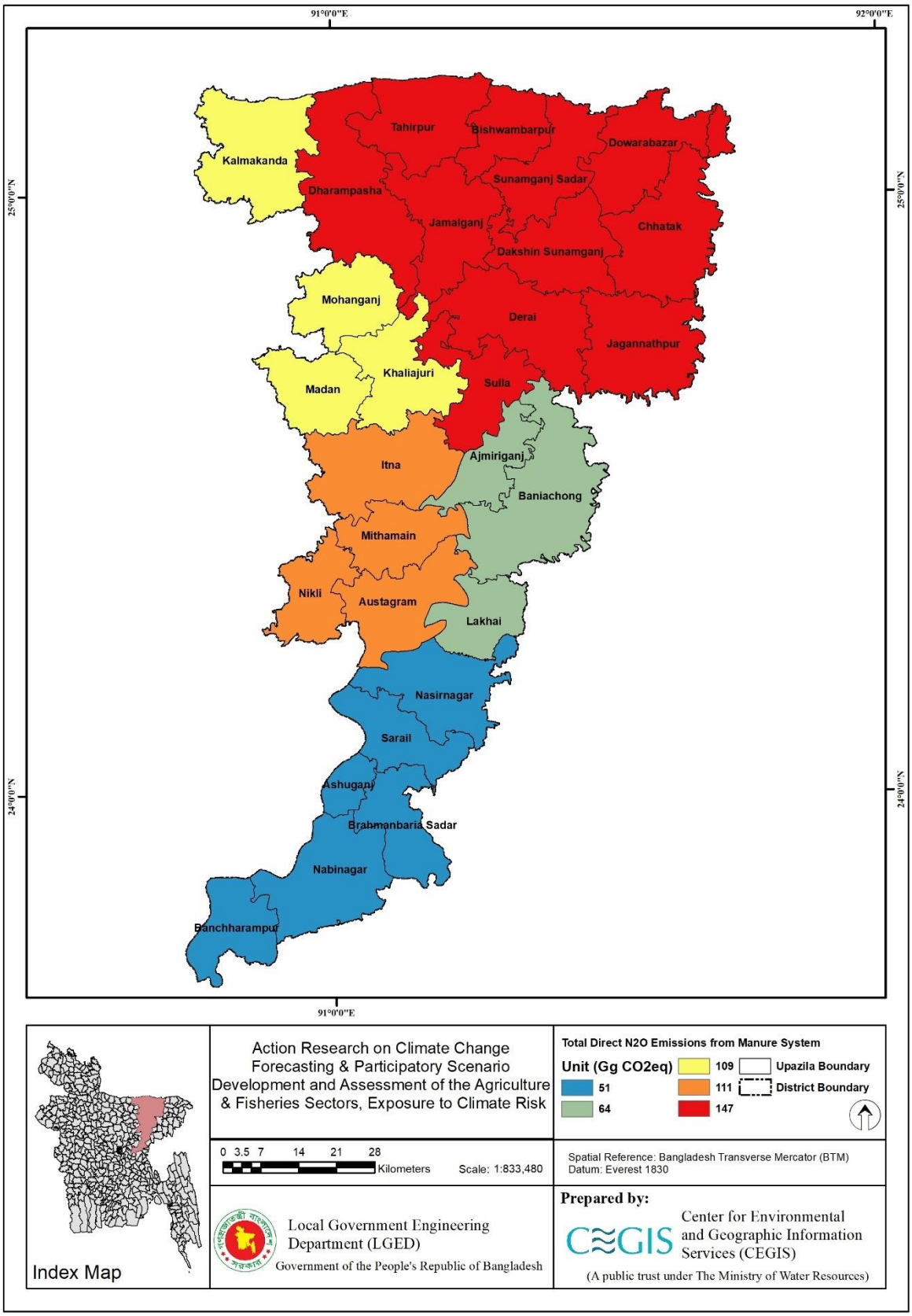


Figure 6.7: Total Direct N_2O Emissions from Manure System

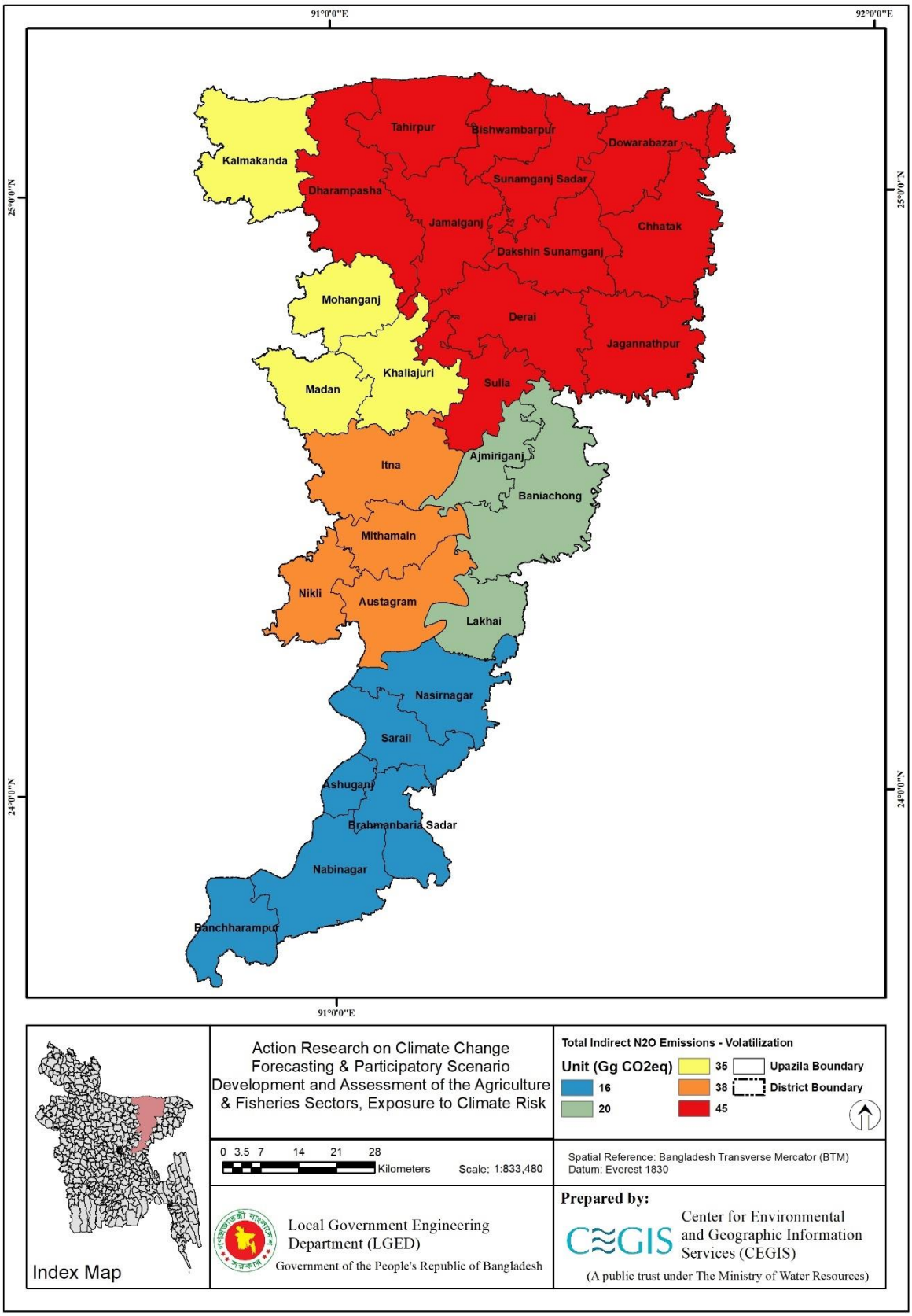


Figure 6.8: Total Indirect N_2O Emissions – Volatilization

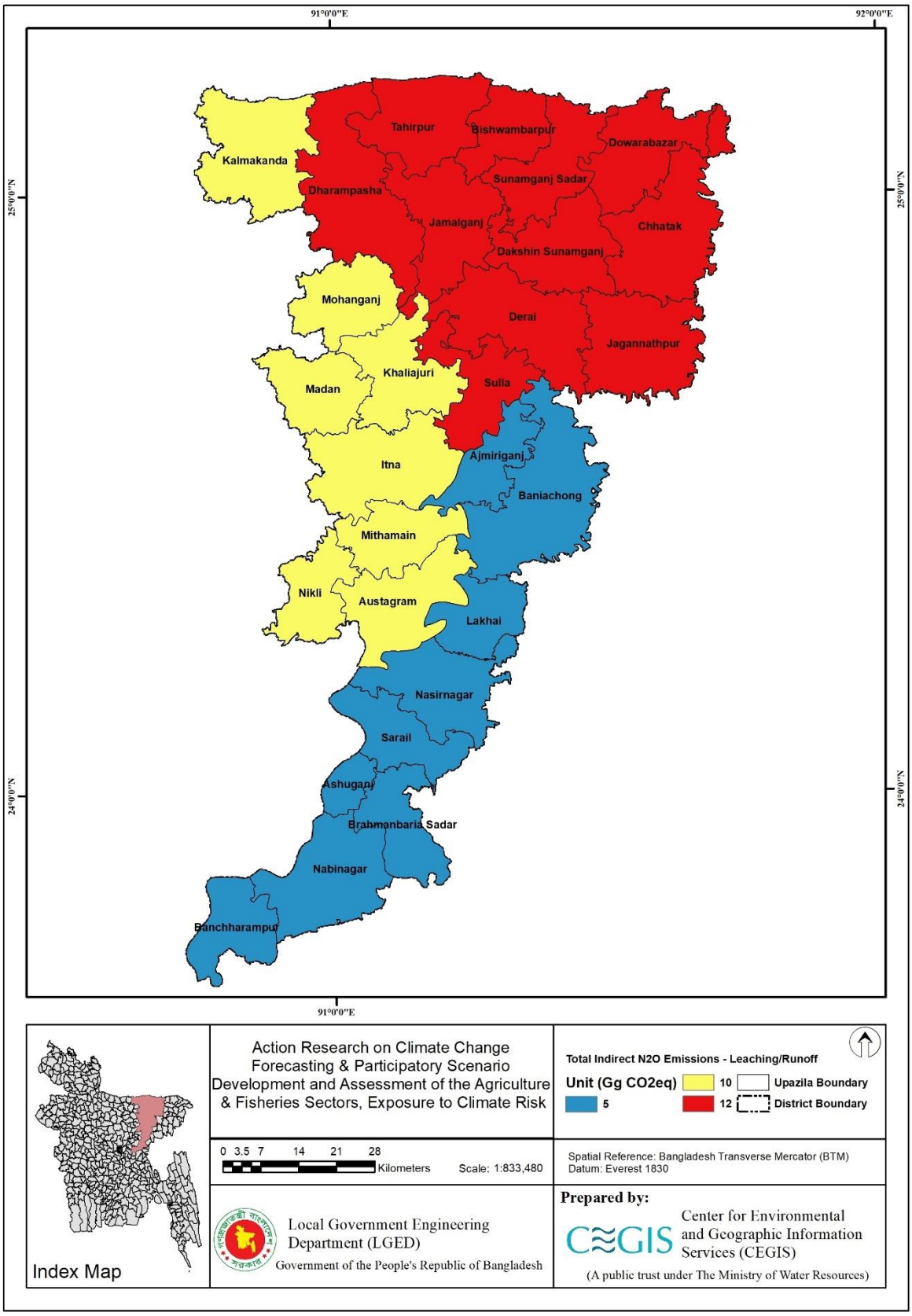


Figure 6.9: Total Indirect N_2O Emissions- Leaching/Runoff

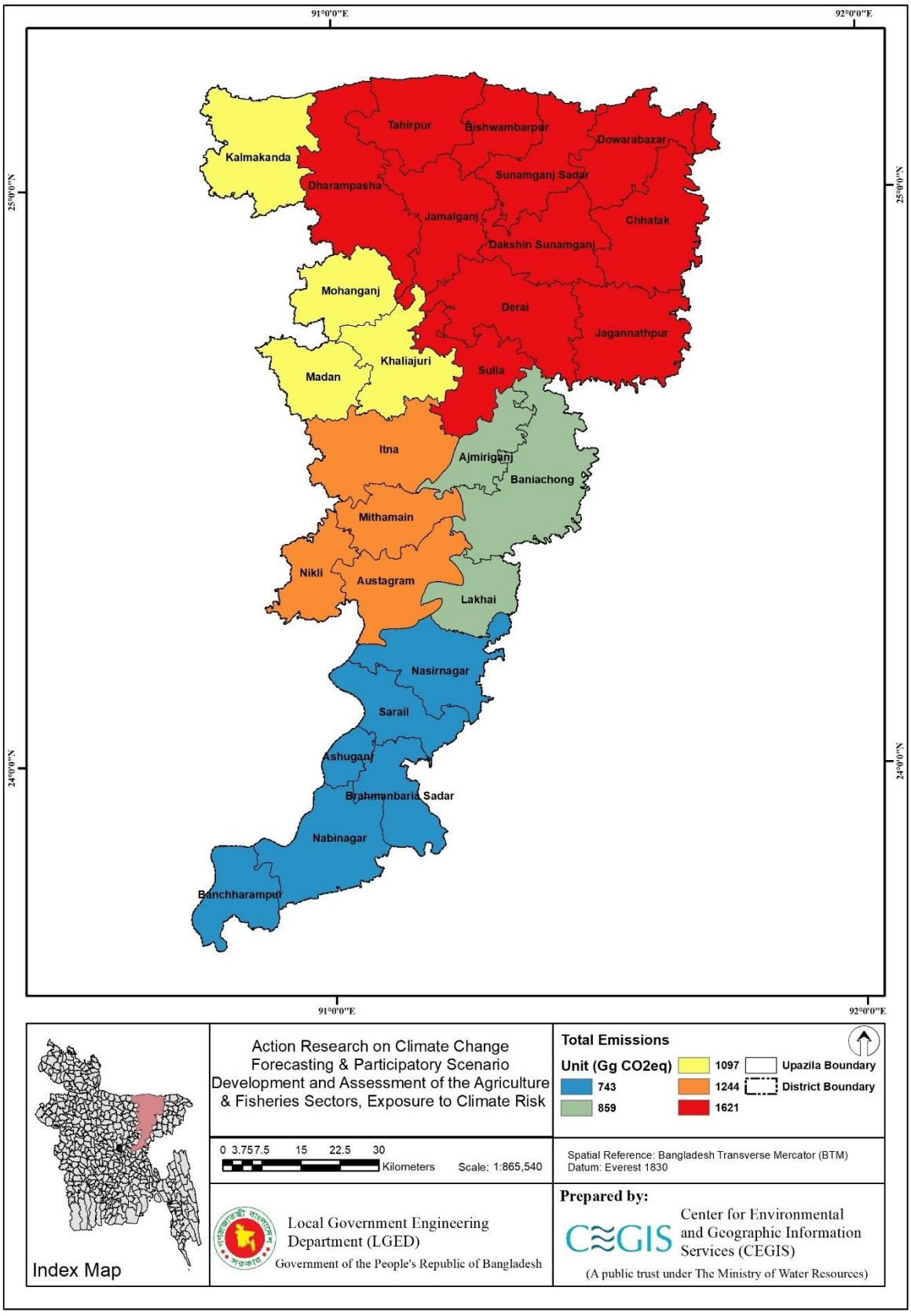


Figure 6.10: Total Emissions in $GgCO_2Eq$ in the Study Area

7. Socio-Economic Assessment

7.1 Socio-Economic Scenario

7.1.1 Population

According to Population and Housing Census 2011, The total population of the five haor districts (Brahmanbaria, Habiganj, Kishoreganj, Netrokona and Sunamganj) is **12.95 million** where **6.37 million** are male and **6.58 million** are female (Table 7.1). The highest number of population lives in Kishoreganj (**3.03 million**) and the lowest in Habiganj (**2.17 million**).

The average population growth rate per annum for these five districts of haor region is **1.54%** where population growth is following a high rate at Sunamganj (2.02%) and low at Kishoreganj (1.14%). In comparison with BBS 2010 data, the annual growth rate per annum decreased for Brahmanbaria, Habiganj and Sunamganj and increased for Kishoreganj and Netrokona.

The average sex ratio (male: female) is 97:100, which indicates that there are 97 males per 100 females. The national sex ratio is 105:100. It should be mentioned that the average sex ratio changed from `104:100 (BBS 2010) to 97:100 (BBS 2011) which indicates the average number of female is increasing in these five haor districts.

The overall population density in the haor districts is 987 per sq km which is lower than the average population density in Bangladesh which is 1142 per sq. km. Brahmanbaria district has the highest population density (1510 per km^2) while only 659 people live per km^2 area in Sunamganj district. Figure 7.1 shows the population distribution and density respectively.

Table 7.1: Population and Housing Census 2011

Census Year	Statistics for	Brahamanbaria	Habiganj	Kishoreganj	Netrakona	Sunamganj
2010	Total Population	2,509,384	1,838,687	2,714,721	1,988,188	2,107,284
	Desnity Per Sq Km	1,244	667	950	725	548
	Male	1,268,922	939,785	1,389,316	1,016,991	1,091,481
	Female	1,240,462	898,902	1,325,405	971,197	1,015,803
	Sex Ratio	101	103	104	105	106
	Growth Rate	1.14	1.42	1.19	1.40	1.66
2011	Total Population	2,953,207	2,171,064	3,028,706	2,229,642	2,564,540
	Desnity Per Sq Km	1,510	792	1,083	813	659
	Male	1,420,990	1,065,908	1,489,738	1,111,306	1,284,520
	Female	1,532,217	1,105,156	1,538,968	1,118,336	1,280,020
	Sex Ratio	93	96	97	99	100
	Growth Rate	1.68	1.72	1.14	1.15	2.02

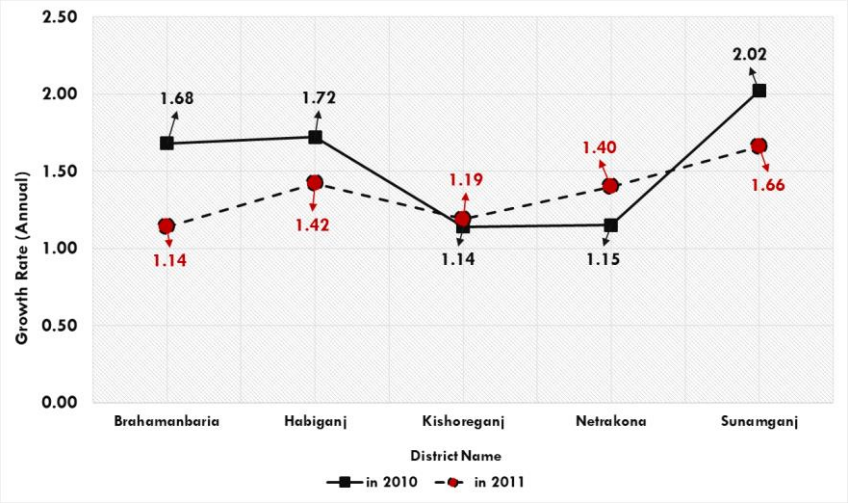


Figure 7.1: Population Distribution and Density

Population Projection

Population of five haor districts have been projected following the **"Incremental Increase Method"** for the year 2021, 2031 and 2051.In this method, growth rate is assumed to be progressively increasing or decreasing, depending upon whether the average of the incremental increases in the past is positive or negative. The population for the future decades is worked out by adding the mean arithmetic increase to the last known population as in the arithmetic increase method, and to this is added the average of incremental increases, once for first decade (2021), twice for second (2031) till 2051;

The expression of the incremental increase method is given by:

$$P_n = P + n.X + [n\ (n+1)/2].Y \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (7.1)$$

Where,

P_n = Population after n'th Decade

X = average increase

Y = incremental increase

P = last known population

Based on the projected population, growth rate has been projected by following equation:

$$P_n = P_0\ (1+r)^t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\

projected that the population will hit the mark of almost 5 Million during 4.83 Million. The distribution of population by sex shows that 1366711 (48.12%) male and 1473787 (51.88%) female constitute the total population of 2840498 in 2011 census in Figure 7.3. But the sex wise projection for next four census persons indicates the number of female will be increasing significantly than the male numbers. It is noticed that both the annual and the intercensal growth rates presented in figure 7.4 have been showing a fluctuating trend since 1974 but following a stationary trend for next four census years.

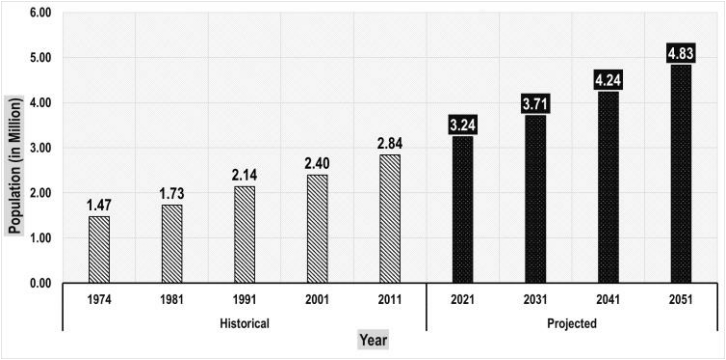


Figure 7.2: Population Projection for Brahmanbaria District

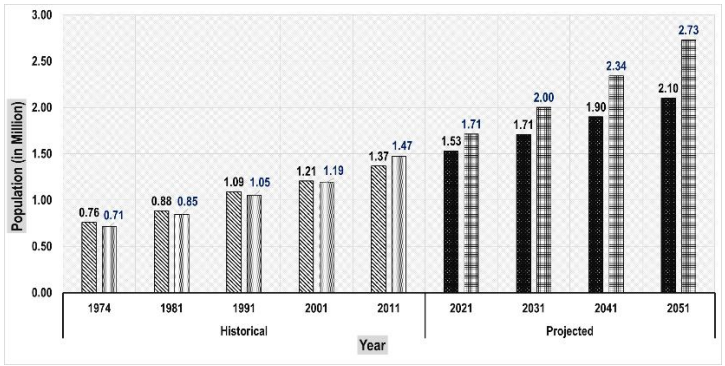


Figure 7.3: Trend and Projection of Population by Sex

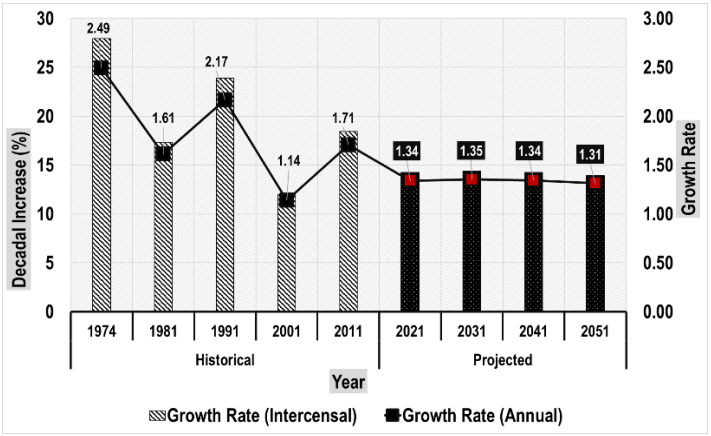


Figure 7.4: Trend and Projection of Growth rate

Habiganj

Population of Brahmanbaria zila along with annual and intercensal growth for the last five consecutive censuses is presented in figure 7.5. Following the increasing trend, it has been

projected that the population will hit the mark of 3.55 Million during 2051.The distribution of population by sex shows that 1025591 (49.09%) male and 1063410 (50.91%) female constitute the total population of 2089001 in 2011 census in figure 7.6. But the sex wise projection for next four census years indicates the number of female will be increasing than the male numbers. It is noticed that both the annual and the intercensal growth rates presented in figure 7.7 have been showing a fluctuating trend since 1974 but following a stationary trend for next four census years.

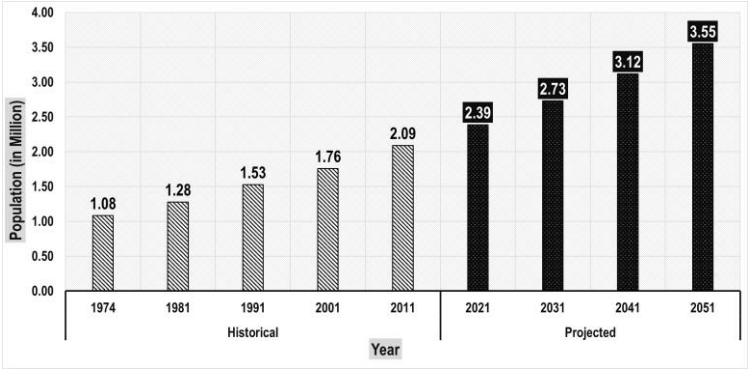


Figure 7.5: Population Projection for Habiganj District

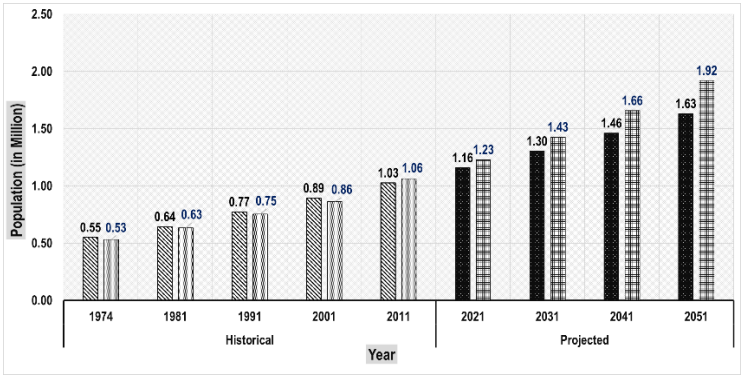


Figure 7.6: Trend and Projection of Population by Sex

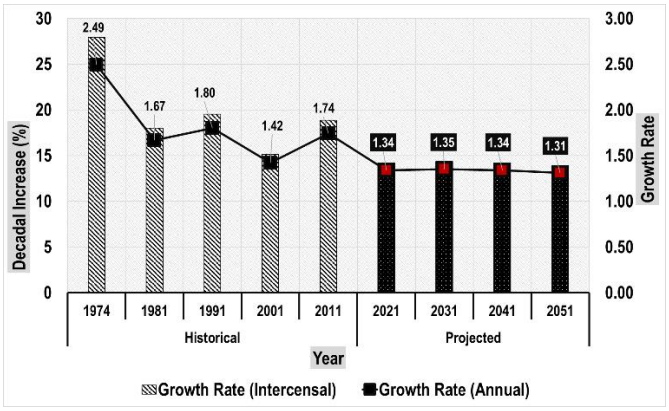


Figure 7.7: Trend and Projection of Growth rate

Kishoreganj

Population of Kishoreganj zila along with annual and intercensal growth for the last five

consecutive censuses is presented in figure 7.8. Following the increasing trend, it has been projected that the population will hit the mark of almost 4.24 Million during 2051.The distribution of population by sex shows that 1,432,242 (49.18%) male and 1,479,665 (50.82%) female constitute the total population of 2911907 in 2011 census in figure 7.9. But the sex wise projection for next four census persons indicates the number of female will be increasing significantly than the male numbers. It is noticed that both the annual and the intercensal growth rates presented in figure 7.10 have been showing a fluctuating trend since 1974 but following a stationary trend for next four census years.

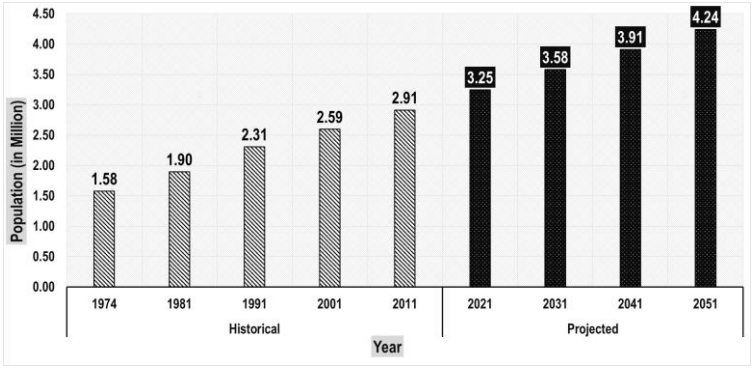


Figure 7.8: Population Projection for Kishoreganj District

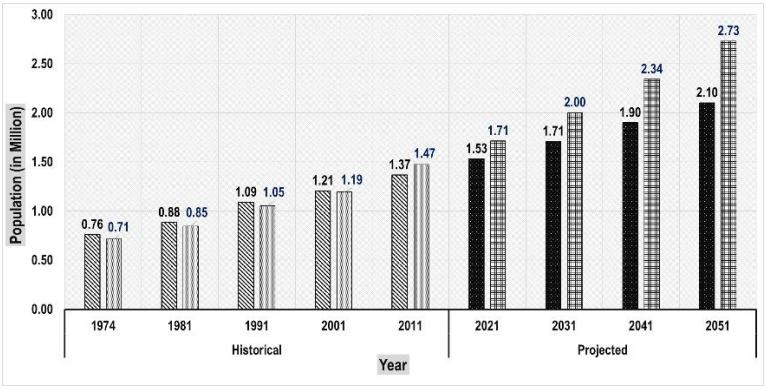


Figure 7.9: Trend and Projection of Population by Sex

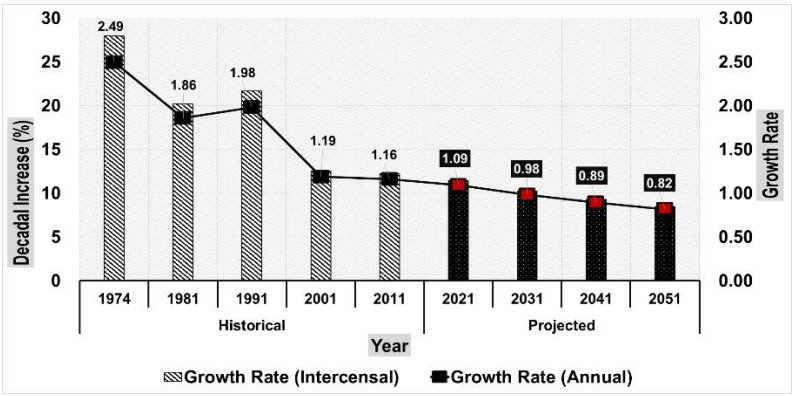


Figure 7.10: Trend and Projection of Growth rate

Netrokona

Population of Netrokona zila along with annual and intercensal growth for the last five

consecutive censuses is presented in figure 7.11. Following the increasing trend, it has been projected that the population will hit the mark of almost 3.28 Million during 2051.The distribution of population by sex shows that 1,111,306 (49.8%) male and 1,118,336 (50.15%) female constitute the total population of 2229642 in 2011 census in figure 7.12. But the sex wise projection for next four census persons indicates the number of female will be increasing significantly than the male numbers. It is noticed that both the annual and the intercensal growth rates presented in figure 7.13 have been showing a fluctuating trend since 1974 but following a stationary trend for next four census years.

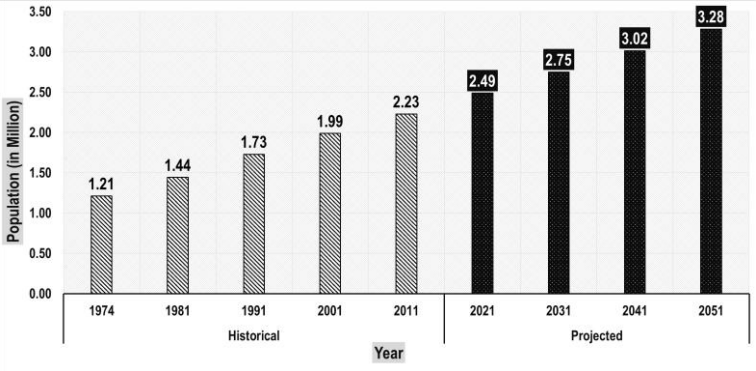


Figure 7.11: Population Projection for Netrokona District

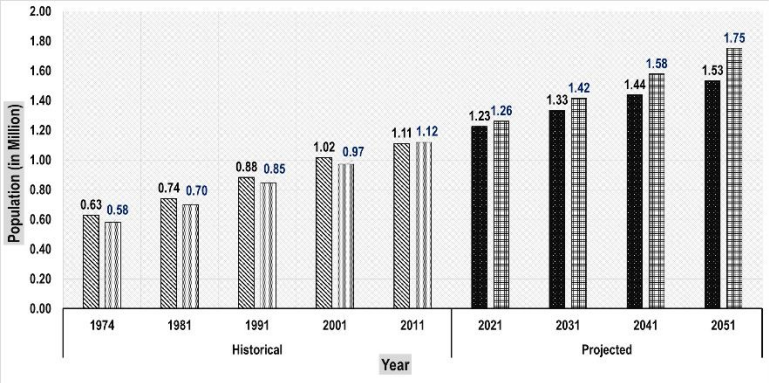


Figure 7.12: Trend and Projection of Population by Sex

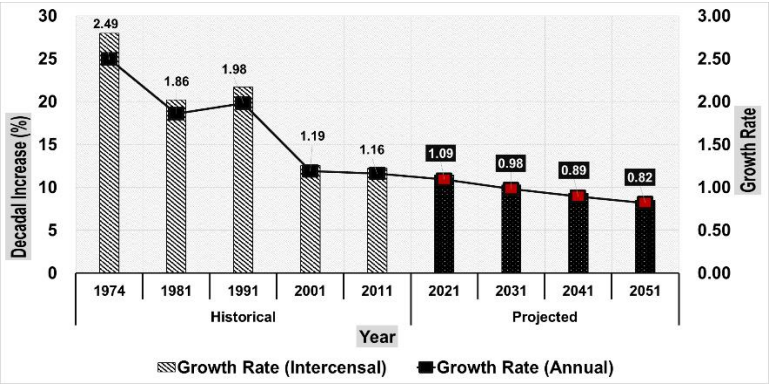


Figure 7.13: Trend and Projection of Growth rate

Sunamganj

Population of Sunamganj zila along with annual and intercensal growth for the last five

consecutive censuses is presented in figure 7.14. Following the increasing trend, it has been projected that the population will hit the mark of almost 4.73 Million during 2051.The distribution of population by sex shows that 1,236,106 (49.99%) male and 1,231,862 (50.08%) female constitute the total population of 2467968 in 2011 census in figure 7.15. But the sex wise projection for next four census persons indicates the number of female will be increasing significantly than the male numbers. It is noticed that both the annual and the intercensal growth rates presented in figure 7.16 have been showing a fluctuating trend since 1974 but following a stationary trend for next four census years.

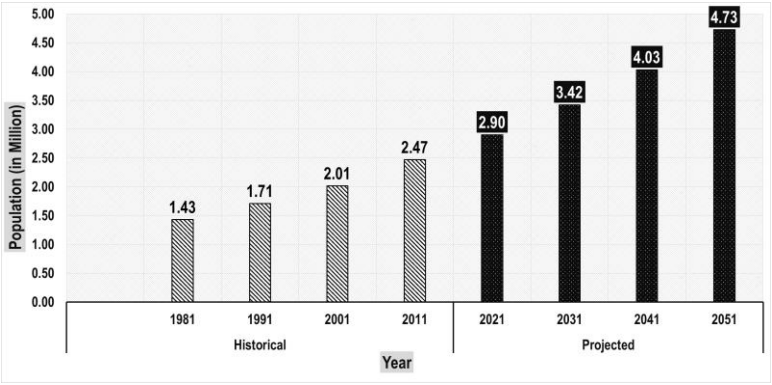


Figure 7.14: Population Projection for Sunamganj District

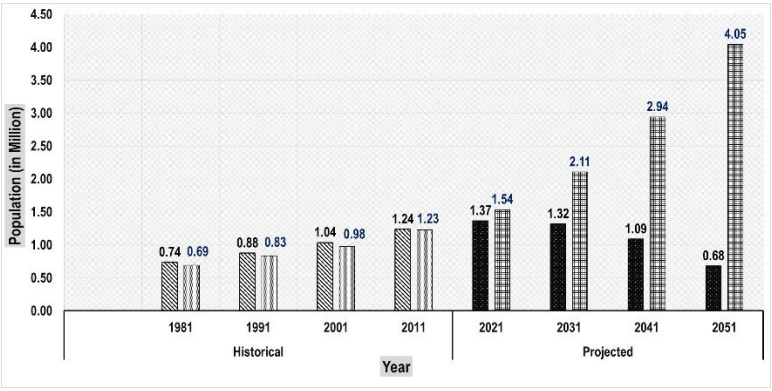


Figure 7.15: Trend and Projection of Population by Sex

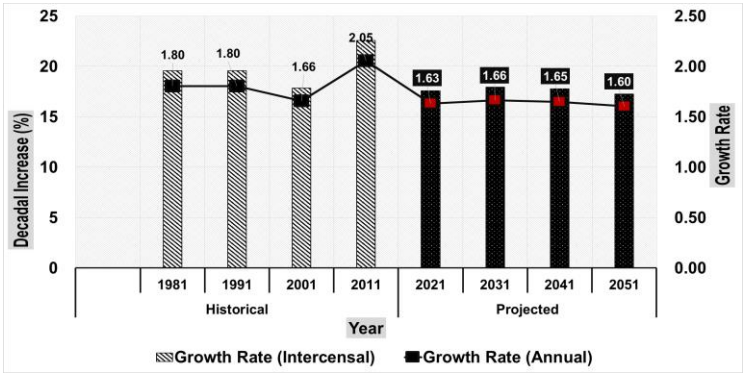


Figure 7.16: Trend and Projection of Growth rate

Population by Brahmanbaria Sub district

It is seen from (Figure 7.17) intercensal growth that highest population increase during the

decade 2001-2011 has taken place in Ashuganj upazila of Brahmanbaria zila with the highest variation of 23.88% followed by Nasirnagar upazila with 20.86%. The major contribution to the total population of zila is made by Brahmanbaria Sadar followed by Nabinagar upazila with 18.38% and 17.37% respectively. It is noticed that total population of Brahmanbaria Sadar has decreased by 16.55% in 2011 compared to 2001.

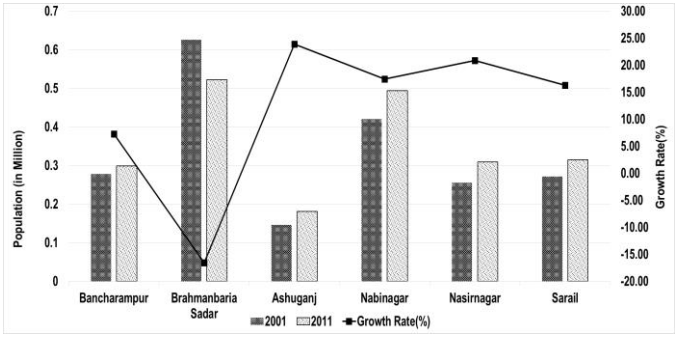


Figure 7.17: Population Projection for Brahmanbaria Sub district

Population by Habiganj Sub district

It is seen from (Figure 7.18) intercensal growth of Habiganj upazilla that the highest population increase during the decade 2001-2011 has taken place in Baniachang upazila with the highest variation of 23.76% followed by Lakhai upazila with 23.31%. The major contribution to the total population of zila is made by Nabiganj upazila followed by Baniachong upazila with 16.50% and 15.90% respectively. On the other hand, the lowest contribution to total population of the zila is made by Ajmiriganj upazila followed by Lakhai upazila with 5.45% and 7.10% respectively.

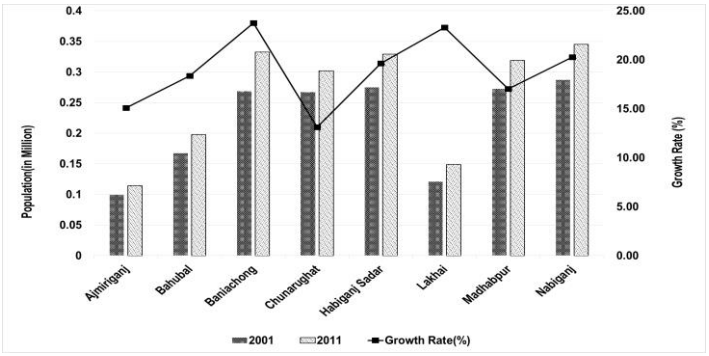


Figure 7.18: Population Projection for Habiganj Sub district

Population by Kishoreganj Sub district

It is seen from (Figure 7.19) intercensal growth of Kishoreganj upazilla that the highest population increases during the decade 2001-2011 has taken place in Bhairab upazila with the highest variation of 20.69% followed by Kishoreganj Sadar with 18.89%. The major contribution to the total population of the zila is made by Kishoreganj Sadar followed by Katiadi upazila with 14.22% and 10.80% respectively. It is noticed in the table that population of Mithamain upazila has decreased by 0.14% in 2011 compared to 2001.

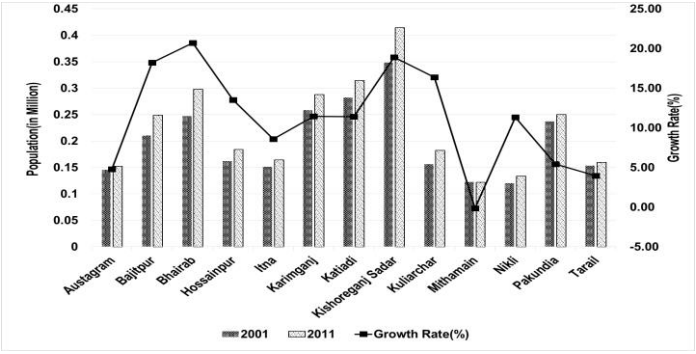


Figure 7.19: Population Projection for Kishoreganj Sub district

Population by Netrokona Sub district

It is seen from (Figure 7.20) intercensal growth of Netrokona upazilla that the major contribution to the total population of Zila is made by Netrokona Sadar upazila (16.72%) followed by Purbadhala (13.94%), Kendua (13.67%), Kalmakanda (12.2%) and Durgapur (10.09%). It is seen that the highest population increase during the decade 2001-2011 has taken place in Khaliajuri Upazila (18.4%) followed by Mohanganj Upazila (16.5%) and Kalmakanda (16.0%). It is noticed that urban population of Khaliajuri Upazila decreased by 0.20% in 2011 compared to 2001.

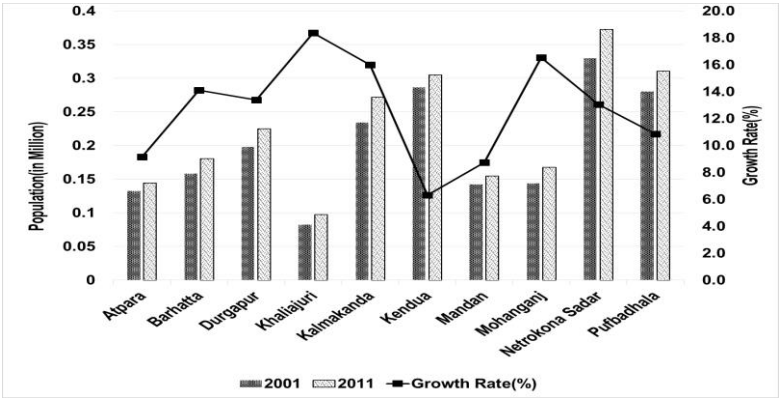


Figure 7.20: Population Projection for Netrokona Sub district

Population by Sunamganj Sub district

It is seen from (Figure 7.21) intercensal growth of Sunamganj upazilla that the highest population increase during the decade 2001-2011 has taken place in Tahirpur upazilla of Sunamganj zilla with the highest variation of 38.67% followed by Dowarabazar with 27.49%. The major contribution to the total population of the zilla in 2011 is made by Chhatak upazilla followed by Sunamganj Sadar with 16.11% and 11.30% respectively. It is noticed that urban population of Bishwambarpur, Jamalganj and Sulla upazilla has decreased by 1.56%, 50.46% and 9.14% respectively in 2011 compared to 2001. Negative variation is found in Sunamganj Sadar upazilla with -24.02% intercensal rate.

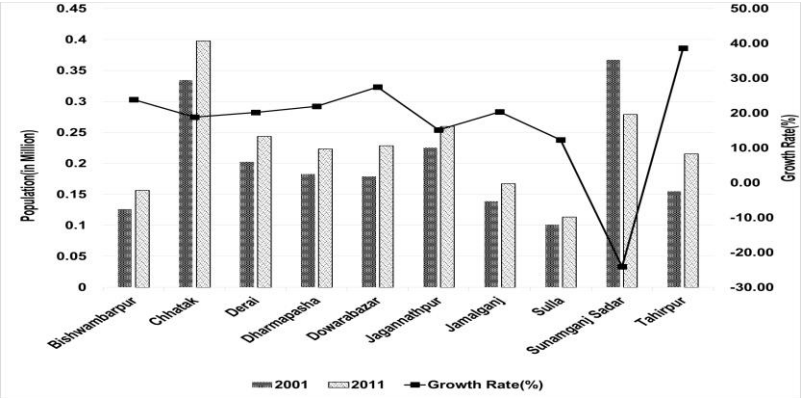


Figure 7.21: Population Projection for Sunamganj Sub district

7.1.2 Settlements

Housing and Settlement pattern of the Haor area is not similar to others part of Bangladesh due to geographical location. Almost all land above the maximum flood level is under permanent cultivation and human settlement. There are extensive plantations and groves of trees around most villages and homesteads and in many areas this creates an aspect of discontinuous forest. The topography of Haor looks like as “Shasher”, that’s why development of housing and settlement in the study area has been followed considering the land topography and levis of river. According to Haor Maste Plan 2010, three patterns have been viewed by analysis of high resolution image. These are 1. Linear settlement pattern, 2. Cluster settlement pattern and 3. Scattered settlement pattern. These patterns have been observed both sides of Canal and along the river bank. The total settlement area and houses number in the study area is 303120 ha and 3244380 respectively. The percentage of the settlement area is 12% of the total study area. Below table shows the percentage of district with their area, number of households with their density falls into Deeply Flooded Area, Medium Flooded Area and Low Flooded Area.

Table 7.2: Percentage of District with their Area, Number of Households and Density

Flood Zone	Percentage of District	Settlement Area (ha)	Number of Households	Density of Households
Deeply flooded area	Sunamganj(65%),Netrokona(10%),Sylhet(5%),Maulvibazar(5%),Habiganj(45%),Kishoreganj(45%),Brahmanbaria(10%)	26,820	454,383	5.1
Medium flooded area	Sunamganj(25%),Netrokona(35%),Sylhet(65%),Maulvibazar(15%),Habiganj(25%),Kishoreganj(15%),Brahmanbaria(60%)	88,426	860,775	4.9
Low flooded area	Sunamganj(10%),Netrokona(55%),Sylhet(30%),Maulvibazar(35%),Habiganj(15%),Kishoreganj(40%),Brahmanbaria(30%)	187,874	1,264,451	5.7

Source: DBHWD 2012

Practically, people of Haor had special attention to build high land for building new settlements considering the aspect of inundation by flash and seasonal flooding. People have to be adaptive with the climate change aspect because of the increased risks of wash out of their settlements especially who are living in the deep Haor Area. In the study area, study findings showed that the tendency to build settlements within the Haor decreased and people tried to make their settlement in the plain land instead of deep Haor area. Even, the cost of making highland increased that has economic impacts for the survival of the Haor people.

7.1.3 Livelihoods and Occupations

The haor area is the habitat for 200 wetland plants, 11 amphibians, 257 birds, 29 mammals & 40 reptile species. Tanguar Haor is designated as Ramsar Site which seasonally harbor up to 60,000 migratory birds and possesses 206 species. The haor area of Bangladesh is the habitat to 143 nos. of native fin fish and 8 nos. of exotic fish species. Some unique fish species such as Rani, Lasu, Ghonia, Mohashol, Nanid, Tila Shol etc. are found here. Approximately, 4.70 million hectares of area is fish habitats which is around 20% of the total fish habitat of the country. The total fisheries production in the FY 2015-16 was 3.08 Million Metric Tons in the haor area comprising of 14% of the total inland fisheries production of the country. Around 0.42 Million MT of capture fisheries comes from the haor area having a contribution of around 84% in the total capture fisheries production of the country.

The occupation of a population depends on the availability of resources, opportunity of employment, etc. in their localities. As per the prepared Haor Master Plan The major occupation of the people of haor districts is agriculture. In the context of the Haor Master Plan, agriculture refers to agriculture/forestry/livestock and agricultural labour. Although a little more than half of the population (53.67%) depends on agriculture, their corresponding Figures for Sylhet and Netrakona districts are not similar; only 35%in Sylhet district depends on agriculture and 71% in Netrakona. There is a remarkable variation in the occupation of the haor population. A great portion earn their livelihood from business (12.52%) followed by non-agricultural labour (6.13%), service (5.65%), fishery (2.59%) and transport (2.39%). A good number of the population (3.41%), especially in Sylhet (10.32%), Maulvibazar (4.64%) and Brahmanbaria (4.56%), depends on remittances coming from home and abroad.

Although there is multivariate occupational diversity in the Haor region, keeping line with the objective this study had special focus on those people who were dependent on agriculture and fisheries sectors. During the field survey, it is found that almost everyone is dependent on Agriculture and Fisheries for their livelihood (Figure 7.22) but no one is dependent on single source. It is therefore found that about 86% people are engaged in agriculture and they are also involved in fisheries sectors as their secondary or alternative option of livelihoods.

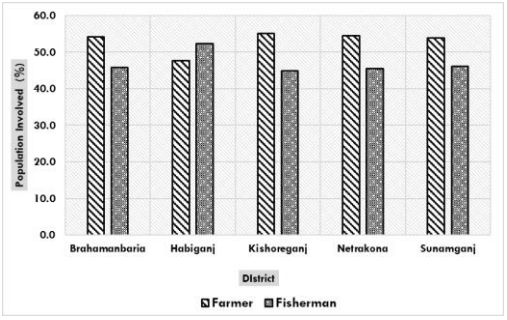


Figure 7.22: Percent People Involved in Agriculture and Fisheries

Figure 7.23 depicts that, In this study area, about 75% (in average) households had the opportunity to involve from alternative sources like animal husbandry, business, small entrepreneurship, rickshaw pulling, private job, government job, boat man etc. Involvement or choice in occupation depends on one's ability, choice, availability of the job.

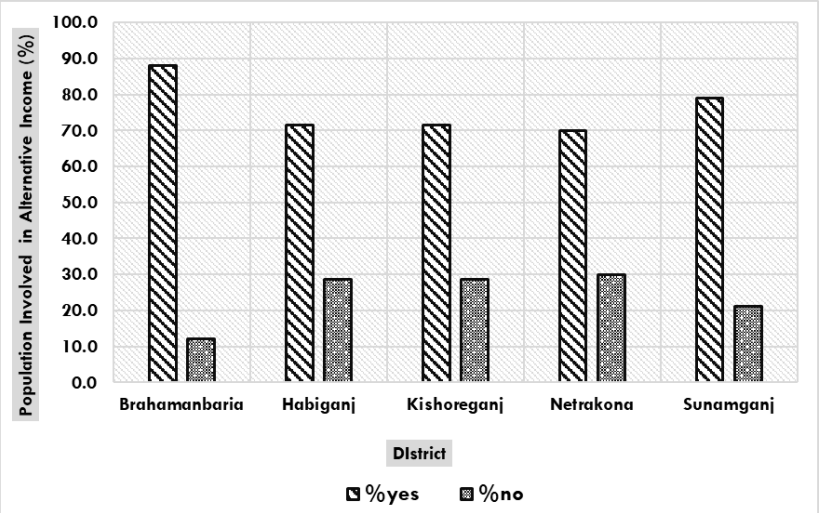


Figure 7.23: Percent People Involved in Alternative Occupation

People of the Haor region start their cropping calendar with the preparation of seed bed in the early November. From that period, agricultural working continued till harvesting in the mid-june before the monsoon period. This is the regular practice oriented in the Haor differ sometimes year to year because of the changes of monsoon period. At this period people are mostly engaged with agriculture in common.

Table 7.3: Present Agriculture Related Community Activities Calendar in Haor region

Sl no.	Activities	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb
1	Nursery and Preparation of Seed Bed												
2	Plantation crops												
3	Interim Care												
4	Harvesting												

Source: Household Survey, CEGIS - 2019

Following table 7.4 showed the regular fish calendar based on the activity. According to the field findings, it is depicted that people start fishing base activities in the mid-may which continued at the October and mid-November. During the stationary period of agriculture (mid june to mid October) many people opt for fishing as second occupation.

Table 7.4: Present Fishing Related Community Activities Calendar in the Haor Region

Sl no.	Activities	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb
1	Exemption of Renu Pona												
2	Fishing												

3	Selling Fish												

The fish habitats of the study area include Haor, beel, floodplain, river, khals and borrow pit. These Haor possesses a huge number of beels which are the main sheltering and breeding grounds of fish. The haor is feed by number of connecting rivers and khals. The khals are both perennial and seasonal in nature. Local peoples and fishers also reported that more than 90 to 100 fish species are available in the study area. Among them the notables are Gonia, Air, Boal, Magur, Baim, Pabda, Meni, Tara Baim, Gutum, Gulsha, Tengra, Shol, Taki, Chela, Batashi, Chanda, Kakila, Foli and Chingri or Prawn, etc. Some also work as day labor or rickshaw puller during off period. Both farmer and fishermen informed that they don't have to involve solely with these activities. However, they utilize their extra time by doing such manual activities which positively impacts to their family income.

Study Findings depicted that Habiganj, Kishoreganj and Netrokona has limited agricultural practices, only Boro HYV is produced in Habiganj and Kishoreganj that is produced in winter season. On the contrary different varieties of Boro- HYV, Boro- Local, Boro- Hybrid is produced other 3 districts along with other crop varieties.

Local farmers reported that along every proposed road alignment, there are agricultural land where farmers are growing different types of crops in different cropping seasons (Kharif-I, Kharif-II and Rabi/Boro seasons). Both single and double cropped areas were reported by the farmers. Crops grown are Jute, HYV Aman, HYV Boro, Oilseed, Vegetables etc. Collection of seeds is one of the problems. Farmers are using High Yielding Varieties (HYV) about 55% and local varieties 45%. Local varieties are used in cases of Aman, oilseeds and vegetables.

Sunamganj and Brahmanbaria have the highest crop variation and Sunamganj is the most vulnerable district in terms of damaging crop due to different hazard. Early flash flood is one of the leading causes of crop damage in haor basin.

7.1.4 Labor Utilization

All labours needed for agriculture and vegetable were recruited from local communities. These two sources provide scope of employment for a range of landless, marginalized and impoverished people of that area. It was found that the practiced agriculture is only source of food for whole year. Sometimes, this is operated by the family labour. In most cases, additional labour is required in this sector which is supplemented from local community.

In paddy cultivation, required laborers are recruited from the local area on the basis of agreed wage. For this sector the wage rate varies between 500 Tk. and 250 Tk. /day for males whereas women's wage rate is about 400 Tk. to 250 Tk. for working 6 hours in a day. And for non-farming sector the wage rate varies between 400 Tk. to 200 Tk. However, a number of local people are engaged in the supply chain of capture fisheries for 6 months, for instance, fishers provide fish to the large fishers that were captured from the adjacent open water bodies.

There are three main sources of livelihood such as capture fisheries from open water bodies during monsoon, agriculture (boro and vegetable) and livestock rearing. Boro rice and vegetable is practiced sparsely in selected lands where land type is high. Conversely, in most of the lands is under water almost in whole cycle of year and local people practices capture fisheries in that time. These capture fisheries are practiced by almost all land owners whether they are large, medium or marginal.

7.1.5 Income

Average monthly income is highest at Kishoreganj (13571 BDT/month) and lowest at Netrokona (9357 BDT/month). People of all the Upazillas of Brahmanbaria, Kishoreganj and Habiganj have a earning of more than 10000 BDT/month. Khaliajuri upazilla (7071 BDT/month) of Netrokona and Bishwambarpur (7142 BDT/month) of Sunamganj have lowest monthly income rate. The amount of income was illustrated based on the result of household survey held during the study period

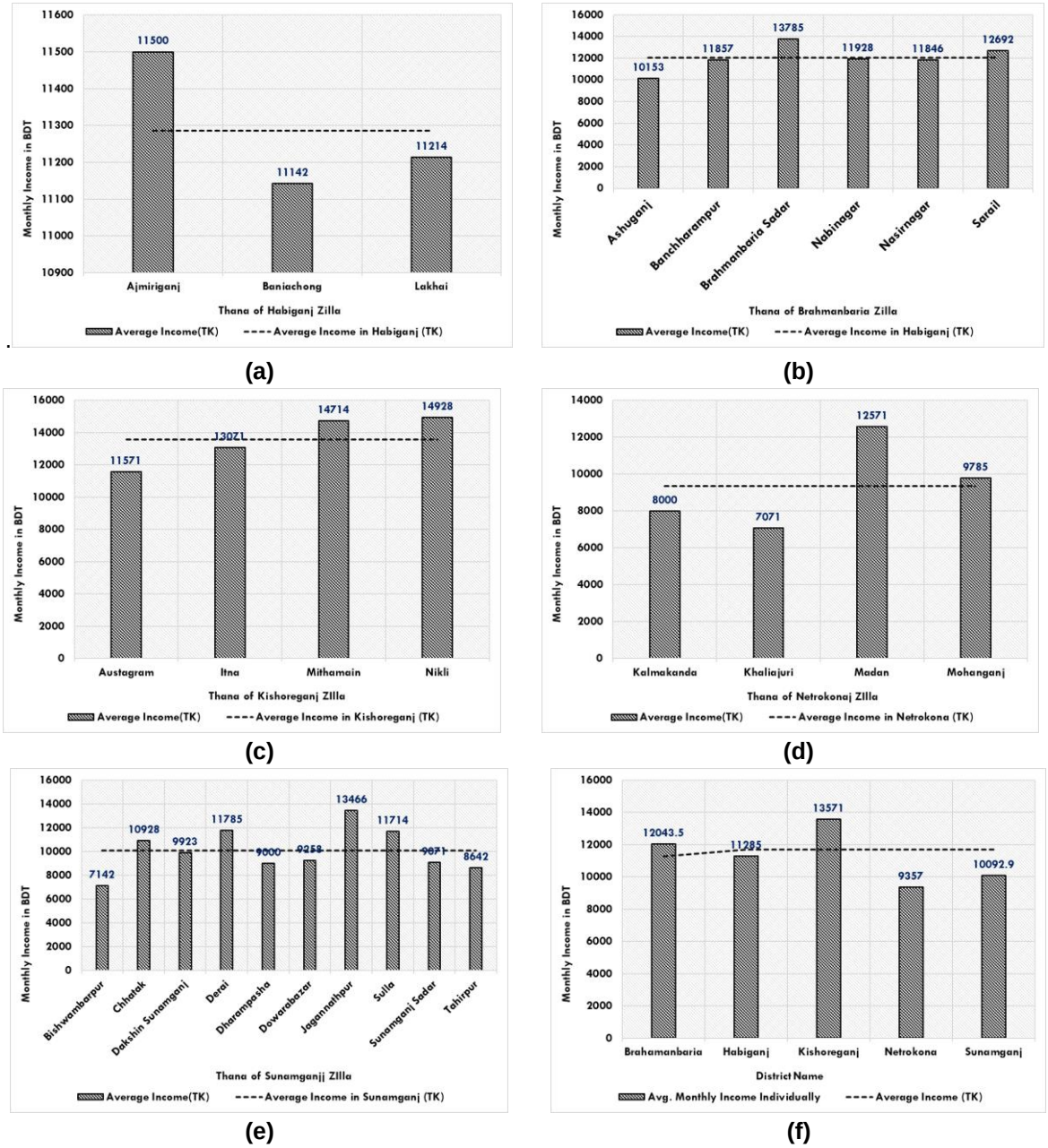


Figure 7.24: Monthly Income at thanas of (a) Haboganj (b) Brahmanbaria (c) Kishoreganj (d) Netrokona and (e) Sunamganj and (f) Average monthly income of each district

Following figure showed the monthly household income of the study area. Income of each district varied because of the location and earning opportunities. Most of the people involved with agriculture have an income range of 5000-10000 BDT/month. Whereas, 20.2% people based in agriculture of sunamganj earns 10000-15000 BDT/month. It is noticed that, people

of Brahmanbaria, Habiganj and Kishoreganj earns more (10000-15000 BDT/month) practicing fisheries rather than agriculture. Income of most of people of of Sunamganj and Netrokona ranges between 5000-10000 BDT/month whether they are involved in Agriculture or Fisheries.

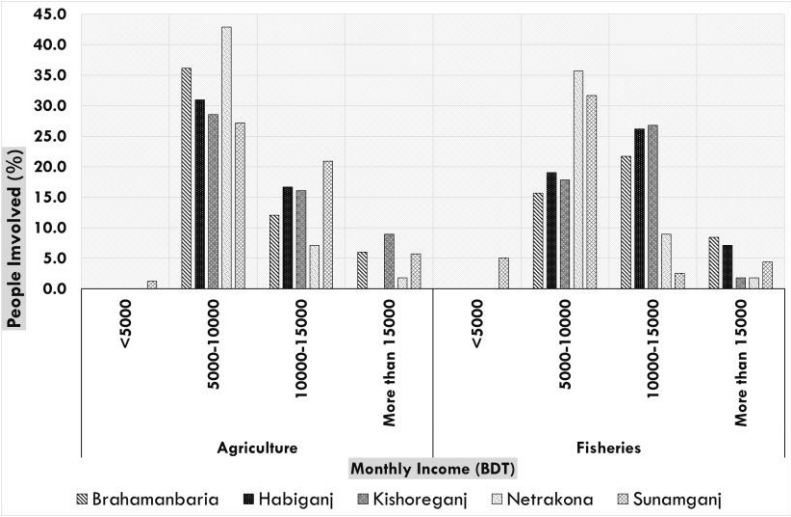
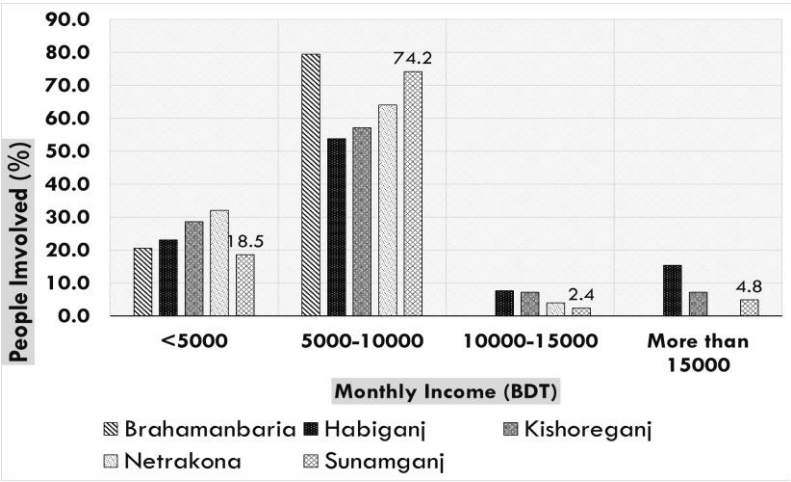


Figure 7.25: Monthly Income Range for Both Agriculture and Fisheries

Source: Household Survey, CEGIS, 2019

7.1.6 Status of Income from the Alternative Sources:

From field survey it has been observed that, about 75% (in average) households had the opportunity for getting income from alternative sources like animal husbandry, business, small entrepreneurship, rickshaw pulling, auto driving, boat driving etc. Figure 7.26 shows that, most of the people from these five (5) districts earns 5000-10000 BDT/month from alternative sources. 20-30% people from these five districts earns less than 5000 BDT from alternative sources.



Source: Household Survey, CEGIS, 2019

Figure 7.26: Income from alternative sources

Figure 7.27 shows the tenure of alternative income in a year. The graph depicts that, in Kishoreganj almost 90% of the people depends on alternative income source for 0-6 months of a year. Whereas, 63% people of Brahmanbaria is found to be engaged in alternative income

sources for more than 6 months, in some cases 12 months a year. The graph clearly depicts that, most of the people of these five (5) districts to some extent dependent on alternative income sources.

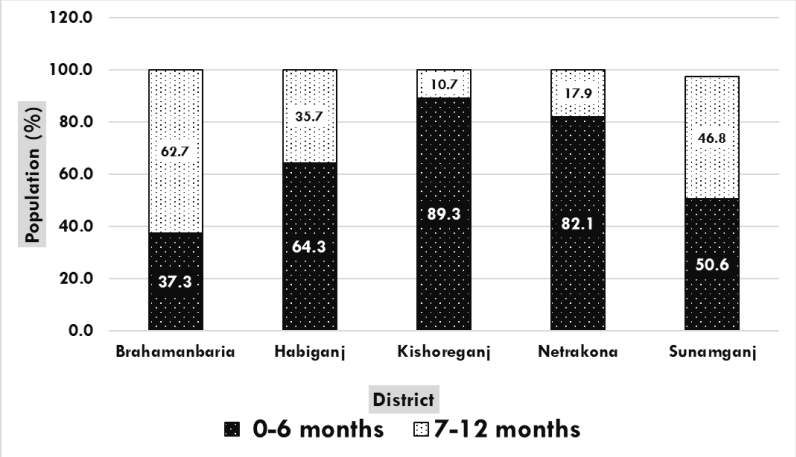
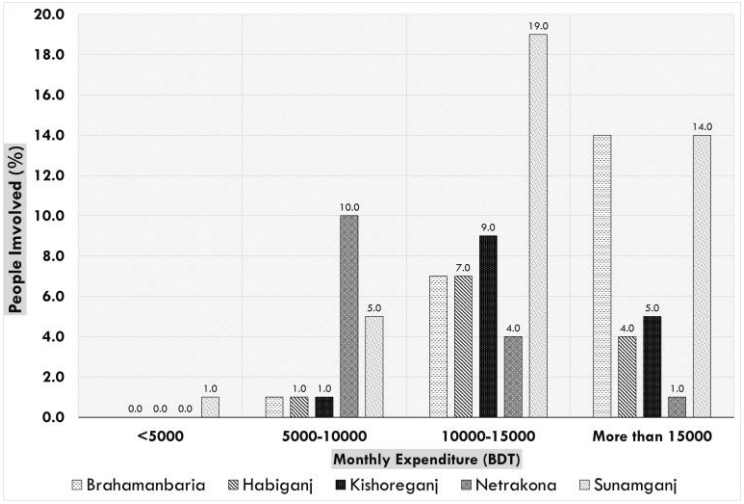


Figure 7.27: Tenure of Alternative Income in a Year

7.1.7 Expenditure and saving

Following Figure 7.28 showed the district specific household expenditure of the study area, according to the result of household survey. The household expenditure of Sunamganj and Brahamanbaria district found high comparing the other districts of the study area. The average expenditure range found BDT 5000-10000 which indicated that the average income and household expenditure are equivalent, as a result the status of savings remain low and deficit would be the common factor for most of the households in the study area.



Source: Household Survey, CEGIS, 2019

Figure 7.28: Status of Expenditure in the study area

In case of saving, most of the households were found in deficit category because of high rate of expenditure. Figure 7.29 clearly shows that most of the people cannot save a penny hence falls in the deficit zone. An average of 6% households had the savings less than BDT 5000. Though people had moderate income (BDT 5000-10000) but number of family members, increased cost of living, rice hike and regular natural disasters made the situation difficult to save money from their income.

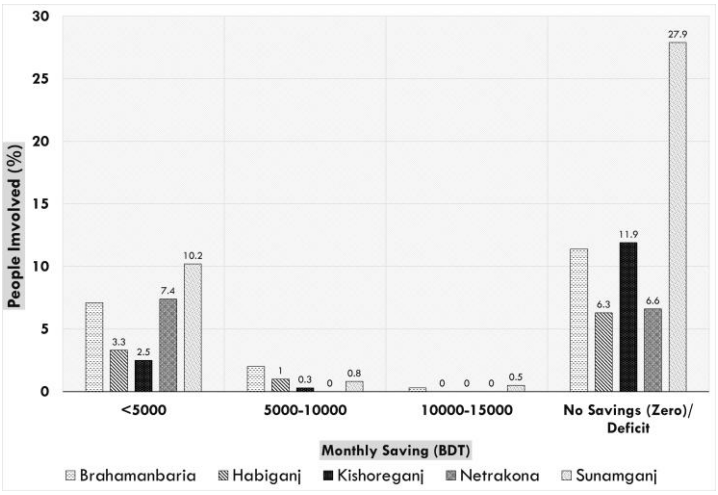


Figure 7.29: Status of saving in the study area

Source: Household Survey, CEGIS, 2019

The final graph Figure 7.30 clearly justifies the write-ups above. It can be clearly understood that the monthly income is almost equal to the monthly expense for all the districts. In an average, people of Sunamganj can save 14% of their income at the end of the month which is the highest. On the other hand, people of Kishoreganj can only save 2% of their income, which falls in the lowest box.

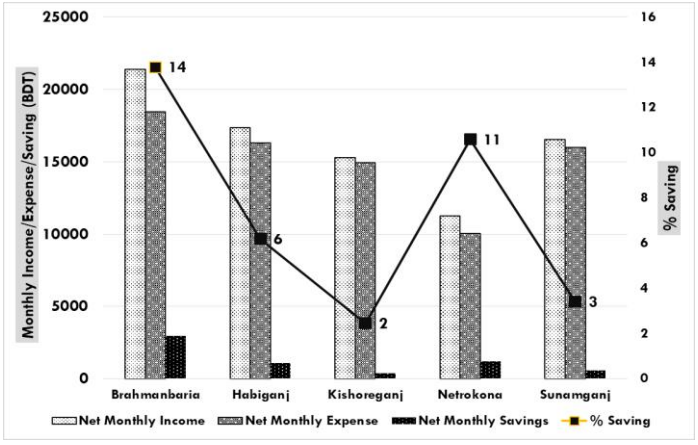


Figure 7.30: Districtwise Status (%) of Saving

Source: Household Survey, CEGIS, 2019

7.1.8 Education

As the literacy rate in haor area is insignificant in comparison with the national rate, there is lower concern about education among the inhabitants. The guardians have lower consciousness about education. Parents are rarely interested to send their children to the educational institutes due to the lack of their education. In addition, in some portion of the study area (Sunamganj and Kishoreganj), there is growing tendency to immigrate to abroad. This tendency is also creating problems in getting educational enlightenment for the haor people. From the, Population and Housing Census 2011, it has been seen that, the rate of literacy (as per 2011 statistics) is higher in Brahmanbaria and lower in Sunamganj. On the other hand, rate of literacy increased in a higher rate in Kishoreganj and at a lower rate in

Netrokona.

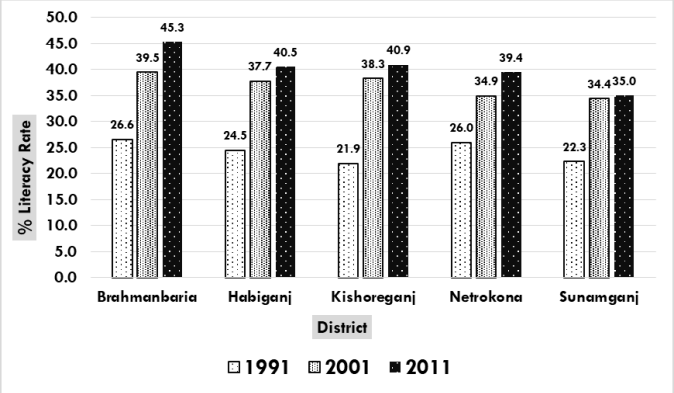


Figure 7.31: Districtwise Literacy Rate from 1991-2011

Source: Population and Housing Census 2011 (Zila_Brahmanbaria)

Brahmanbaria

The literacy rate of population 7 years and above is shown in Figure 7.32. It is noticed that the literacy rates for both sex, male and female have been increasing since 1991 but the increasing rates are found not so much encouraging during the intercensal period 2001-2011. The increasing rates show that there are only 14.77% percentage points during the decade under reference (2001-2011). It is also evident that, the rate of literacy among females are quite higher than the male.

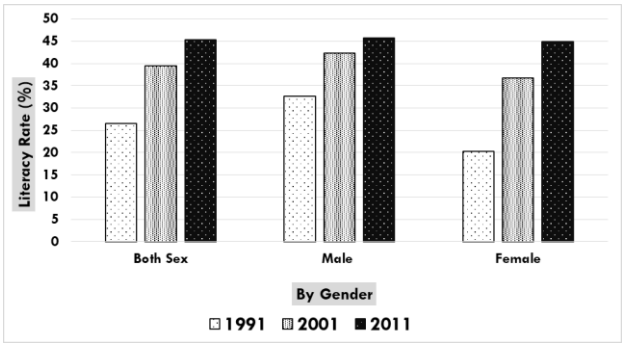


Figure 7.32: Literacy Rate of Population (%) by Gender

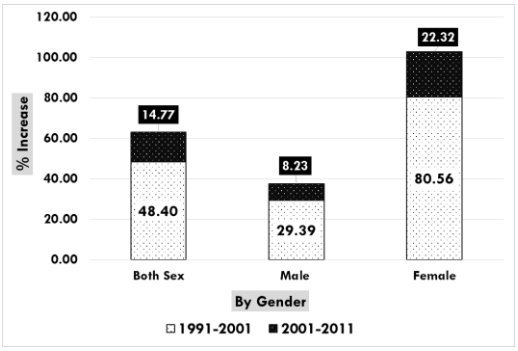


Figure 7.33: % Increase in Literacy Rate by Gender

Source: Population and Housing Census 2011 (Zila_Brahmanbaria)

Habiganj

The literacy rate of population 7 years and above is shown in Figure 7.34. It is noticed that the literacy rates for both sex, male and female have been increasing since 1991 but the increasing rates are found very much discouraging during the intercensal period 2001-2011. The increasing rates show that there are only 7.42% percentage points during the decade under reference (2001-2011). It is also evident that, the rate of literacy among females are remarkably higher than the male.

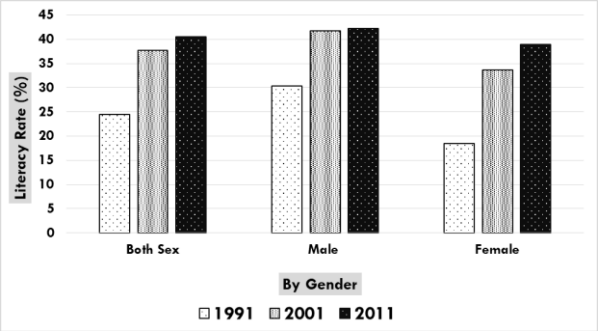


Figure 7.34: Literacy Rate of Population (%) by Gender

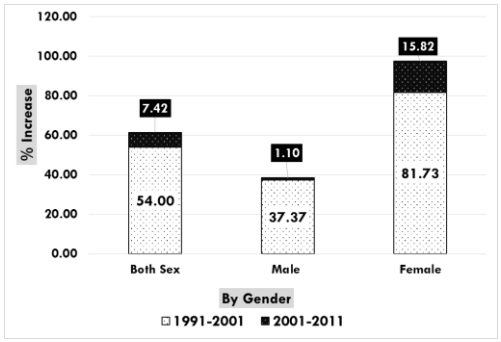


Figure 7.35: % Increase in Literacy Rate by Gender

Source: Population and Housing Census 2011 (Zila_Habiganj)

Kishoreganj

The literacy rate of population 7 years and above is shown in Figure 7.36. It is noticed that the literacy rates for both sex, male and female have been increasing since 1991 but the increasing rates are found not so much encouraging during the intercensal period 2001-2011. The increasing rates show that there are only 6.79% percentage points during the decade under reference (2001-2011). It is also evident that, the rate of literacy among females are quite higher than the male where the increase in rate of male literacy are quite disappointing.

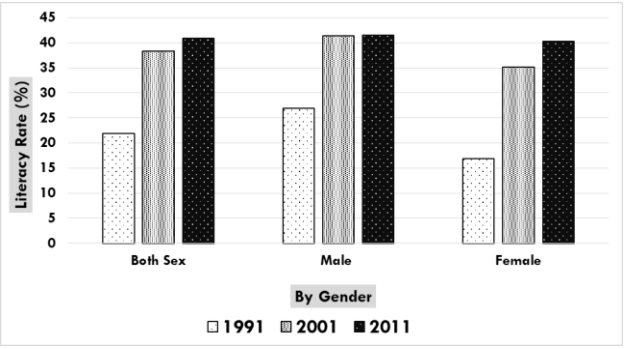


Figure 7.36: Literacy Rate of Population (%) by Gender

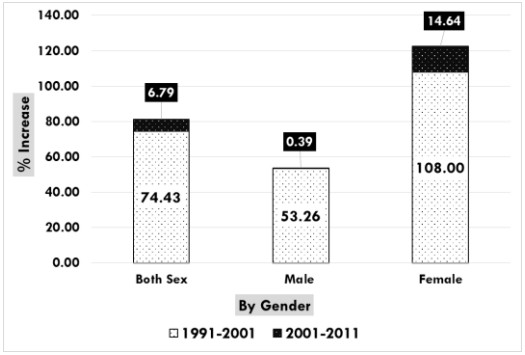


Figure 7.37: % Increase in Literacy Rate by Gender

Source: Population and Housing Census 2011 (Zila_Kishoreganj)

Sunamganj

The literacy rate of population 7 years and above is shown in Figure 7.38. It is noticed that the literacy rates for both sex, male and female have been increasing since 1991 but the increasing rates are found not so much encouraging during the intercensal period 2001-2011. Moreover, male literacy rate has been found to be decreased in the decade 2001-2011. The increasing rates show that there are only 1.77% during the decade under reference (2001-2011) which is quite low. It is also evident that, the rate of literacy among females are quite higher than the male where the increase in rate of male literacy are quite disappointing.

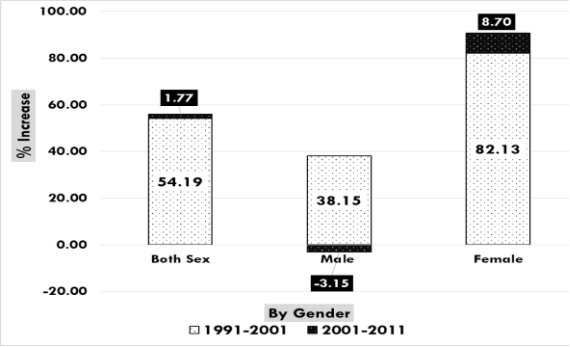


Figure 7.38: Literacy Rate of Population (%) by Gender

Figure 7.39: % Increase in Literacy Rate by Gender

Source: Population and Housing Census 2011 (Zila_Sunamganj)

Netrokona

The literacy rate of population 7 years and above is shown in Figure 7.40. It is noticed that the literacy rates for both sex, male and female have been increasing since 1991 but the increasing rates are found not so much encouraging during the intercensal period 2001-2011. Moreover, male literacy rate has been found to be decreased in the decade 2001-2011. The increasing rates show that there are only 12.88% during the decade under reference (2001-2011) which is quite low. It is also evident that, the rate of literacy among females are quite higher than the male.

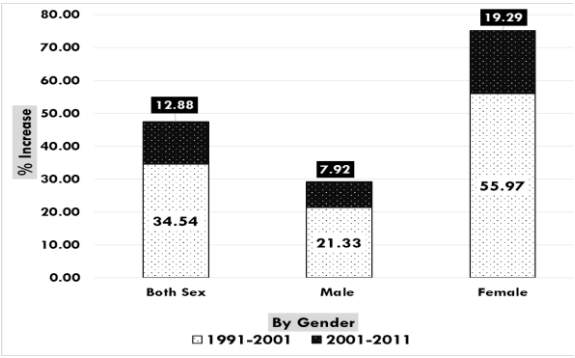


Figure 7.40: Literacy Rate of Population (%) by Gender

Figure 7.41: % Increase in Literacy Rate by Gender

Source: Population and Housing Census 2011 (Zila_Netrokona)

7.1.9 Health Service

Shortage of health service centers, shortage drugs and medicines, poor transportation and communication facilities, shortage of doctors/nurses and other staffs, lack of services in emergency moment are main pitfalls of health services in haor area. In haor area, it is found that various type of problems related to health sector are prevalent. In this case, most people identified transportation and communication problems.

Human Resource for Health

These infrastructures are useful with the availability of the doctors, nurses and necessary equipments needed for the treatment of the patients. Better treatment of the patients depends on the availability of health infrastructures, doctors, nurses, and necessary drugs and equipments. Table 7.5 shows the human resources and bed for the patients available in the health infrastructures (hospitals, clinics and FWCs) of the seven haor districts. The numbers

of doctors, nurses and beds in the hospitals with a little exception are higher compared to that in the clinics, FWCs and maternity centers of the study area. Exceptionally the numbers of nurses of FWCs in Sunamganj and Maulvibazar are higher. However, the numbers of doctors in hospitals are 47, 194, 41, 82, 148, 63 and 59 in Sunamganj, Sylhet, Habiganj, Maulvibazar, Kishoreganj, Netrokona, and Brahmanbaria districts, respectively. Their corresponding figures in clinics are 7, 166, 5, 19, 17, 19, and 7, in FWCs are 7, 35, 8, 25, 13, 21, and 35, and in maternity centers are 3, 4, 6, 7, 13, 3, and 2, respectively.

Table 7.5: Human resources and bed by health facilities

District	Hospitals			USC/UH&FWCs			CC	Maternity Centers	
	Doctor	Nurse	Bed	Doc	FWV	MA	Field staff	Doctor	FWV
Brahmanbaria	59	166	285	35	49	35	-	2	3
Habiganj	41	112	269	8	36	10	-	2	4
Kishoreganj	148	157	630	13	30	15	-	4	6
Netrokona	63	162	297	27	54	54	-	1	3
Sunamganj	47	120	278	22	42	42	-	2	3

Here, CC-Community Clinics, FWV-Family Welfare Visitor, MA-Medical Assistant

Source: Field survey and retrieved from, www.bangladeshgov.org on 22/12/2010

Access to people to existing health services

There is shortage of specialized doctors and trained medical officers as well as also lack of hospitals/ and community clinics. The only upazila based govt. hospital is located at upazila level that is far from villages. Further, existing union health and family welfare centre and community clinics are not also easily accessible as unlike plain area, haor area is characterized by clustered village surrounded by haor waterbodies. Navigation is their only mode of transportation during wet season that is not speedy vehicle.

Most of the doctors are not qualifies, rather they are mere quack or dispensary chemists. On an average, there is 20 percent MBBS physicians and the rest of 80 percent are dispensary physicians, local healer, quack and son on (Source: PCM and FGD, Haor Master Plan). Mass people mostly depend on those inexperienced quack physicians for health services. As a result, they are deprived of quality health services.

7.1.10 Transportation and Communication Networks

There is a regular inundation every year. People are mostly use the water transport during the monsoon period. Beyond the monsoon period, bikes and rickshaws are considered as the prime mode of communication which was significantly used by the people of Haor area.

Because of the inundation, school and college going students suffer a lot to go to their educational institutions. It is therefore, a common problem arise for getting easy accessibility to move from one place to another.

There were two types of roads in the haor: a) all weather road and b) submersible road. During hazard, most of the road (submersible road) went under the water. At that period, boat became the only mode of communication. Movement through foot was found highest in Brahamanbaria district. Boat was widely used in Kishoreganj and Netrokona. After the disaster, road condition became worsened, earthen road got spoiled. At that period Van, Rickshaw (Pulled by Man), Auto Rickshaw (pulled by battery) was the only the major mode of communication in Haor

region. The following table represents detail mode of communication during and post disaster period.

Table 7.6: Communication and Transportation System due to Climate Change Induced Disaster

District	Auto(Battery Fueled)		Boat		On foot		Van		Rickshaw	
	Before Disaster	After Disaster	Before Disaster	After Disaster	Before Disaster	After Disaster	Before Disaster	After Disaster	Before Disaster	After Disaster
Brahamanbaria	2.4	78.3	97.6	72.3	75.9	83.1	84.3	27.7	1.2	91.6
Habiganj	9.5	95.2	97.6	54.8	11.9	50.0	38.1	11.9	11.9	100.0
Kishoreganj	7.1	100.0	100.0	53.6	1.8	41.1	35.7	0.0	8.9	100.0
Netrakona	1.8	85.7	100.0	53.6	10.7	98.2	28.6	7.1	0.0	41.1
Sunamganj	0.0	52.5	95.6	53.8	13.3	72.2	51.9	5.7	0.0	64.6

It was found that roadways mainly connected the area to the upazila headquarter. Although the road networks of most of the upazila sadars are satisfactory but the union level road network is unpleasant. There are three types of road networks such as pucca (paved), brick soling and katcha (muddy). At present, roads are narrow, muddy and even there are no road networks at different parts of Dharampasha, Tahipur and Jamalganj upazila. People dependent on fully water way to solve their different kinds of necessity. Lack of communication with upazila head quarter limits the scope of socioeconomic development of haor featured villages. The inhabitants of haor areas always become victim of misty character of nature. Out of all natural disasters, flash flood and afal (wave action) cause severe damage. All of the road networks become eroded due to flood and surges of wave action.

7.2 Socio-Economic Challenges due to Climate Risks

7.2.1 Loss of Income

Different hazard strike in this region every year. Due to climate induce disaster people of this region faced financial problem. This study finds that changes over the period of 28 years (1991-2018). The loss of income varied from one year to another. But In the year of 2004 and 2017, the loss was significantly increased due to flash flood.

In 2004, the disaster induced income reduction was mostly in Brahmanbaria affecting 98% people there. The second affected district due to disaster is Sunamganj, affecting 89% of people's income. The lowest affected district was Netrokona in 2004 disaster. The 2007 disaster has caused reduction in income of Sunamganj affecting almost 88% people. The second affected district was Netrokona including 83% people. The lowest affected people are from Brahmanbaria comprising 21% people. This disaster induced low income has forced all people in Kishoreganj and 97% of people in Habiganj to fall in financial crisis. 78% people from Brahmanbaria and 71% people from Habiganj was unable to overcome the financial crisis and became poor.

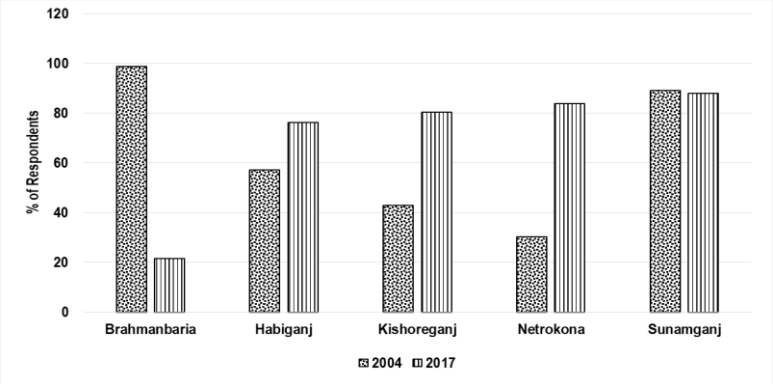


Figure 7.51: Reduced income in 2004 & 2017

The main challenges after any hazards is to cope with the post hazard situation. Due to crop loss and other damages, farmers and fishermen in every district had faced financial crisis very acutely. In Brahmanbaria, another impact of reduced income faced by the 87% of people is food scarcity. Except in Netrokona, on an average 50% people from other district suffers from food scarcity. 78% people of Brahmanbaria became poor aftermath disaster. Borrowing money to overcome economic crisis is common in Netrokona and Brahmanbaria as 68% and 53% people respectively suffer from this. Other than these impact, the haor people also faces problem in medical treatment, borrowing money from NGO etc.

7.2.2 Loss of Property

The severity of flash floods and seasonal flood due to climate change induced intensive rainfall has increased in last few years. Damage from flash flooding has been increasing each year resulting loss of crops, property and production as well as affecting agricultural activities in the flooded areas. The loss of property is highest in Netrokona, Brahmanbaria and Sunamganj due to flash flood which is more than 5 lacs taka. Again the cost of property loss in Sunamganj due to seasonal flood is approximately 5lacs in total. Climate change induced heavy rainfall also cost property damage around 3 lacs in Netrokona. Hazards like cyclones are noted for aggravating poverty through destruction of food stocks and insufficient assets of the poorer households and through making employment opportunities scarce. From the graph, it is observed that cyclone brings the severe property loss in Sunamganj bringing cost of more than 6 lacs in total. Land erosion and wave action is a major problem in the haor areas. Human settlements, infrastructures and villages are engulfed by land erosion and wave action (locally known as Afal) during pre-monsoon flash flood and monsoon flooding. The loss of drought is very low in each district.

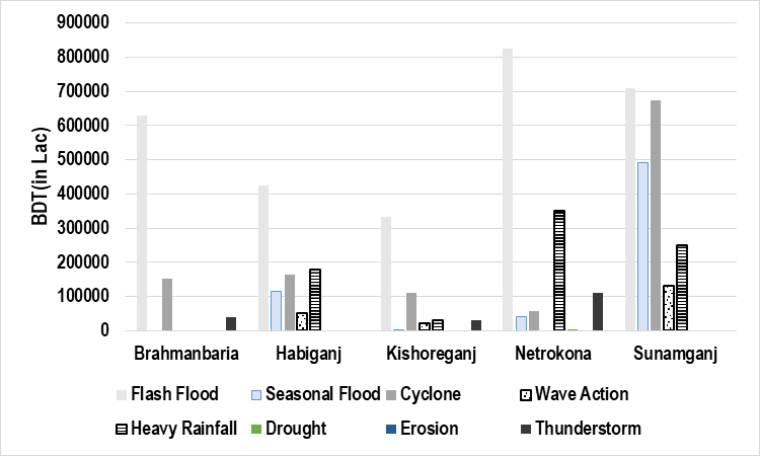


Figure 7.52: Property Loss due to Disaster

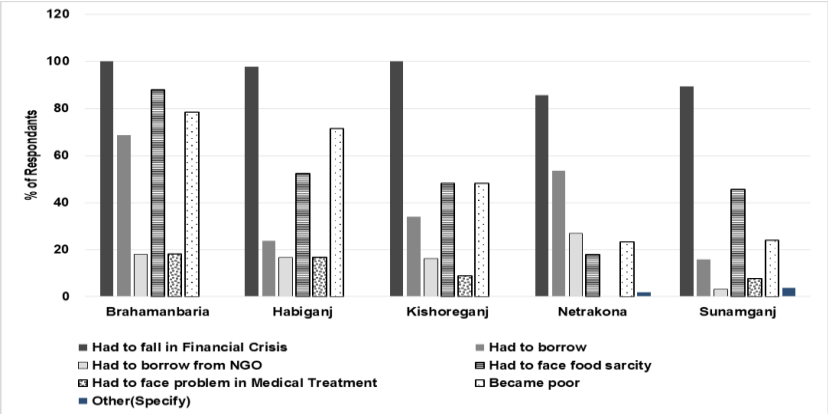


Figure 7.53: Impact of Decreased Income

Climate change leads to many changes in global development and security, especially energy, water, food, society, job, diplomacy, culture, economy and trade (Islam, M. N., & van Amstel, A. 2018). The impacts on agro and fishers base livelihoods become visible and fall in risks because of the increasing flood, tidal surge, cyclone, and wave action. The geographically remoteness, ecologically vulnerable and environmentally isolated Haor area located in north eastern part of Bangladesh. People of this Haor are mostly dependent on the Haor ecosystem. The livelihoods is onerous and creates risks because of the climatic events (Rabby, T. G. 2012). The damage due to the seasonal and flash flood, people's livelihood options are in risks and create problem for socio-economic sustainability. The loss of assets, poor economic growth in terms of climate base pertained risks, the Socio economic condition of people in this area are facing challenges.

The Climatic risks and challenges in Haor region are analyzed in this following section:

7.2.3 Drinking Water Supply and Sanitation Crisis

The five districts are mostly inhabited by poor and disadvantaged groups lacking access to basic water supply services and sanitation. The situation is compounded by flash foods, which are major threat to crop areas. Usually these areas are flooded from October. Most of the tubewells are submerged during monsoon and flood periods, creating scarcity of drinking water and facilitated sanitation thus threatening the health of the Haor community.

The main drinking water sources of the Haor region are Tube-well, wells, ponds, river, canals

etc. From the recent survey, it has been observed that more than average 95% people of the Haor region depends on Tube wells as their main drinking water source. But due to climate change induced disasters, the imagery changes on a large scale. In the Table 7.7 below, the impact of climate change induced disaster scenario has been presented. From the table it is evident that, due to submergence of tube wells during floods, around 30% people of Habiganj, Kishoreganj and Sunamganj have to collect water from Haor and boil it after disaster. Higher percentage of these three areas fall into deeply flooded zone. More than 85% people of Brahmanbaria and Netrokona still seems to be able to access tube weill for safe water supply as most of the areas of these two districts falls into medium flooded area (Netrokona) and low flooded area (Brahmanbaria).

Table 7.7: Impact of Climate Change Induced Disaster on Drinking Water Source

District	Normal Scenario of Source of Drinking Water			Aftermath Effect of Disaster on Source of Drinking Water			
	%Tube-well	%Rivers	%Pond/ Ditch	%Tube-well	%Collecting from remote places	%Boiling water collecting from Haor	%Others
Brahamanbaria	98.8	0.0	0.0	86.2	4.3	9.6	0.0
Habiganj	100.0	0.0	0.0	60.9	10.1	29.0	0.0
Kishoreganj	98.2	3.6	1.8	51.2	17.4	31.4	0.0
Netrakona	100.0	0.0	0.0	88.9	1.6	9.5	0.0
Sunamganj	98.1	0.6	0.0	62.5	0.9	33.9	2.7

The major problems of sanitation in high-groundwater table and flood-prone areas of Bangladesh are inadequate latrine capacity and groundwater contamination due to high-water table and reduced / lost accessibility and surface water contamination due to flooding of latrine. The level of knowledge on health and sanitation of the people is very low.

In Haor region, water borne-diseases are very common especially to the children and the elderly people. A few years back, the sanitation layout of the Haor region was very poor. Due to massive concern and huge infrastructural development by the Government, the picture of sanitary issues has been largely improved. But even today all the people are not under the safe sanitation program. And during the climate change induced disasters, the situation gets even worse. As the Haor region is situated in the low-land, latrines go under water, excrement starts to float over water. As a result, in average only 42.20% people use sanitary latrine in the haor region. The poorest scenario is in Netrakona 34.79%.

Table 7.8: District wise Use of Sanitary Latrine in Haor Area

Location of Haor	Use of Sanitary Latrine
Sunamganj	40%
Habiganj	41%
Netrakona	35%
Kishoreganj	49%
Brahmanbaria	46%

(Haor Master Plan, 2012)

Districtwise scenario of using of protected and unprotected Sanitation system (%) in haor area

is very poor. In average 40.83% use protected sanitation systems and 59.18% useunprotected Sanitation systems. Out of the 5 haor districts 3 use more than 70% unprotected sanitation system, 2 use more than 40% unprotected sanitation system, and only 1 use around 30% unprotected sanitation system. The Kishoreganj uses around 85% unprotected sanitation system.

Table 7.9: District wise Ratio using Protected and Unprotected Sanitation System in Haor

District	Protected Sanitation System %	Unprotected Sanitation System %	Total %
Kishoreganj	15.62	84.37	100
Brahmanbaria	70.55	29.49	100
Netrakona	24.07	75.03	100
Habiganj	54.68	45.39	100
Sunamganj	29.86	70.09	100

DPHE, 2010

As the Haor region is situated in the low-land, latrines go under water, excrement starts to float over water. Below table shows the problems that arises after a disaster. The table 7.9 clearly depicts that, in most cases the latrine goes under water. In cases of Sunamganj and Brahmanbaria only 26%-32% (approximately) people said that they have constructed temporary sanitary latrine through bamboo (%). 90% people of Habiganj and Kishoreganj have the bamboo shelfed temporary latrine.

Table 7.10: District wise Ratio Effected by Flood

District	Latrine goes under water (%)	Constructing temporary sanitary latrine through bamboo (%)
Brahamanbaria	98.8	26.5
Habiganj	95.2	90.5
Kishoreganj	98.2	91.1
Netrakona	42.9	71.4
Sunamganj	64.6	31.6

7.2.4 Crisis of Drinking Water Source

The main drinking water sources of the Haor region are Tube-well, wells, ponds, river, canals etc. From the recent survey, it has been observed that more than 95% people of the Haor region depends on Tube wells as their main drinking water source. But due to climate change induced disasters, the imagery changes on a large scale. The other sources of drinking water are also largely damaged due to the long term aftermaths of climate change. From graph it is evident during disaster, the percentage of dependency on tubewell reduces in an alarming rate on each district. For instance, in Habiganj the dependency on tubewell usually is 100% but after disaster it reduces to 60%. As, after disaster the dependency on river is impossible than usual, people on each district depends largely on boiling water after collecting from haor. If tubewell and boiling of water is not possible, people collect water from remote places.

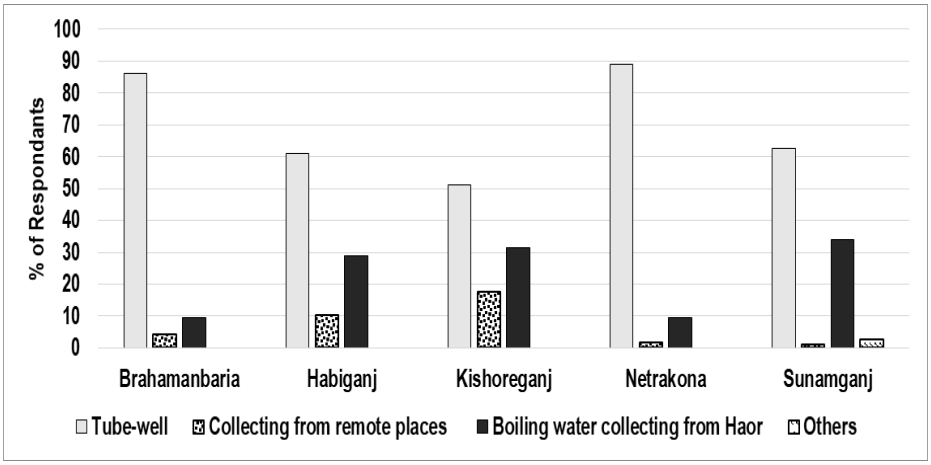


Figure 7.54: Drinking Water Source during Disaster

7.2.5 Health Issues

Diseases both communicable and non-communicable are prevalent in the haor area.The communicable and non-communicable diseases in the haor area are Asthma, Peptic Ulcer, Anemia, ARI, Warm Infection, Hypertension, Diarrhea, Malnutrition, Skin Diseases, Dysentery, Malaria, Pneumonia, and Fever (flue). From among these diseases incidence of Peptic Ulcer, Diarrhea, Anemia, ARI, Asthma, Worm Infection, Skin disease and Hypertension is higher in rank. People of the haor area get treatment for injury owing to assault. Incidence of injury owing to assault is also very high in the haor area as, assault is a crucial social problem in the haor area.

The scenario of the sanitation facilities of haor regions is very much unpleasant. There is severe lack of perception and awareness about healthy sanitation system. Majority of the households possess temporary toilets (kacha). Most of the haor dependent households cannot afford the establishment cost of water sealed or permanent toilets. So people usually do not buy ring slab because of their impoverishment. Latrines made by ring-slab usually become damaged by heavy streams. In housing practices there are lower sanitations facilities. As the haor area is consuming shortage of homestead land and also as it is densely populated area local people are not interested to leave the valuable lands for building sanitation structures instead of building houses.

It is evident from the statistics that most of the people use Pit latrine with slab but no lid, no water seal in the haor districts. Very low number of households has improved sanitation facilities in Kishoreganj (14%), Netrokona (24%) and Sunamganj (30%) districts. 30-37% households use improved sanitation facility in the district of Sunamganj. Sylhet and Maulvibazar have medium coverage of improved sanitation facilities of 44% and 45% respectively. Compared to others Brahmanbaria (56%) and Habiganj (53%) has very high rate of improved sanitation coverage even more than the national rate.

Table 7.11: Proportion of population using an improved sanitary facility

District	Type of Sanitation Facility														Number of households sharing toilet facility		
	Flush to piped sewer system	Flush to septic sewer system	Flush to unknown place/slab	Pit latrine with slab and water seal	Ventilated Improved Pit latrine (VIP)	Pit latrine with slab and lid	Pit latrine with slab but no lid, no water seal	Pit latrine with slab and flap, no water seal	Pit latrine without slab/ open pit	Compositing toilet	Bucket or Tub or bucket latrine	Open or hanging latrine	No facilities or bush or field	Other	One	Two	THREE +
Brahmanbaria	0	12	1	14	6	36	8	3	10	0	0	7	1	3	65	16	20
Habiganj	0	4	1	14	9	25	15	2	7	1	1	15	5	2	68	21	9
Kishorganj	0	3	2	10	0	4	46	2	13	0	0	12	7	1	60	18	22
Maulvibazar	0	13	2	9	3	23	20	3	10	2	1	4	8	2	78	11	11
Netrakona	0	4	2	12	0	11	32	5	13	1	0	8	13	1	68	15	16
Sunamganj	0	7	1	8	1	17	14	3	15	1	2	23	5	2	73	12	15
Sylhet (includ. city corp.)	0	25	2	11	2	9	28	2	9	0	0	6	4	1	78	12	11
Dhaka Div	11	12	5	18	1	19	18	2	5	0	0	4	4	1	63	14	23
Chittagong Div.	0	18	3	13	4	36	10	3	5	0	0	4	3	1	72	14	14
Sylhet Div.	0	14	2	11	4	17	19	3	11	1	1	12	6	2	74	14	12
National	4	11	2	21	3	22	17	2	6	0	0	4	6	1	68	15	16

Source: MICS, 2009

**Calculated using the UNICEF-WHO JMP definition of hygienic sanitation.*

***Calculated as per the GoB definition of improved/hygienic sanitation.*

Recent surveys reflect that, most of the people has to excrement in the open space and has to build temporary latrines with bamboos. The sanitation problem causes various diseases in the region of which most of them are water-borne, of which fever, diarrhea, typhoid, cholera and skin diseases are the most prevailing ones. The graph shows that, diarrhoea has severe impact on each district but mostly of Habiganj, Kishoreganj and Brahamnbaria. The second highest disease is fever which is also predominant over all the districts. Chicken pox is predominant while affecting 92% and 89% people of Habiganj and Kishoreganj. Kishoreganj is also affected by skin disease with the percentage of 80. Arthrities pain, high BP, TB, Gastric etc has less effect on people over all the districts. This graph clearly shows that disease increases after disaster.

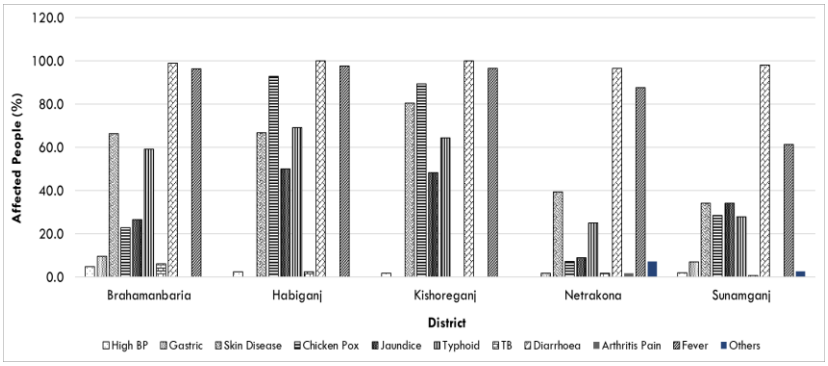


Figure 7.55: Disease after a Disaster Happen

7.2.6 Transportation and Electricity Crisis

There is a famous saying in the haor areas “Borshakale nao ar shuknakale pao” which literally means “boats during monsoon and feet during dry season”. Haor area remains under water for 4-6 months during the pre-monsoon and monsoon season. The roads are submerged during this period making it impossible to move from one place to other without using the boat. People in the haor region use roads during the dry season and use boats during the wet season to move from one place to the other. Majority of the roads are unpaved (kucha) and rest of the paved (pucca) roads get inundated. In haor areas road transportation is not smooth due to the insufficient road network. Navigation is possible only during monsoon but during dry season navigation is impossible due to insufficient water flow. Due to the unique characteristics of haor, transportation network with a combination of waterway and roadway has developed over the years.

The causes of degradation of transportation system is mainly a few and can be divided into the following natural and anthropogenic causes:

- Natural Causes
  - Flash floods
  - Afal or wave erosion
  - Annual inundation
  - Water logging
  - Tidal charge
  - Siltation & sedimentation
- Anthropogenic
  - Earthwork in embankments
  - Lack of repairing
  - Lack of dredging
  - Lack of enough flood/water control infrastructures

A few years back, the scheme of communication & transportation system in the Haor region was not that well connected. But due to the massive infrastructural development, construction of new roads and submergible embankments the scenario has changed drastically. And this improvement has an enduring positive effect on the economic development of the Haor region. But this scheme changes drastically due to the continuing negative effects of climate change.

Table 7.12: Comparison of percentage of people using various mode of transportation before and after climate change induced disasters

District	Auto(Battery Fueled)		Boat		On foot		Van		Rickshaw	
	Before Disaster	After Disaster	Before Disaster	After Disaster	Before Disaster	After Disaster	Before Disaster	After Disaster	Before Disaster	After Disaster
Brahamanbaria	78	2	72	98	83	76	28	84	92	1
Habiganj	95	10	55	98	50	12	12	38	100	12
Kishoreganj	100	7	54	100	41	2	0	36	100	9
Netrakona	86	2	54	100	98	11	7	29	41	0
Sunamganj	53	0	54	96	72	13	6	52	65	0

Due to climate change induced hazards, the whole transportation and communication context of the Haor region changes on a large scale. As, flash floods are the prominent disasters of the area, the roads get under water then. So, Battery fueled auto, van, rickshaw etc. become almost inaccessible. In the five districts under study area, the battery fueled auto and rickshaw are the most popular mode of transportation under normal circumstances. From the recent household survey, it is depicted that people of Habiganj, Kishoreganj and Netrokona use battery fueled auto as a mode of transportation 95%,100% and 86% respectively. But due to climate change induced disasters the scenario changes drastically. The percentage falls down to 10%,7%and 2% respectively. Rickshaw is another very popular mode of transportation in the haor region. In Brahmanbaria, Habiganj and Kishoreganj almost all the people use rickshaw. But the percentage drops to 1%,12% and 9% respectively due to the adverse effect of climate change induced disasters.

During disasters, percentage of people using boat and non-machined van rises on a large scale. Recent survey suggests that the percentage of people using boat as a mode of transportation rises to almost 100% during disaster. Again, the percentage of people of Brahmanbaria using van rises from 28% to 84% before and after the climate change induced disasters.

Again, during climate change induced disasters, the movement of people gets disrupted on a large scale. From the study, it is depicted that the percentage of people Netrokona moving on foot of drops down from 98% to 11%. The context is almost same for other districts like Habiganj and Sunamganj too. Percentage of people moving on foot drops down to 12% and 13% respectively. In a word, the context of communication and transportation gets completely disrupted due to climate change induced disasters.

7.2.7 Inadequate Embankment

The physical setting of Haor region is a unique wetland ecosystem in Bangladesh, which creates a variety of difficulties for the dwellers of the Haor area. This wetland ecosystem and livelihood system of village people are not similar as others wetland and village ecosystem of Bangladesh. Every year, the Haor inhabitants are frequently affected by the flash flood, generated in the steep upland catchments adjacent to the region in India. These flash floods spill onto low lying flood plain lands in the region, inundating crops, damaging infrastructure by erosion and reducing the village extent of Haor region and often causing loss of lives and properties. From the graph it is evident that, the protection of house and land by embankment

is not sufficient enough in most of the upazilla. Although in Brahmanbaria, most of the respondents (95%) responded positively to safety ensured by embankment. Almost 70% people's house and land in Sunamganj is protected by embankment but the rest suffer from damages to their property by disaster. Only 16% and 10% people of Kishoreganj and Netrokona respectively is sheltered by embankment. The worst sufferer are people of Habiganj where all of them has to face loss of land and house because they are not protected by embankment during disaster.

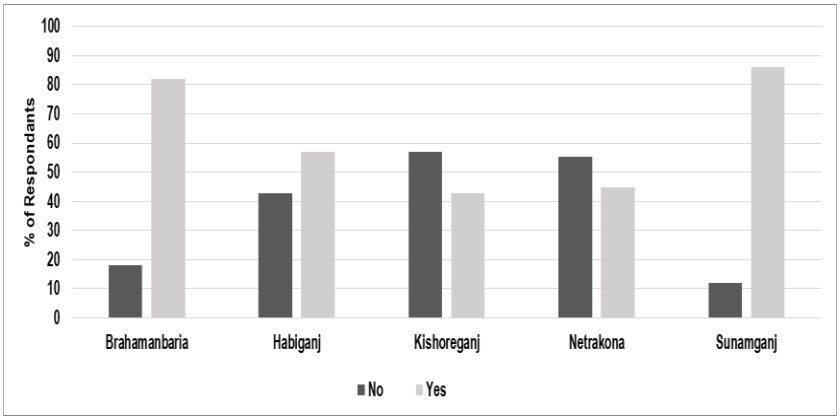


Figure 7.56: Percentage of People Protected by Embankment

7.2.8 Weak Early Warning Dissemination

The districts of Sunamganj, Sylhet, Moulvibazaar, Habiganj, Kishorganj and Netrokona, located in the depressed portion are the most vulnerable due to flash floods. In Haor area, flash flood and seasonal flood cause crop damage which is considered as a big threat to the people, especially who work as sharecroppers or landless labourers. Sometimes, the flash flood comes early, just before the rice harvesting and during that time the people of Haor basin, do not even get the time to harvest their crop. In this study we found that local people are not acquainted with the high yielding crop which would be harvested before the flash flood. Though flood forecasting plays an important role for early flood warning, in the year of 2016-2017, local people of those area are not properly benefited to the flood forecasting. For this reason, large amount of damage had been occurred in those year.

Transfer of flash flood analys showed that the most popular medium is announcement through mike of mosques in with percentage of 97% and 98% in Habiganj or Kishoreganj resepcetively. Again in Sunamganj 83% people are informed through SMS or phone call which is the most used medium there. The information system popular in Netrokona is through radio or television as 89% people get to inform by this system. In Brahmanbaria 92% of people gets to know through use of mike. The least system used in all district was observed to be through union parishad. Though there are various flood forecasting system, the benefit from this is very small. As per the benefit graph it is evident that, people from all over the district are not benefitted that much from this flood forecasting system.

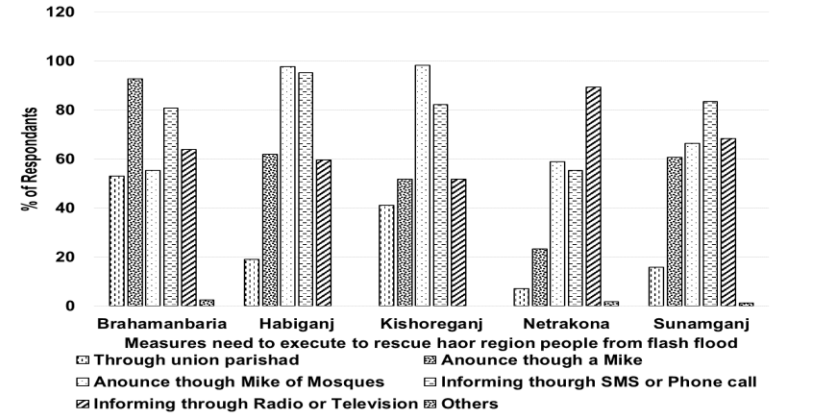


Figure 7.57: Transfer of forecast of flash flood

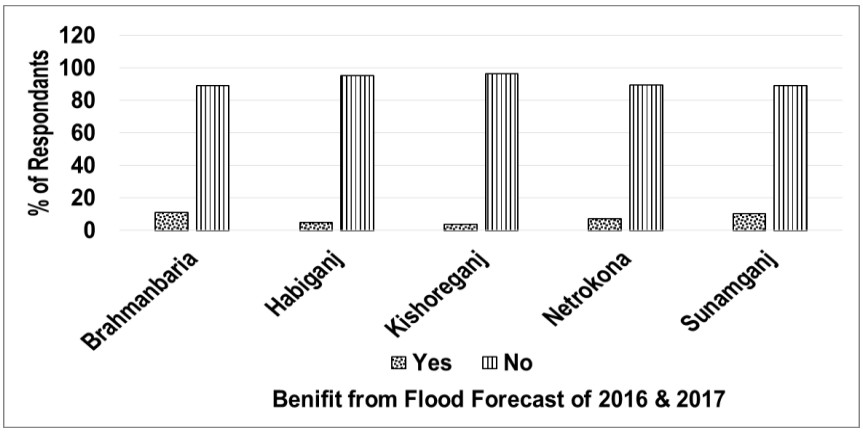


Figure 7.58: Benefit from Flood Forecast

Source: CEGIS, Household Survey- 2019

7.2.9 Changed Occupational Calendar

Present time of working in the field of agriculture and fisheries sectors was identified during surveys. Following Table 7.13 showed the working time for those who are involved in agriculture, fishers, day labor, business and rickshaw pulling. As, agriculture is the main occupation in the area, significant changes of time of working has been found in agriculture practices in recent years. Presently, farmers start to their crop calendar by the mid November and by 1st week of May in most of the northern part of the study area. Traditionally, farmers started the crop calendar maximum from mid-december and end by mid-May or end of May. Figure 7.59 shows traditional crop calendar from Haor Master Plan, 2012. The risks of early flash floods due to increased pre-monsoon heavy rainfall changed the crop calendar where farmers started (where possible) to manage their work planting early harvesting crops. On the other hand, because of the lying water, fishers get more time in which they have to start their fisher's base activities.

Table 7.13: Time of Working in the Haor Region

Community Activities	Recent Practices											
	Months											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Agriculture	✔	✔	✔	✔	✔					✔	✔	✔
Fisheries	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
Day Labor	✔	✔	✔	✔	✔	✔			✔	✔	✔	✔
Business	✔	✔	✔	✔	✔	✔			✔	✔	✔	✔
Rickshaw Pulling	✔	✔	✔	✔	✔				✔	✔	✔	✔

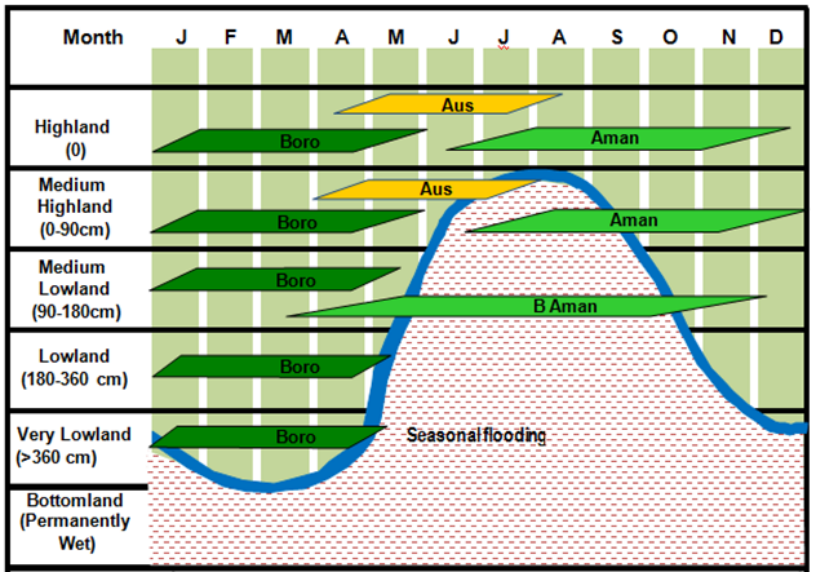


Figure 7.59: Traditional crop calender of Haor area (Source: Haor Master Plan, 2012)

7.2.10 Changed Cropping Calendar

Presently, farmers are not so much aware about modern technology due to lack of training and lack of agricultural mechanization deteriorated grain and seed quality and accelerated post-harvest loss. Government and private organization take some different initiative to reduce the fisheries and agricultural losses. Agriculture mechanization through combined harvesters and grain drying devices, training of seed growers, providing hybrid seeds, facilities of seed storage, improvement of marketing system etc. might help to increase the agricultural production and fulfil the demand of the local farmers in the study area significantly.

In every district, most of the local people said, they need advanced and cold tolerable paddy seeds to reduce the losses. In this study, we found that farmer is benefited in every district for the flood protection structure. More than 40% agricultural production increased due to different type of infrastructure. Due to those infrastructural development, damage of crops and water logging problem also decreased in those study area.

In the sub district of Brahmanbaria the usual crops noticed were Boro(local), Boro(HYV), Aman(local), Aman(HYV),Aman (broadcast) spread over their usual duration. After seasonal flood Boro(HYV) is dominantly for different duration over the district. After Flash flood, Boro(HYV), Aman(HYV), Aman(Local) is grown in different duration over the district. The sub

districts of Habiganj show that before seasonal and flash flood Boro(HYV) and Aman(HYV) were available. It is observed that the effect of seasonal ad flash flood is only seen on Aman (HYV). Boro(local), Boro(HYV), Aman(local), Aman(HYV),Aush(Local), maize and wheat are the main crops grown befor seasonal and flash flood in Kishoreganj. After Flash flood and seasonal flood the scenario is same as Habiganj and Brahmanbaria. The condition crop pattern and crop calendar scenario is same for Netrokona and Sunamganj. The effect of flash and seasonal flood on crop calendar is severe for which only Boro(HYV) is available after disaster during March-April and the whole winter time.

7.2.11 Gender Issues

The regular activities of women after a climate induced disaster become hampered in many ways. They have to manage their whole work and felt sometimes hardship during the post hazard period. Duck rearing, child rearing, rice husking, floating gardening are the common practice among the women of Haor region (Sharma, 2010). Women used to have some extra job for managing their family, children and domestic animals. It caused hardship and challenges because of poor communication system and remoteness of villages in the Haor area.

Following Table 7.14 shows that how women the activities differed due to the regularly occurred hazard in the Haor area. Because of the changes, women face challenges to manage their activities at the post hazard situation.

Figure 7.14: Women's Activities in Regular and Post Hazards Periods

Regular Activities	After Climate Induced Disaster
Collection of Water	Collection of Fuel from market or localities
Child Rearing	Hardship in reaching children at schools
Making of Cooking fuel	Making of Tin Stove
Household Gardening	Water Collection from remote area or localities
Rice Husking	Management of Rice for cooking and allocation of dry foods
Animal husbandry and poultry	Arranging fodder for domestic animals

Source: Field Data, CEGIS, 2019.

It is observed from figure 7.60 that in Brahmanbaria the acute problem for women mostly is to constructing tin stoves for cooking.86% women in Brahmanbaria and all women in Habiganj and Kishoreganj suffer from constructing temporary latrine. 64% of women faces problems while searching for better sanitation provision which is alarming. Women in Netrokona suffer less compared to other districts.

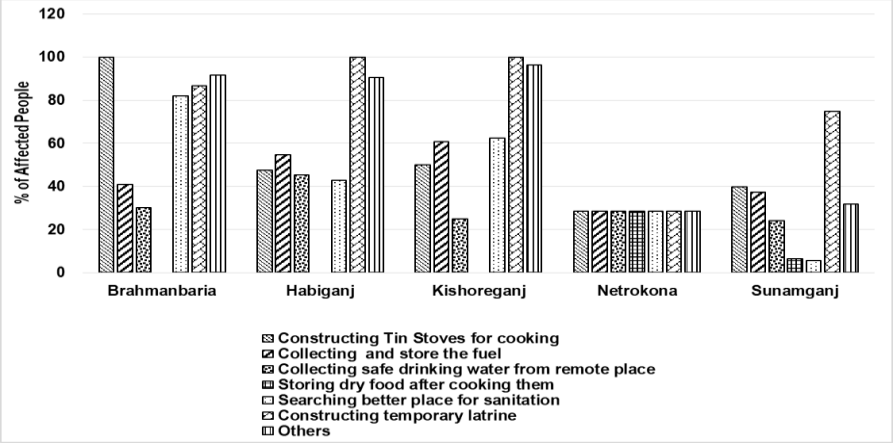


Figure 7.60: Problems Women Adapt During Disaster

Figure 7.61 shows that the problems women face during disaster is mostly to cook food in every district. In Brahmanbaria 30% of women has reported to face this problem. Collecting drinking water is also a major problem in Brahmanbaria and Kishoreganj.24% women from Netrokona and 15% women in Habiganj find it hard to move from one place to another during disaster. Crisis for having treatment during pregnancy is a very common problem among women in all district.

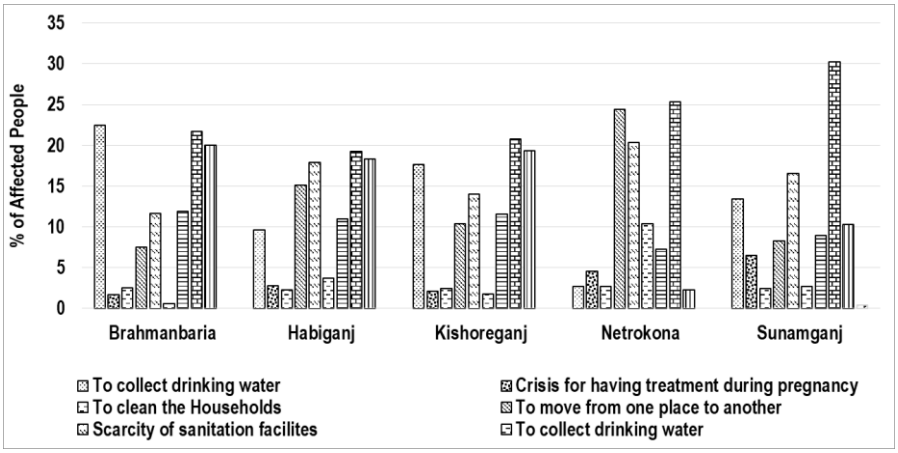


Figure 7.61: Problems Women Faces during Disaster

7.2.12 Hampered Community Events

Field findings from the household survey revealed that, many regular community activities get hampered due to different hazard phenomena in a year. Table 7.15 clearly indicates that which community events are typically hampered by different hazards in the study area.

Table 7.15: Community Events Hampered by Climate Change Induced Hazards

Hazards	Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		Jan		Feb	
Flash Floods																								
Seasonal Floods																								
Heavy Rainfall																								
Temperature Rise																								
Wave Action																								
Hail Storm																								
Cold Snap																								
Thunderstorm																								
Drought																								
Erosion																								
Sedimentation																								
Communitiy Activities	**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**		**Jan**		**Feb**	
Nursery and Preparation of Seed Bed																								
Plantation of Crops																								
Interim Care of Crops																								
Harvesting of Crops																								
Exemption of Renu Pona																								
Fishing																								
Selling Fish																								
Rickshaw Pulling																								
Day Labor																								
Business																								
Duck Rearing or Poultry Farming																								
Boat Riding																								
Firewood Collection																								
Collection of Aquatic and Other Plants																								
Collecton of Reeds and Grasses																								

Source: Field Data, CEGIS, 2019

7.2.13 Hampered Fuel Collection

The usual sources of fuel for the people of the Haor region are: lumber, liquefied petroleum gas (LPG) gas cylinders, Kerosene etc. From the survey, it has been observed that more than 90% people of the Haor region depends on Lumber as their main source of fuel, which are available around them. The graph on source of fuel during heavy rainfall depicts that, during rainy season major percentage of people have to buy fuel from market in every district. Another popular source of fuel during rainy season is collecting it from distant places. Almost 80% people has to collect fuel from distant place in Brahmanbaria and more than 50% people in other districts are dependent on this source too. Despite, lending from relative's house is another main source of fuel for 73% of people of Brahmanbaria during rainy season, it is not that much common among other people of other districts.

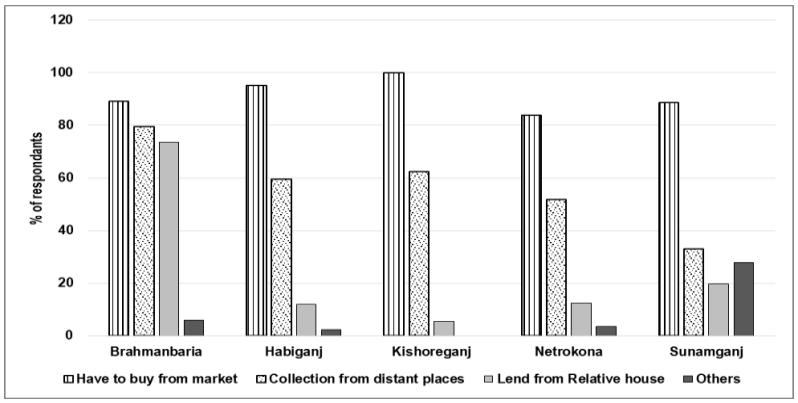


Figure 7.62: Source of Fuel during Rainy Season

Due to climate change and its impact, the after disaster scenario is shown in figure 7.63. Collecting fuel from market while paying high price is a very huge challenge for the people in each district as their income do not support this. Collecting fuel from distant place is another challenge that 32% people of Brahamnabaria and 21% people of Habiganj has to go through. Almost 27% people of Netrokona have to use previously stored fuel to cope up with after disaster scenario.

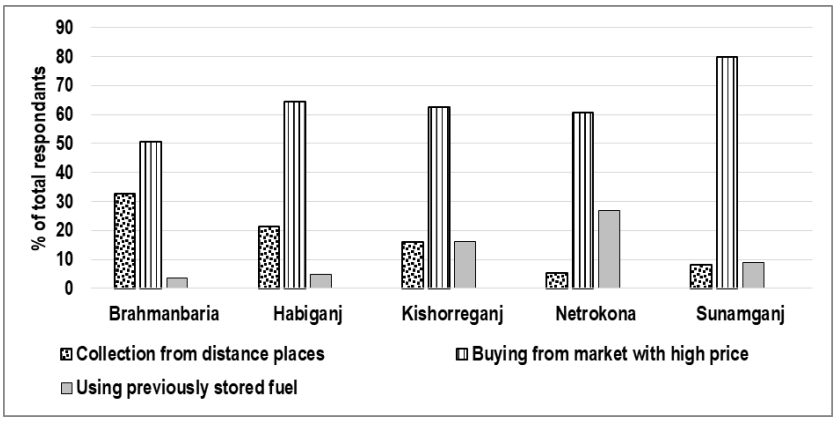


Figure 7.63: Source of Fuel after Disaster

7.2.14 Livestock Rearing

The livestock resources of the Haor region are mainly cattle, buffalo, goat, sheep, chicken and duck. Poultry farming is a very popular occupation of the region. Due to climate change disasters, it becomes quite a challenge for the people to protect their lives and also to collect food for the livestock. During disaster the accommodation for livestock is another crucial challenge in every district. From the graph it is evident, that in most cases on each district livestock settles on high road during disaster. To protect livestock during disaster 95% people in Brahmanbaria and 76% of Sunamganj reported to keep their livestock on high embankment. In Netrokona 67% people and 64% people of Habiganj reported to use another place which is school shelter. Keeping in school shelter is a famous method other than in Sunamganj. Accommodation of livestock on top of the building is not an effective place in any district.

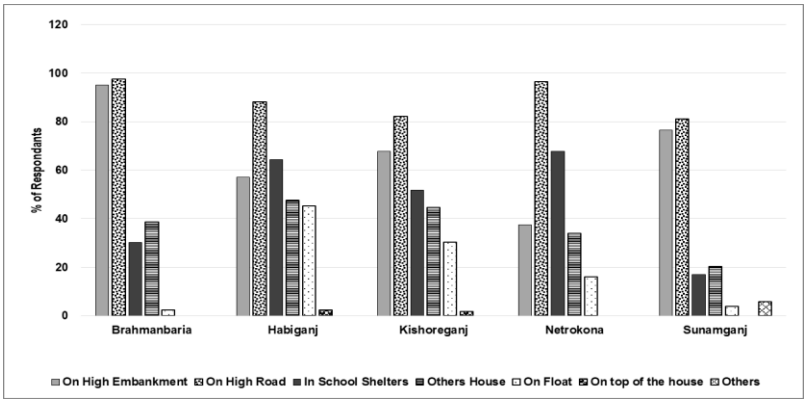


Figure 7.64: Settlement of Livestock during Disaster

Preserving food for livestock is also challenging for the people of haor region. To collect food, most of the people have to go the high ground from which hay, straw is collected and even have to buy food for the livestock from market with a much higher price. It poses a great

challenge for the people. In each district people usually try to preserve food for livestock by storing them on the high ground (where hay is stored). Keeping food on the high ground from which hay, straw is collected is another popular place in every district other than Netrokona. Whereas, 58% and 50% people of Netrokona and Sunamganj depend on water hyacinth for food of livestock. Purchasing from the market is another option people have to go for during disaster, specifically 95% people in Brahamanbaria settle for this option.

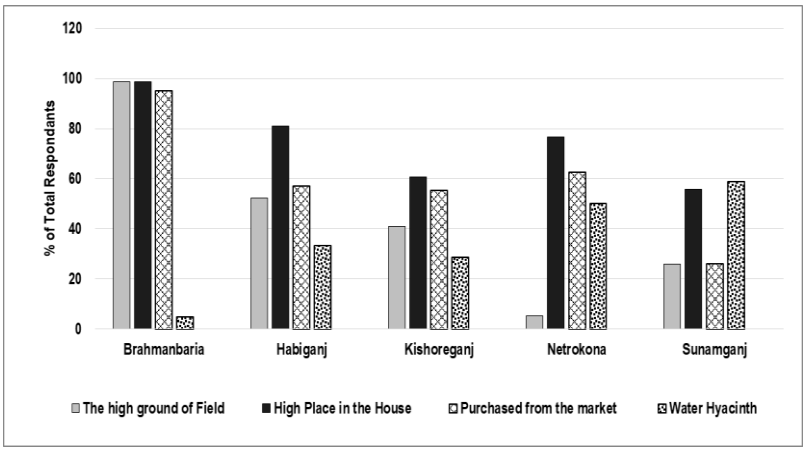


Figure 7.65: Food Source of Livestock during Disaster

7.2.15 Lack of Knowledge on Climate Resilience

In Haor area, flash flood and seasonal flood cause crop damage, loss of property and other harm which is overall a big threat to the people. From the figure 7.66 and figure 7.67 it is evident that people of haor region are neither benefitted by village protection program nor they have received any training for climate change. Though flood forecasting plays an important role for early flood warning, in the year of 2016-2017, local people of those area are not properly benefited by the flood forecasting. For this reason, large amount of damage had been occurred in those year while village protection program existed. Again, due to lack of knowledge on climate change and its adaptive measure, local people are not acquainted with the high yielding crop which would be harvested before the flash flood. In addition to that, farmers are not so much aware about modern technology due to lack of training and lack of agricultural mechanization which deteriorated grain and seed quality and accelerated post-harvest loss.

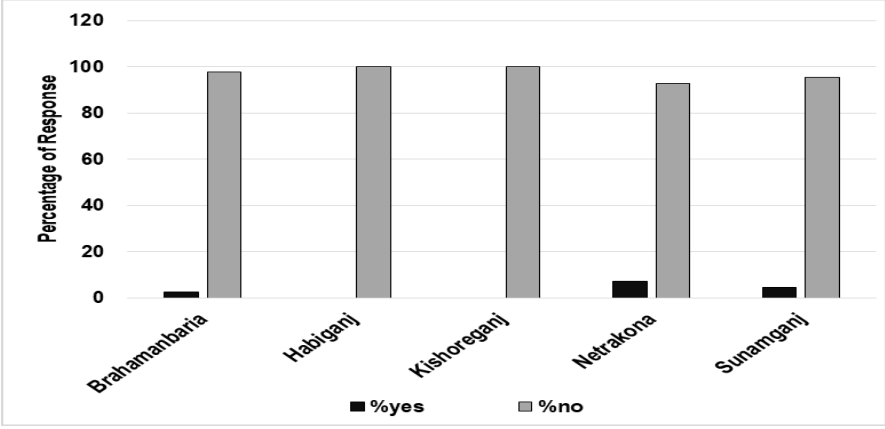


Figure 7.66: District Benefitted by Village Protection Program

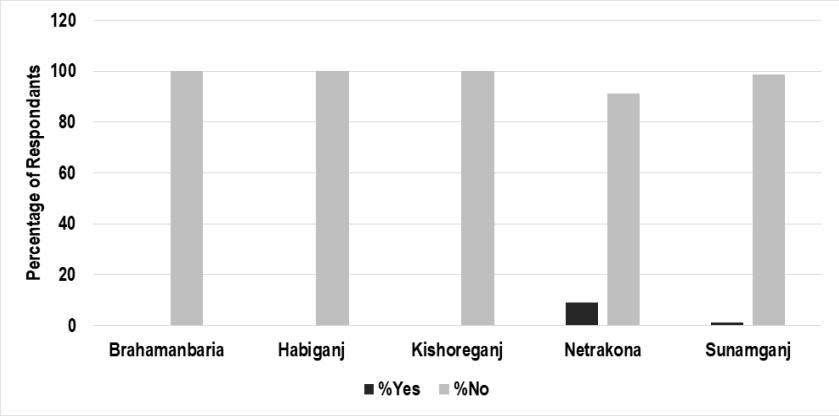


Figure 7.67: Percentage of People Receiving Training

7.2.16 Threshold of Climate Change Risk

Temperature, CO_2 and rainfall are the most influencing environmental indicators of rice yield. Boro rice is the most productive rice type in Haor region. Table 7.16 indicates impact on yield (in percentage) due to increase and decrease of temperature, CO_2 and rainfall data. Temperature rise negatively effects on crop yield. If minimum and maximum temperature increase in 4°C, the yield is decreased as 22.87%. On the other hand, increase in CO2, positively effects on crop production. If the overall percentage of CO2 increase at 200ppm, then the percentage of yield will be increased in 12%. But increase of 200ppm CO2 has a significant negative impact on environmental balance. Moreover, water is a prime component for rice production. To produce one kg rice, 3000 litre of water is needed (Bhuiyan et al., 1995). At present, about 80% of groundwater is used for irrigation, of which 73% is used exclusively by Boro farmers (Rahman and Ahmed, 2008). Another 20% of water comes from rainfall. Table 7.16 indicates that if rainfall decreased at 10 mm, the percentage of yield will be decreased at 14.3. On the other hand, excessive water caused by heavy rainfall, flooding etc. decreased crop production.

Table 7.16: Impact of Temperature, CO2 and rainfall on Boro rice yield (Bosak, 2010)

Temperature	Impact on yield (%)
Maximum temperature **2°C** increase	-6.09
Maximum temperature **4°C** increase	-16.0
Minimum temperature **2°C** increase	-4.17
Minimum temperature **4°C** increase	-8.9
Minimum and Maximum temperature **2°C** increase	-10.41
Minimum and Maximum temperature **4°C** increase	-22.87
CO_2	
CO_2 **50 ppm** increase	+3.47
CO_2 **100 ppm** increase	+6.47
CO_2 **200 ppm** increase	+11.97
Combination of CO_2 and Temperature	
Minimum and Maximum temperature **2°C** increase and CO_2 **50 ppm** increase	-8.28
Minimum and Maximum temperature **2°C** increase and CO_2 **100 ppm** increase	-4.95
Minimum and Maximum temperature **2°C** increase and CO_2 **200 ppm** increase	+1.37
Minimum and Maximum temperature **4°C** increase and CO_2 **50 ppm** increase	-24.66
Minimum and Maximum temperature **4°C** increase and CO_2 **100 ppm** increase	-21.79
Minimum and Maximum temperature **4°C** increase and CO_2 **200 ppm** increase	-14
Rainfall	
5 mm reduction	-6
10 mm reduction	-14.3

Table 7.17: Critical Temperature for the development of Rice plant at different growth stages (Yoshida, 1978)

Growth Stage	Critical temperature (°C)		
	Low	High	Optimum
Germination	16-19	45	18-40
Seedling emergence	12	35	25-30
Rooting	16	35	25-28
Leaf elongation	7-12	45	31
Tilering	9-16	33	25-31
Initiation of panicle primordia	15	-	-
Panicle differentiation	15-20	30	-
Anthesis	22	35-36	30-33
Ripening	12-18	≥ 30	20-29

Moreover, temperature has also significant effects on various growth stage of rice plant. Generally, typical development stage of a rice plant will be categorized into 9 growth stages such as Germination, Seedling emergence, Rooting, Leaf elongation, Tilering, Initiation of panicle primordia, Panicle differentiation, Anthesis and Ripening (Figure 7.68). In every stage of a rice plat, different optimum temperature are needed. Table 7.17 indicates different optimum temperature of different stage of plant lifespan. Ensuring expected crop production, maintaining optimum temperature is recommended.

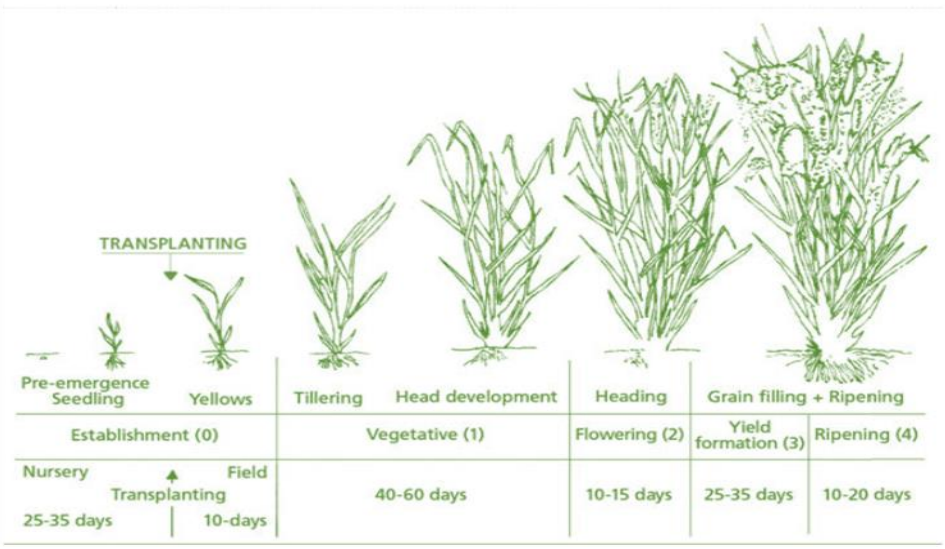


Figure 7.68: Typical development stages of a rice plant

In Bangladesh, flood is one of the major reason for water logging in crop fields. Table 7.18 shows flood damage percentage of yield by considering submergence percentage of plant height. These damages assume clear flood water which are slightly less damaging than water with high silt content, and do not account for damages from water current.

Table 7.18: Flood damage percentage of yield (Hussain, 1995)

Submergence of 25-50% of plant height				
Growing Stages	**Days of Submergence**			
	3-6	**7-9**	**10-14**	**15 or more**
10 days after transplanting	10	15	20	30
Maximum tillering	10	15	25	40
Panicle initiation	0	0	30	40
Heading	0	0	30	40
Early grain filling	0	0	30	40
Maturity	0	25	40	40
Submergence of 50-75% of plant height				
Growing Stages	**Days of Submergence**			
	3-6	**7-9**	**10-14**	**15 or more**
10 days after transplanting	10	40	50	60
Maximum tillering	5	50	60	70
Panicle initiation	15	40	50	60
Heading	15	40	50	60
Early grain filling	20	40	60	70
Maturity	20	40	60	70
Submergence of 75% or more of plant height				
Growing Stages	**Days of Submergence**			
	3-6	**7-9**	**10-14**	**15 or more**
10 days after transplanting	40	80	100	100
Maximum tillering	40	60	80	100
Panicle initiation	50	70	100	100
Heading	40	80	100	100
Early grain filling	30	60	80	100
Maturity	30	60	80	100

The Haor basin is the most important fishing zone in the country. Haor has inland capture of fishery of habitat containing approximately 2,695,529 ha floodplain (FRSS, 2016). Therefore, a lot of different fishes are produced in the region. Fishes productivity depends on water concentration of oxygen dissolved, temperature, pH level, BOD, COD and so on. Meanwhile, ensuring optimal water temperature is greatly needed for fish productivity as well. Table 7.19 indicates some example (10) of Haor fishes and their optimal temperature with Lower Lethal Limit (LLL) and Upper Lethal Limit (ULL). The table reveals that optimal temperature range of overall fishes is around 20°C -30°C and normalized lowest LLL and highest ULL are less than 16^0C and greater than 32^0C, respectively. Some analysis shows that the average temperature range of haor region is approximately 24°C -28°C which is suitable for survival of haor fishes (Islam el al., 2014). The water temperature of the region is not so hot or not so cold, that is why the water environment in respect of temperature, is suitable of the hoar fishes. Therefore,

increase in surface air temperature will have significant effect on fisheries production if it crossed the optimal range.

Table 7.19: Optimal, Lower Lethal Limit (LLL) and Upper Lethal Limit (ULL) of temperature for fishes of Haor area

Sl. No.	Scientific Name	English Name	Local Name	Optimal Temp (^{0}C)	LLLT (^{0}C)	ULLT (^{0}C)
1	*Cirrhinus reba*	Reba carp	Lasu	22°C -25°C	20^{0}C<	>30^{0}C
2	*Notopterus notopterus*	Freshwater Knife Fish	Foli	22°C -27°C	16^{0}C<	>32^{0}C
3	*Chitala chitala*	Featherback/knifefish	Chital	25°C - 30°C	16^{0}C<	>32^{0}C
4	*Labeo rohita*	Roho	Rui	20°C -25°C	Does not thrive at temperatures below 14^{0}C	>30^{0}C
5	*Cirrhinus cirrhosus*	Mrigal carp	Mrigel	20°C -25°C	Feeding become less at below 15^{0}C-16^{0}C.	>30^{0}C
6	*Wallago attu*	Freshwater shark	Boal	22°C -27°C	16^{0}C<	>32^{0}C
7	*Ompok pabda*	Pabda catfish	Pabda	22°C -27°C	18^{0}C<	>28^{0}C
8	*Sperata aor*	Long-whiskered Catfish	Ayer	22°C -27°C	16^{0}C<	>32^{0}C
9	*Eutropiichtheys vacha*	Schilbid catfish	Bacha	24°C -30°C	18^{0}C<	>30°C
10	*Anguilla bengalesis*	Indian mottled eel	Baem	25°C -30°C	The feeding activity in *Anguilla* sp. was stopped in less than 10°C.	At 38^{0}C stop all activity

7.2.17 The Context of Haor base Livelihoods

The climatic risks identified in the Haor Region. However, people of Haor region have distinct livelihoods features which are mostly dependent on Haor ecosystem. But the trends started here that have some differences and not likely behave as same at the present time made a considerable risks for the existing livelihoods of Haor people. Following the Figure 7.69 showed that what the factors are interplayed to make the livelihoods risks for those people living in the Haor region. The risks pertained because of the climatic events occurred in the Haor area every year. The major factors are a) Damage of crops, b) extra production cost, c) damage of culture fishes, d) Seasonal Migration, and e) inundation.

The risks mainly occurred when any of the climatic events occurred and made considerable effects in the aspect of both agriculture and fisheries base livelihoods. Because of the increase risks of climatic hazards, the risks of Livelihoods were increasing and the sustainability of livelihoods in the Haor region were to fall into challenges in the coming future.

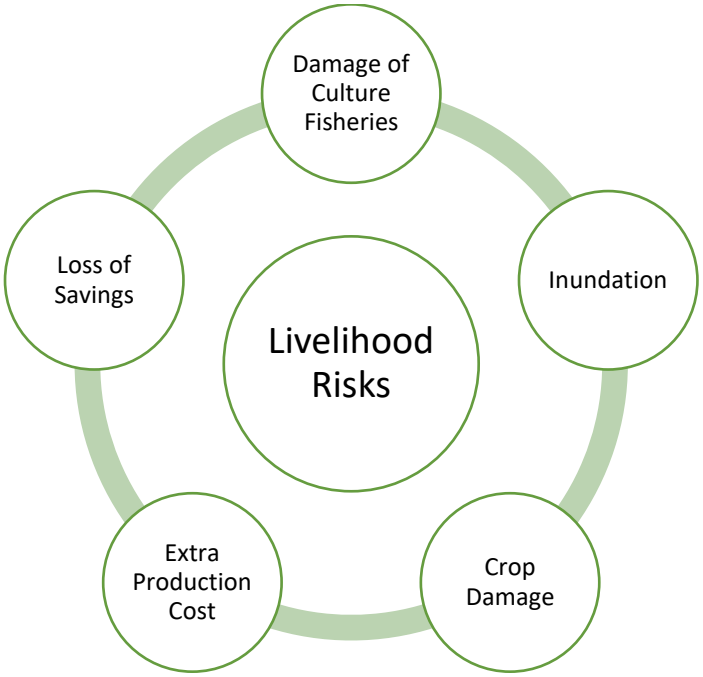


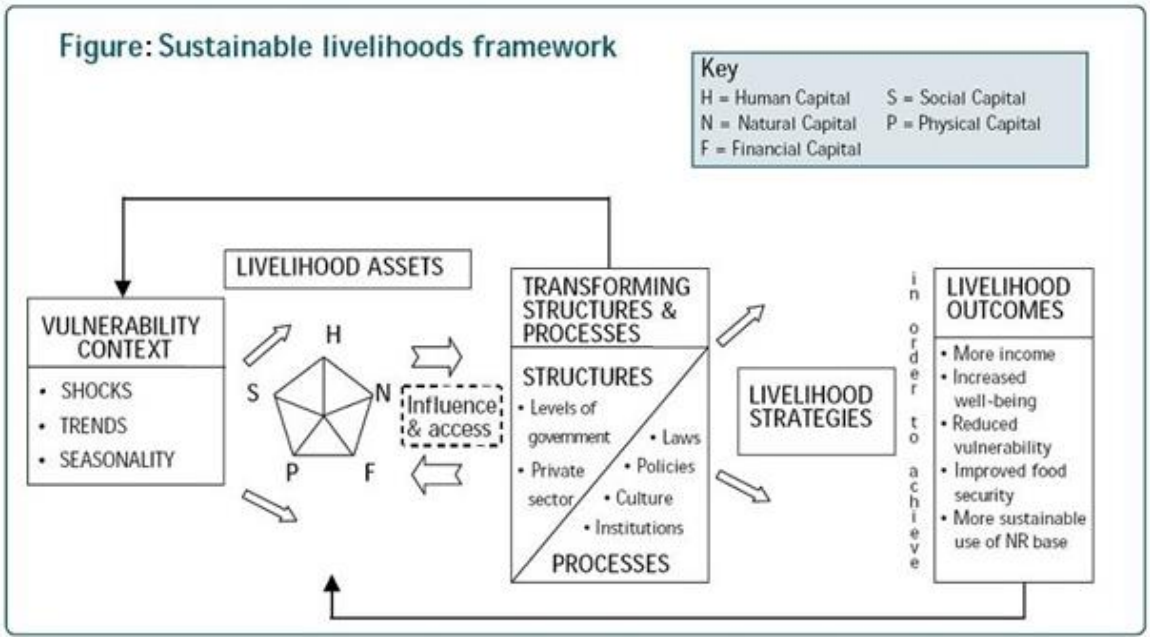
Figure 7.69: Factors of Livelihood Risks due to the Hazards in the Haor Regions

7.2.18 Sustainability of Livelihoods

The sustainable livelihoods idea was first introduced by the Brundtland Commission on Environment and Development to link with the socioeconomic and ecological considerations in a cohesive, policy-relevant structure. The concept expanded, especially in the context of Agenda 21, and advocated for the achievement of sustainable livelihoods as a broad goal for poverty eradication in the 1992 United Nations Conference on Environment and Development (UNCED). In this way, the sustainable livelihoods could serve as 'an integrating factor that allows policies to address 'development, sustainable resource management, and poverty eradication simultaneously.

In a classic 1992 paper, Sustainable Rural Livelihoods: Practical concepts for the 21st Century, Robert Chambers and Gordon Conway proposed the following composite definition of a sustainable rural livelihood: A livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living: a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term.

Following Figure 7.70 showed the sustainable livelihood framework suggested by UNCED in 1992. Based on this framework, the livelihood aspects of Haor region considered and risks of those livelihood assets were identified relating to the increasing climatic hazards occurred in the Haor Region as a result of climate change.



Source: UNCED, 1992

Figure 7.70: Sustainable Livelihood Framework developed by UNCED

Based on the study findings, financial capital which is one of the important livelihood assets is is in risks because of the regular crop damage due to the flash and seasonal flooding. Recurrence of different hazards (e.g. flash floods, seasonal floods, wave actions) were common during the pre-monsoon and monsoon period in the Haor region. It was learnt that the area has to face regular inundation by flooding have been increasing since last ten (10) years. Because of the increase rate of early flash flood people of the Haor region got such shocks in which the livelihoods risks were being increased with the pressure financial damage.

Early flash flood was the most prominent hazards and it mostly affected the agriculture and fishing sectors. Based on the study findings, it was found that damages occurred because of crop loss, loss of cattle, household assets, fisheries and other resources. The most affected hazards were cyclone, flash flood, seasonal flood, heavy rainfall, and wave action. There were different sectors of damages found as per the study findings. Because of the study objectives, this study focused on both agriculture and fisheries sectors. About BDT 255,000 (yearly average) crops were lost because of the hazards (i.e. Cyclone, Flash Flood, Seasonal Flood, Heavy Rainfall and Wave Action). Besides, about an amount of BDT 247,313 (yearly average) was lost with the occurred hazards in a year.

Following Figure 7.71 showed how people were forced to change their occupation for their survival and livelihoods. Because of the flood occurred in 2004, about 33.3% of people had become jobless, and 46.5% of people had to change their occupation. Since the majority (53%) in the study area was dependent on agriculture, they had to face great losses in income and occupation because of the major flooding. In the agricultural sector, about 23.3% people had become jobless, and others had started working as fishermen, boatmen, day laborers, and rickshaw pullers, as they could not continue their cultivation. About 5% day laborers reduced because of flash flood in this region.

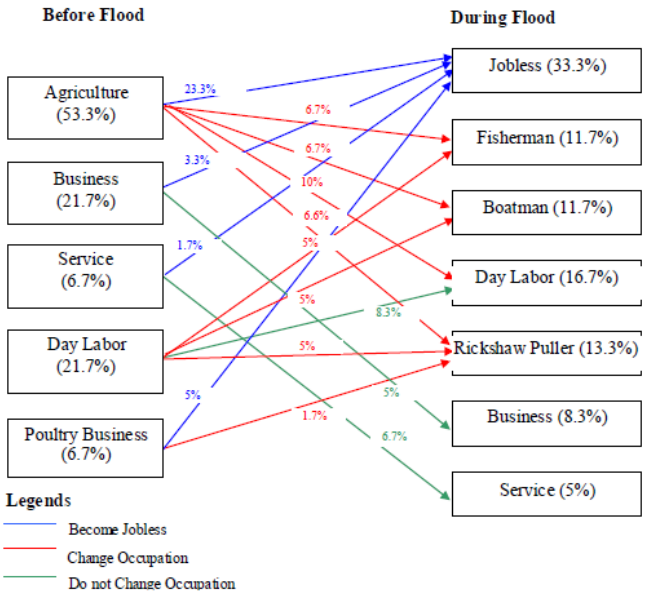


Figure 7.71: Shifting of Occupation due to 2004 Flood

The main challenges after any hazards is to cope with the post hazard situation. Due to crop loss and other damages, farmers and fishermen got in such situation like fish out of water. Even in cases they don't have the capacity to buy food and daily chores for family. Some of them take loan from NGO and other sources. Taking out loans and borrowing rice, salt, oil, and other necessary items were the main financial coping strategies of households in response to floods. The loans were taken to face financial crisis, especially for food. In an average 13-15% of cases, they borrowed money from moneylenders at high interest rates (12%–25%), since, it was not easy to take loans from other sources such as neigbours, relatives, NGOs, and banks.

7.3 People's Perception for Sustainability and Resilience

According to the findings of this Household Survey, there were common recommendations like dredging of canals, river dredging, embankment construction or repairing and others. Most of the people had common consensus about the recommendations that were required for mitigating the risks of the Haor region. Because of the geographical locations, most of the people in Netrokona and Sunamganj districts were agreed to do emphasis on the construction of embankment and repairing to continue the smooth movement of water flow in this region. Following Table 7.20 illustrates the people's perception against identified major problems in Agriculture and Fisheries sector:

Table 7.20: People's Perception against Identified Major Problems in Agriculture and Fisheries Sector

Problems	Solutions
Agriculutre Sector	
• Early flash flood hampering crop loss. • Cold injury occurs due to early and flash flood problem due to late transplanting. • Silted up of River and Beel and Khals	• Creation of job during monsoon season. • Policy reformed for Haor region • Crop intensification project should be needed in Haor region.

Problems	Solutions
• Late recession. • Late recession of water occur in last year and early recession in this year. • Increase the seasonal climatic variation. • Increases the post-harvest loss due to irregular rainfall during harvesting and processing of Boro crop this year (2018) • Lack of job during monsoon season • Increases the migration gradually.	• Silo should be established in Haor region. • Integration should be needed among different organization • Timely construction of embankment and repairing to continue the smooth movement of water flow and obstract flow before crop harvesting
Fisheries Sector	
• Erratic rainfall and early flash flood effect on successful fish spawning and breeding; • Absorbed eggs in fish body due to change of flooding time; • High water temperature due to high air temperature and low depth during pre-monsoon season causes threat on survival of offspring or minnow; • Filling deep pool area of river due to siltation. The deep pool area functions as over wintering refugees for brood fishes; • Degradation of riverine habitat due to siltation, erosion, etc.; • Hampering longitudinal migration of fishes due to reducing river depth and connectivity during dry season; • The perennial Beels convert into seasonal Beels due to siltation; • Loss of fish breeding, feeding and nursing ground; • Shifting of river channel due to erosion.	• Establishing sanctuary in river and Beel; • Need re-excavation of Beels; • Taking Beel Nursery and fry release Program; • Introduce fishing ban period for exclusively Haor region; • Stop fishing during peak breeding season; • Constitute “Task Force” for monitoring illegal and indiscriminate fishing; • Empowering local DoF office for leasing the water bodies; • Monitoring budget for local DoF office should be allocated considering area of water bodies; • Give VGD or VGF for fishers; • Beel leased should be given among real fishers; • Application of fisheries act and rules, strictly; etc. • Promoting cage fish culture and pen fish culture;

Following Figure 7.72 shows a pathway for people participation in all stage of project implementation, according to the study findings. It was suggested that a project needs to have that plan in which it can incorporate local experience and knowledge with the participatory way.

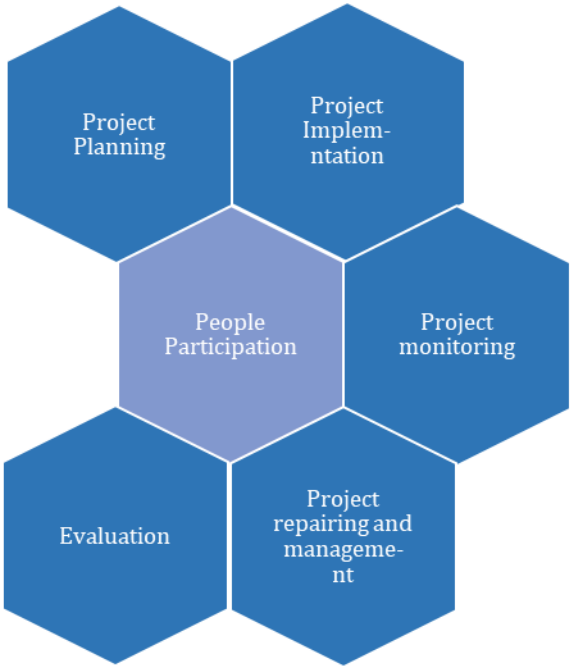


Figure 7.72: People participation in all stage of Project Cycle

8. Community Based Climate Change Risk Assessment

8.1 Introduction

Haor region of Bangladesh is exposed to various climate change induced hazards, like early flash floods, erratic rainfall, thunderstorm, hailstorm, Afal (wave generated by wind in the haor) etc. Prevailing trend and projected future trend analysis described in Chapter 5, indicates that, impact of climate change is increasing the frequency and intensity of these climate change induced hazards and thereby risk for life and properties. Therefore, risk has been assessed in this Chapter using both participatory and scientific tools to understand the future potential risks due to climate change induced hazards. Assessed risk and its spatial distribution maps, prioritization of risk and hotspots in risk have been described and illustrated in the following sections.

8.2 Risk Assessment Process

Vulnerability and risk assessment encompass various approaches and techniques ranging from indicator-based global or national assessments to qualitative participatory approaches of local level vulnerability and risk assessment (IPCC, 2012). In this study, qualitative risk assessment has been performed due to climate change and particularly focusing in agriculture and fisheries sectors, using both participatory and scientific tools. The overall risk assessment process has been illustrated in the following conceptual framework:

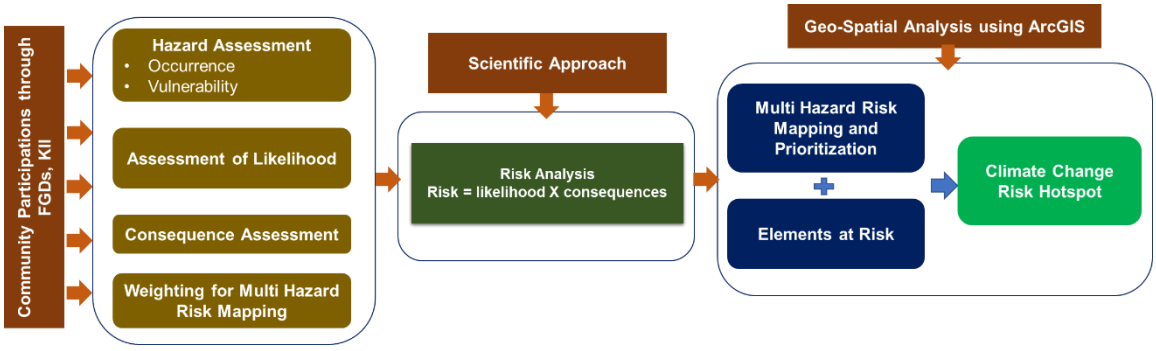


Figure 8.1: Conceptual Framework of the Community based Climate Change Risk Assessment

8.2.1 Scientific Approach

IPCC (2012) in "Special Report on Managing Risks of Extreme Events and Disasters to Advance Climate Change Adaptation" defined disaster risk as,

The likelihood over a specified time period of severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.

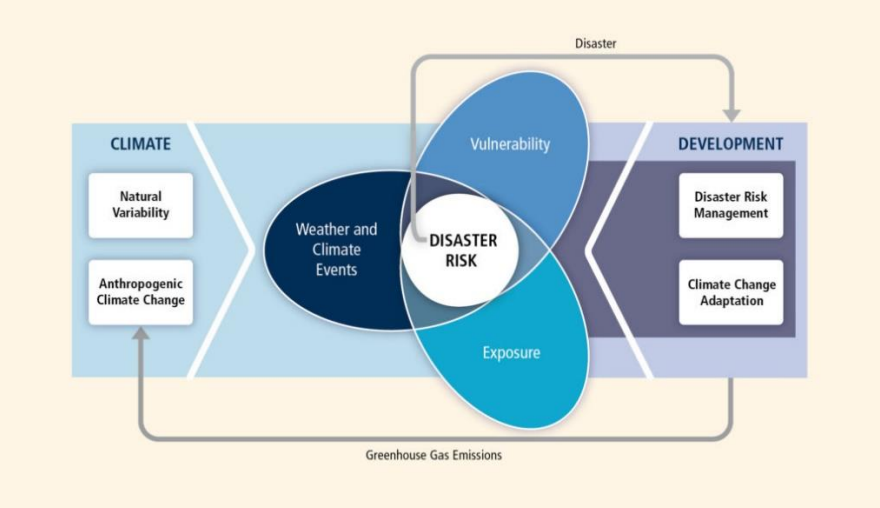


Figure 8.2: Concept of Risk Management and Adaptation (IPCC, 2012)

Furthermore, IPCC (2001) also referred risk as the function of probability and magnitude of different hazards. Table 8.1 illustrates the summary of definitions of risk in different literatures.

Table 8.1: Definitions of risk and hazard (IPCC, 2012)

Author(s)	Risk definition
Smith, 1996 (p5)	Probability x loss (probability of a specific hazard occurrence) *Hazard = potential threat*
IPCC, 2001 (p21)	Function of probability and magnitude of different impacts
Morgan and Henrion, 1990 (p1)/Random House, 1966	"Risk involves an 'exposure to a chance injury or loss'"
Adams, 1995 (p8)	"A compound measure combining the probability and magnitude of an adverse effect"
Jones and Boer, 2003; (also Helm, 1996)	Probability x consequence *Hazard: an event with the potential to cause harm, e.g. tropical cyclones, droughts, floods, or conditions leading to an outbreak of disease-causing organisms*
Downing et al., 2001	Expected losses (of lives, persons injured, property damaged, and economic activity disrupted) due to a particular hazard for a given area and reference period. *Hazard: a threatening event, or the probability of occurrence of a potentially damaging phenomenon within a given time period and area. Integrated Land use Planning and Water Resources Management (ILPWRM)*
Downing et al., 2001	Probability of hazard occurrence *Hazard = potential threat to humans and their welfare*

Author(s)	Risk definition
Crichton, 1999	"Risk" is the probability of a loss, and depends on three elements, hazard, vulnerability and exposure."
Stenchion, 1997	Risk might be defined simply as the probability of occurrence of an undesired event [but might] be better described as the probability of a hazard contributing to a potential disaster…importantly, it involves consideration of vulnerability to the hazard
UNDHA, 1992	Expected losses (of lives, persons injured, property damaged, and economic activity disrupted) due to a particular hazard for a given area and reference period. Based on mathematical calculations, risk is the product of hazard and vulnerability

However, this study considered the risk as represented by probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur i.e.

Risk = probability of occurrences of hazards x extent of consequences due to climate change induced hazards ……..Eq. (1)

8.2.2 Participatory Approach

To understand the community perceptions about risks and prioritization, total 56 Focused Group Discussions (FGDs) were arranged in 28 upazillas of the study area. Local level stakeholders from community specifically farmers, fishermen, women, locally influential peoples, labors or marginal people etc. participated in those workshops. A preliminary screening of vulnerable upazillas were performed before identifying and engaging those groups of people through preliminary field visit and conducting Key Informant Interview (KII) with relevant personnel, where FGDs were conducted. The sessions were pre-arranged following standard participatory norms of FGDs. Checklists prepared for FGDs and KII are attached in Appendixes.

During FGDs of risk assessment, community perceptions have been counted on identification of vulnerable group of people, occurrences of hazards, probability of occurrences of hazards and extent of potential consequences in the study area due to climate change induced hazards. Simple scoring techniques as Table 8.2 have been used to gather information on their perceptions of hazard occurrence which has been used for further analysis of climate change risk assessment. Same scoring technique has been used for gathering perceptions on potential consequences of hazards.

Table 8.2: Scoring Technique for Occurrence of Hazards and Consequence Analysis

Level of Impact/Effect	Score
No Impact/Effect	0
Low Impact/Effect	1
Medium Impact/Effect	2
High Impact/Effect	3

In addition, information on likelihood or probability of occurrence of identified climate change induced hazards have also been gathered from FGDs along with most vulnerable groups. Later, likelihood of occurrence of hazards have been reclassified into following scale,

Table 8.3: Scoring Technique for Probability of Occurrences of Hazards

Hazard Occurrence Period in Year	Frequency	Likelihood Score
1	Very Frequent	4
2	Frequent	3
3		
5	Moderately Frequent	2
10	Less Frequent	1

8.2.3 Risk Analysis

Risk score has been calculated following the IPCC (2012) defined formula i.e. Eq. (1) multiplying the likelihood or probability and consequence score, where scores for likelihood and consequence have been gathered from the community perceptions using participatory tool. Likelihood and consequence score of every Upazilla against each hazard have been averaged arithmetically before the multiplication. In this way, risk score has been found for each of the 28 Upazilla against each of the identified hazards. Normalization of score has been performed to convert the scores of communities in a range from 0 to 1. Functional relationship has been considered to compute the normalized score. Besides, the normalized score has been reclassified to set level of risk.

Normalization formula:

Normalized Score = 1 - [(Max-Respective Score)/(Max-Min)] ……..Eq. (2)

Table 8.4: Reclassification Technique of Normalization Score

Level of Risk	Range of Normalized Score
Low	=< 0.4
Medium	0.41-0.7
High	• > 0.7

Assessed risk level for individual hazard has been further updated and finalized using the available secondary spatial exposure maps for the study area. Previous published reports like Haor Master Plan (2012), National Climate Vulnerability Assessment (2018) etc. have been extensively reviewed and used to finalize the Risk score.

8.2.4 Multi-Hazard Risk Assessment and Prioritization

Multi-hazard risk assessment has been done summing the normalized scores of all individual hazards for all Upazilla of the study area. In this case, the same risk level classification has been used to present the level of combined risk. Priority rank for 28 Upazillas has been found out from the ultimate total normalized score of the combined risk.

8.2.5 Risk Hotspot Mapping

Apart from the priority of the Upazilla in terms of climate change risk particularly focusing on the Agriculture and Fisheries sectors, hotspot has been identified in the risk area. To perform the hotspot mapping, several important elements of risk has been identified, which actually directly or indirectly linked to life and properties of the community, if climate change induced hazards occur. They are:

- Settlement
- Health Facilities (Community Clinic, Hospital, Family Welfare Center)
- Educational Institutes (Primary School, High School, College, Madrasah, University)
- Growth Center
- Godown
- Ghats
- Rural Market
- Other Key Infrastructures (Mosque, Post Office, Police Stations etc.)
- Embankment of BWDB
- Beels
- Fish Sanctuaries
- LGED Roads
- RHD Roads
- Rail Network

These elements of risk have been overlaid on climate change hazard induced risk area to generate the hotspot in the risk area. This overlaying has been performed using spatial analyst extension of ArcGIS and resulting raster data layers were created using either point density or line density tool. Following formula has been used to perform the overlay,

Total Score = ∑Wi x Si

Where, W= weightage of 1,2,3,….n elements at risk and S= Score of the 1,2,3,….n raster layers

In this study, equal weight has been considered for spatially overlaying, as all of the considered elements at risk are equally important in the study area in the context of Agriculture and Fisheries sectors.

8.3 Identification of Hazards Occurrence

8.3.1 Occurrence of Hazards

Community people of the study area identified the most occurrence of hazards in their respective Upazilla during FGDs. According to their perceptions, temperature rise, erratic rainfall, drought, early flash floods, thunderstorm, Afal or wave action, hailstorm, erosion and siltation and cold snaps are major climate change induced hazards which they face very frequently. Their overall perceptions considering 28 Upazillas are described as follow:

Temperature Rise: The people of haor area referred that the maximum temperature in the summer season is increasing each year. Extended hot season and short but extreme winter period is observed. Community people are being affected by this variability of temperature rise.

Erratic Rainfall & Drought: Effect due to the irregular rainfall is very significant to the people of haor region as most of them are depended on agriculture. From their feedback, it's clear that the rainfall pattern is more erratic than past. Extreme event like drought also occurs frequently during the seeding duration. Farmers are being mostly affected by this change.

Early Flash Floods: Haor people face flash floods very frequently, which is almost usual thing for their livelihoods. Therefore, they showed most concern for early flash floods rather than regular flash floods. Community people reiterated the early flash floods event of 2017, when bulk portion of their boro crop (rice) were washed away before harvesting.

Thunderstorm: Lightning is a major threat to the working people of haor region. As there is limited protective measures available for the thunderstorm, death or injury is almost certain. In every FGD, people mentioned that every year people like farmer, fishermen or laborers, working or returning home were hit by lightning during the thunderstorm and this tendency is increasing.

Afal (wind generated waves): During the full monsoon, when the haors reach at its full capacity, large waves are developed by the wind as the fetch length increases. As per the participants, this Afal weaken the embankment and causes damage to settlements.

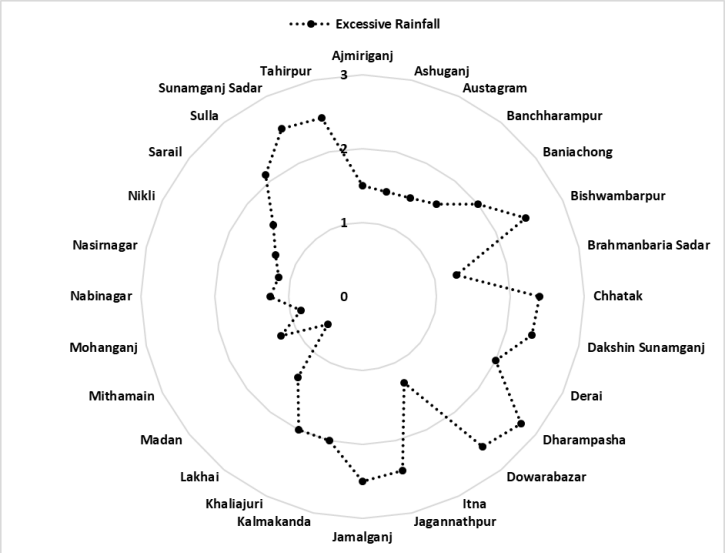
Hailstorm: Farmers are constantly in fear of hailstorm as it can destroy their crop within an hour. Besides it also damages their houses and other infrastructures. The increasing rate of hailstorm is a major concern for them.

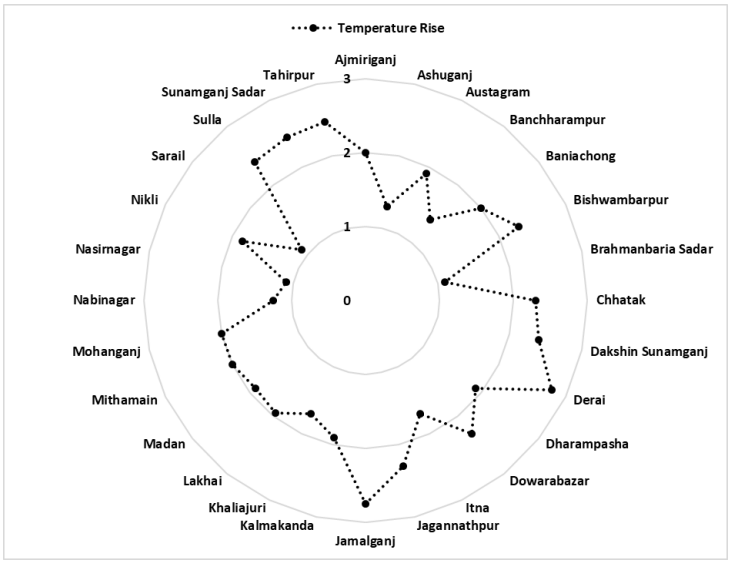
Riverbank Erosion: Through the field visit it was found that river bank erosion is not a major concern in the haor region, although major erosion process is ongoing on Surma River and its tributary river in Dowarabazar, Surma and Jaykalas UP.

Siltation: Siltation is found as one of major issues, which is increasing gradually. As the flashy transboundary rivers from India carry a large amount of silt, it settles partially in the haors during monsoon as the water is stagnant. Local stakeholders informed that rivers are losing their capacity due to siltation which results in increasing inundation of flood plain even for short-scale rainfall and flash flood.

Among the disasters mentioned above, flash flood, thunderstorm and hailstorm are the main concerns for the haor region. As the participants specified that, every year at least one of these disasters like, flash flood or hailstorm occurs and fully or partially destroys their crops.

The community rankings for individual hazards among Upazilla also shows the variation of occurrences of hazards, like most of the northern Upazillas emphasized that early flash flood is the most frequent event, whereas southern Upazillas gave less emphasis on early flash floods. Figure 8.3 illustrates community rankings based on the occurrence of different climate change induced hazards in the study area.

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Dharampasha
Dowarabazar
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Jagannathpur
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Kalmakanda
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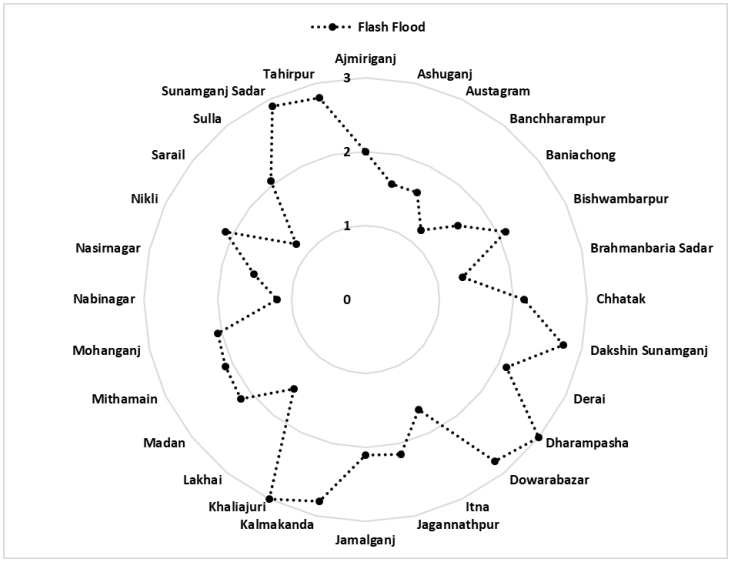
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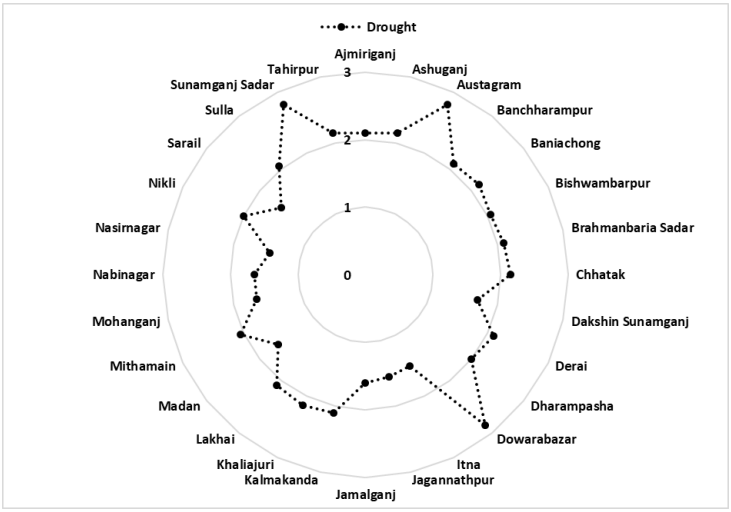
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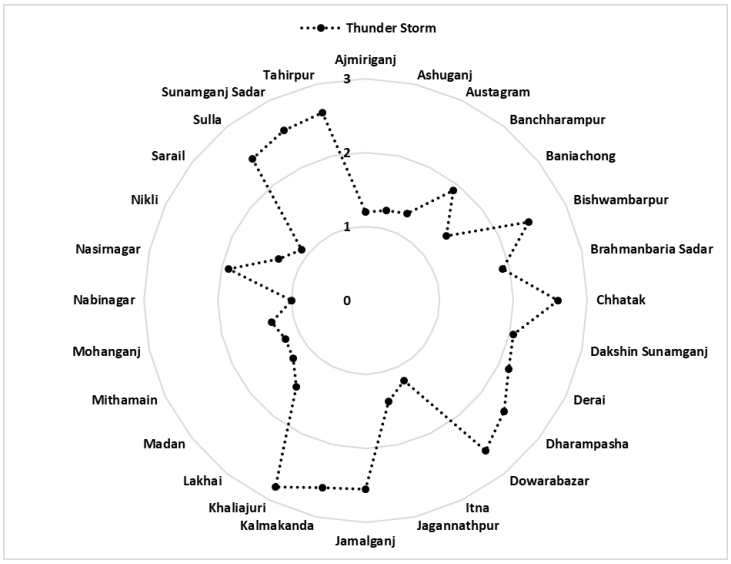
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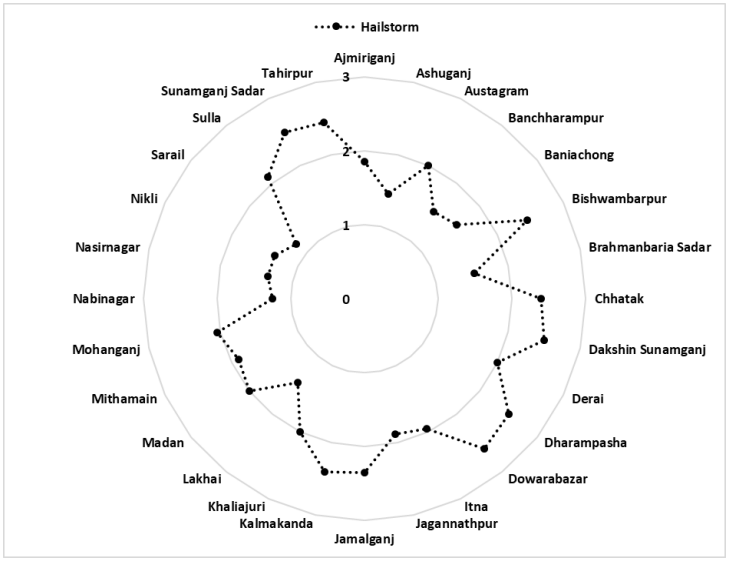
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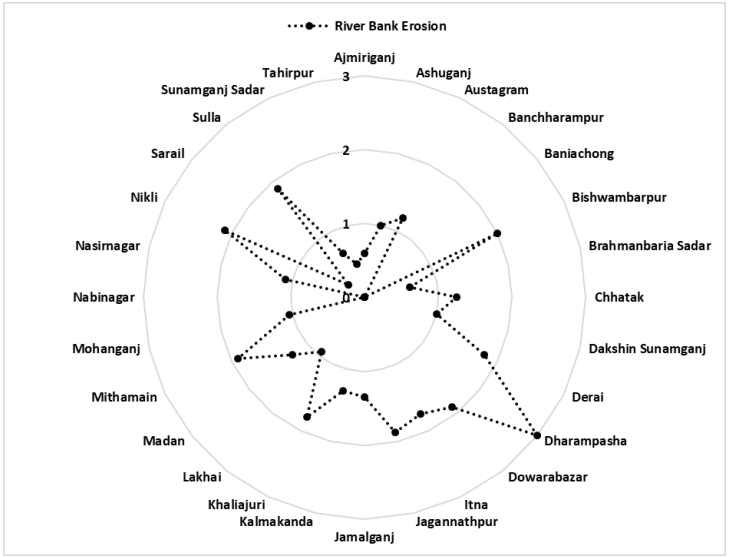
River Bank Erosion
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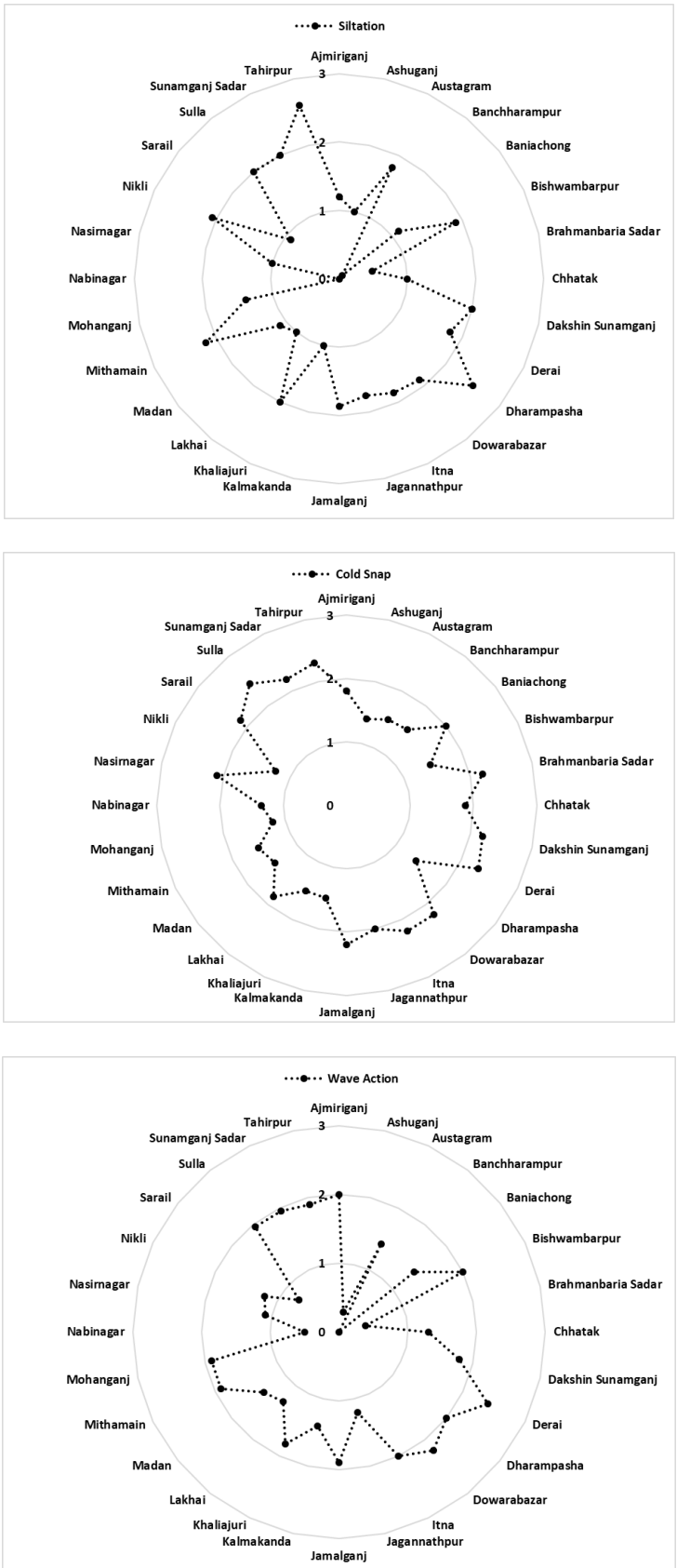
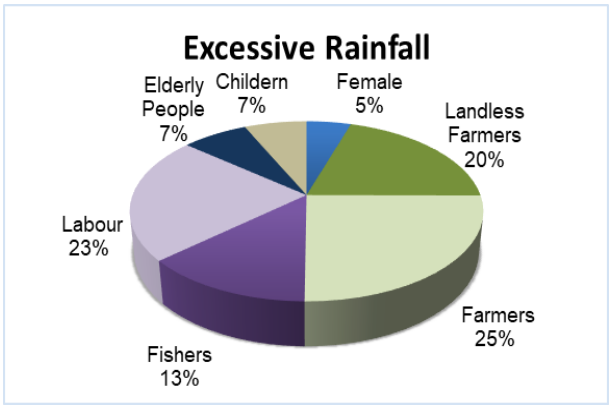
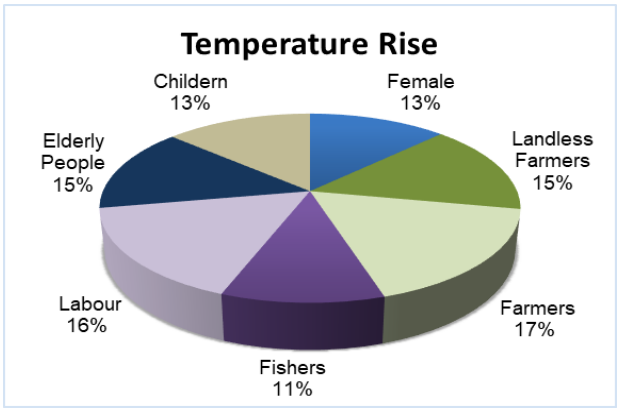


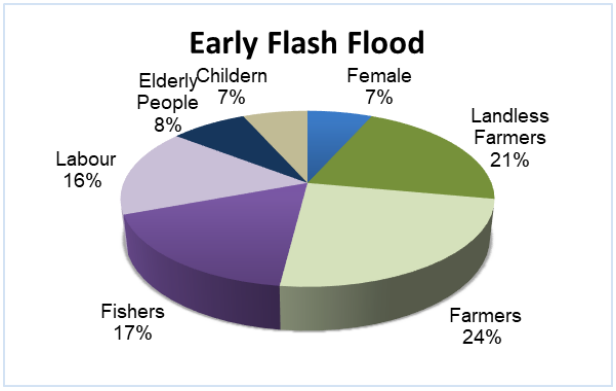
Figure 8.3: Community Rankings on Hazard Occurrences

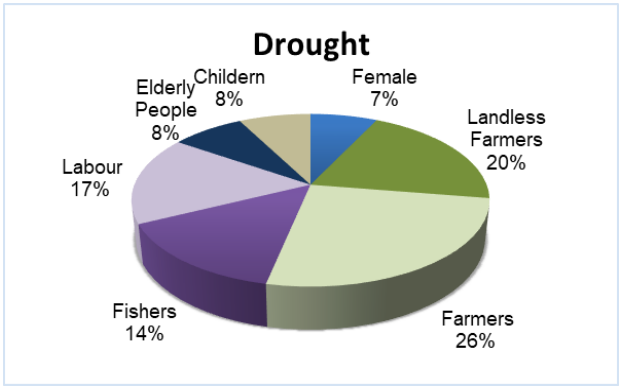
8.3.2 Vulnerability due to Hazards Occurrence

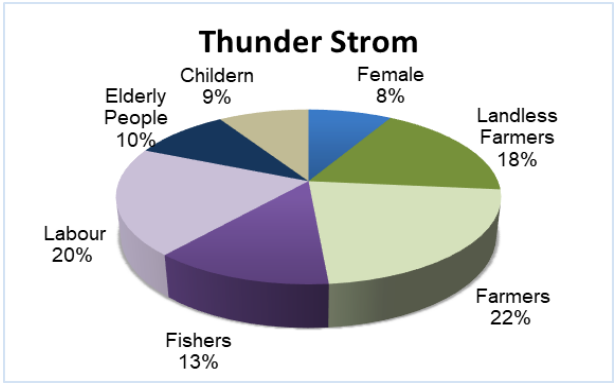
Community people have also identified vulnerable communities due to the climate change induced hazards occurrences. In most of the cases, they opined that farmers, landless farmers and laborers will be more vulnerable due to these hazards. According to the assessment, on an average, 26% respondents perceived that farmers will be the most vulnerable due to potential consequences of hazards, whereas 20% respondents voted on land less farmers, 16% for labourers and 15% for fishermen. Rest of respondents expressed that female, children and elderly people will be in a vulnerable position equally. Figure 8.4 represents the community perceptions on vulnerable groups of community due to climate change induced hazards.

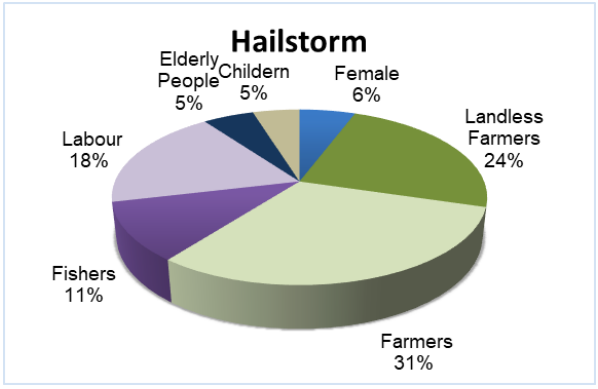












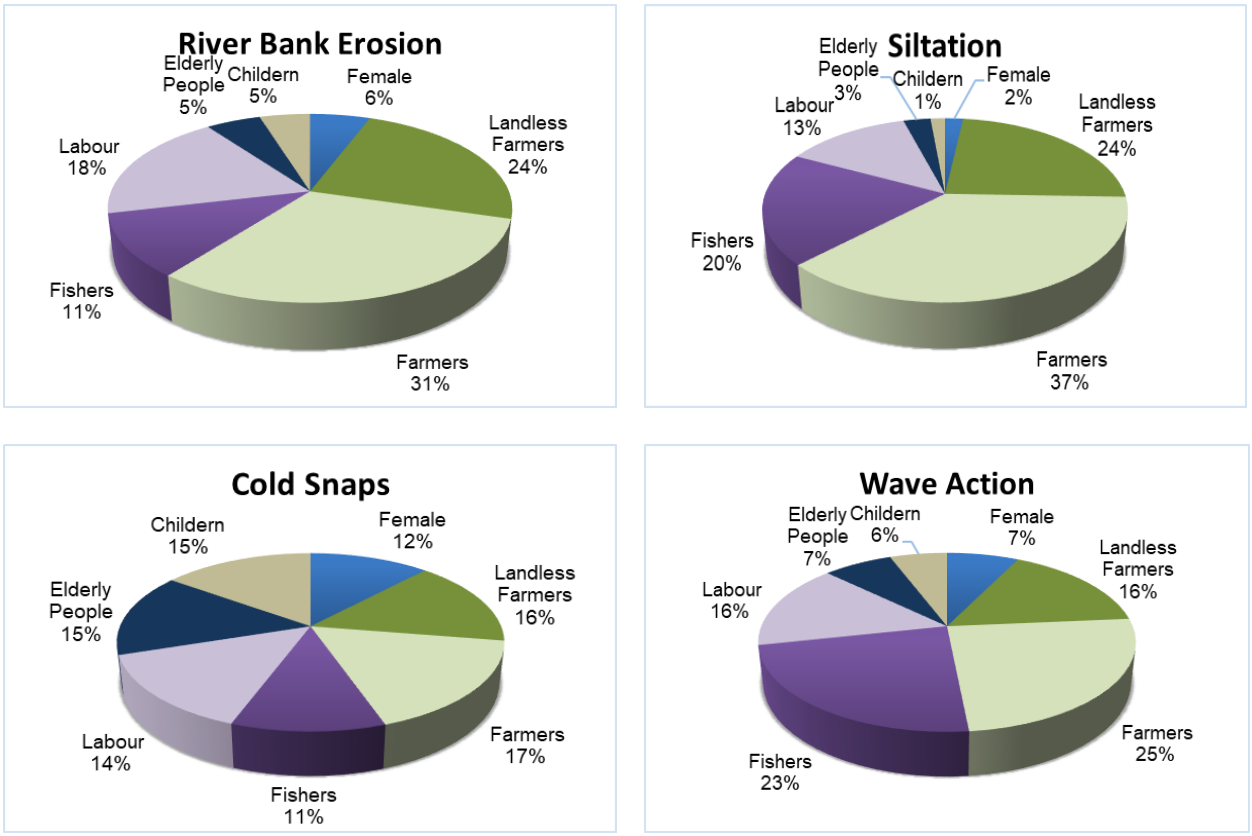
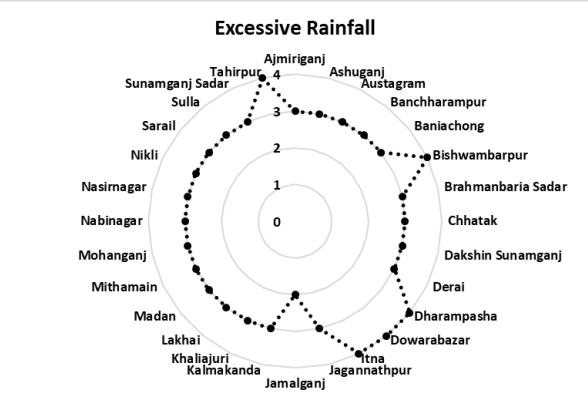


Figure 8.4: Community Perceptions on Vulnerability of Community People due to Climate Change Induced Hazards

8.4 Likelihood Assessment

Community people also assessed likelihood or probability of occurrences of different climate change induced hazards. Maximum respondents expressed that temperature rise is very frequent phenomena now and would be as usual in future, whereas excessive rainfall will occur once in 2 to 3 years. The frequency of the occurrence of early flash floods would be as excessive rainfall i.e. once in 2 to 3 years, as early flash floods is mostly triggered by excessive rainfall. Respondents from Nabinagar Upazilla of Brahmanbaria District only opined that there would be very less probability to occur early flash floods in that area. Thunderstorm and hailstorm are occurring damage very frequently i.e. almost every year according to the perceptions of community people, which will prevail in future also. Mixed feedback has been found regarding likelihood assessment of drought. Either once in every year or within 2 to 3 years, drought may occur as opined by the respondents equally for two scenarios. Erosion and siltation problem would be severe once in 2-3 years according to their perceptions. People of Sunamganj and Netrokona face severe wave action problem almost in every year than other parts of the study area. In other parts, frequency of occurrence has been perceived as once in 2 to 3 years. Likelihood of occurrence of cold snaps is found also as highly frequent, not very high.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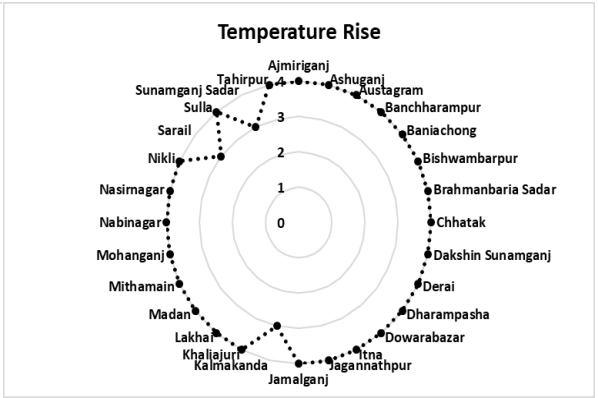
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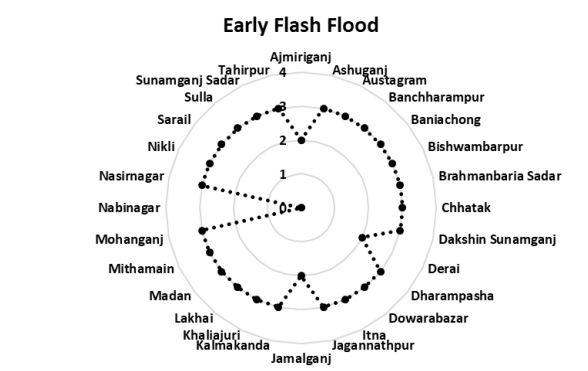
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Derai
Dharampasha
Dowarabazar
Itna
Jagannathpur
Jamalganj
Kalmakanda
Khaliajuri
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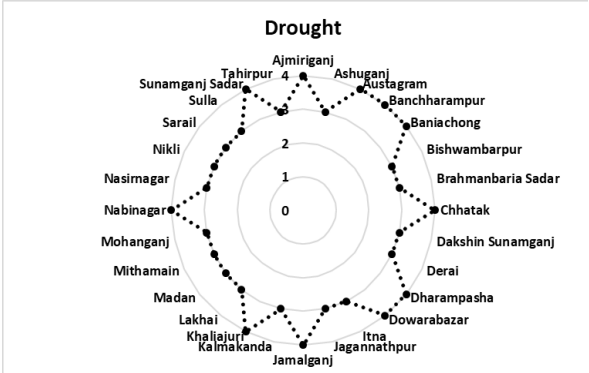
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Dharampasha
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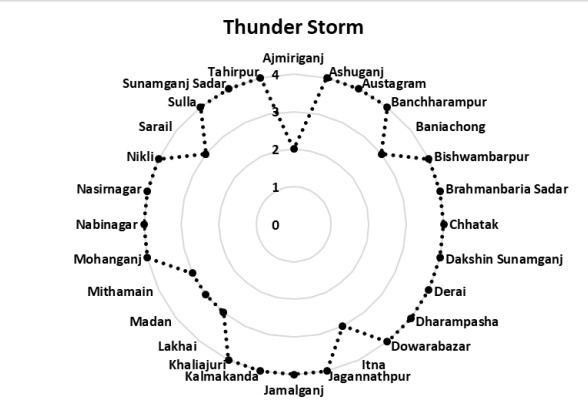
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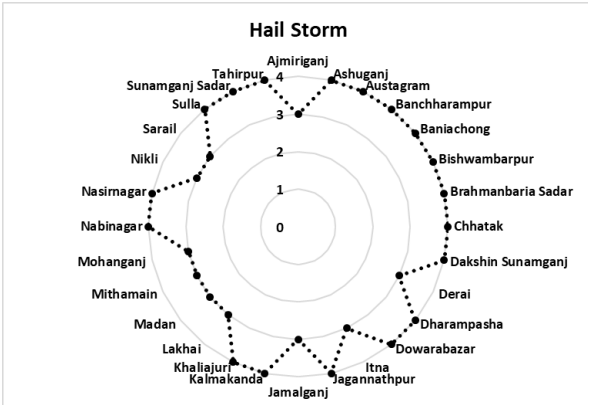
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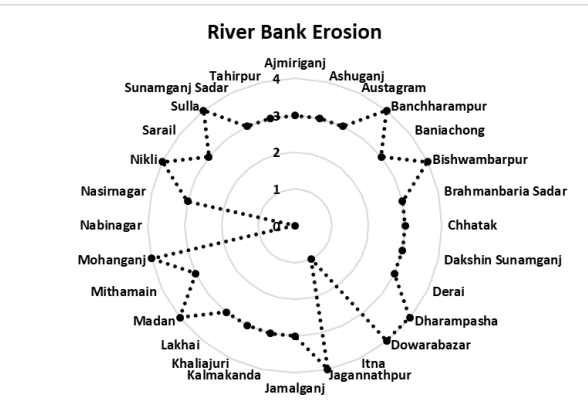
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Derai
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Dowarabazar
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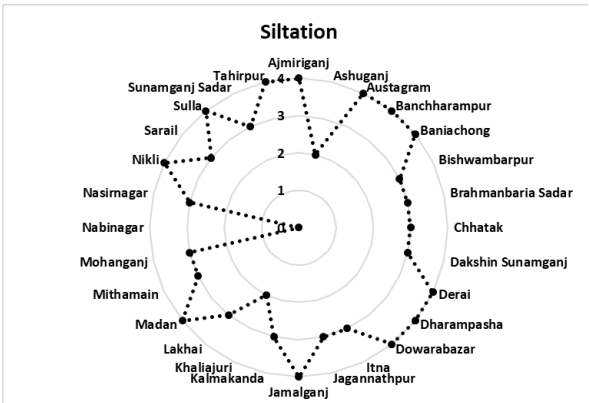
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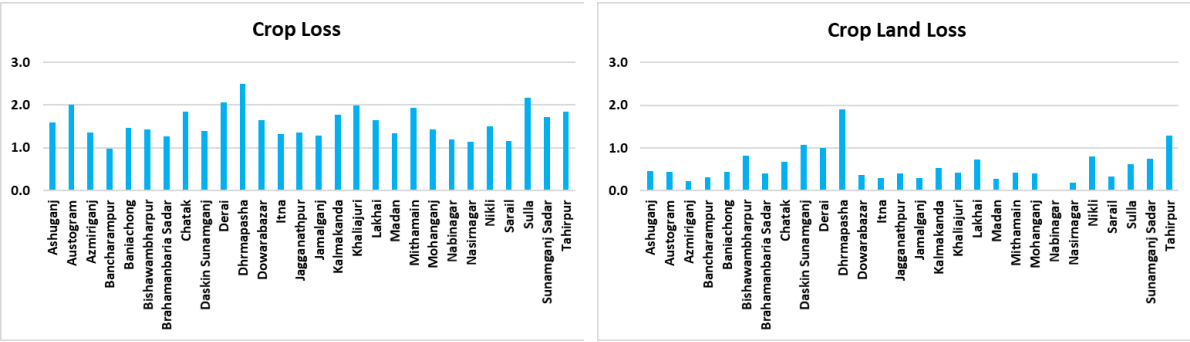
Figure 8.5: Community Perceptions on Likelihood or Probability of Occurrences of Climate Change induced Hazards

8.5 Assessment of Consequences

Potential consequences of climate change induced hazards have been perceived through the FGDs using simple scoring techniques. According to the assessment, most hazardous consequences would be the loss of crops as frequency of early flash floods is increasing and due to damage of crops before harvesting. As a result, the study area would face massive crop loss. Although, they did not anticipate massive crop land loss due to those hazards. Loss of households is the second most considered negative consequence which would occur in the study area. There are chances of loss of fish production too in a mild manner. Most interestingly, community people did not express major concerns over potential loss of income, which indicates that they are used to with the alternative livelihoods, if their main occupations were hampered. Apart from these, anticipations have been made on deterioration of drinking water quality, health issues and hampered education almost uniformly among all the Upazilla, but not severely as crop production loss. Following Figure 8.6 illustrates consequence scoring by the community people in the study area.



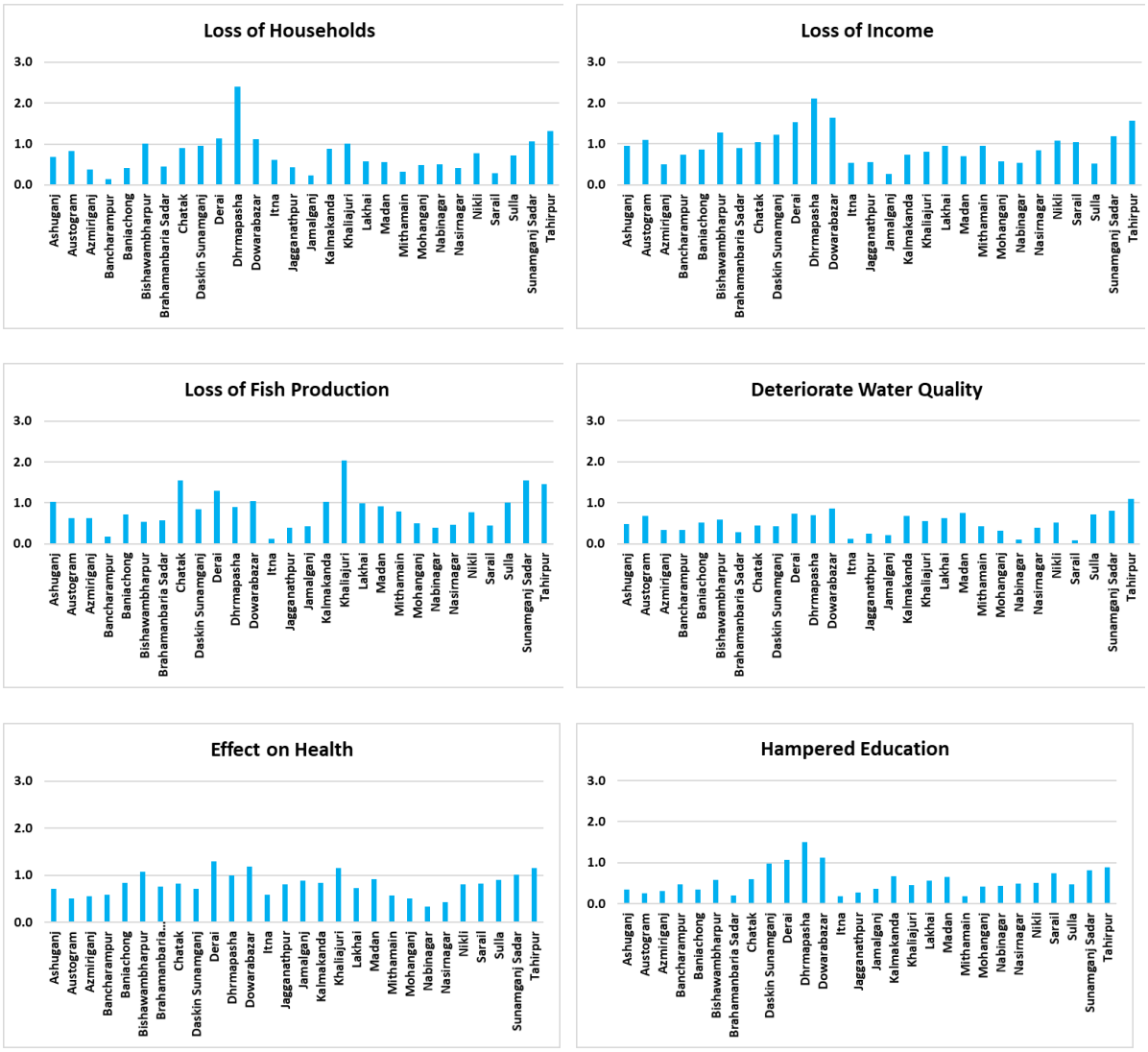


Figure 8.6: Community Perceptions on Potential Consequences of Climate Change induced Hazards

8.6 Risk Assessment and Prioritization

8.6.1 Risk due to Individual Hazard

Risk assessment has been performed multiplying probability and consequence scores derived from the community response data and normalizing the value using standard formula. After analysis, future risk due to each of the identified climate change induced hazards has been determined on the basis of estimated normalized score. Table 8.5 shows the normalized risk score for the 28 Upazillas of the study area for each of the climate change induced hazards. Figure 7-16 illustrates the climate change risk maps for individual hazards. Spatial variation of climate change risk has been presented in those maps using a three class risk level map. The results show that, Kalmakanda, Sunamganj Sadar, Dakshin Sunamganj, Dhamrapasha, Khaliajuri, Dowarabazar and Tahirpur are under high climate change risk due to early flash floods, whereas, Bishwambharpur, Jamalganj, Derai Upazillas are under medium risk level despite being located in the deeply flooded area. But the normalized scores for these upazillas are quite nearest to the lower threshold of the high risk level i.e. 0.7. Therefore, the risk map

shows the variation of risk level in a relative scale, which may vary on the basis of the context. Sometimes, the risk map due to individual hazard shows sudden or irregular changes in the risk level, which may be due to the variation of community perceptions and lack of homogeneity in the knowledge level of groups of community people. Albeit study team validated each and every individual hazard risk map comparing with secondary database available in different published literatures, reports and CEGIS own resources and found quite satisfactory outcome from the community-based risk maps.

Table 8.5: Risk Score for Individual Climate Change Induced Hazard

District	Upazilla	Temperature Rise	Excessive Rainfall	Early Flash Floods	Wave Action	Hailstorm	Coldsnap	Thunderstorm	Drought	River Bank Erosion	Siltation
Habiganj	Ajmiriganj	0.457	0.340	0.556	0.727	0.464	0.440	0.000	0.485	0.175	0.381
Brahamanbaria	Ashuganj	0.314	0.180	0.222	0.273	0.357	0.400	0.324	0.697	0.400	0.381
Kishoreganj	Austagram	0.657	0.260	0.370	0.545	0.429	0.280	0.235	1.000	0.400	0.571
Brahamanbaria	Banchharampur	0.000	0.000	0.093	0.000	0.286	0.000	0.412	0.515	0.000	0.048
Habiganj	Baniachong	0.486	0.600	0.389	0.545	0.357	0.800	0.206	0.515	0.000	0.286
Sunamganj	Bishwambarpur	0.771	0.740	0.685	0.795	0.857	0.440	0.824	0.485	0.400	0.619
Brahamanbaria	Brahmanbaria Sadar	0.400	0.220	0.185	0.386	0.000	0.640	0.588	0.424	0.050	0.000
Sunamganj	Chhatak	0.857	0.900	0.630	0.432	0.964	1.000	1.000	0.485	0.350	0.381
Sunamganj	Dakshin Sunamganj	0.771	0.720	1.000	0.841	0.857	0.560	0.647	0.182	0.250	0.429
Sunamganj	Derai	0.829	0.580	0.648	1.000	0.536	0.520	0.647	0.667	0.650	0.667
Sunamganj	Dharampasha	0.657	1.000	0.741	0.795	1.000	0.200	0.941	0.394	1.000	1.000
Sunamganj	Dowarabazar	0.800	0.780	0.759	0.682	0.964	0.680	0.941	0.758	0.500	0.429
Kishoreganj	Itna	0.457	0.220	0.685	0.795	0.429	0.560	0.206	0.303	0.625	0.619
Sunamganj	Jagannathpur	1.000	0.860	0.593	0.432	0.536	0.880	0.324	0.000	0.625	0.429
Sunamganj	Jamalganj	0.829	0.740	0.685	0.818	0.786	0.480	0.882	0.152	0.175	0.476
Netrakona	Kalmakanda	0.514	0.520	0.704	0.409	0.786	0.120	0.765	0.152	0.375	0.381
Netrakona	Khaliajuri	0.514	0.680	0.778	0.932	0.679	0.080	1.000	0.485	0.475	0.429
Habiganj	Lakhai	0.657	0.360	0.333	0.477	0.393	0.760	0.176	0.515	0.225	0.381
Netrakona	Madan	0.429	0.160	0.648	0.614	0.643	0.320	0.353	0.394	0.025	0.190
Kishoreganj	Mithamain	0.429	0.220	0.519	0.705	0.464	0.280	0.059	0.576	0.700	0.571
Netrakona	Mohanganj	0.486	0.480	0.667	0.818	0.571	0.160	0.235	0.303	0.325	0.429
Brahamanbaria	Nabinagar	0.000	0.140	0.000	0.000	0.357	0.240	0.029	0.152	0.000	0.000
Brahamanbaria	Nasirnagar	0.029	0.060	0.222	0.432	0.286	0.480	0.529	0.152	0.100	0.286
Kishoreganj	Nikli	0.571	0.240	0.537	0.614	0.429	0.360	0.118	0.424	0.700	0.667
Brahamanbaria	Sarail	0.000	0.180	0.185	0.364	0.000	0.600	0.147	0.394	0.100	0.333
Sunamganj	Sulla	0.714	0.420	0.685	0.795	0.571	0.600	0.794	0.424	0.625	0.524
Sunamganj	Sunamganj Sadar	0.943	0.800	0.815	0.864	0.750	0.520	0.912	0.727	0.325	0.619

District	Upazilla	Temperature Rise	Excessive Rainfall	Early Flash Floods	Wave Action	Hailstorm	Coldsnap	Thunderstorm	Drought	River Bank Erosion	Siltation
Sunamganj	Tahirpur	0.800	0.940	0.815	0.864	0.750	0.440	0.912	0.455	0.325	0.810

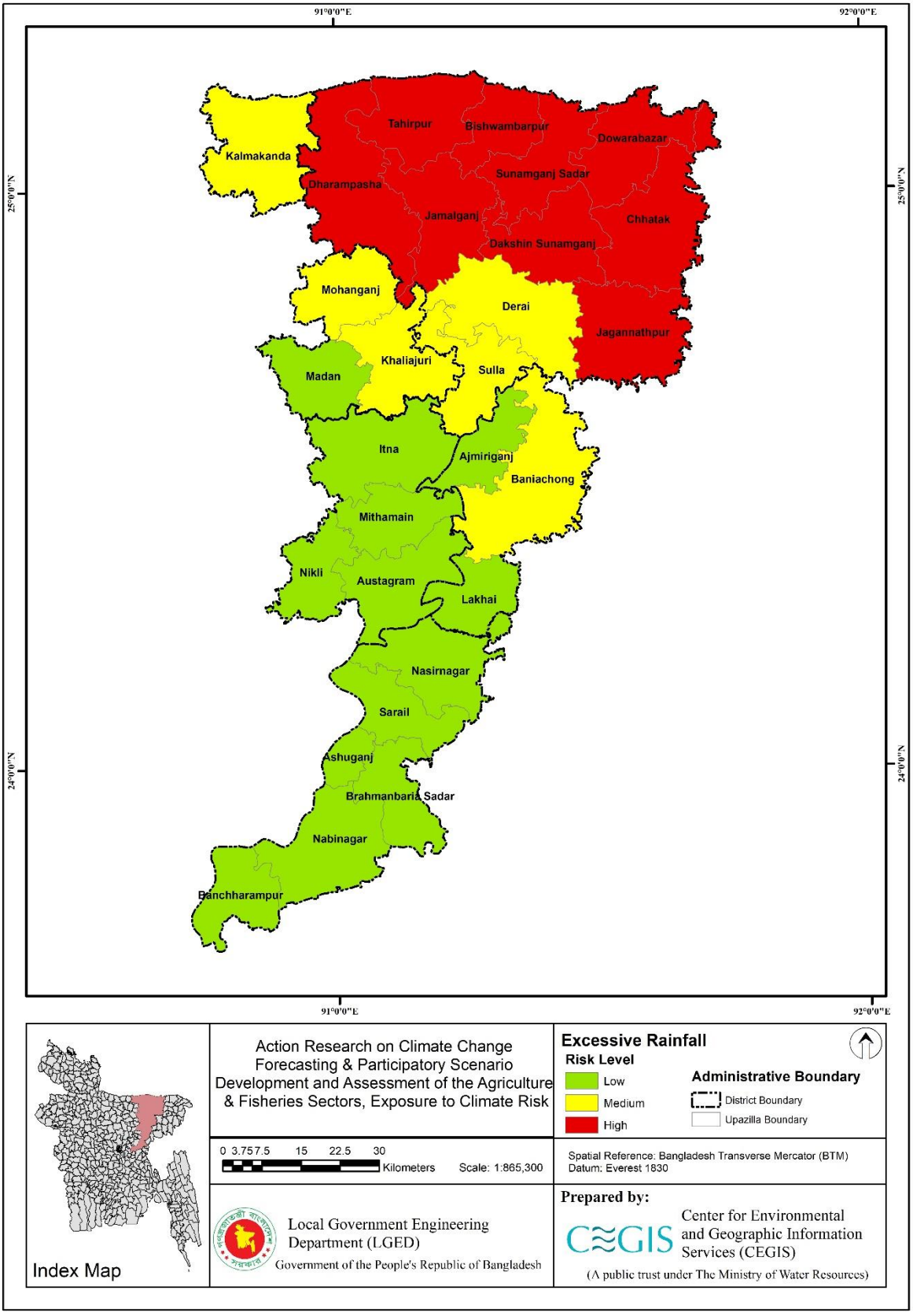


Figure 8.7: Climate Change Risk (Excessive Rainfall) of the Study Area

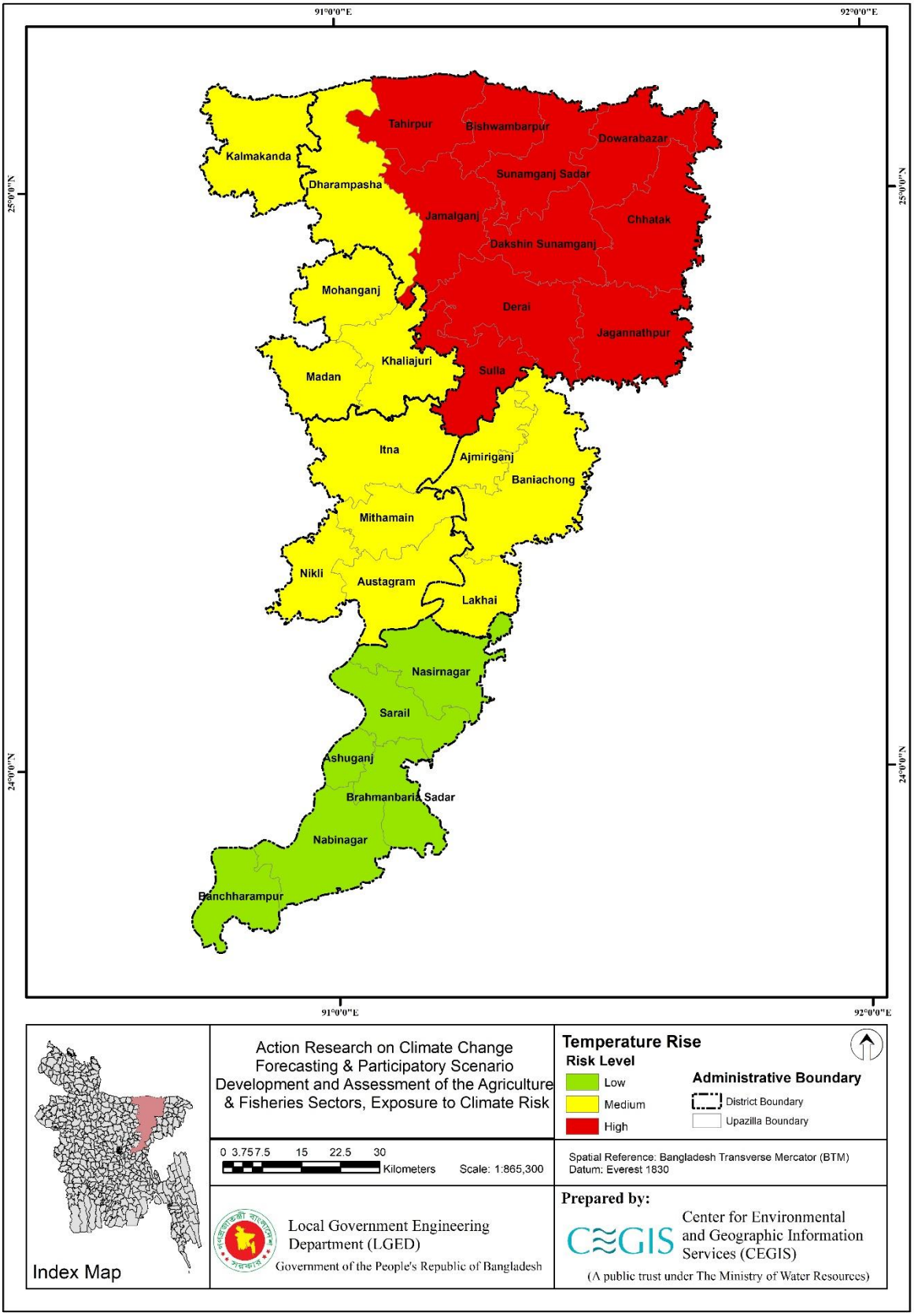


Figure 8.8: Climate Change Risk (Temperature Rise) of the Study Area

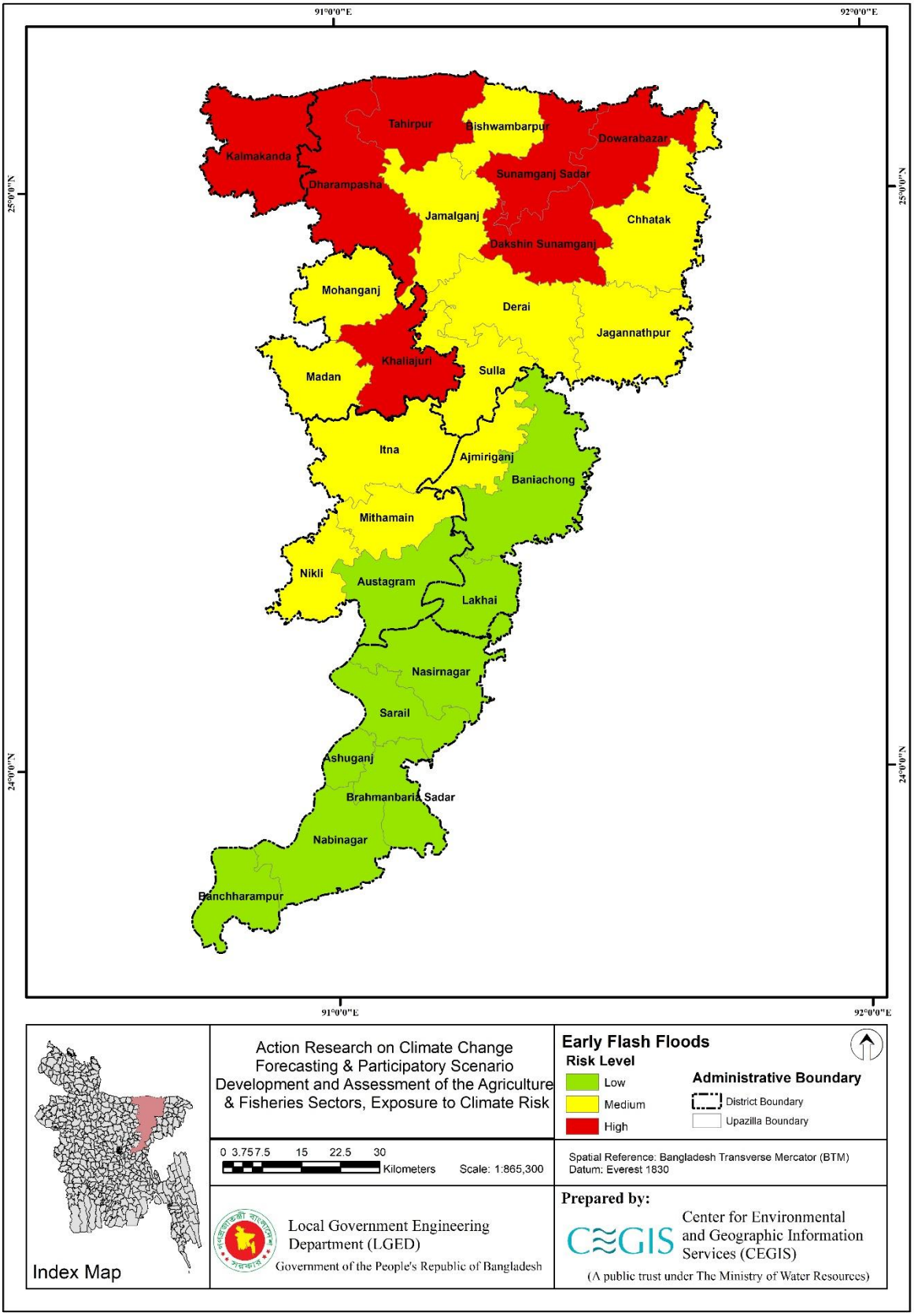


Figure 8.9: Climate Change Risk (Early Flash Floods) of the Study Area

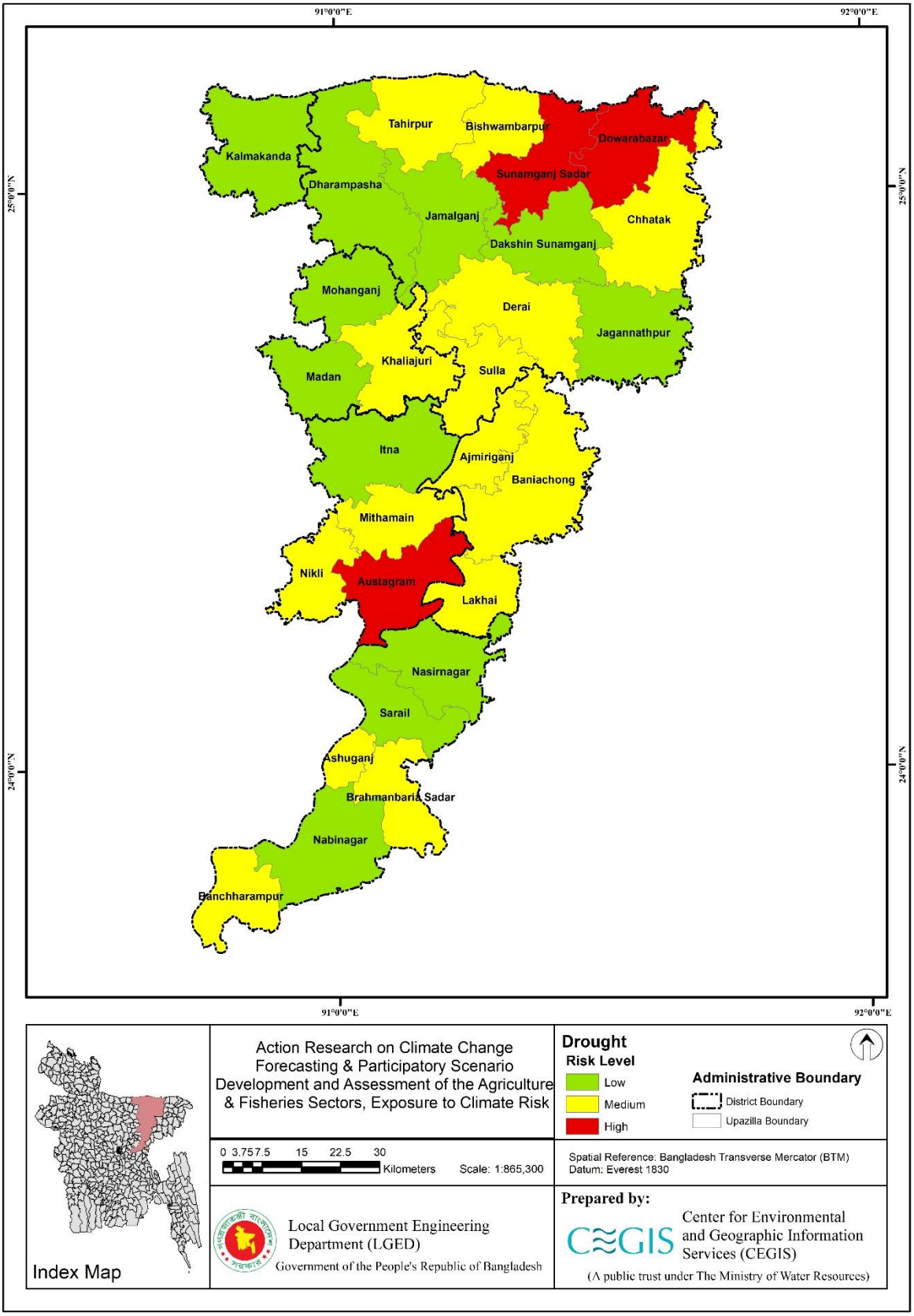


Figure 8.10: Climate Change Risk (Drought) of the Study Area

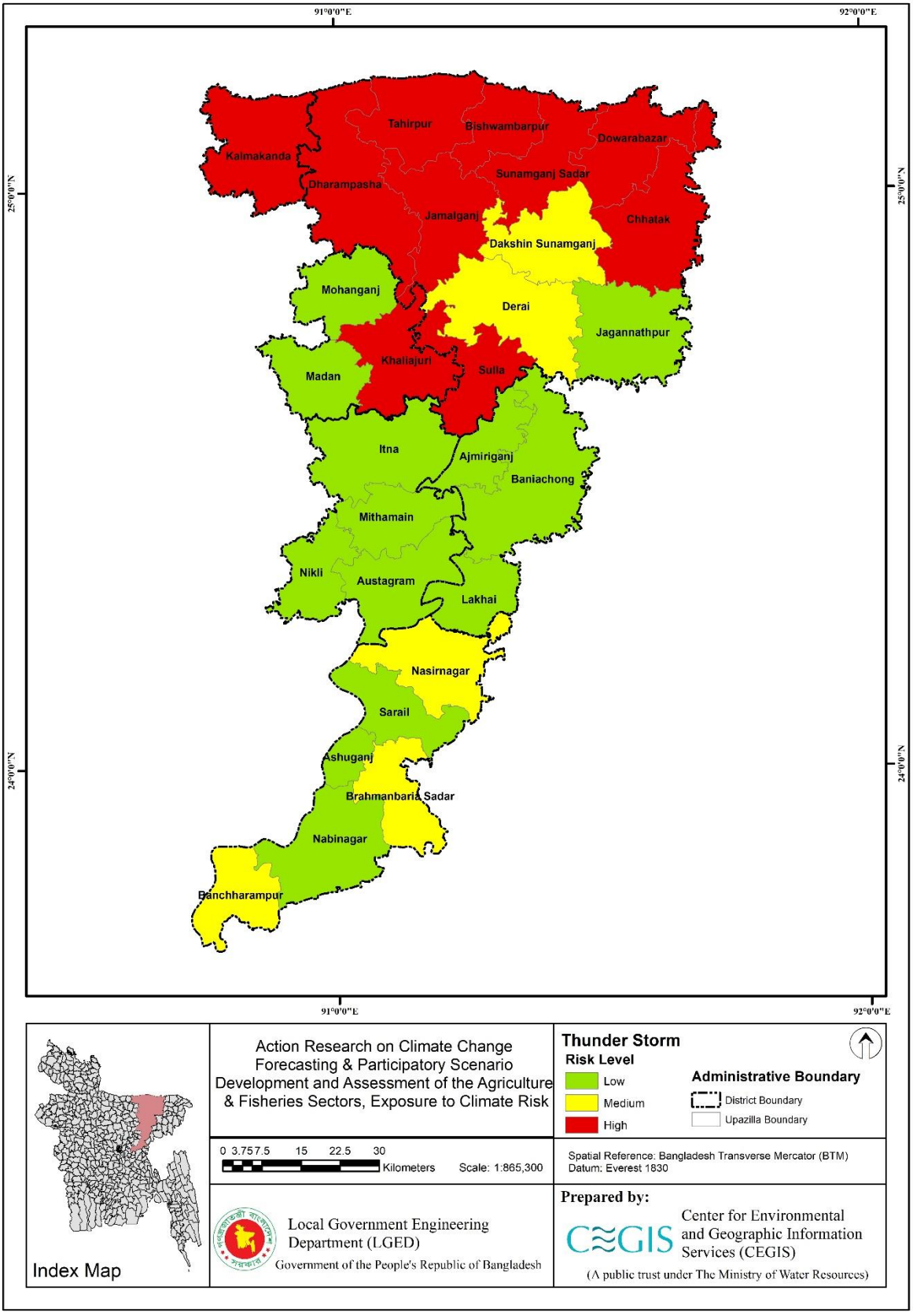


Figure 8.11: Climate Change Risk (Thunder Storm) of the Study Area

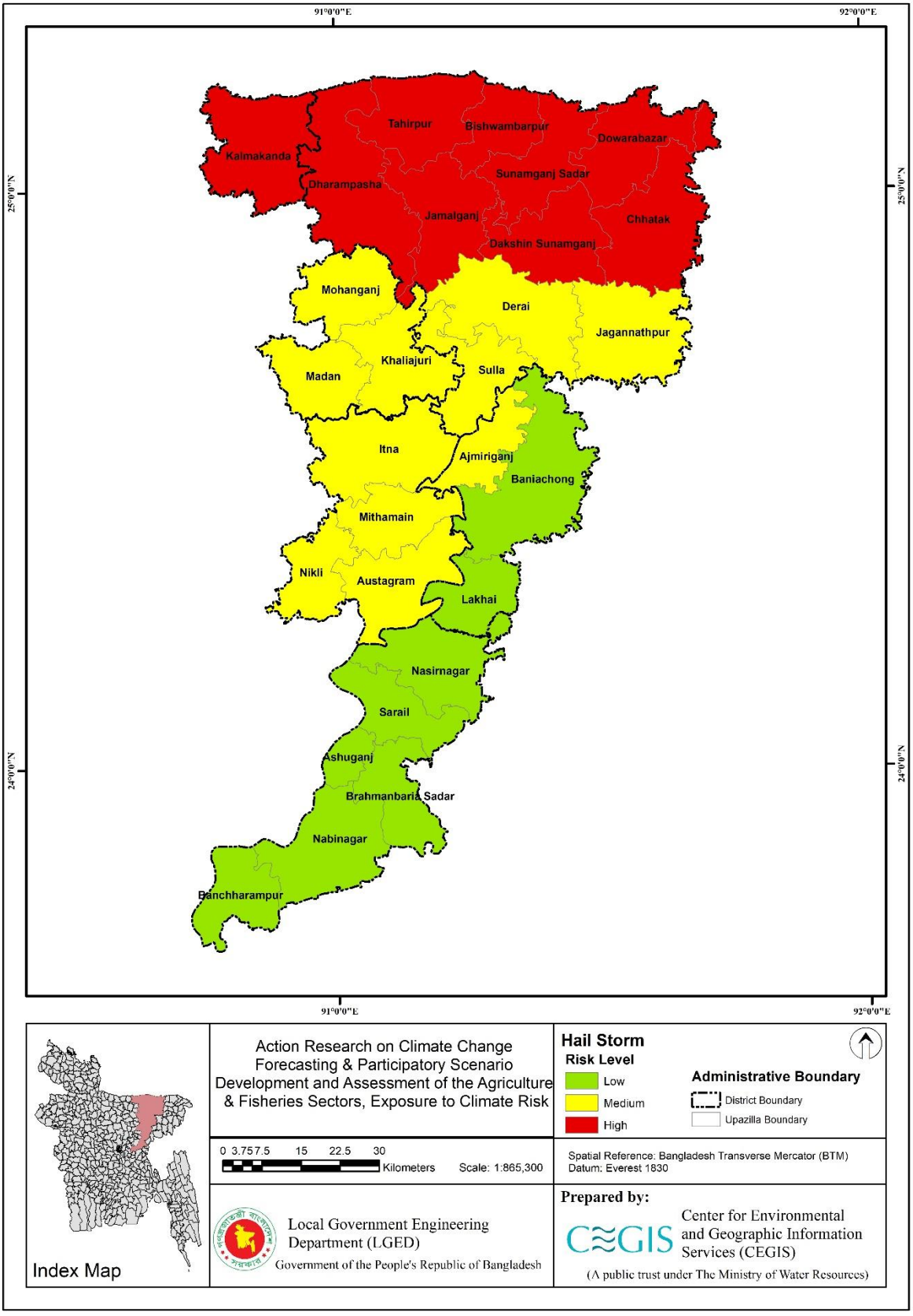


Figure 8.12: Climate Change Risk (Hail Storm) of the Study Area

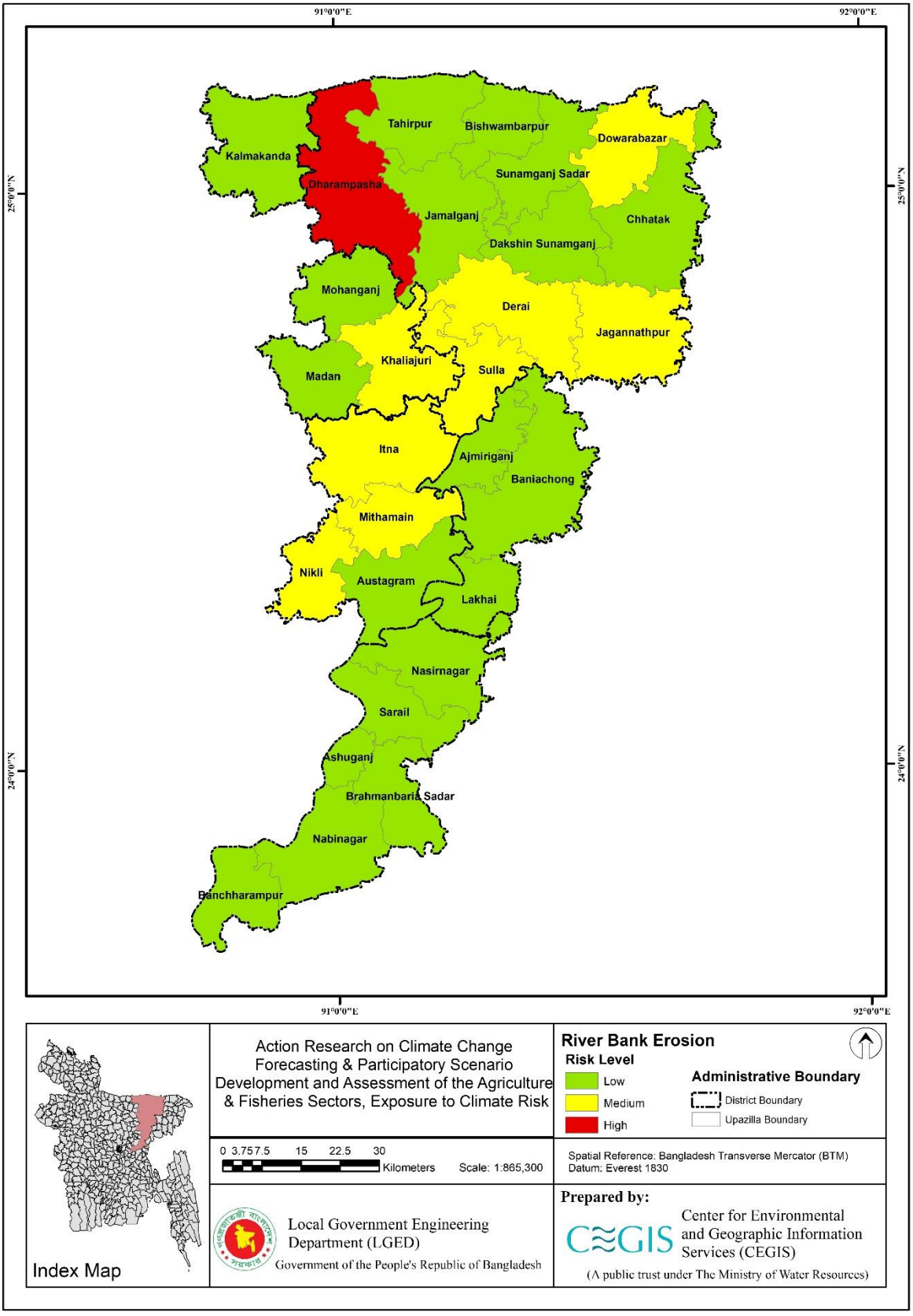


Figure 8.13: Climate Change Risk (River Bank Erosion) of the Study Area

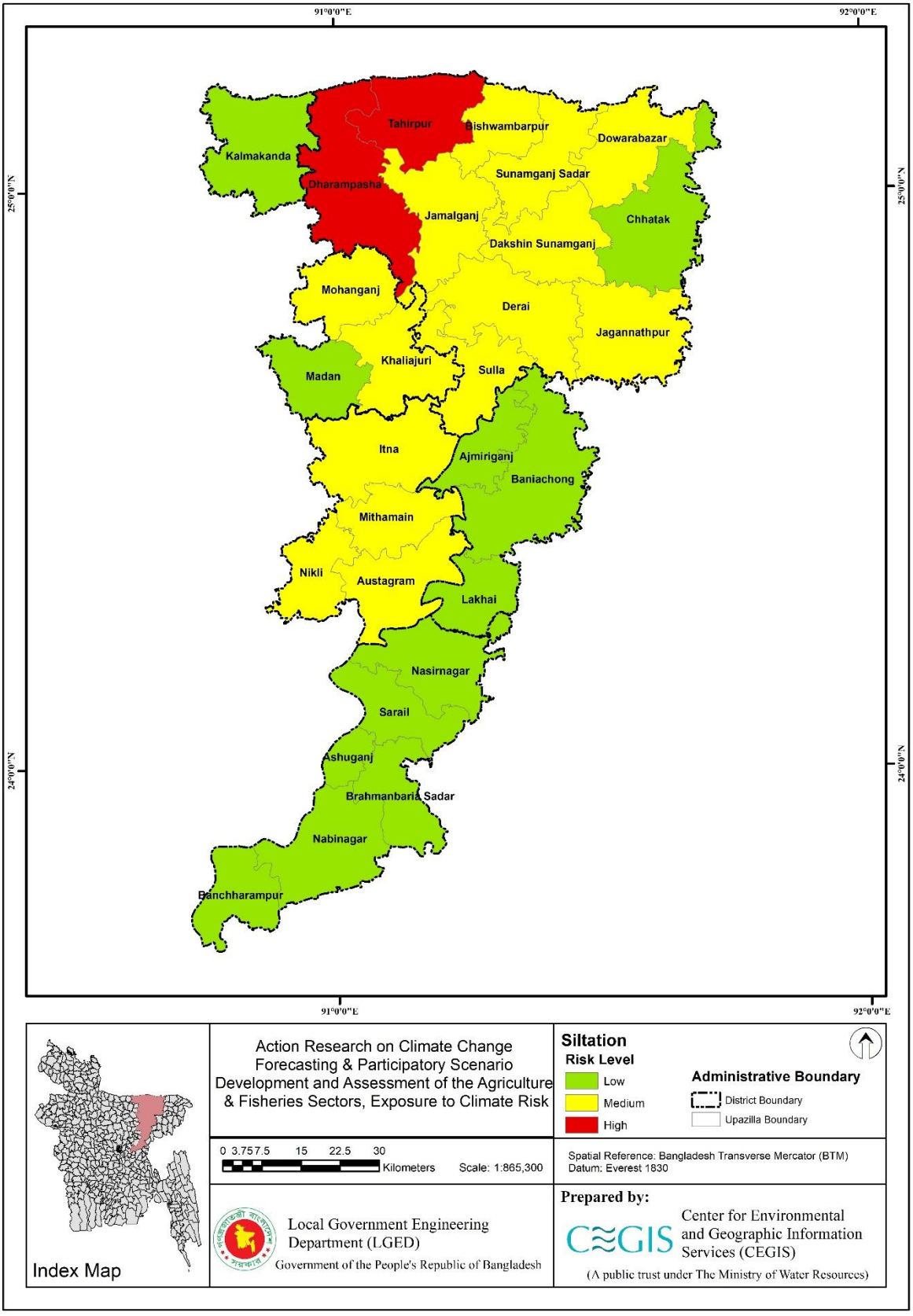


Figure 8.14: Climate Change Risk (Siltation) of the Study Area

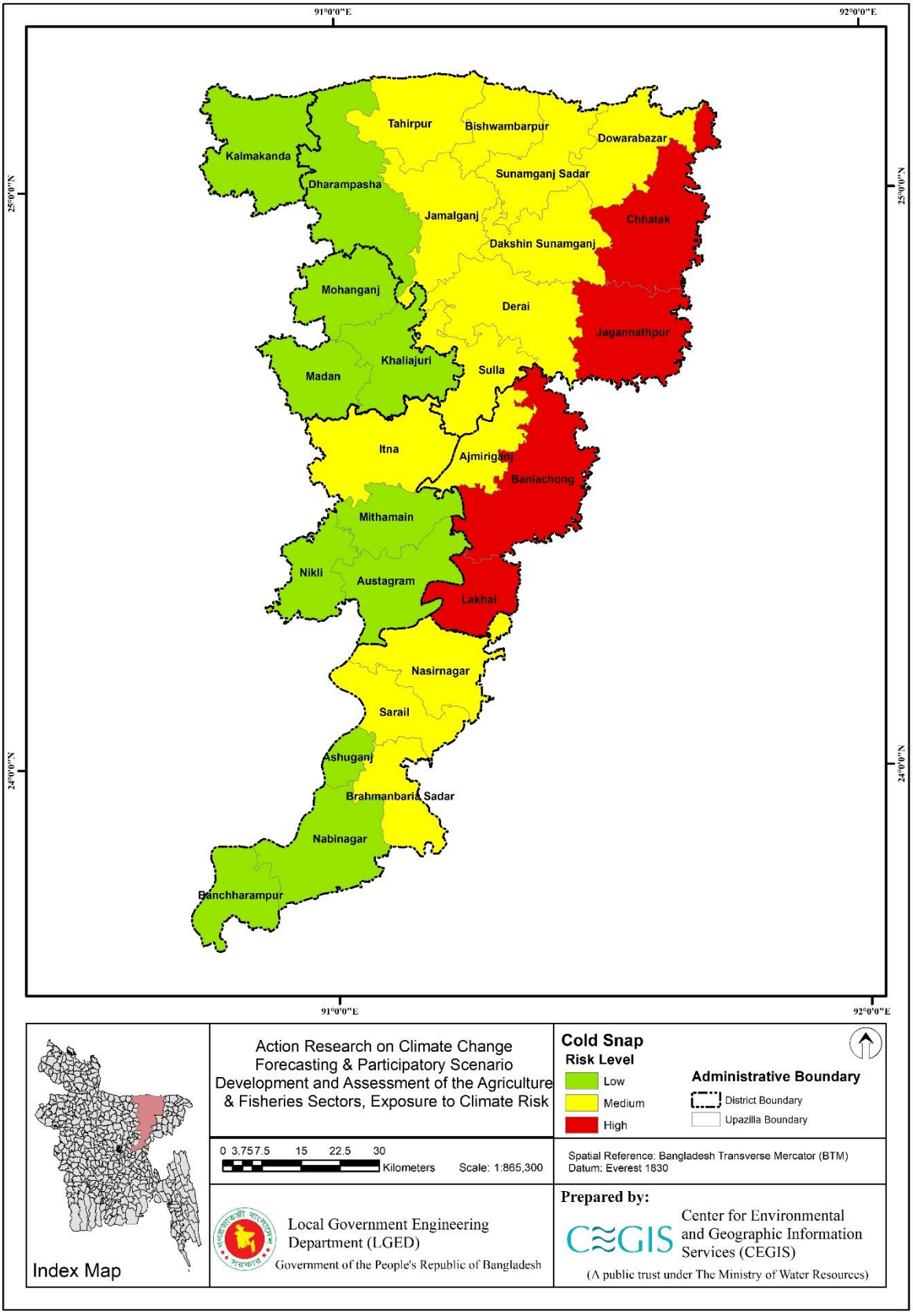


Figure 8.15: Climate Change Risk (Cold Snap) of the Study Area

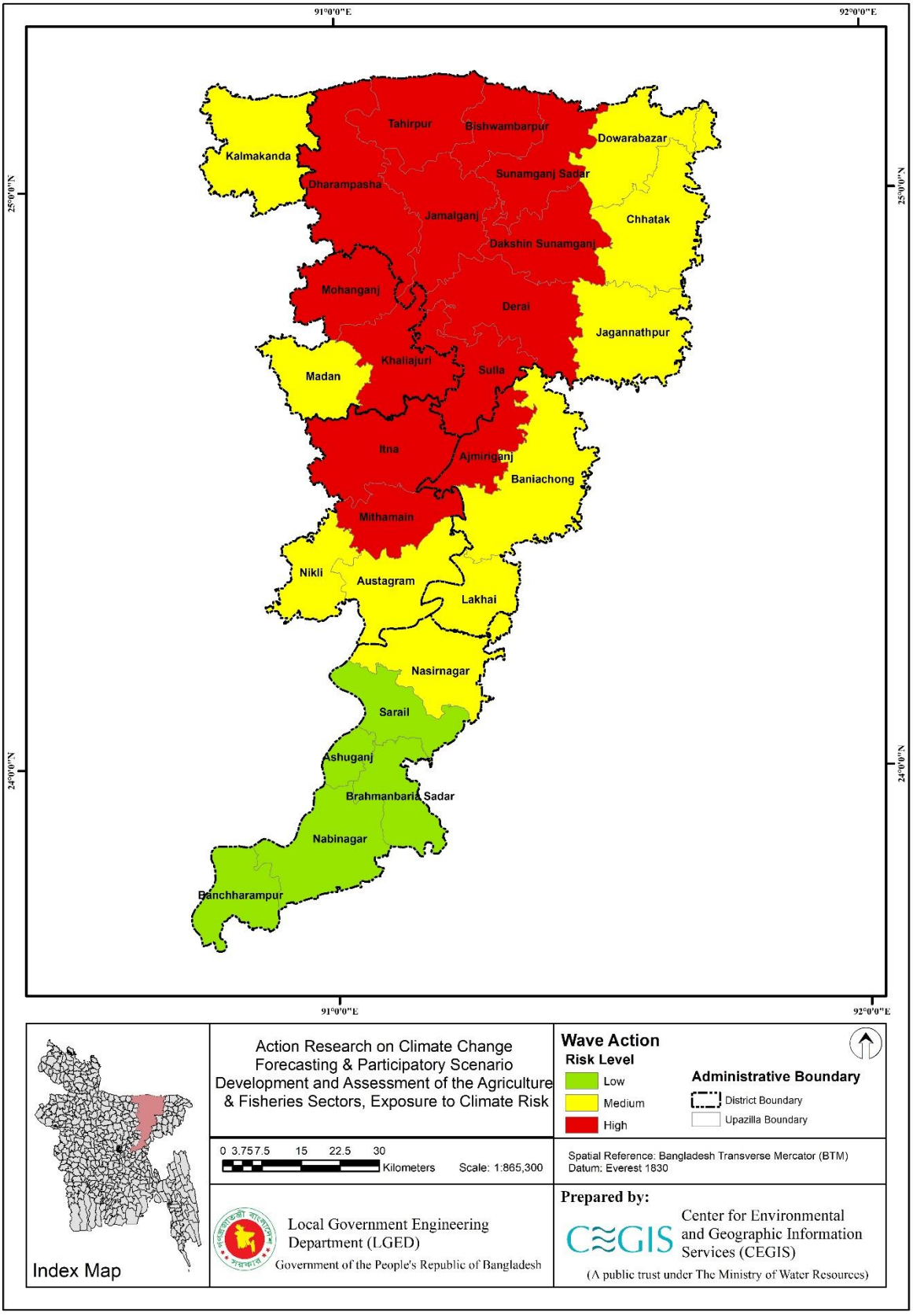


Figure 8.16: Climate Change Risk (Wave Action) of the Study Area

8.6.2 Risk due to Multi-Hazard and Prioritization

Sperate climate change risk maps for individual hazards might create ambiguity among decision makers, during taking any adaptation plan holistically. Therefore, multi-hazard risk maps have been prepared taking weighted sum of the normalized score of each hazard for each Upazilla. The weight for multi-hazards has been derived from the Focused Group Discussions (FGDs). According to the community preferences, early flash floods and drought both got highest 12% weightage as the study area might face early flash flood very frequently, 11% weightage for temperature rise, hail storm and thunder storm as these three hazardous events are evidently increasing their frequency and intensity. Community people has given less emphasis (8% weightage) on river bank erosion and wave action among all identified climate change induced hazards. Total weightage has been counted in a scale of 100. Based on this information, the multi-hazard weighted sum of normalized scores has been calculated for each of the 28 Upazillas considering same combination of weights for each Upazilla. Finally, multi-hazard climate change risk map has been produced from the calculated total normalized score. Figure 8.18 shows the multi-hazard climate change risk map for the study area. As the developed multi-hazard risk map has been found very consistent with the expert judgment, the weights derived from the community has been used as it is.

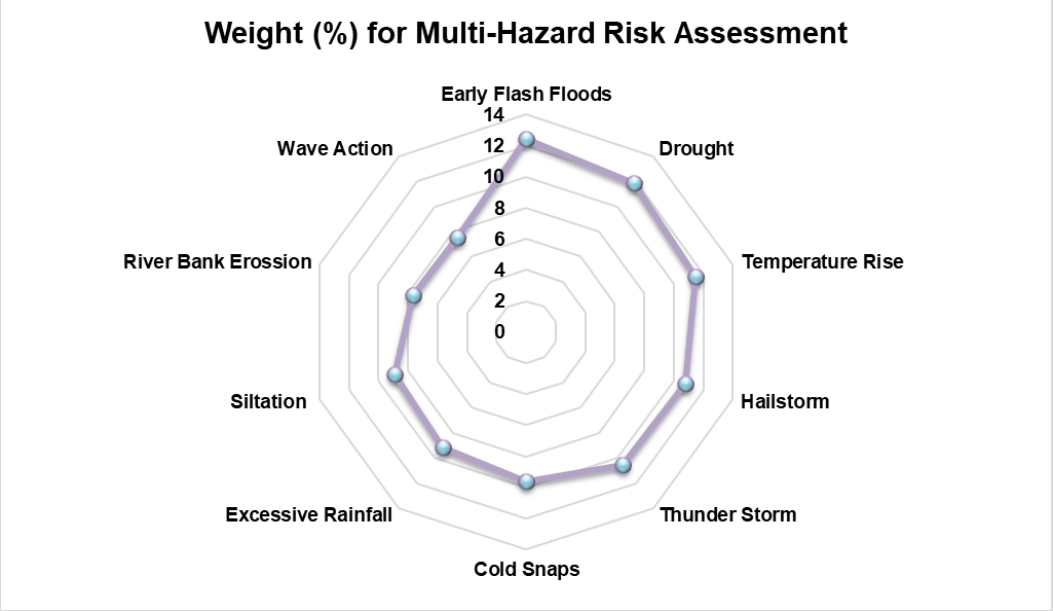


Figure 8.17: Weight Derived from Community People for Multi-Hazard Risk Assessment

According to the multi-hazard risk map, 12 upazillas has been found under high risk level, 11 Upazillas under medium risk and 5 Upazillas under low risk level. Mostly, north-eastern Upazillas are found under high risk level. A priority rank of the Upazillas has been prepared using the calculated normalized score. Among all Upazillas, those of Sunamganj District and one Upazilla from Netrokona District are considered as high priority in terms of multi-hazard climate change risk in the study area, whereas, first three priority Upazillas are Dharmapasha, Dowarabazar and Sunamganj Sadar. Table 8.6 represents the priority ranking of the 28 Upazillas of the study area in terms of climate change induced multi-hazard risk.

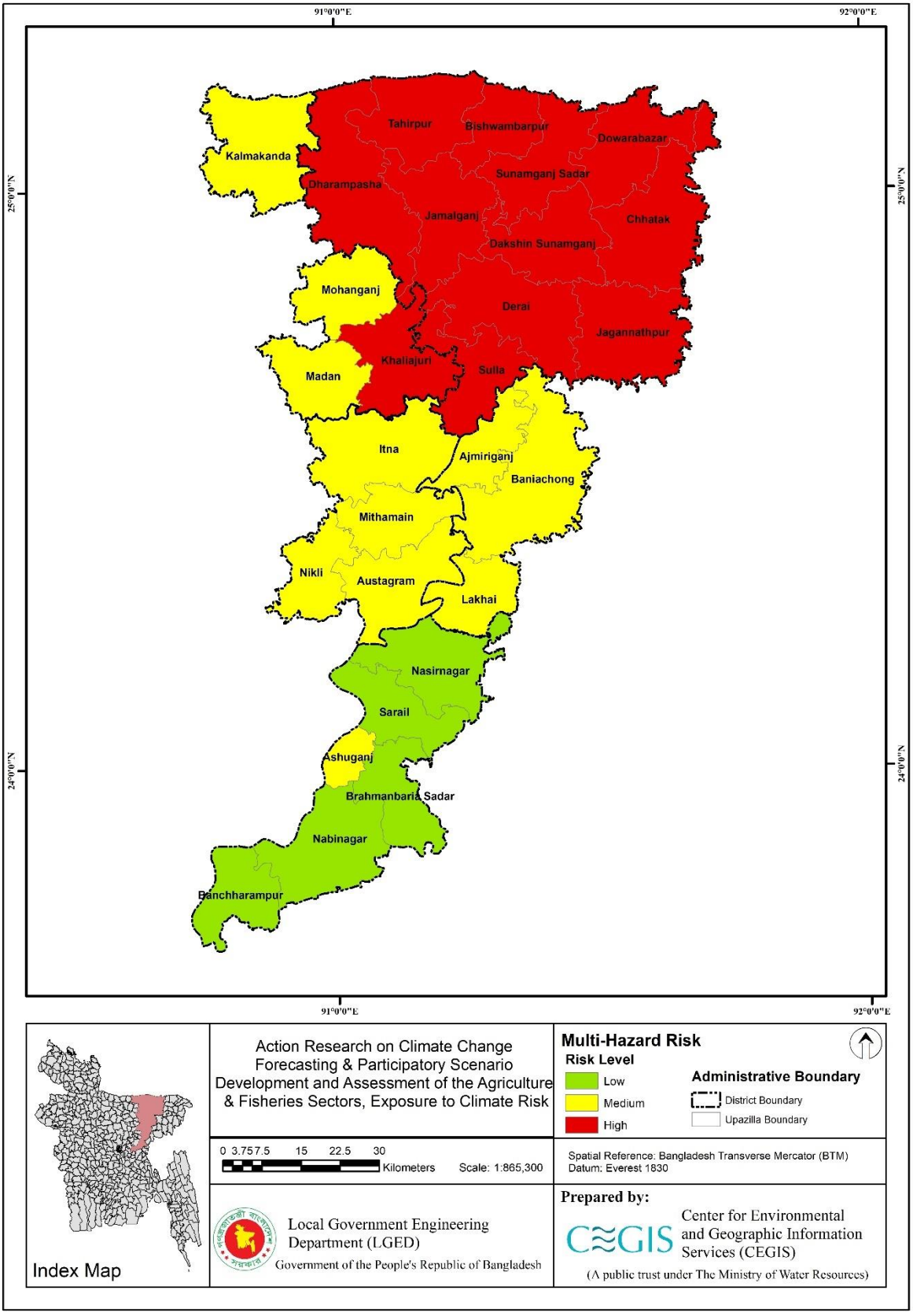


Figure 8.18: Climate Change Risk for Multi-Hazards

Table 8.6: Prioritization of the 28 Upazillas According to Multi-Hazard Climate Change Risk

District	Upazilla	Normalized Score	Risk Level	Rank
Sunamganj	Dharampasha	1.000	High	1
Sunamganj	Dowarabazar	0.978	High	2
Sunamganj	Sunamganj Sadar	0.971	High	3
Sunamganj	Chhatak	0.933	High	4
Sunamganj	Tahirpur	0.931	High	5
Sunamganj	Derai	0.867	High	6
Sunamganj	Bishwambarpur	0.860	High	7
Sunamganj	Dakshin Sunamganj	0.812	High	8
Sunamganj	Sulla	0.782	High	9
Sunamganj	Jamalganj	0.768	High	10
Netrakona	Khaliajuri	0.768	High	11
Sunamganj	Jagannathpur	0.704	High	12
Kishoreganj	Austagram	0.590	Medium	13
Kishoreganj	Itna	0.584	Medium	14
Netrakona	Kalmakanda	0.578	Medium	15
Kishoreganj	Nikli	0.550	Medium	16
Kishoreganj	Mithamain	0.531	Medium	17
Netrakona	Mohanganj	0.529	Medium	18
Habiganj	Lakhai	0.511	Medium	19
Habiganj	Baniachong	0.498	Medium	20
Habiganj	Ajmiriganj	0.471	Medium	21
Netrakona	Madan	0.449	Medium	22
Brahamanbaria	Ashuganj	0.400	Medium	23
Brahamanbaria	Brahmanbaria Sadar	0.300	Low	24
Brahamanbaria	Nasirnagar	0.238	Low	25
Brahamanbaria	Sarail	0.198	Low	26
Brahamanbaria	Banchharampur	0.080	Low	27
Brahamanbaria	Nabinagar	0.000	Low	28

8.7 Elements at Risk

The information on elements at risk is the most important thing to know, once the multi-hazard risk map has been prepared. The multi-hazard risk map may give ideas of spatial variation of risk at macro level or a broad area which are under high risk. But if the high risk zone did not contain any significant quantity of elements at risk, then the investment on the basis of the risk map only can cause a failure or loss of financial resources. Therefore, study team tries to identify most important elements which may face risk due to climate change induced hazards. Elements at risk for the study area has been identified using the community perceptions i.e. socio-economic context analysed from household survey results under this study as well as from the Haor Master Plan (2012) and DBHWD (2017). As, socio-economic resources and infrastructures will be worst affected due to the climate change induced hazards, which are also directly linked with life and livelihood of the community people, most of the elements are identified from these categories. Apart from that, perennial beels and fish sanctuaries have been considered as elements at risk due to the particular focus of this study on agriculture and fisheries sector. The submersible embankments by BWDB or LGED both are very crucial for the study area in connection with crop production as well as maintaining communication or connectivity with other parts of the country, therefore, roads, embankment and rail networks are also considered under elements at risk. In total 14 categories of elements at risk has been identified which are as following:

- Settlement
- Health Facilities (Community Clinic, Hospital, Family Welfare Center)
- Educational Institutes (Primary School, High School, College, Madrasah, University)
- Growth Center
- Godown
- Ghats
- Rural Market
- Other Key Infrastructures (Mosque, Post Office, Police Stations etc.)
- Embankment of BWDB
- Beels
- Fish Sanctuaries
- LGED Roads
- RHD Roads
- Rail Network

Density of these elements of risk has been analysed using spatial analyst extension of ArcGIS to identify which part of the study area has most densely populated elements at risk. These analyses have facilitated further to identify hotspot risk areas in the study area. Figure 8.19 to Figure 8.36 illustrate spatially varied density of elements at risk in the study area. The density analysis has been performed using line density and dot density tools of ArcGIS and resulted in raster layers having 50m pixel size.

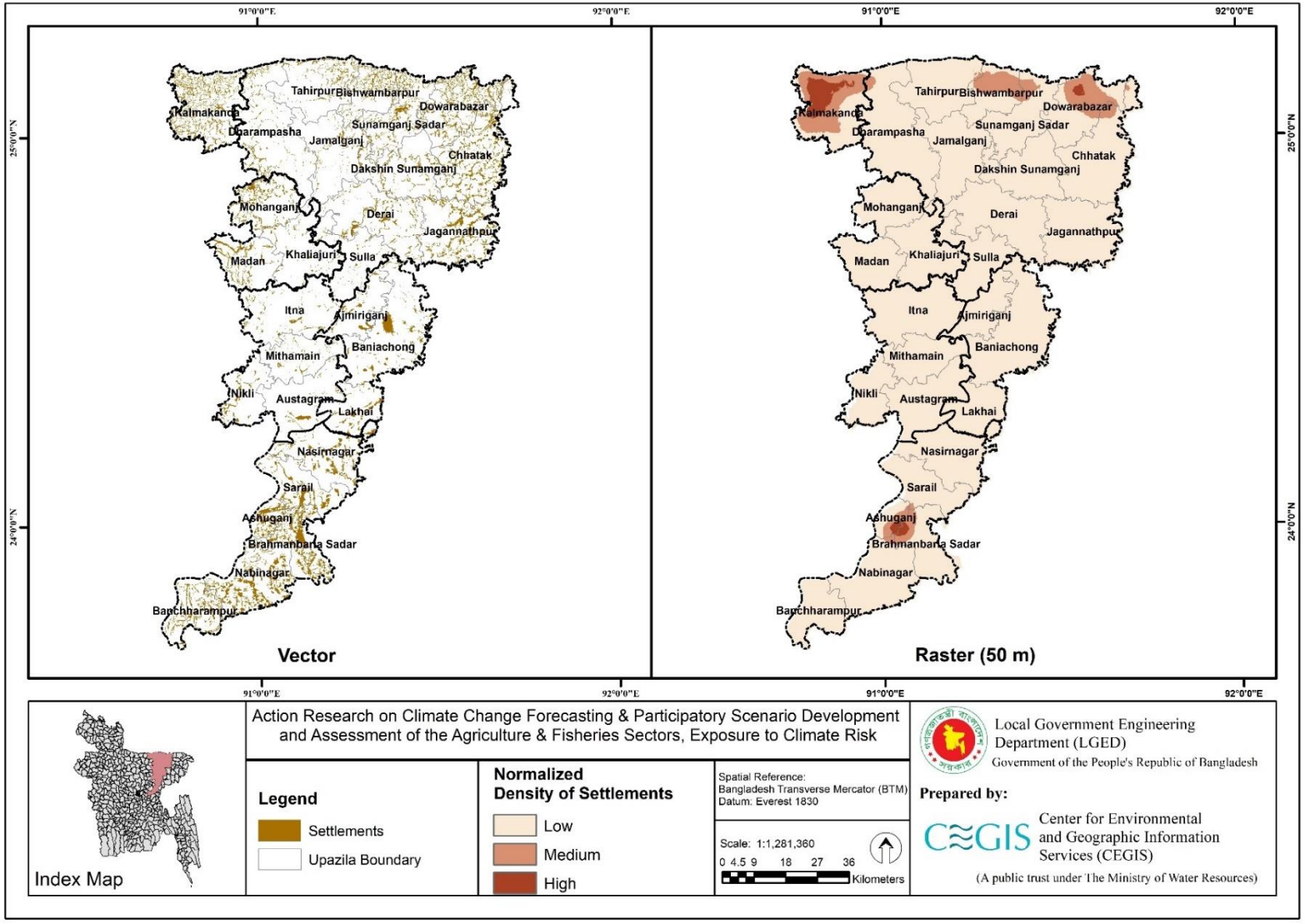


Figure 8.19: Elements at Risk (Settlements) in the Study Area

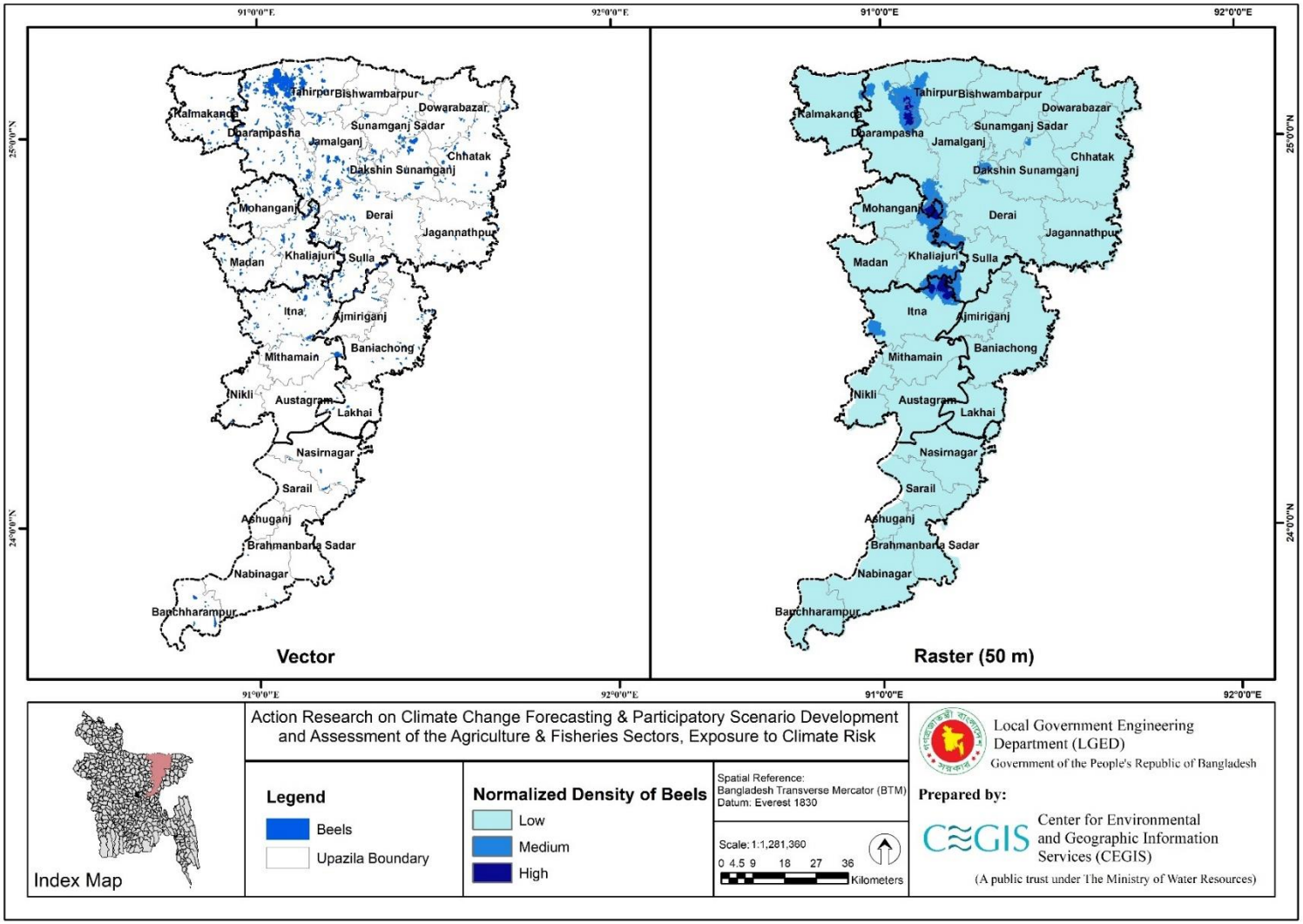


Figure 8.20: Elements at Risk (Perennial Beels) in the Study Area

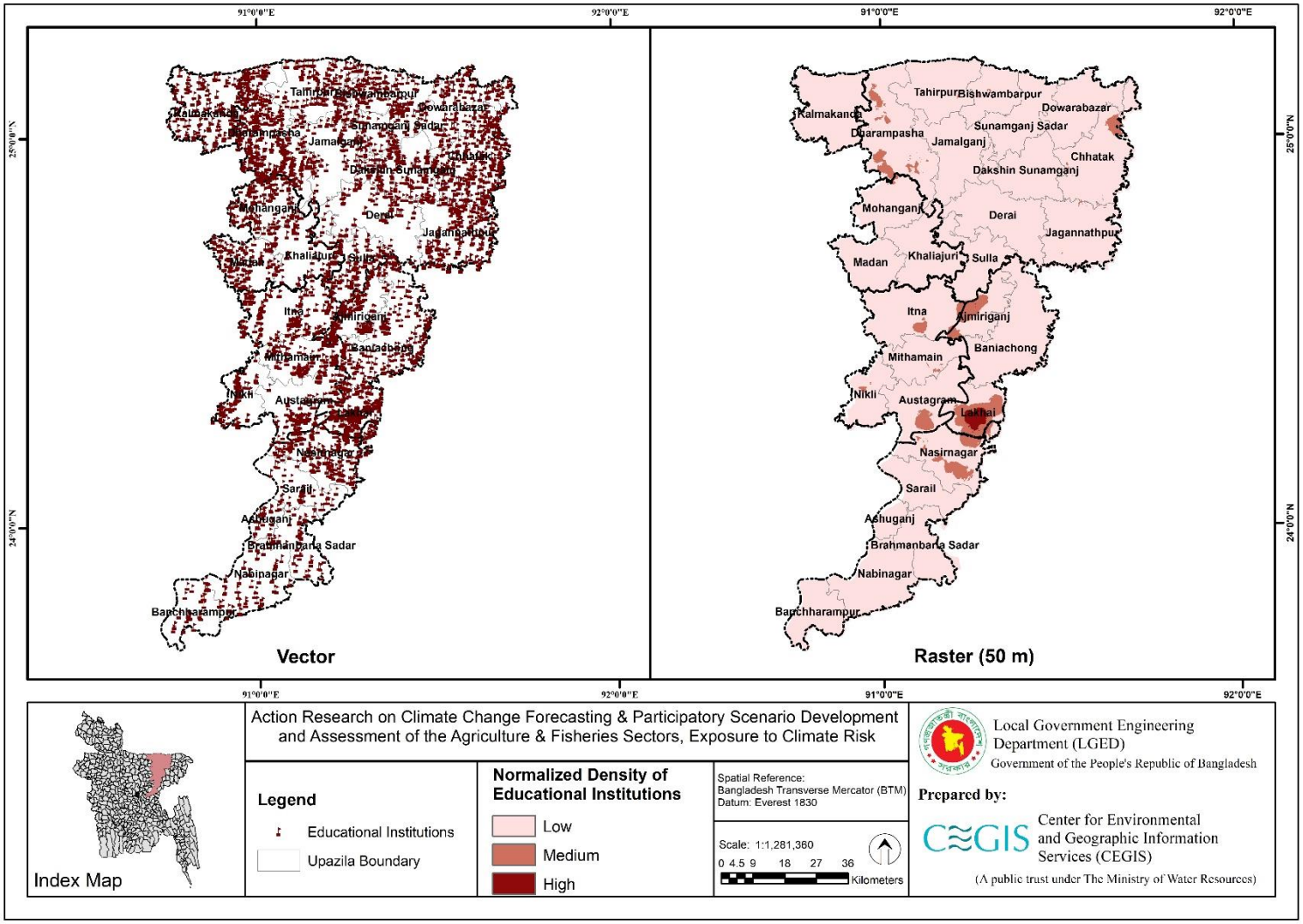


Figure 8.21: Elements at Risk (Educational Institutes) in the Study Area

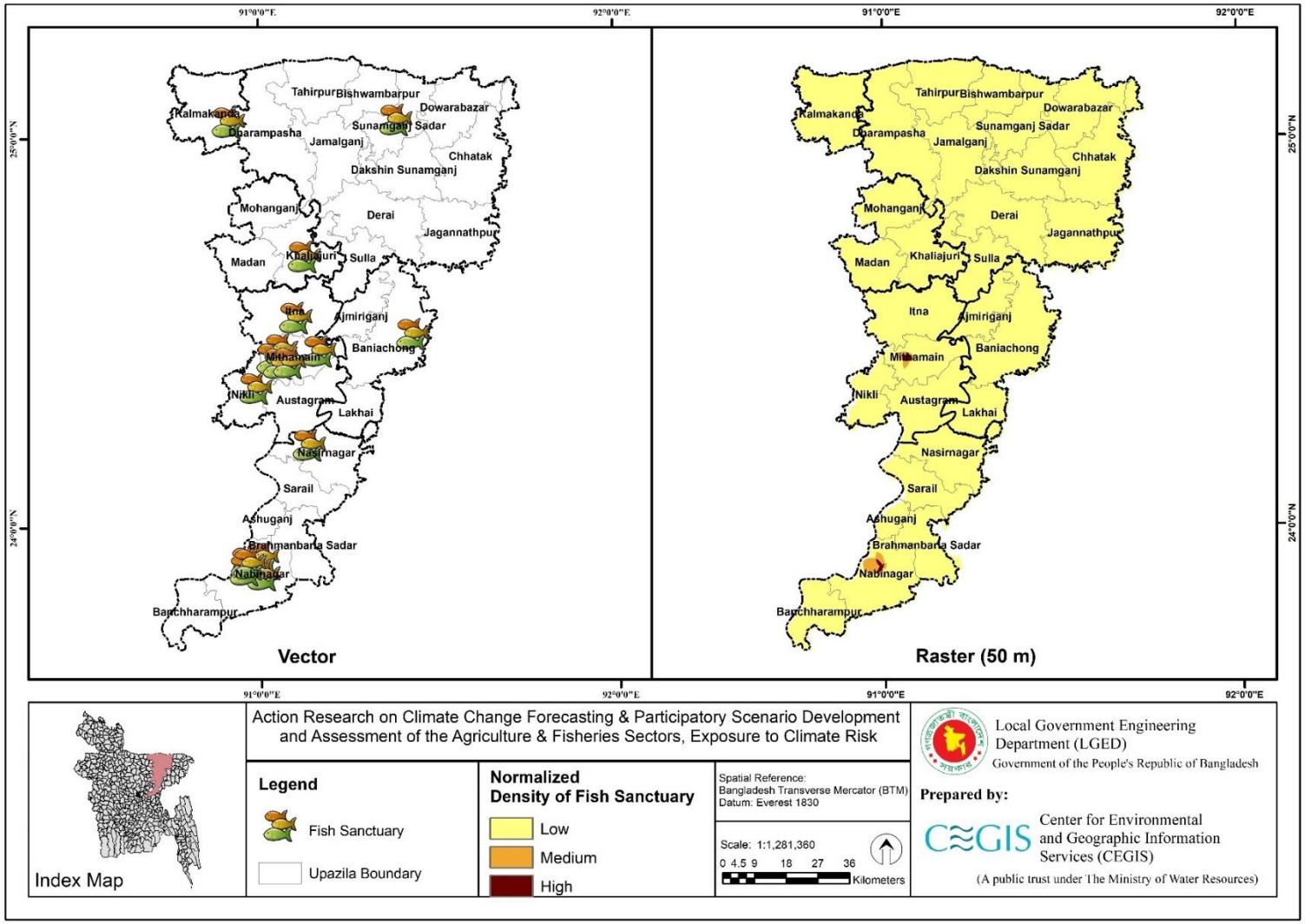


Figure 8.22: Elements at Risk (Fish Sanctuary) in the Study Area

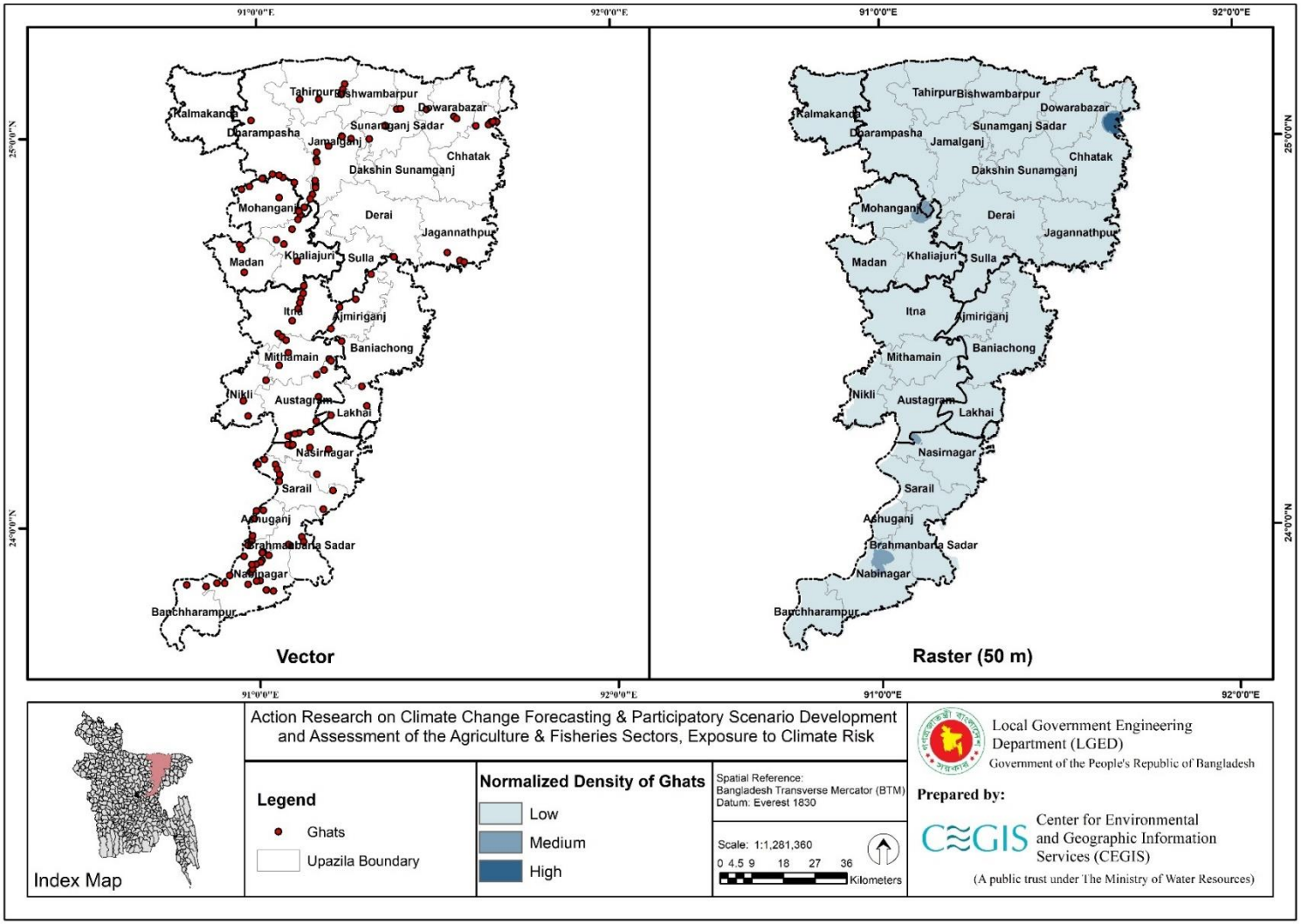


Figure 8.23: Elements at Risk (Ghats) in the Study Area

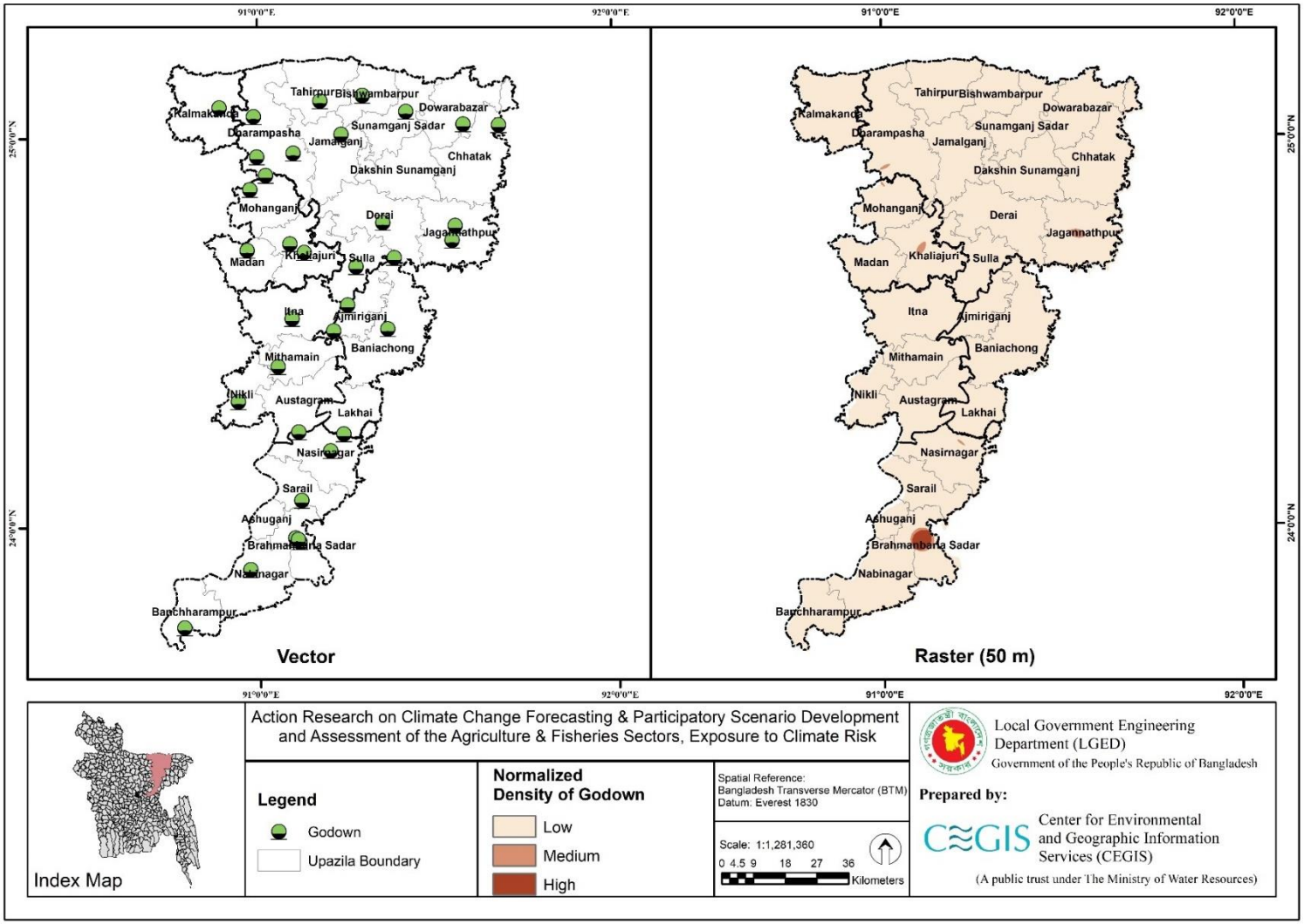


Figure 8.24: Elements at Risk (Godown) in the Study Area

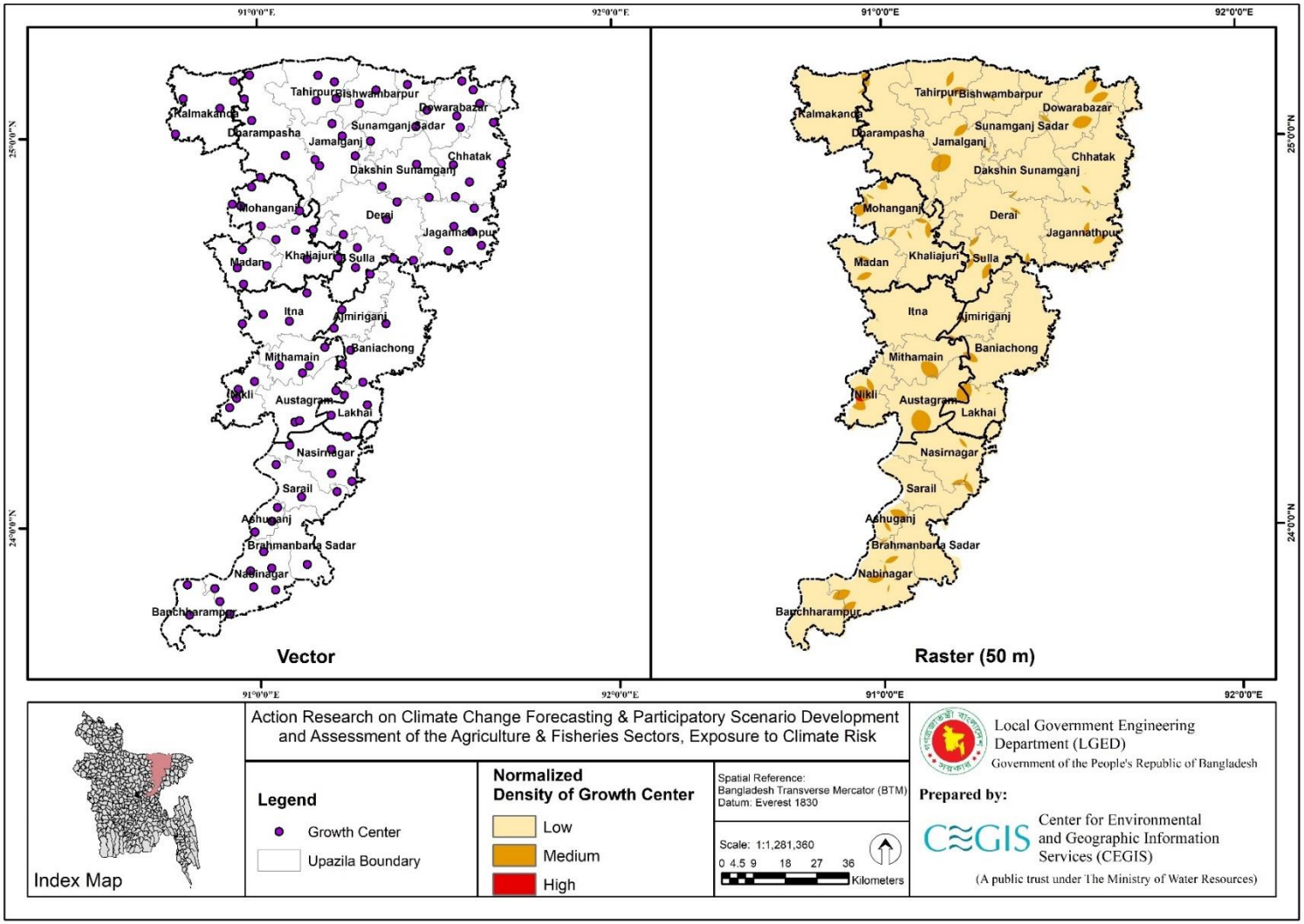


Figure 8.25: Elements at Risk (Growth Center) in the Study Area

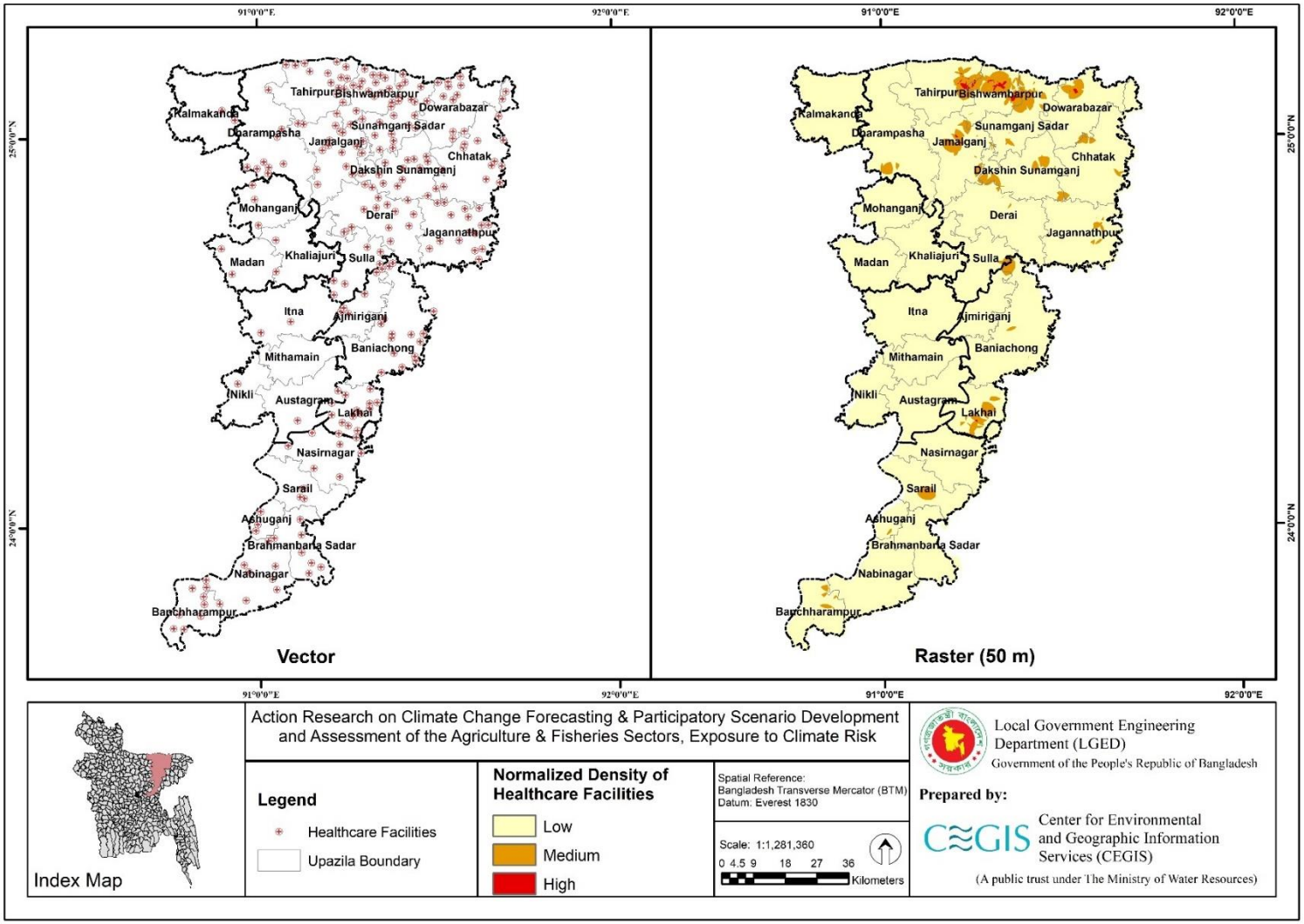


Figure 8.26: Elements at Risk (Healthcare Facilities) in the Study Area

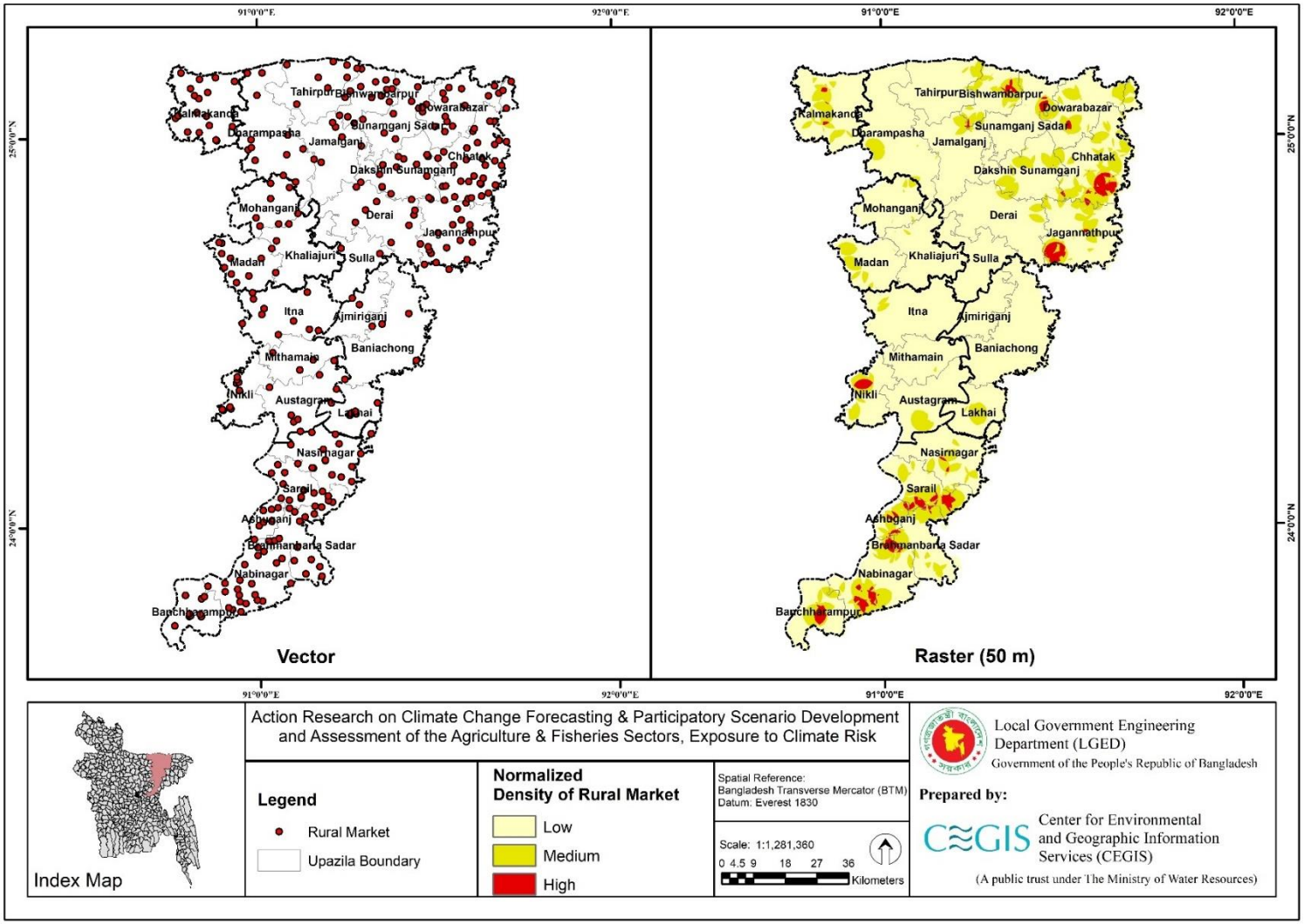


Figure 8.27: Elements at Risk (Rural Market) in the Study Area

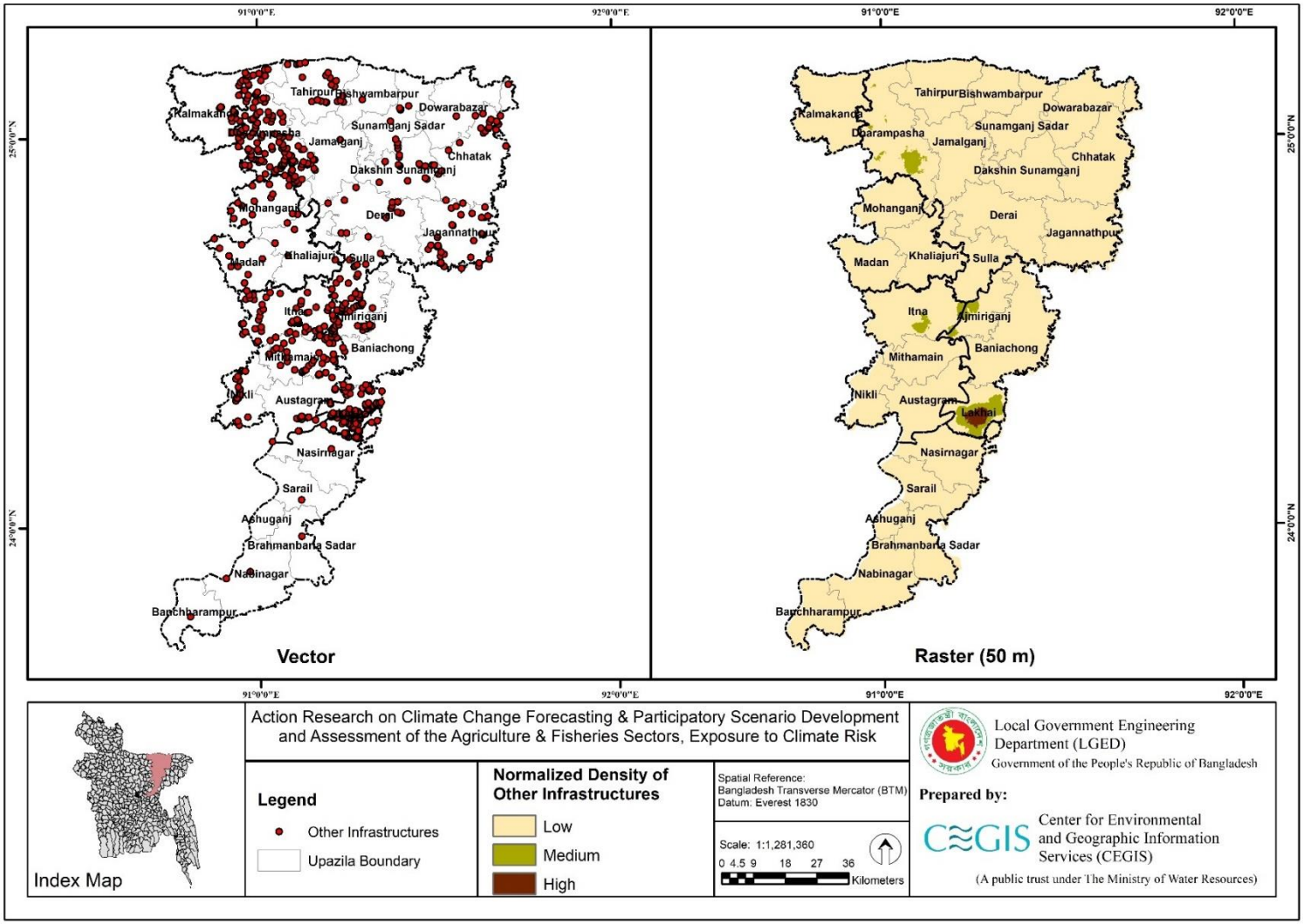


Figure 8.28: Elements at Risk (Other Infrastructures) in the Study Area

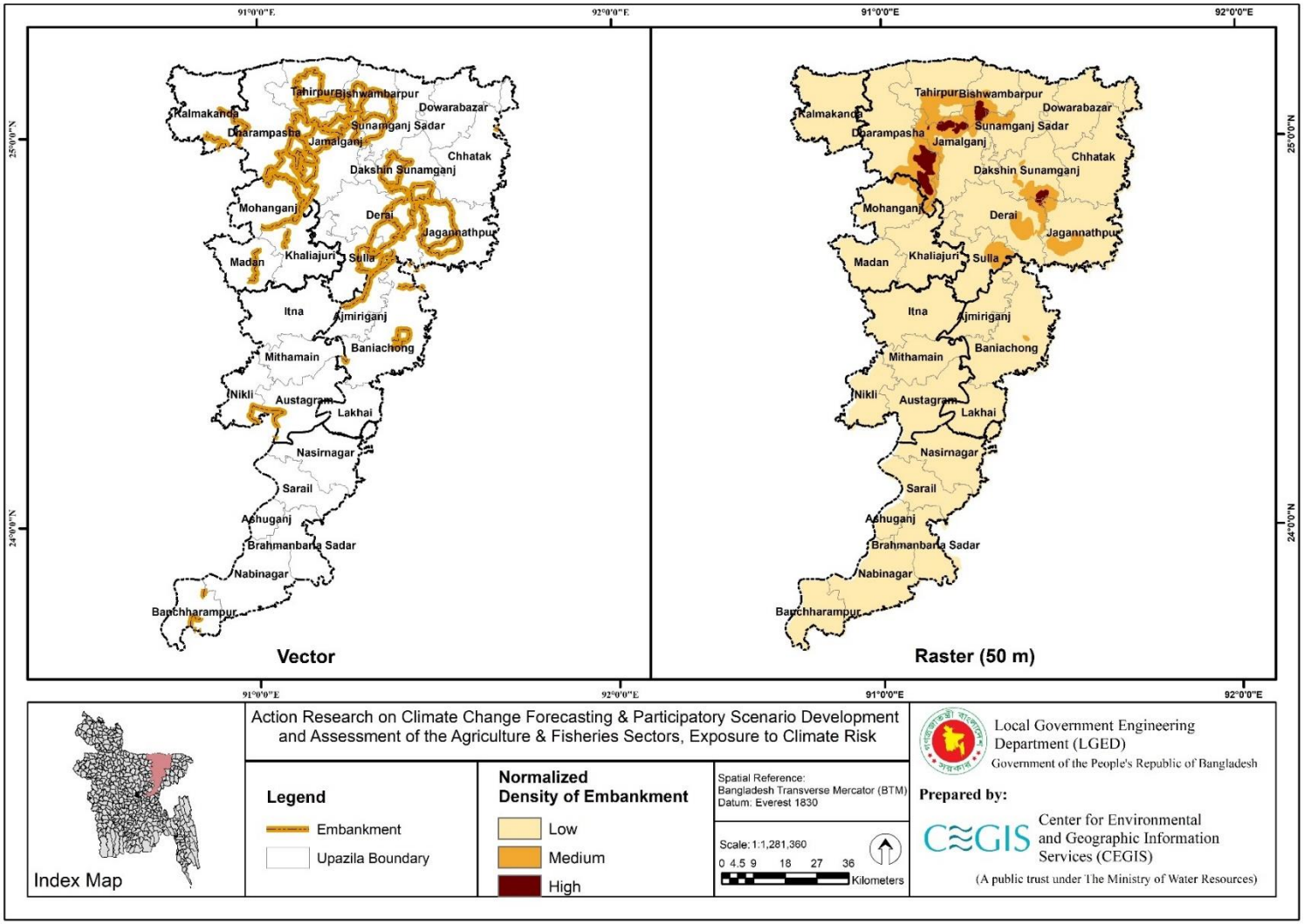


Figure 8.29: Elements at Risk (BWDB Embankment) in the Study Area

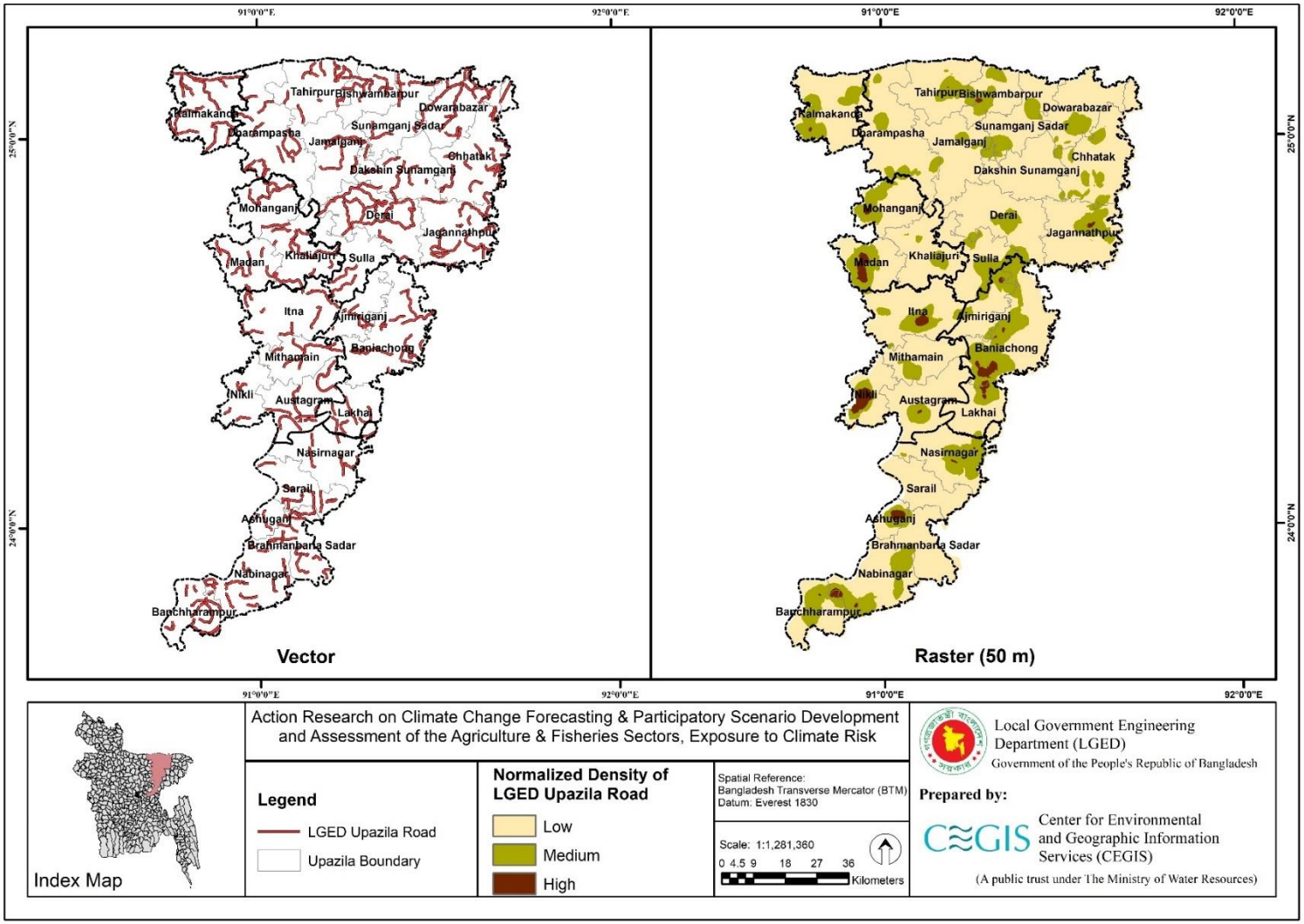


Figure 8.30: Elements at Risk (LGED Upazilla Road) in the Study Area

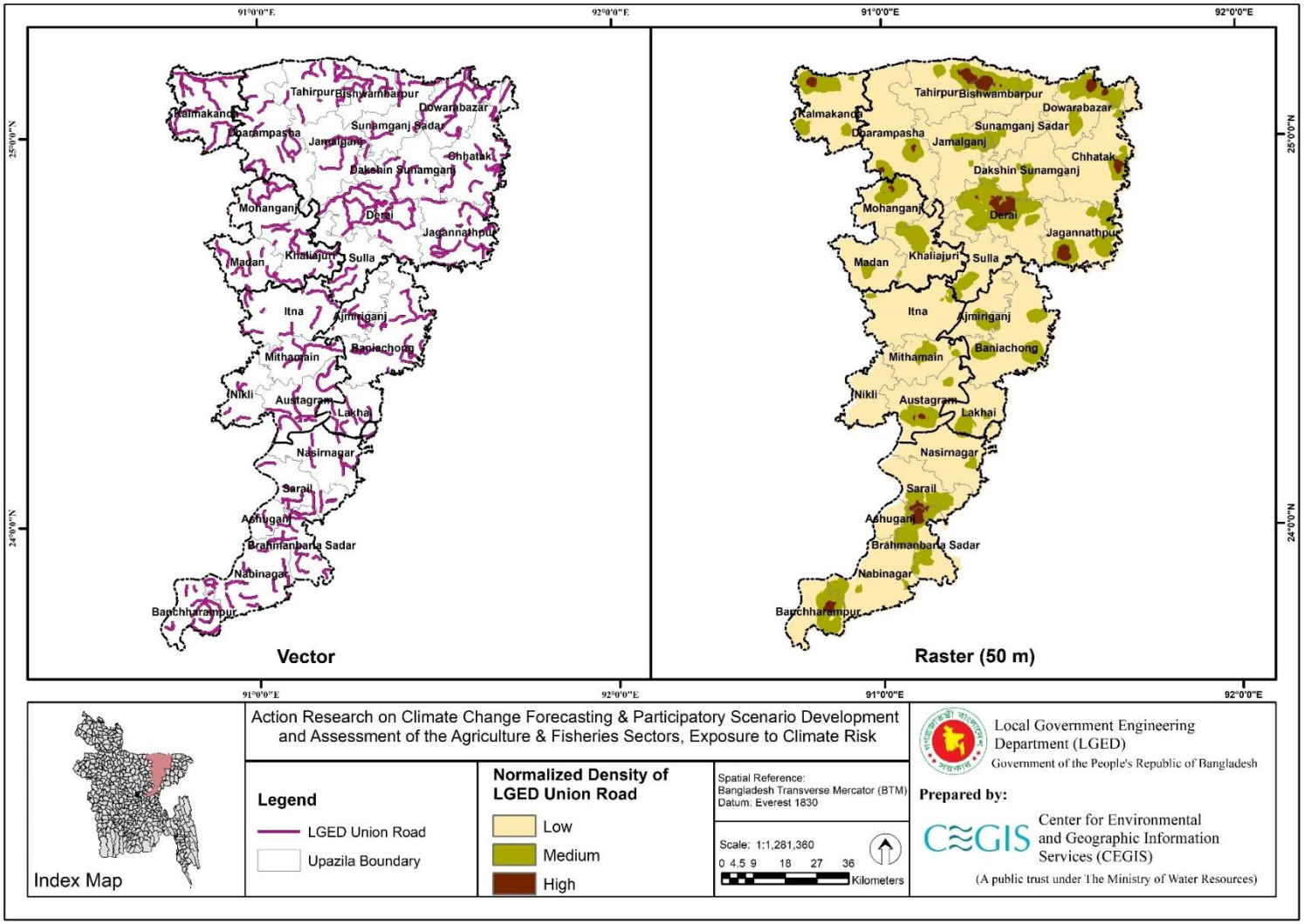


Figure 8.31: Elements at Risk (LGED Union Road) in the Study Area

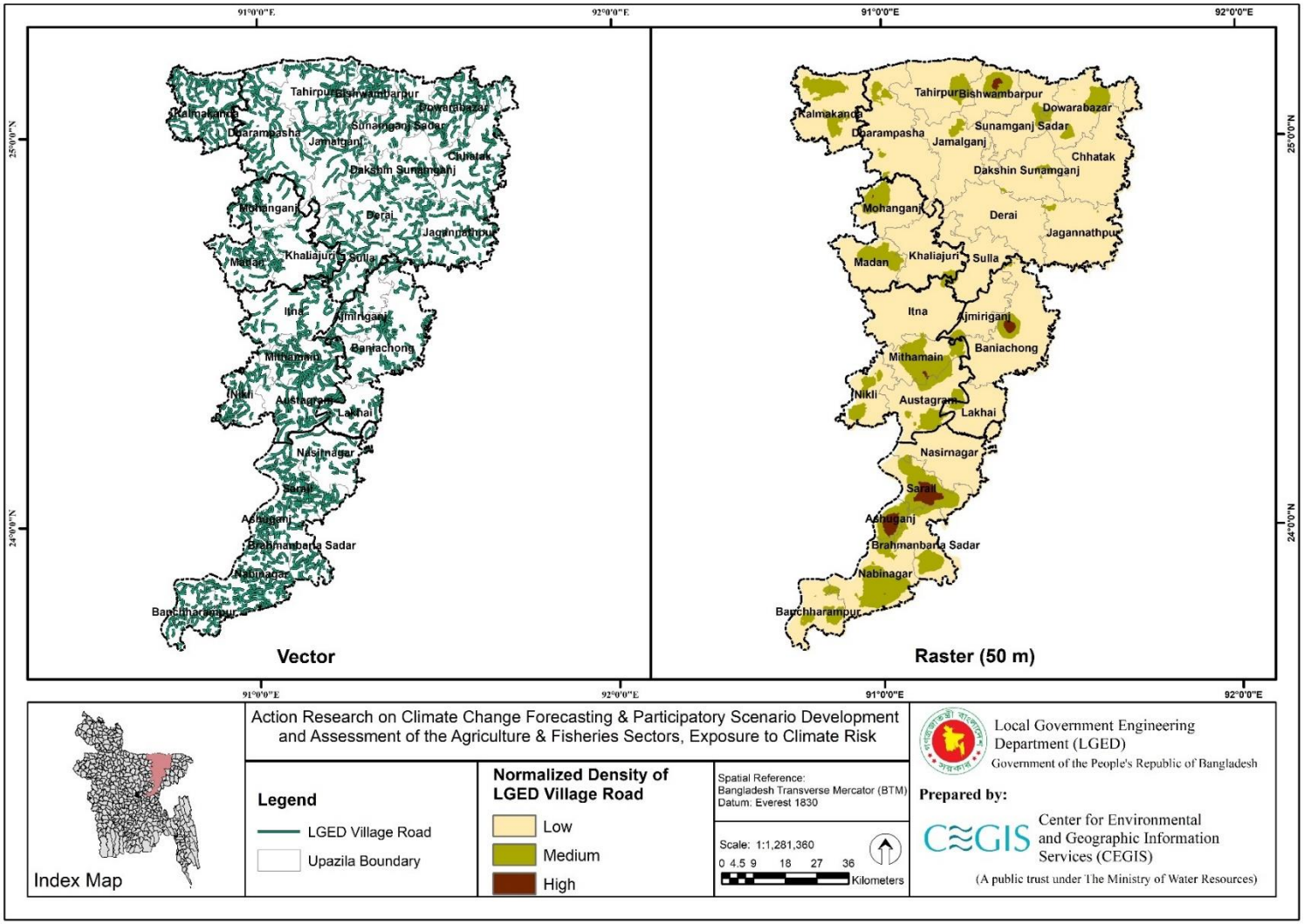


Figure 8.32: Elements at Risk (LGED Village Road) in the Study Area

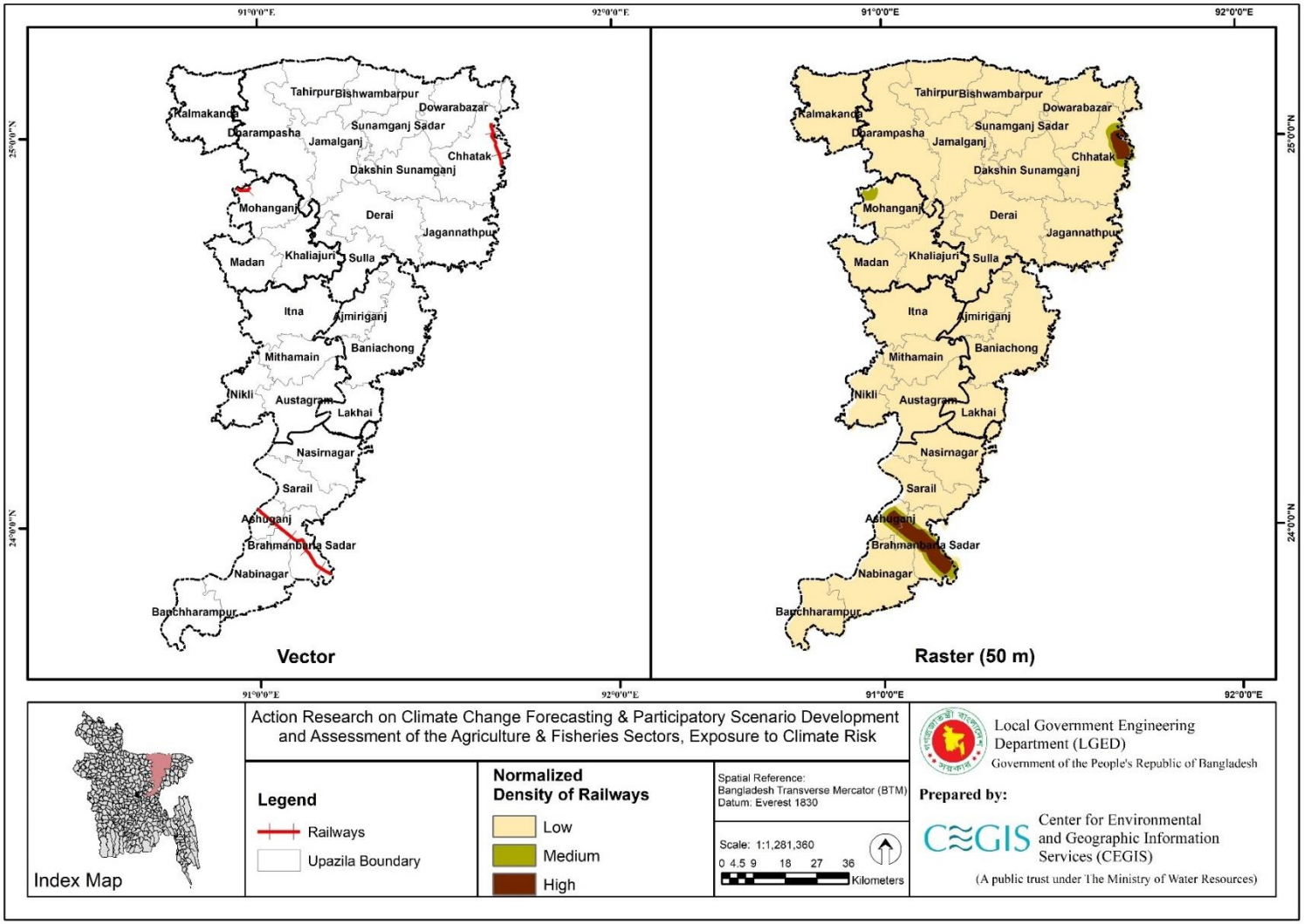


Figure 8.33: Elements at Risk (Railways) in the Study Area

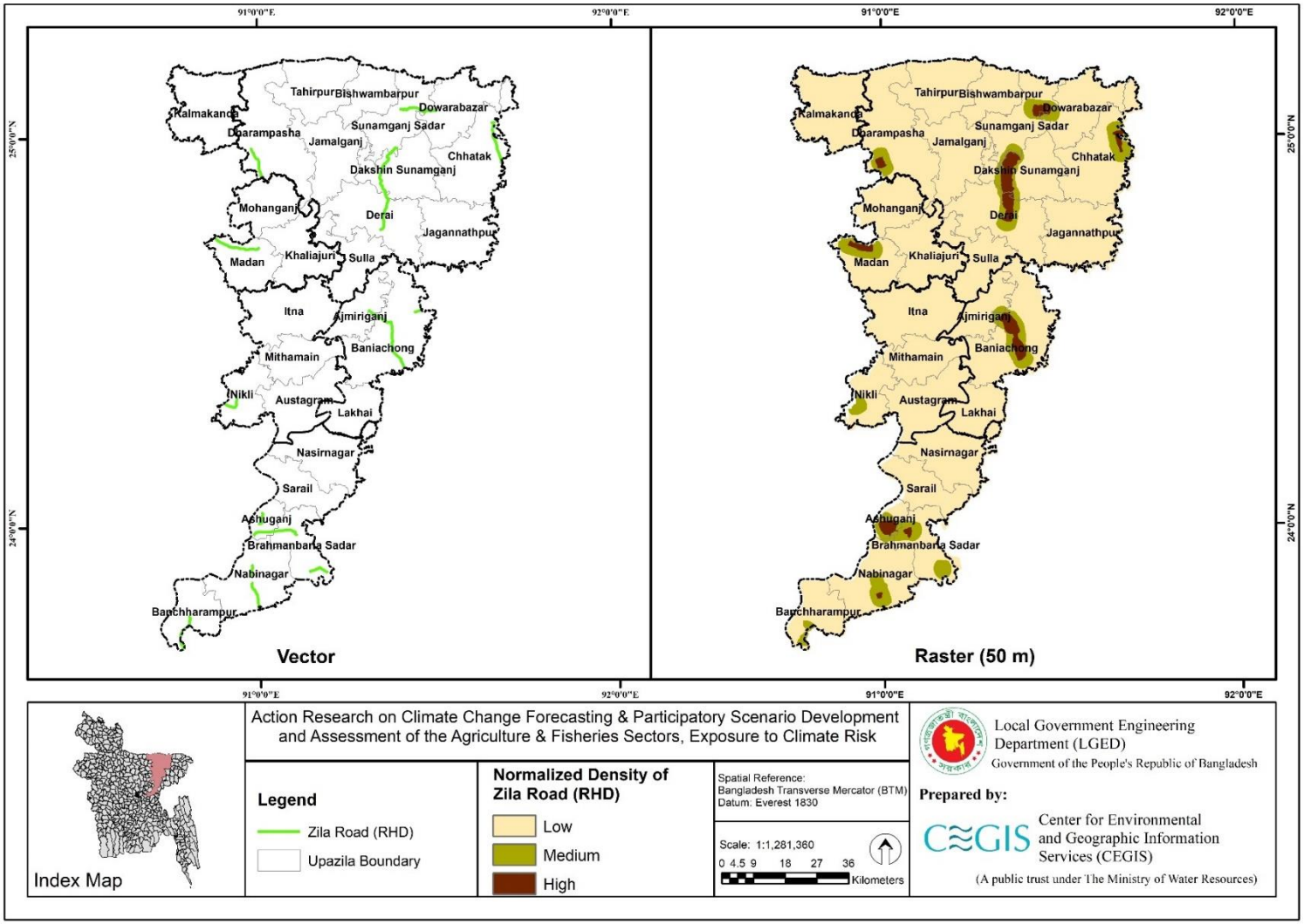


Figure 8.34: Elements at Risk (RHD Zilla Road) in the Study Area

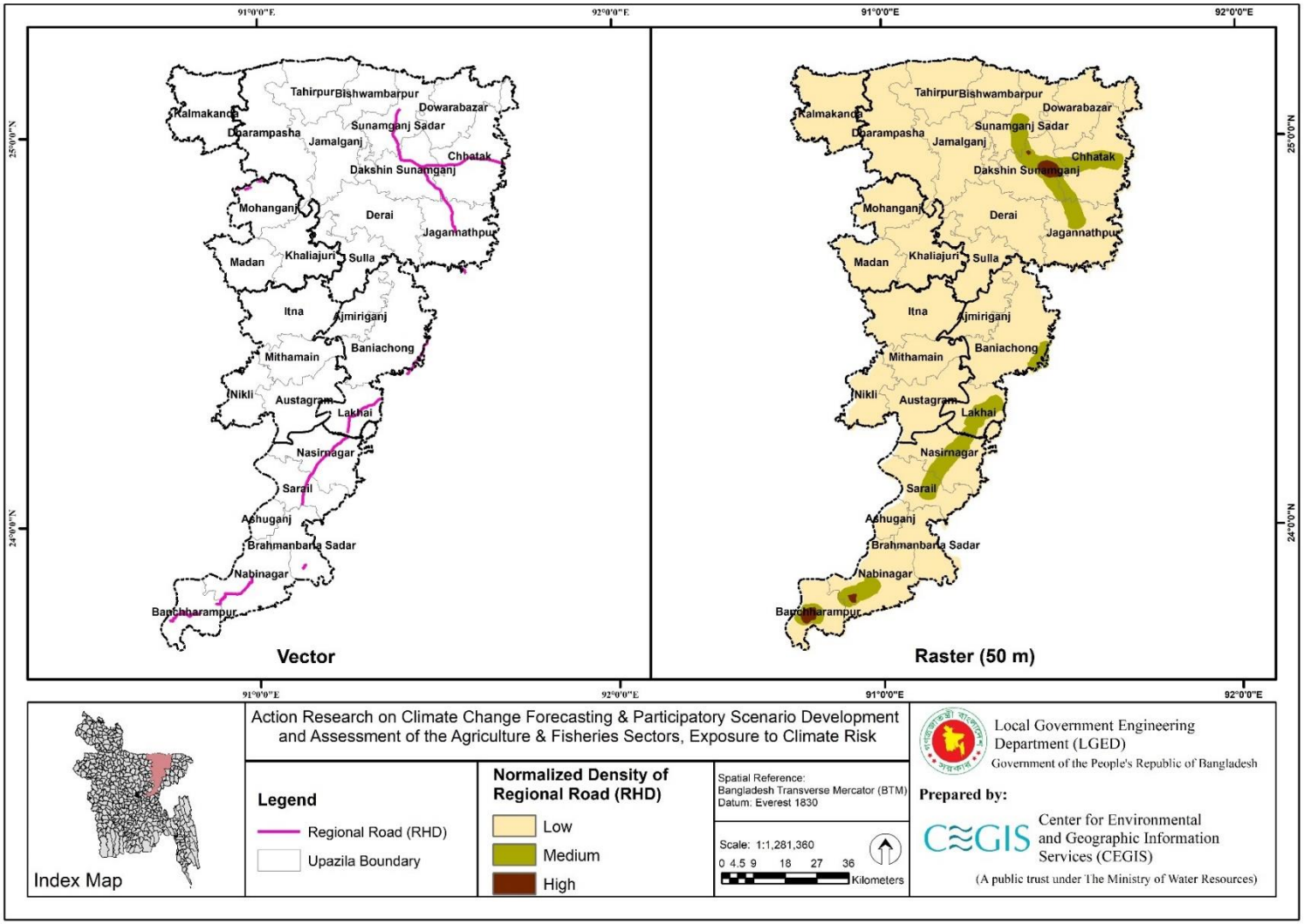


Figure 8.35: Elements at Risk (RHD Regional Road) in the Study Area

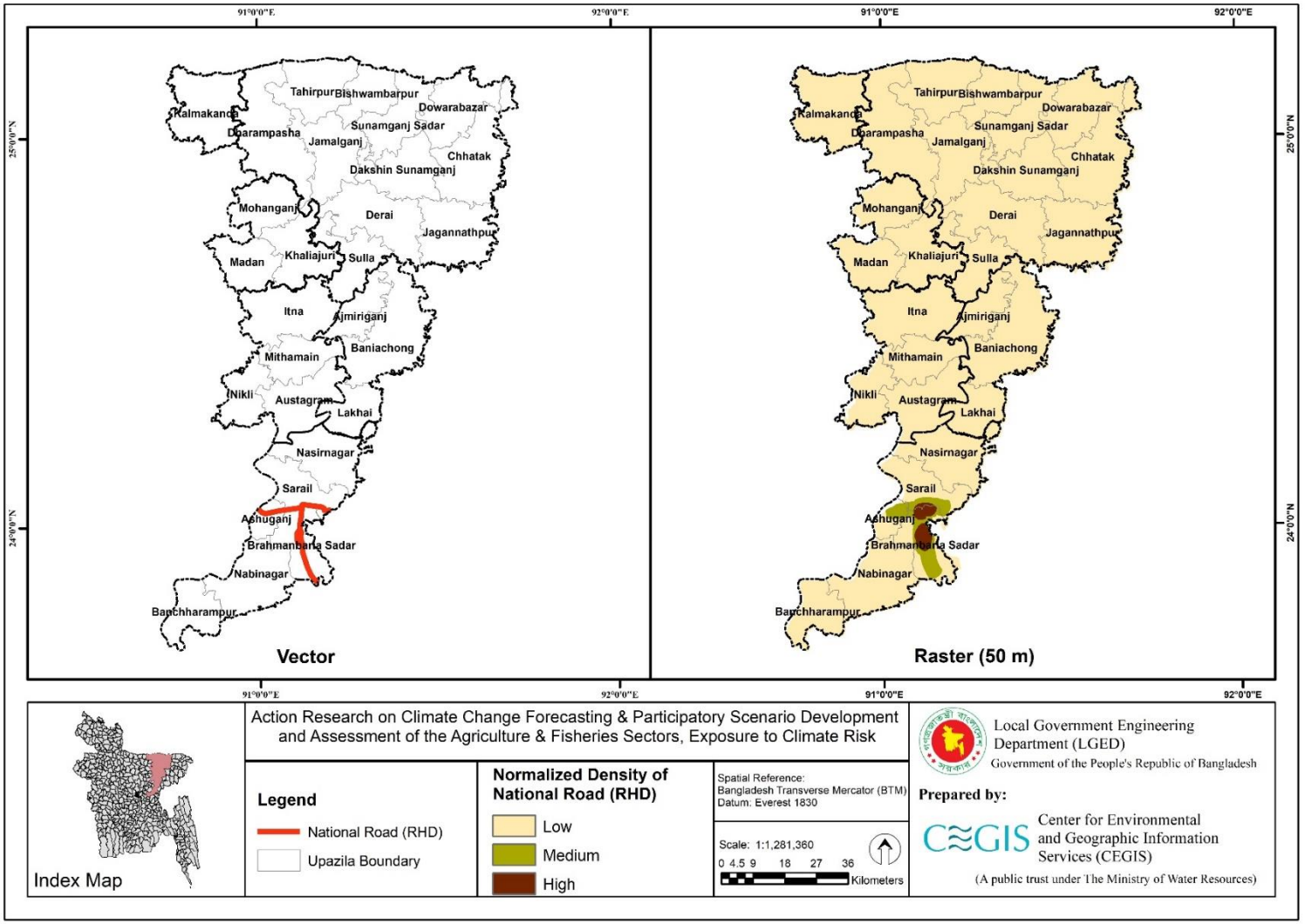


Figure 8.36: Elements at Risk (RHD National Road) in the Study Area

8.8 Risk Hotspot Mapping

In order to specifically intervene in a high-risk priority site specific area, local engineers or decision makers should know about that site, which is not possible to identify from the risk map. Therefore, risk hotspot mapping has been performed using weighted overlay of elements at risk layer and the multi-hazard climate change risk layers using spatial analyst extension of ArcGIS. For simplicity of analysis, equal weights have been considered for each of the identified elements at risk as damages to the identified elements would significantly negatively impact the life, livelihood and property of community people, if any climate change induced hazard occur. After the weighted overlay, a climate change risk hotspot map has been prepared, which specifically depicts which site-specific area are needed to be considered for immediate interventions in terms of potential risk due to climate change induced hazards. Figure 8.38 illustrates the climate change risk hotspots of the study area. Around 100 unions are under the climate change risk hotspot area. Table 8.7 shows the list of unions which are identified as hotspot risk areas in the study area. This list has been selected based on the criteria that the hotspot Union should cover at least thirty percent of its area as moderate to severe layers of hotspot map. Some unions in the southern part of the study area are found as risk hotspot, despite being located in low climate change risk level as the elements at risk are very densely located. The ultimate outcome of this community-based climate change risk assessment i.e. risk hotspot map will facilitate local engineers, Agriculture and Fisheries related stakeholders and decision makers to make choice on the intervention as well as intervention needs.

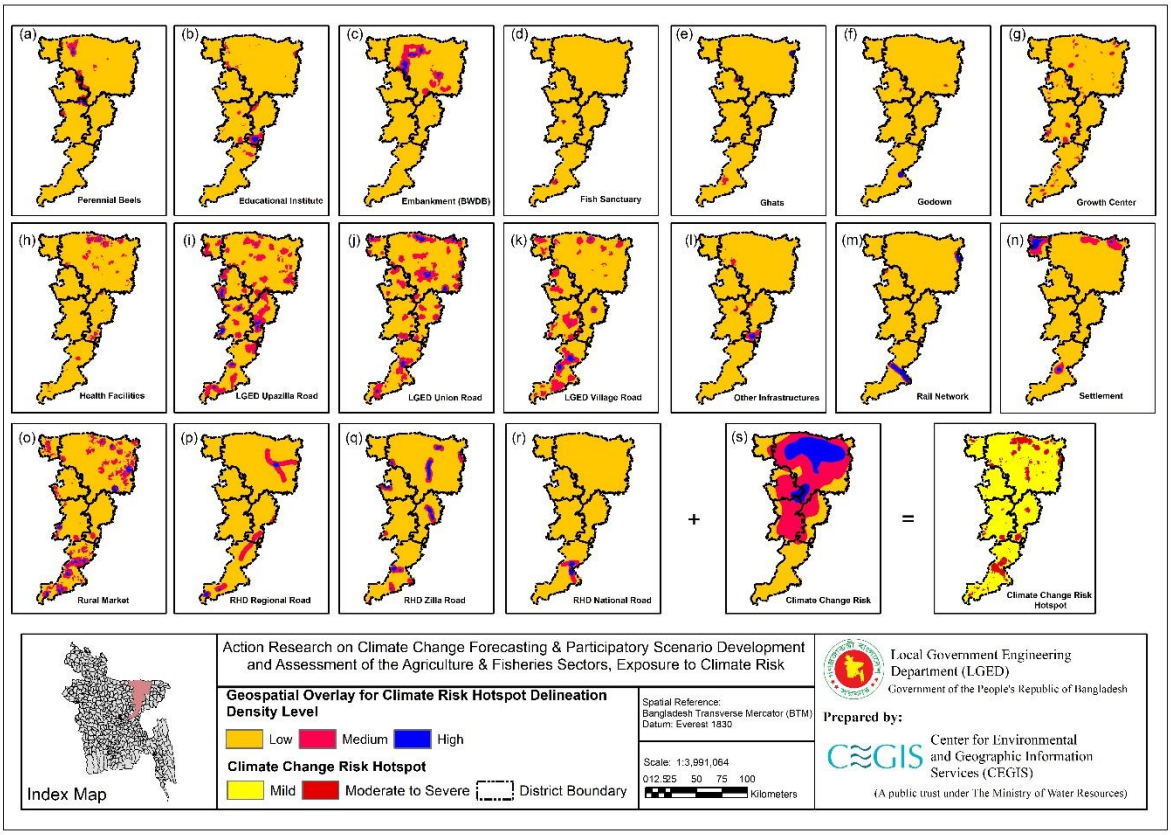


Figure 8.37: Weighted Overlay of Elements at Risk and Multi-Hazard Climate Change Risk to Identify Climate Change Risk Hotspot

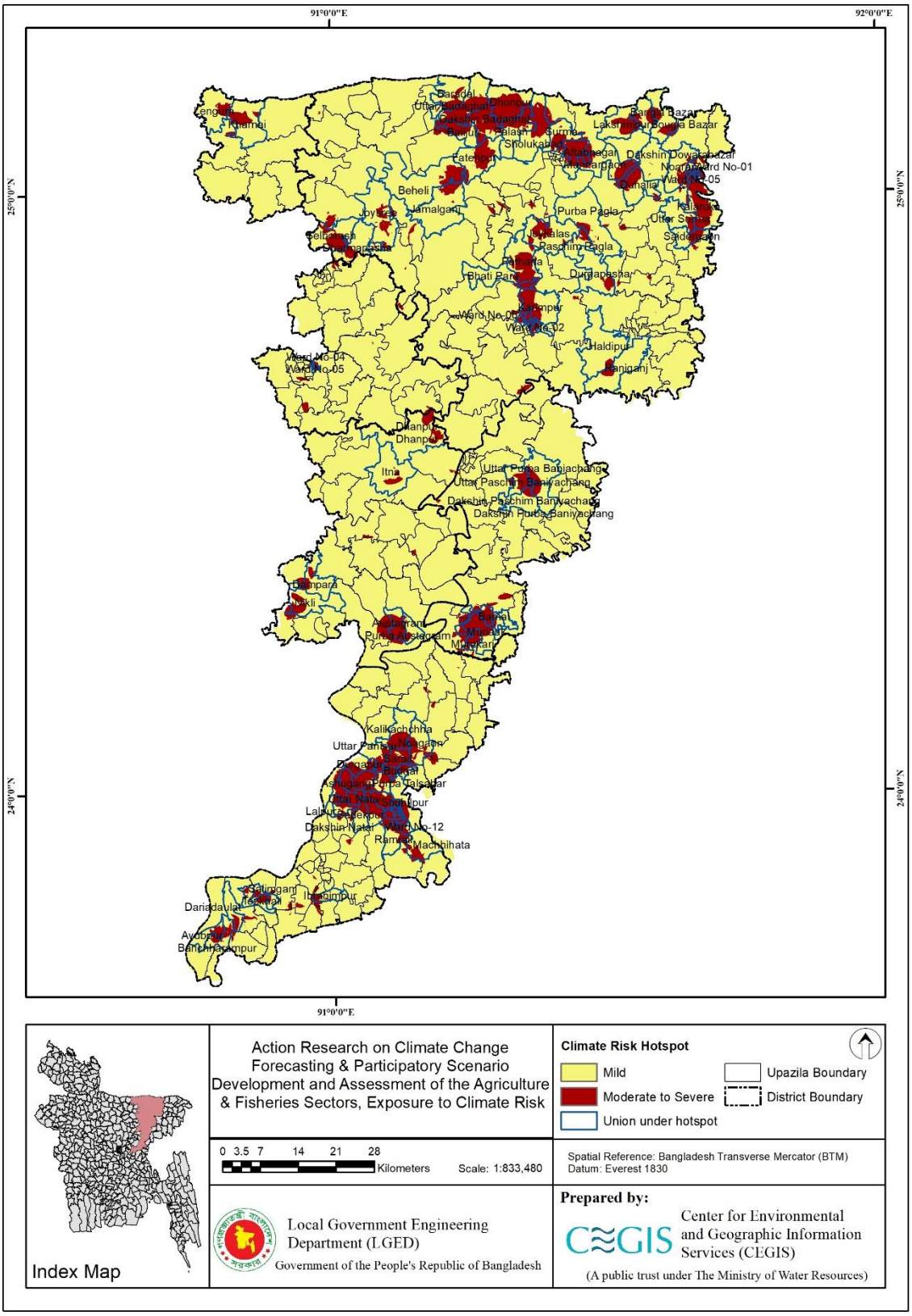


Figure 8.38: Climate Change Risk Hotspot of the Study Area

Table 8.7: List of Unions under Climate Change Risk Hotspots

Sl. No.	District	Upazilla	Union
1	Brahamanbaria	Banchharampur	Ayubpur
2		Banchharampur	Dariadaulat
3		Banchharampur	Tezkhali
4		Banchharampur	Banchharampur
5		Brahmanbaria Sadar	Ward No-01
6		Brahmanbaria Sadar	Ward No-02
7		Brahmanbaria Sadar	Ward No-03
8		Brahmanbaria Sadar	Ward No-05
9		Brahmanbaria Sadar	Ward No-06
10		Brahmanbaria Sadar	Ward No-07
11		Brahmanbaria Sadar	Ward No-08
12		Brahmanbaria Sadar	Ward No-09
13		Brahmanbaria Sadar	Ward No-11
14		Brahmanbaria Sadar	Ward No-12
15		Brahmanbaria Sadar	Dakshin Natai
16		Brahmanbaria Sadar	Shuhilpur
17		Brahmanbaria Sadar	Machhihata
18		Brahmanbaria Sadar	Purba Talsahar
19		Brahmanbaria Sadar	Ramrail
20		Brahmanbaria Sadar	Sadekpur
21		Brahmanbaria Sadar	Uttar Natai
22		Brahmanbaria Sadar	Budhal
23		Ashuganj	Araisidha
24		Ashuganj	Ashugang
25		Ashuganj	Durgapur
26		Ashuganj	Lalpur
27		Ashuganj	Paschim Talsahar
28		Ashuganj	Sharifpur
29		Ashuganj	Tarua
30		Nabinagar	Ibrahimpur
31		Nabinagar	Salimganj
32		Sarail	Kalikachchha
33		Sarail	Noagaon
34		Sarail	Sarail
35		Sarail	Uttar Panisar
44	Habiganj	Baniachong	Uttar Purba Baniachang
45		Baniachong	Uttar Paschim Baniyachang
46		Baniachong	Dakshin Purba Baniyachang
47		Baniachong	Dakshin Paschim Baniyachang
48		Lakhai	Bamai
49		Lakhai	Murakari
50		Lakhai	Muriauk
36	Kishoreganj	Austagram	Austagram
37		Austagram	Purba Austagram

Sl. No.	District	Upazilla	Union
38		Itna	Dhanpur
39		Itna	Itna
40		Nikli	Dampara
41		Nikli	Nikli
91		Itna	Dhanpur
42	Netrakona	Kalmakanda	Kharnai
43		Kalmakanda	Lengura
92		Madan	Ward No-04
93		Madan	Ward No-05
51	Sunamganj	Bishwambarpur	Dakshin Badaghat
52		Bishwambarpur	Dhonpur
53		Bishwambarpur	Fatehpur
54		Bishwambarpur	Palash
55		Bishwambarpur	Sholukabad
56		Chhatak	Ward No-01
57		Chhatak	Ward No-03
58		Chhatak	Ward No-05
59		Chhatak	Ward No-06
60		Chhatak	Ward No-07
61		Chhatak	Ward No-08
62		Chhatak	Ward No-09
63		Chhatak	Kalaruka
64		Chhatak	Noarai
65		Chhatak	Saidergaon
66		Chhatak	Uttar Surma
67		Dakshin Sunamganj	Patharia
68		Derai	Ward No-01
69		Derai	Ward No-02
70		Derai	Ward No-06
71		Derai	Ward No-07
72		Derai	Ward No-08
73		Derai	Ward No-09
74		Derai	Bhati Para
75		Derai	Karimpur
76		Dharampasha	Joysree
77		Dharampasha	Selborash
78		Dowarabazar	Bougla Bazar
79		Dowarabazar	Dakshin Dowarabazar
80		Dowarabazar	Duhalia
81		Dowarabazar	Lakshmipur
82		Dowarabazar	Mannargaon
83		Dowarabazar	Bangla Bazar
84		Jamalganj	Beheli
85		Jamalganj	Jamalganj
86		Sunamganj Sadar	Aftabnagar

Sl. No.	District	Upazilla	Union
87		Sunamganj Sadar	Surma
88		Tahirpur	Balijuri
89		Tahirpur	Uttar Badaghat
90		Tahirpur	Baradal
94		Dakshin Sunamganj	Durgapasha
95		Dakshin Sunamganj	Joykalas
96		Dakshin Sunamganj	Paschim Pagla
97		Dakshin Sunamganj	Purba Pagla
98		Dharampasha	Dharmapasha
99		Jagannathpur	Haldipur
100		Jagannathpur	Raniganj

9. Participatory Scenario Development

9.1 Introduction

This Chapter focuses on the development of participatory scenario for climate change induced disaster risk management in the context of the Agriculture and Fisheries sectors. Community engagement during different stages of scenario development is the key tool to make the process participatory. However, expert knowledge from multi-disciplinary stakeholders have also been used during the scenario development process. Prioritized adaptation measures for different scenarios with adaptive pathways in respect to different time slices are found as the major outcome of the scenario development process, which will facilitate local engineers and decision makers for taking site specific community recommended measures in the study area and will enhance resilience of the community people improving their lives and livelihoods.

9.2 Participatory Scenario Development Process

Participatory Scenario Development has become a very much appreciable tool for the environmental planners to strengthen communities' adaptation approaches and to reduce vulnerabilities against socio-economic losses. Scenarios are neither predictions of socioeconomic development nor impacts of changing climate; rather they are plausible descriptions of how the future might develop, using current information and assumptions about future trends. They also help to explore the differing outcomes that might result if basic assumptions are changed. In order to fully explore opportunities from scenario approaches, growing attention is being devoted not only to the developed scenarios, but also to the scenario development process. This includes an increasing emphasis on stakeholders' involvement in developing scenarios – referred to as participatory scenario development (PSD). In this section, the procedures of completing participatory scenario development has been described.

The PSD process takes 5 steps: (1) drivers of change, (2) visioning, (3) backcasting, (4) barriers and enablers, and (5) prioritizing. Following Figure 9.1 shows PSD process and its activities.

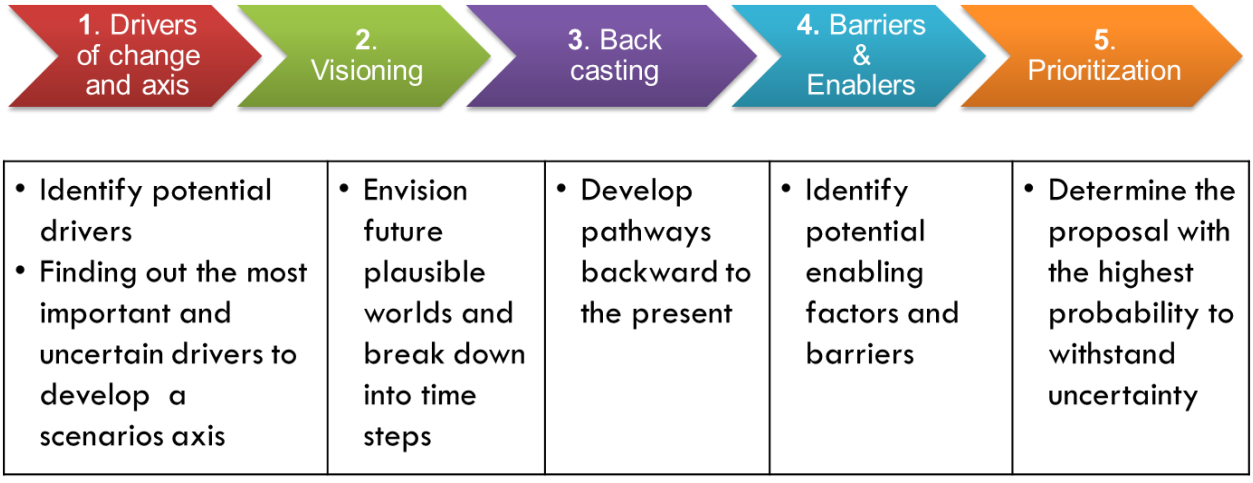


Figure 9.1: Overview of the PSD Process

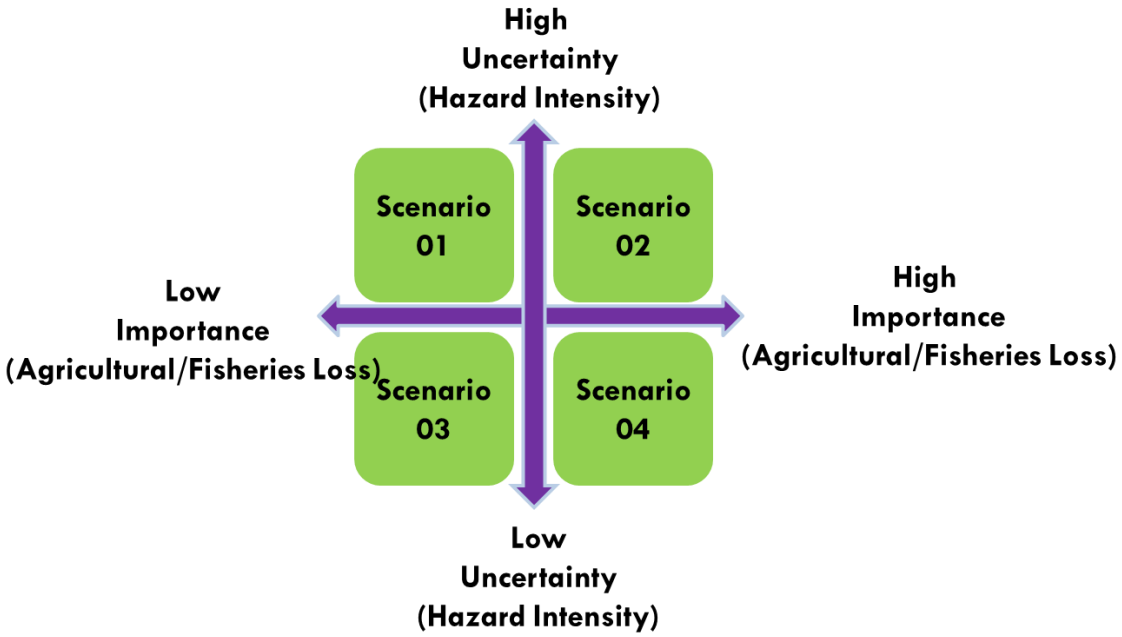


Figure 9.2: Typical Four Axis Scenarios

Figure 9.3: Glimpses of Participatory Scenario Development Workshop in Different Places of the Study Area

9.3 Driver Selection and Scenario Development

9.3.1 Preliminary Selection of Drivers and Uncertainties

As a first step of participatory scenario development, drivers and uncertainties have been identified and selected to facilitate the process of scenario development. In this regard, series of drivers and uncertainties have been identified using expert judgment and findings of Chapter 5 and Chapter 7, where trend and future projections of different drivers and uncertainties have been analysed. Having that information following list of drivers and uncertainties have been selected preliminarily:

- Population
- Economic Growth
- Land Use Change
- Increased Intensity and Frequency of Hazards
- Climate Change
- Agricultural Growth
- Management of Water Resources or IWRM
- Ecosystem and Biodiversity
- Upstream Development
- Change of Agro-Technology

Socio-economic indicators like population and economic growth always prevail as driving factors of future scenarios in respect to development of any sectors in a region. Land use change due to urbanization or industrialization is also a dynamic factor which may change the future scenarios, although change of land use almost certain considering the growing population and development needs. Agricultural growth may be an important driver for future scenarios specifically for the study area as this area produces and contributes to the national crop and fisheries production very extensively, which may influence very significantly at national level growth and economy. This agricultural growth would be triggered further by management of integrated water resources management, change of agro-technology, change of land use and water availability considering upstream development. Therefore, management of water resources, change of agro-technology and upstream development are also important drivers which include inherent uncertainties for shaping future scenarios. Haor area is highly reach with its unique ecosystem and biodiversity, which enhances the biodiversity richness index of the country and provide tangible and intangible ecosystem services, which can be treated as one of the drivers. On top of all issues, climate change due to global warming has become now an evident threat to the country as well as to the study area specifically, which inherits huge uncertainties and can shape the future scenarios in many plausible ways. Increased intensity and frequency of climate change induced hazards specifically flash floods and thunderstorms is also a major concern of the study area, but they ultimately govern by the main external driver climate change itself.

Having all this information, a screening criterion has been set to select two drivers at least, which are both mostly important and contains deep uncertainty. Those criteria are:

- Relevance with the study objectives
- Relevance with specific agriculture and fisheries sectors
- Relevance with socio-economic development of the study area
- Contribution to the national socio-economic development
- Relevance with government vision

Feedback of multi-disciplinary experts from agriculture, fisheries and social sectors have been used to select drivers and uncertainties finally using these criterions. Following the screening criterion, agricultural growth and climate change have been selected as the drivers for Participatory Scenario Development (PSD), as climate change is the major deep uncertainties in the area and agricultural growth (including both crop and fisheries) is the other most important factors, which have enough strength to shape the future scenarios of the study area. As this study specifically focuses on agriculture and fisheries sector, agricultural growth gets enough emphasis over other important drivers. However, other preliminary drivers somehow directly or indirectly related to selected major two drivers. Therefore, information of those drivers has been used in the narrative development.

9.3.2 Axis and Scenario Development

Four axis scenarios have been developed using the selected two drivers and uncertainties. These are:

- Moderate climate change-Low Agricultural growth
- Extreme climate change-Low Agricultural growth
- Moderate climate change-High Agricultural growth
- Extreme climate change-High Agricultural growth

The moderate climate change follows the suggested climate change scenario according to the RCP 4.5. So, this axis of the climate change driver assumes a moderate climate change and some global efforts in mitigating GHG emissions. The extreme climate change axis assumes an extreme climate change scenario according to the RCP 8.5, which considers minimum efforts in GHG emission reduction, lesser mitigation efforts and larger climate change impacts. The Agricultural growth driver is differentiated as low and high scenarios. The low scenario will include mostly business as usual approach to agricultural growth while the high scenario will include more organized and futuristic approach to enhance agricultural growth proactively. Figure 9.4 shows the four quadrants of developed scenarios.

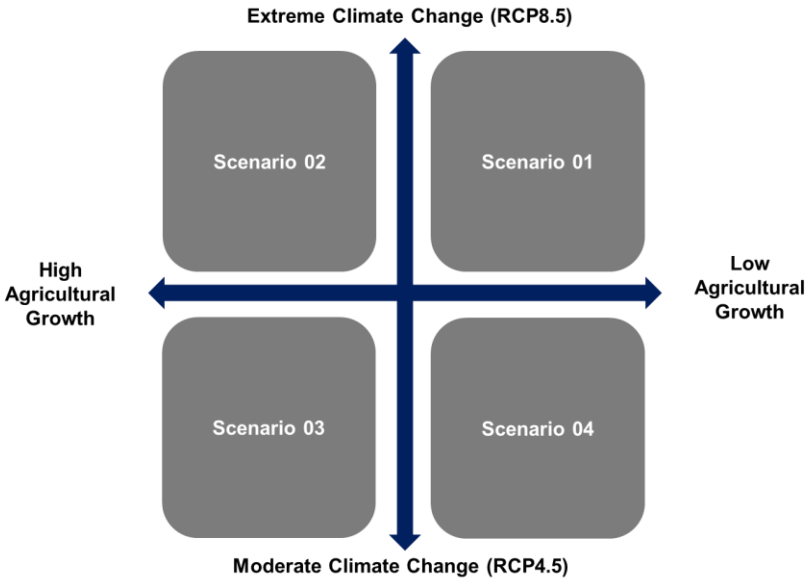


Figure 9.4: Developed Scenarios using Participatory and Scientific Perceptions

9.4 Narrative Development (Visioning)

Narrative of four scenarios has been developed using the community perceptions from household survey and Focused Group Discussions (FGDs), trend analysis and future projections described in Chapter 5 and expert judgment. A group of community people, local stakeholders, experts on climate change, agriculture and fisheries, sociology were involved in this narrative development process. Qualitative analysis has been included where it is not possible to perform quantitative analysis due to lack of data at Upazilla level. Narrative has been developed in following two steps:

- **Narrative of present condition**: present condition of selected and their associated drivers and uncertainties as well as presently facing impact of climate change induced hazards on agriculture and fisheries have been narrated in this step.
- **Narrative of future condition:** future condition of selected and their associated drivers and uncertainties as well as potential impact of climate change induced hazards on agriculture and fisheries considering developed four scenarios have been narrated in this step. Future condition has been narrated in three time slices i.e. 2030s, 2050s and 2080s to make it consistent with the projections made in earlier Chapters.

9.4.1 Present Condition

The present condition of the drivers is needed to properly understand the changes in the future due to changing driver conditions. As climate change is a major driver, the present condition of the climatic pattern is considered as a baseline situation. The annual average maximum temperature in the study area is 30°C while the annual average minimum temperature is 20°C. The annual rainfall is 4200 mm in the study area with around 65% rainfall (2800 mm) during monsoon season (JJAS) and around 25% (1050 mm) during pre-monsoon season (MAM).

Another driver is the agricultural growth. This includes the situation of current and future production in crops, fisheries and livestock. Rice is the major crop in haor region. Among the cultivated area rice covers more than 95%. Total rice production in the selected five districts is about 4.38 million metric tons of which Aus, Aman and Boro contribution is 5%, 26% and 69% respectively. At present total rice demand of the study area is 2.0 million metric tons. About 2.38 million metric tons rice is surplus after fulfilling the local demand.

Bangladesh is one of the leading fish producing countries with a total fish production of 42.77 lakh MT in 2017-18 of which five Haor districts contribute about 3.6 lakh MT (8.6% of total) against the required demand of 1.3 lakh MT. Most of the production comes from capture fisheries (61%). majority of the captured fish production is from floodplain (48%), followed by beels (10%) and rivers (2%). Most of the culture fishery is from ponds (33%) with productivity about 3.81 MT/Ha.

9.4.2 Future Scenarios

The scenario narratives are presented in Figure 9.5. The following sections describe the scenarios.

Moderate climate change-Low Agricultural growth

This scenario assumes a moderate climate change and a business as usual approach in agricultural growth. In this scenario, annual average maximum temperature in the study area is predicted to rise by 0.6°C (2030), 0.8°C (2050) and 1°C (2080) in future. The annual average minimum temperature is predicted to rise by 0.9°C (2030), 1.2°C (2050) and 1.4°C (2080). So,

the change in minimum temperature is higher. The annual rainfall is predicted to rise by 9% (2030), 10% (2050) and 13% (2080) in future. The pre-monsoon season (MAM) rainfall is predicted to rise by 35% (2030), 35% (2050) and 36% (2080). So, in future more rainfall is going to occur during pre-monsoon which is very threatening to agriculture. As this will increase early flash floods, boro rice production will be damaged. In this scenario, early flash flood is expected to be slightly frequent by 2030 and 2050 and more frequent by 2080. Consequently, other climate induces hazards are also expected to become more frequent and intensify during 2030 and 2050 and further increase by 2080. Similarly, the erosion and siltation issues are also expected to follow similar trend in the future.

As the agricultural growth driver is on the low axis, there are no additional efforts to enhance production. So, due to climate change impacts, rice production might be reduced 1.1%, 2.5% and 2.7% in 2030s, 2050s and 2080s respectively. The scenario will have small amount crop diversification slightly increasing by 2080. Similarly, use of different agricultural technology will be very minimal in the future. These technologies cover little and limited improvement in farming practice and varietal enhancement. Farm practices might include introduction of additional secondary tillage, limited level seed replacement, water management etc. Due to the introduction of these technologies and better farm practice, damages to yield could be reduced upto 15%.

Under low level climate smart technological enhancement, rice production might be increased by 5%, 3% and 2% in 2030s, 2050s and 2080s respectively. The local rice demand will be increased to 3.0, 3.8 and 3.7 million tons in 2030s, 2050s and 2080s respectively but the surplus will be reduced in the stated time frame. The existing rice production will fulfill the local demand even in 2080s without technological enhancement. However, local food demand for other crops might not be fulfilled in this time frame by local production. Even technological enhancement could not make any significant change.

The fisheries production in future is expected to rise heavily by 2030 and reduce in 2050 and further reduce to lower than present state by 2080. It is estimated that the Haor districts will produce about 4.37 lakh MT and 5.34 lakh MT of fish production in 2030 and 2050. The local required demand is 1.6 lakh MT, 1.8 lakh MT and 1.75 lakh MT in 2030, 2050 and 2080 respectively. As the habitat and production is more from the capture segment and not from culture, it might benefit from increased flooding. But in later part of century, due to cumulative impacts of climate induces hazards, the habitats might be threatened and reduced in size causing reduction in total production. For the culture fisheries, increased flooding will cause reduced production and damages during the whole periods. The technologies used in this scenario might cover little and limited improvement in farming practice and varietal enhancement. Farming practices might include introduction of additional inputs including feed with technological transformation from traditional to extensive fish culture, limited level species replacement, water management etc.

High Agricultural Growth-RCP8.5	Present	2030	2050	2080	High Agricultural Growth-RCP4.5	Present	2030	2050	2080
Temperature:	Annual Average Max Temp: 30°C	0.6	1	1.7	Temperature:	Annual Average Max Temp: 30°C	0.6	0.8	1
	Annual Average Min Temp: 20°C	1	1.5	2.4		Annual Average Min Temp: 20°C	0.9	1.2	1.4
Rainfall:	Annual Rainfall: 4200 mm	9%	9%	14%	Rainfall:	Annual Rainfall: 4200 mm	9%	10%	13%
	Pre-monsoon Rainfall: 1050 mm	36%	33%	35%		Pre-monsoon Rainfall: 1050 mm	35%	35%	36%
Early Flash Floods:	Increasing Trend	+	++	+++	Early Flash Floods:	Increasing Trend	+	+	++
Other Hazards:	Lightening, Hailstorm etc. are gradually increasing	+	++	+++	Other Hazards:	Lightening, Hailstorm etc. are gradually increasing	+	+	++
Erosion & Siltation:	Erosion: Not Sever, Constant	+	++	+++	Erosion & Siltation:	Erosion: Not Sever, Constant	+	+	++
	Siltation: Sever, Related to Rainfall	+	++	+++		Siltation: Sever, Related to Rainfall	+	+	++
Crop Production:	4.38 million metric tons	++	+++	+++	Crop Production:	4.38 million metric tons	++	+++	+++
Fisheries Production:	3.6 lakh MT (8.6% of total)	++	+++	+++	Fisheries Production:	3.6 lakh MT (8.6% of total)	++	+++	+++
Supply-Demand Nexus:	Supply is surplus for both crop and fisheries (54% Rice, 64%)	++	++	+	Supply-Demand Nexus:	Supply is surplus for both crop and fisheries (54% Rice, 64%)	++	++	++
Diversification:	Main crop mostly rice and Boro (69%) is dominating type majority of the captured fish production is from floodplain (48%)	++	++	+++	Diversification:	Main crop mostly rice and Boro (69%) is dominating type majority of the captured fish production is from floodplain (48%)	++	++	+++
Use of Technology:	Mostly traditional, Use of advance technology to some extent.	++	+++	+++	Use of Technology:	Mostly traditional, Use of advance technology to some extent.	++	+++	+++
Low Agricultural Growth-RCP8.5	**Present**	**2030**	**2050**	**2080**	**Low Agricultural Growth-RCP4.5**	**Present**	**2030**	**2050**	**2080**
Temperature:	Annual Average Max Temp: 30°C	0.6	1	1.7	Temperature:	Annual Average Max Temp: 30°C	0.6	0.8	1
	Annual Average Min Temp: 20°C	1	1.5	2.4		Annual Average Min Temp: 20°C	0.9	1.2	1.4
Rainfall:	Annual Rainfall: 4200 mm	9%	9%	14%	Rainfall:	Annual Rainfall: 4200 mm	9%	10%	13%
	Pre-monsoon Rainfall: 1050 mm	36%	33%	35%		Pre-monsoon Rainfall: 1050 mm	35%	35%	36%
Early Flash Floods:	Increasing Trend	+	++	+++	Early Flash Floods:	Increasing Trend	+	+	++
Other Hazards:	Lightening, Hailstorm etc. are gradually increasing	+	++	+++	Other Hazards:	Lightening, Hailstorm etc. are gradually increasing	+	+	++
Erosion & Siltation:	Erosion: Not Sever, Constant	+	++	+++	Erosion & Siltation:	Erosion: Not Sever, Constant	+	+	++
	Siltation: Sever, Related to Rainfall	+	++	+++		Siltation: Sever, Related to Rainfall	+	+	++
Crop Production:	4.38 million metric tons	+	-	--	Crop Production:	4.38 million metric tons	+	-	--
Fisheries Production:	3.6 lakh MT (8.6% of total)	++	-	--	Fisheries Production:	3.6 lakh MT (8.6% of total)	++	+	-
Supply-Demand Nexus:	Supply is surplus for both crop and fisheries (54% Rice, 64%)	+	-	--	Supply-Demand Nexus:	Supply is surplus for both crop and fisheries (54% Rice, 64%)	+	-	--
Diversification:	Main crop mostly rice and Boro (69%) is dominating type majority of the captured fish production is from floodplain (48%)	+	+	++	Diversification:	Main crop mostly rice and Boro (69%) is dominating type majority of the captured fish production is from floodplain (48%)	+	+	++
Use of Technology:	Mostly traditional, Use of advance technology to some extent.	+	+	+	Use of Technology:	Mostly traditional, Use of advance technology to some extent.	+	+	+

Figure 9.5: Summary of narratives of the four scenarios of PSD

Extreme climate change-Low Agricultural growth

This scenario assumes extreme climate change and a business as usual approach in agricultural growth. In this scenario, annual average maximum temperature in the study area is predicted to rise by 0.6°C (2030), 1°C (2050) and 1.7°C (2080) in future. The annual average minimum temperature is predicted to rise by 1°C (2030), 1.5°C (2050) and 2.4°C (2080). So, the change in minimum temperature is higher and overall higher increases in both maximum and minimum temperature than in moderate climate change axis. The annual rainfall is predicted to rise by 9% (2030), 9% (2050) and 14% (2080) in future. The pre-monsoon season (MAM) rainfall is predicted to rise by 36% (2030), 33% (2050) and 35% (2080). So, in future more rainfall is going to occur during pre-monsoon which is very threatening to agriculture. The future rainfall situation is similar to that of moderate climate change axis. As this will increase early flash floods, boro rice production will be damaged. In this scenario, early flash flood is expected to be slightly frequent by 2030, more frequent by 2050 and much more frequent by 2080. Consequently, other climate induces hazards are also expected to become more frequent and intensify during 2030, 2050 and 2080. Similarly, the erosion and siltation issues are also expected to follow similar trend in the future.

As the agricultural growth driver is on the low axis, there are no additional efforts to enhance productions. So, due to climate change impacts, rice production might be reduced 1.1%, 2.5% and 2.7% in 2030s, 2050s and 2080s respectively. The scenario will have small amount crop diversification slightly increasing by 2080. Similarly, use of different agricultural technology will be very minimal in the future. These technologies cover little and limited improvement in farming practice and varietal enhancement. Farm practices might include introduction of additional secondary tillage, limited level seed replacement, water management etc. Due to the introduction of these technologies and better farm practice, damages to yield could be reduced upto 15%.

Under low level climate smart technological enhancement rice production might be increased by 4%, 3% and 1% in 2030s, 2050s and 2080s respectively. The local rice demand will be increased to 3.0, 3.8 and 3.7 million tons in 2030s, 2050s and 2080s respectively but the surplus will be reduced in the stated time frame. The existing rice production will fulfill the local demand even in 2080s without technological enhancement. However, local food demand for other crops might not be fulfilled in this time frame by local production. Even technological enhancement could not make any significant change.

The fisheries production in future is expected to rise heavily by 2030 and reduce in 2050 and further reduce to lower than present state by 2080. It is estimated that the Haor districts will produce about 4.37 lakh MT and 5.34 lakh MT of fish production in 2030 and 2050. The local required demand is 1.6 lakh MT, 1.8 lakh MT and 1.75 lakh MT in 2030, 2050 and 2080 respectively. As the habitat and production is more from the capture segment and not from culture, it might benefit from increased flooding. But in later part of century, due to cumulative impacts of climate induces hazards, the habitats might be threatened and reduced in size causing reduction in total production. For the culture fisheries, increased flooding will cause reduced production and damages during the whole periods. The technologies used in this scenario might cover limited improvement in farming practice and management perspectives. Farming practices might include introduction of additional inputs including feed with technological transformation from extensive to semi intensive fish culture, management of open water body, fish sanctuary establishment, etc.

Moderate climate change-High Agricultural growth

This scenario assumes a moderate climate change and a more organized and futuristic approach to enhance agricultural growth proactively. In this scenario, annual average maximum temperature in the study area is predicted to rise by 0.6°C (2030), 0.8°C (2050) and 1°C (2080) in future. The annual average minimum temperature is predicted to rise by 0.9°C (2030), 1.2°C (2050) and 1.4°C (2080). So, the change in minimum temperature is higher. The annual rainfall is predicted to rise by 9% (2030), 10% (2050) and 13% (2080) in future. The pre-monsoon season (MAM) rainfall is predicted to rise by 35% (2030), 35% (2050) and 36% (2080). So, in future more rainfall is going to occur during pre-monsoon which is very threatening to agriculture. As this will increase early flash floods, boro rice production will be damaged. In this scenario, early flash flood is expected to be slightly frequent by 2030 and 2050 and more frequent by 2080. Consequently, other climate induces hazards are also expected to become more frequent and intensify during 2030 and 2050 and further increase by 2080. Similarly, the erosion and siltation issues are also expected to follow similar trend in the future.

As the agricultural growth driver is on the high axis, there will be additional efforts to enhance productions. So, due to climate change impacts, rice production might be reduced 1.4%, 2.6% and 2.9% in 2030s, 2050s and 2080s respectively. The scenario includes introduction of very high level of climate smart technologies e.g. residue incorporation, residue tillage, Alternate wetting and drying, site specific Nitrogen management, improved irrigation pump efficiency, farm trainings etc. Due to the introduction of these technologies and better farm practice, damages to yield could be reduced upto 75%. This scenario will have medium to high crop diversification increasing in the future periods. Similarly, use of different agricultural technology will be increasing from medium to high in the future.

Under high level climate smart technological enhancement rice production might be increased by 27%, 26% and 25% in 2030s, 2050s and 2080s respectively. The local rice demand will be increased to 3.0, 3.8 and 3.7 million tons in 2030s, 2050s and 2080s respectively but the surplus will be reduced in the stated time frame. The existing rice production will fulfill the local demand even in 2080s without technological enhancement. However, local food demand for other crops might not be fulfilled in this time frame by local production. So, innovative technological enhancements like floating gardens, raised bed etc. will be utilized to enhance production.

The fisheries production in future is expected to rise heavily by 2030 and reduce in 2050 and further reduce to lower than present state by 2080. It is estimated that the Haor districts will produce about 4.37 lakh MT and 5.34 lakh MT of fish production in 2030 and 2050. The local required demand is 1.6 lakh MT, 1.8 lakh MT and 1.75 lakh MT in 2030, 2050 and 2080 respectively. As the habitat and production is more from the capture segment and not from culture, it might benefit from increased flooding. But in later part of century, due to cumulative impacts of climate induces hazards, the habitats might be threatened and reduced in size causing reduction in total production. For the culture fisheries, increased flooding will cause reduced production and damages during the whole periods. To overcome these damaging phenomena, proactive measures like cage/ pen culture, introduction of more resilient and more productive fish variety, public awareness, forecasting of disaster events etc. will be utilized. These measures will ensure that the fisheries production in future will rise heavily by 2030 and further increase by 2050 and 2080. The technologies used in this scenario might cover modern farming practice, good quality of fish seed and varietal enhancement. Farming

practices might include introduction of modern culture technology Farming practices might include introduction of additional inputs including feed with technological transformation from traditional to extensive fish culture, limited level species replacement, water management etc.

Extreme climate change-High Agricultural growth

This scenario assumes extreme climate change and a more organized and futuristic approach to enhance agricultural growth proactively. In this scenario, annual average maximum temperature in the study area is predicted to rise by 0.6°C (2030), 1°C (2050) and 1.7°C (2080) in future. The annual average minimum temperature is predicted to rise by 1°C (2030), 1.5°C (2050) and 2.4°C (2080). So, the change in minimum temperature is higher and overall higher increases in both maximum and minimum temperature than in moderate climate change axis. The annual rainfall is predicted to rise by 9% (2030), 9% (2050) and 14% (2080) in future. The pre-monsoon season (MAM) rainfall is predicted to rise by 36% (2030), 33% (2050) and 35% (2080). So, in future more rainfall is going to occur during pre-monsoon which is very threatening to agriculture. The future rainfall situation is similar to that of moderate climate change axis. As this will increase early flash floods, boro rice production will be damaged. In this scenario, early flash flood is expected to be slightly frequent by 2030, more frequent by 2050 and much more frequent by 2080. Consequently, other climate induces hazards are also expected to become more frequent and intensify during 2030, 2050 and 2080. Similarly, the erosion and siltation issues are also expected to follow similar trend in the future.

As the agricultural growth driver is on the high axis, there will be additional efforts to enhance productions. So, due to climate change impacts, rice production might be reduced 1.4%, 2.6% and 2.9% in 2030s, 2050s and 2080s respectively. The scenario includes introduction of very high level of climate smart technologies e.g. residue incorporation, residue tillage, Alternate wetting and drying, site specific Nitrogen management, improved irrigation pump efficiency, farm trainings etc. Due to the introduction of these technologies and better farm practice, damages to yield could be reduced upto 75%. This scenario will have medium to high crop diversification increasing in the future periods. Similarly, use of different agricultural technology will be increasing from medium to high in the future.

Under high level climate smart technological enhancement rice production might be increased 26%, 26% and 24% in 2030s, 2050s and 2080s respectively. The local rice demand will be increased to 3.0, 3.8 and 3.7 million tons in 2030s, 2050s and 2080s respectively but the surplus will be reduced in the stated time frame. The existing rice production will fulfill the local demand even in 2080s without technological enhancement. However, local food demand for other crops might not be fulfilled in this time frame by local production. So, innovative technological enhancements like floating gardens, raised bed etc. will be utilized to enhance production.

The fisheries production in future is expected to rise heavily by 2030 and reduce in 2050 and further reduce to lower than present state by 2080. It is estimated that the Haor districts will produce about 4.37 lakh MT and 5.34 lakh MT of fish production in 2030 and 2050. The local required demand is 1.6 lakh MT, 1.8 lakh MT and 1.75 lakh MT in 2030, 2050 and 2080 respectively. As the habitat and production is more from the capture segment and not from culture, it might benefit from increased flooding. But in later part of century, due to cumulative impacts of climate induces hazards, the habitats might be threatened and reduced in size causing reduction in total production. For the culture fisheries, increased flooding will cause reduced production and damages during the whole periods. To overcome these damaging

phenomena, proactive measures like cage/ pen culture, introduction of more resilient and more productive fish variety, public awareness, forecasting of disaster events etc. will be utilized. These measures will ensure that the fisheries production in future will rise heavily by 2030 and further increase by 2050 and 2080. The technologies used in this scenario might cover habitat restoration, establishment of fish sanctuary, large scale beel nursery program, modern farming practice, good quality of fish seed and varietal enhancement. Farming practices might include introduction of modern culture technology, transformation from extensive to semi intensive or highly intensive fish culture, training on modern fish culture, etc.

9.5 Formulation of Adaptation Measures

9.5.1 Principle of Formulation of Adaptation Measures

Adaptation measures have been formulated considering the anticipated impacts derived from the Focused Group Discussions (FGDs) and household survey. Although, community people did not able to identify and differentiate all adaptation measures in respect to future time slices and cross sectoral issues, interactive discussions revealed different kind of existing coping mechanism in practice, which they preferred to continue in future. Study team formulated adaptation measures emphasizing the community perceptions described in Chapter 7. Effort has been made to formulate adaptation measures in such a way that all socio-economic challenges found from the community feedback would reduce significantly. Already outlined adaptation measures in the Bangladesh Climate Change Strategy and Action Plan (BCCSAP, 2009), Bangladesh Delta Plan 2100 and Haor Master Plan (2012) have also been taken into considerations to synchronize government vision during formulation of adaptation measures in respect to agriculture and fisheries sector. Both hard and soft measures have been included in the final adaptation measures list. Furthermore, following six key thematic areas have been covered through identified adaptation measures, e.g.

- Protection from early flash floods, drought, wave action, siltation, thunderstorm and other climate change induced hazards
- Strengthening early warning and dissemination system
- Emergency preparedness and response
- Capacity development for Disaster Risk Reduction
- Awareness raising
- Enhance resilience against Climate Change Risk

Taking all above mentioned principles into considerations adaptation measures have been proposed for three levels. They are:

- Policy level- for mainstreaming in planning
- Institutional level- for practical implementation and it’s sustainability
- Community level- for making participatory and enhance resilience

9.5.2 Existing Coping Mechanism

Following coping mechanism has been found in practice through scenario development Focused Group Discussions (FGDs) and Key Informant Interview (KII):

- Dumping of Soil in Damaged or Breached Portion of Embankments
- Cutting of Embankment to Facilitate Drainage of Waterlogged Area
- Piling Up Stones and Tree Plantation (Hijal, Karach, Chailla Ghash) around the Houses
- Digging of Beel to Make Temporary Sanctuary for Fishes

- Raising Platform of Houses
- Initiatives for Financial Crisis Management, Seed Supply and Awareness Raising by Non-Government Organizations (NGOs) like BRAC, ASA or Grameen Bank along with the Government.
- Engage in Cattle rearing and handicrafts manufacturing activities

Figure 9.6 and Figure 9.7 show the community perceptions regarding existing coping mechanism against climate change induced hazards and their advantages.

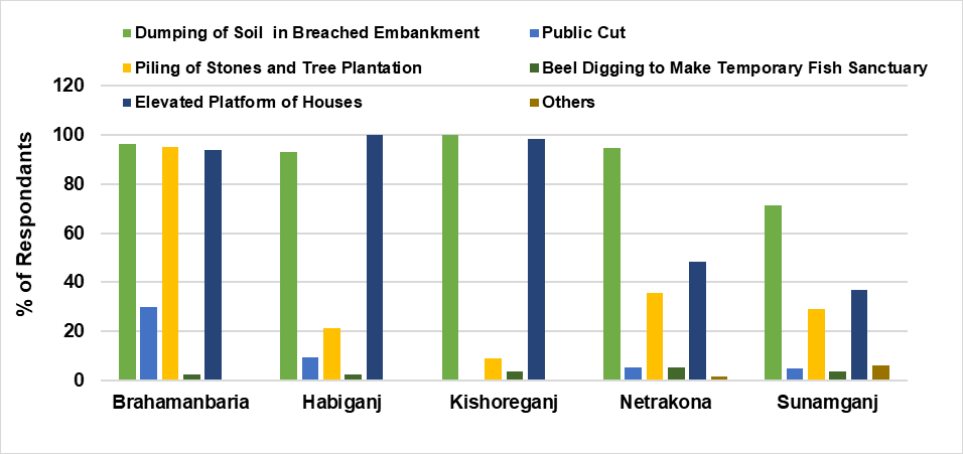


Figure 9.6: Community Perceptions of Existing Coping Mechanism in the Study Area

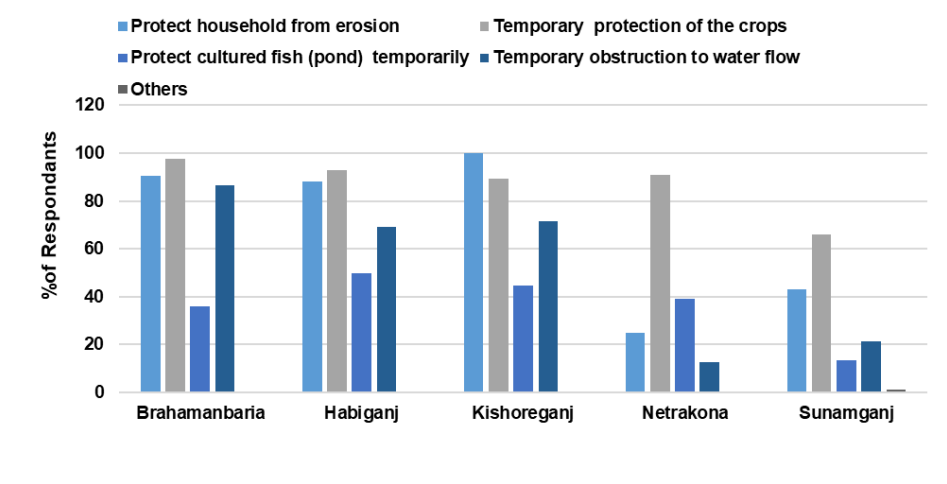


Figure 9.7: Advantages of Existing Coping Mechanism in Practice

Apart from these measures, many other measures are already in practice according to published reports and literatures. Like slope protection to some extent using vetiver grass, community and SMS based early warning dissemination system.

Figure 9.8: Community Giving Recommendations on Future Adaptation Options during PSD Workshop

9.5.3 Recommended Future Adaptation Measures by the Community

During PSD workshops, a list of adaptation measures has been recommended by the community people and their benefits have been acknowledged. Figure 9.9 shows recommended adaptation measures by the community. Community people also appreciated the infrastructure development initiatives by the Government i.e. submersible embankment or cross drainage structures construction. They acknowledged that their agriculture-based income has been increased reducing crop damage and ensuring protection against sudden flash floods by those infrastructures. Albeit, emphasis has been given to ensure timely operation and maintenance these infrastructures to make these initiatives sustainable one. Figure 9.10 and Figure 9.11 show benefits received by the Government initiatives for infrastructures development and urges for timely operation and maintenance works respectively.

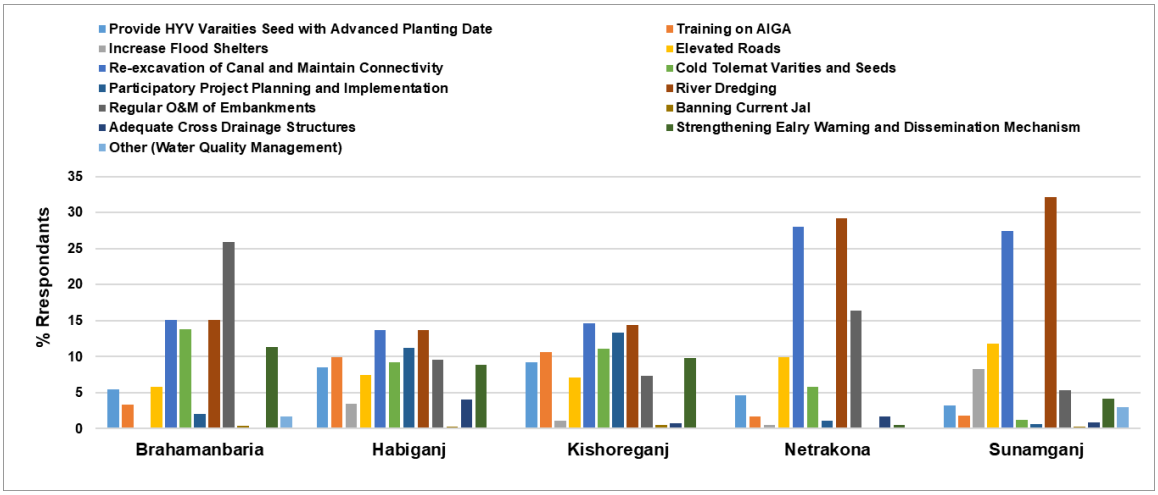


Figure 9.9: Recommended Adaptation Measures by the Community

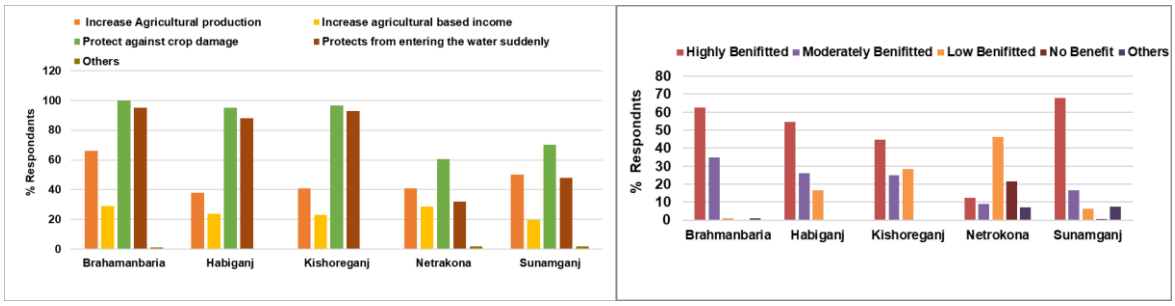


Figure 9.10: Benefits Received by the Community due to Govt. Initiatives for Infrastructure Development

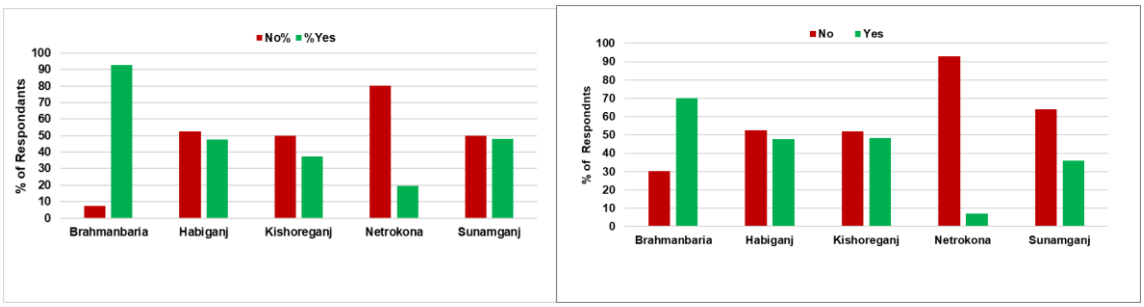


Figure 9.11: Functioning Status of Embankments and Cross Drainage Structures (Left) and Timely Operation and Maintenance (Right)

Community recommended adaptation measures as a sustainable solutions are as following:

- Promotion of HYV (High Yielding Variety) and Ensure Supply of HYV Seeds to the Community
- Skill Development Training on Alternative Income Generation Activities (AIGA)
- Increase number of Flood Shelters
- Construction of Elevated Roads
- Promotion of Cold Tolerant Varieties and Ensure Supply of Seeds to the Community
- Re-excavation of Khals to Maintain Connectivity of Beels and Rivers
- Ensure Community Participation during Project Formulation, Execution and Completion

- Regular Dredging of Rivers to Maintain Navigability and Reduce Siltation Problem
- Construction and Regular Operation and Maintenance of Submersible Embankments
- Ban Use of Current Jal for Fishing
- Ensure Adequate Drainage Facilities Constructing Culverts and Bridges
- Strengthening Early Warning and Dissemination System for Flash Floods
- Engage Community Level Medium (like union parishad, community miking or miking through mosque) etc for Effective Dissemination of Early Warning Information
- Slope Protection for Village Settlements through CC Block, Geo Textile Bag and Eco-Friendly Solutions.
- Promotion of Boat School.
- Emergency Relief Boat/ School Transportation Boat.
- Boat Ambulance.
- Community Driven Digital Dashboard for Dissemination of Early Warning System
- Construction of Seed Store.
- Flood Relief Center/Community School
- Awareness Raising Program engaging NGOs and local administration
- Research and Development and Promotion of Short Duration HYV Varieties
- Crop Insurance Mechanism
- Flood Insurance Mechanism
- Ease of Loan Facilities for Crisis Management and Rehabilitation

9.5.4 Selected Adaptation Measures

Based on the summary of existing coping practices, adaptation measures and suggestions from community the proposed adaptation measures have been selected to facilitate the scenario development process:

Policy level (P)

1. Protect agriculture and vulnerable communities from floods;
2. Management of River and water resources;
3. Management of sustainable communication network (roads and waterways) in haor area
4. Sustainable management of haor ecosystem and biodiversity; and
5. Integrated land and water resources management

Institutional level (I)

1. **Flood protection structure construction, maintenance and rehabilitation:** This measure includes construction, maintenance (O&M) and rehabilitation of flood protection structures (e.g., embankments, submersible embankments, elevated roads, temporary dams). Additionally, flood shelter, relief centre, raised land platform for protection from flood is also included in this measure.
2. **Protective works for wave action protection:** Wave action is an important hazard for the haor area population. The protection from this includes tree plantation (Hijal, Karach, chailla grass etc.) around houses/ settlements, revetment in important areas, slope protection of embankment/ settlements using CC blocks, geotextiles layer, vetiver grass etc.
3. **Dredging / excavation of river, canals, khals for maintaining navigability and conveyance capacity:** Maintaining rivers, canals, khals and beels for conveyance and navigability is a prime concern for Haor areas. This measure includes excavation,

dredging etc. for rivers/ canals/ beels, management of dredged material to raise community structures and repairing of embankments etc.

4. **Provide forecast and early warning information for different hazards:** As the hazard frequency and intensity is increasing with climate change impacts, forecasting and early warning of different hazards is getting more importance in the Haor area. This measure includes production of operational forecasting and early warning, enhancement of forecast lead time and efficient and quick dissemination (SMS, digital dashboards at community gathering places).
5. **Enhance communication networks in haor area:** This measure includes increasing connectivity, regular maintenance and promoting environment friendly approaches of communication. Introduction of boat based regular transportation, waterways-based transportation, submersible embankments/ roads with adequate drainage structures (culverts, bridges), promotion of boat school, emergency relief boat, boat ambulance/ medical camps etc. are some of the possible adaptation actions.
6. **Sustainable management of haor ecosystem:** The haor ecosystem is the lifeline of the area and its sustainable management is needed to promote species biodiversity, enhance production etc. This includes beel excavation to enhance/ allowing fish sanctuary, banning fishing nets of very small opening, ensuring drainage from waterbodies in a sustainable way, protection and promotion of local plant, birds and fish species etc.
7. **Integrated, seeds, fertilizer and pesticide management:** Crop production sustainability is needed for future proof agriculture. To ensure this, integrated inputs supply (seeds, fertilizer and pesticides) management is needed. This will ensure optimum crop production along with ecosystem protection through controlled water quality, treatment of fertilizer, waste and pesticide flow. The inputs supply should be ensured through community level network of stores.
8. **Increase irrigation efficiency:** The rice cultivation practice used currently does not use efficient irrigation. There are several technologies to increase irrigation efficiency which could improve Boro crop irrigation need situation. This measure will include awareness building, community mobilization etc. to improve irrigation efficiency.
9. **Facilitate use of advanced agricultural technologies and crop diversification:** This measure will include institutional level facilitation in adaptation of advanced agricultural technologies (e.g., introduction of additional secondary tillage, seed replacement, water management, residue incorporation, residue tillage, Alternate wetting and drying, site specific Nitrogen management, improved irrigation pump efficiency, farm trainings etc.) and organized effort in crop diversification to minimize climate induced hazard threats.
10. **Facilitate agricultural technology transfer and value chain management:** This measure will include institutional level facilitation in transfer of new technologies (e.g., HYV seeds, climate tolerant seeds, short duration crop seeds, IPM, Alternate wetting and drying, site specific Nitrogen management, new cultivars with specific capacity etc.) and careful analysis of agricultural value chain and efforts to climate proof the value chain.
11. **Facilitate community groups to act as medium:** Community engagement is very important for sustainable actions. So, this measure focuses on facilitating community groups to act as a medium for technology transfer, early warning dissemination, monitoring and protection of resources, project formulation and implementation, awareness building etc.
12. **NGO initiatives:** This measure involves several initiatives generally covered by the Non-Government Organizations (NGO). These includes financial support during crisis

through loans, seed supply, awareness raising, training on agricultural technologies, alternative income generating activities etc.

13. **Training for alternate Income Generating Activities:** This measure include facilitation on training for different Alternate Income Generating Activities like cattle rearing, handicraft manufacturing, home-based small factories etc.

Community Level (C)

1. Tree plantation
2. Use of good quality seeds, HYV crops, climate tolerant crops, short duration crops etc.
3. Changing planting date of Boro crops
4. Palm tree plantation
5. Improved house structures
6. Public awareness building through community groups
7. Crop diversification (Low level, Medium level, Advanced level)
8. Use of climate smart agricultural technologies (Low level, Medium level, Advanced level)
9. Alternative livelihoods

9.6 Adaptation Pathway (Back casting)

Adaptation pathways have been developed on the basis of selected timeline i.e. short term (2030s), medium term (2050s) and long term (2080s). They are as following:

Moderate Climate Change-Low Agricultural growth

Policy Measure	Adaptation Option	2030	2050	2080
P-1	I-1			
P-1	I-2			
P-1, P-2, P-3	I-3			
P-1	I-4			
P-3	I-5			
P-2, P-4	I-6			
P-4,P-5	I-7			
P-5	I-8			
P-5	I-9			
P-5	I-10			
P-5	I-11			
P-1, P-4, P-5	I-12			
P-1	I-13			
P-1, P-4	C-1			
P-5	C-2			
P-1	C-3			
P-1	C-4			
P-1	C-5			
P-2, P-4, P-5	C-6			
P-5	C-7			
P-5	C-8			
P-1	C-9			

Extreme Climate Change-Low Agricultural growth

Policy Measure	Adaptation Option	2030	2050	2080
P-1	I-1			
P-1	I-2			
P-1, P-2, P-3	I-3			
P-1	I-4			
P-3	I-5			
P-2, P-4	I-6			
P-4,P-5	I-7			
P-5	I-8			
P-5	I-9			
P-5	I-10			
P-5	I-11			
P-1, P-4, P-5	I-12			
P-1	I-13			
P-1, P-4	C-1			
P-5	C-2			
P-1	C-3			
P-1	C-4			
P-1	C-5			
P-2,P-4,P-5	C-6			
P-5	C-7			
P-5	C-8			
P-1	C-9			

Moderate Climate Change-High Agricultural growth

Policy Measure	Adaptation Option	2030	2050	2080
P-1	I-1			
P-1	I-2			
P-1, P-2, P-3	I-3			
P-1	I-4			
P-3	I-5			
P-2, P-4	I-6			
P-4,P-5	I-7			
P-5	I-8			
P-5	I-9			
P-5	I-10			
P-5	I-11			
P-1, P-4, P-5	I-12			
P-1	I-13			
P-1, P-4	C-1			
P-5	C-2			
P-1	C-3			
P-1	C-4			
P-1	C-5			
P-2,P-4,P-5	C-6			
P-5	C-7			
P-5	C-8			
P-1	C-9			

Extreme Climate Change-High Agricultural growth

Policy Measure	Adaptation Option	2030	2050	2080
P-1	I-1			
P-1	I-2			
P-1, P-2, P-3	I-3			
P-1	I-4			
P-3	I-5			
P-2, P-4	I-6			
P-4,P-5	I-7			
P-5	I-8			
P-5	I-9			
P-5	I-10			
P-5	I-11			
P-1, P-4, P-5	I-12			
P-1	I-13			
P-1	C-3			
P-1	C-4			
P-1	C-5			
P-2,P-4,P-5	C-6			
P-5	C-7			
P-5	C-8			
P-1	C-9			

9.7 Prioritization of Adaptation Measures

The prioritization of the adaptation measures has been done based on several prioritization criteria. These are;

- Fund requirement (amount)
- Role of timely availability of fund
- Resources Optimization
- Scope of Community Engagement
- Adequate Capacity
- Coordination
- Enabling Environment
- Need from Community
- Benefit level

The institutional and community level adaptations are separately evaluated for prioritization on a scale of -3 to 3. The policy level measures are more strategic kind of measures and for this reason they are not prioritized. The following tables present the scores and prioritization ranking.

Institutional Level

Adaptation Option	Fund requirement (amount)	Timely availability of fund	Resources Optimization	Community Engagement	Lack of Adequate Capacity	Lack of Coordination	Enabling Environment	Need from Community	Benefit level	Total score	Rank
I-1	-3	-3	1	1	3	0	3	3	3	8	13
I-2	-1	0	1	2	3	0	2	3	2	12	2
I-3	-3	0	1	1	3	1	2	2	2	9	9
I-4	-1	2	2	1	1	2	1	2	2	12	2
I-5	-2	2	1	2	1	-1	1	2	3	9	9
I-6	-1	2	2	2	1	1	1	1	2	11	6
I-7	-1	2	1	2	2	1	1	2	1	11	6
I-8	0	1	1	3	2	0	2	1	2	12	2
I-9	0	0	2	3	2	2	2	2	2	15	1
I-10	0	0	1	3	2	1	2	1	2	12	2
I-11	0	0	1	3	1	-1	1	2	2	9	9
I-12	-1	-2	2	3	2	-1	2	3	1	9	9
I-13	0	1	1	3	2	0	2	1	1	11	6

Community Level

Adaptation Option	Fund requirement (amount)	Timely availability of fund	Resources Optimization	Community Engagement	Lack of Adequate Capacity	Lack of Coordination	Enabling Environment	Need from Community	Benefit level	Total score	Rank
C-1	2	0	2	3	2	2	2	3	3	19	1
C-2	0	-1	2	3	1	1	1	2	3	12	4
C-3	0	0	2	3	0	2	2	2	2	13	3
C-4	1	0	1	2	3	1	1	3	2	14	2
C-5	-2	0	1	2	2	2	2	1	2	10	6
C-6	1	0	1	2	1	1	2	1	3	12	4
C-7	0	-2	2	1	-1	-1	1	1	3	4	9
C-8	0	-2	2	1	-1	-1	2	2	3	6	8
C-9	0	0	1	1	1	-2	2	2	2	7	7

10. Guideline on Climate Change Adaptation

10.1 Introduction

The purpose of this chapter is to develop a guideline on Climate Change Adaptation which will specifically facilitate local government administration or local engieenrs and planners to make deicison on climate change adaptation in the context of Haor area. This guideline focuses on participatory process and mainstreaming climate change adaptation into local level planning process. Many parts of the guideline are adopted from following three guidelines as both are mostly relvant with this case-

- Local climate change adaptation planning: A guide for government policy and decision makers in Victoria
- Adapting to Climate Change: Guidance for Protected Area Managers and Planners
- Guidelines for Climate Change Adaptation at Local Level for Alps

Hoeever, developed resources of CEGIS for Integrating Climate Change Adaptation into Government Planning Process of Bangladesh training financed by GIZ Bangladesh under Planning Commission has also been used to make the guideline consistent with already referred knowledge base.

10.2 Principles of Climate Change Adaptation Guideline

This Climate Change Adaptation guideline is developed on the basis of following principles:

- Priorities of Bangladesh Climate Change Strategy and Action Plan (BCCSAP, 2009)
- Priorities of National Adaptation Programme of Action (NAPA, 2008)
- Strategies of Bangladesh Delta Plan 2100
- Climate Change Adaptation Plan for Bangladesh Agriculture
- Strategies of Haor Master Plan 2012
- Community engagement through bottom-up approach
- Priorities of Sustaibale Delta Goals
- Ensuring mainstreaming climate change adaptation into local government planning process
- IPCC and UNFCC recommended targets to limit temperature rise and it's consequenes on vulnerable countries like Bangladesh
- Enhancement of resilience against climate change induced hazards
- Coimmunity level capacity development
- Research for strengthening exisiting practices of climate change adaptation

10.3 Guidelines for Climate Change Adaptation

10.3.1 Establishing Local Context

Apart from gathering quantitative data on climate change and its impacts, qualitative social

research can play a crucial role in local adaptation planning – to:

1) Understand local perceptions of risks
2) Explore the adaptive capacity of individuals and groups
3) Harness local knowledge
4) Enable tailored engagement

Investing in qualitative social research as a part of adaptation initiatives can enable government agencies to:

1) Garner support for and participation in its activities
2) Prioritize and tailor programs to facilitate, build, harness and or conserve adaptive capacity
3) Enhance the design of programs through inclusion of local knowledge or by fostering co delivery models
4) Increase local awareness of and ability to manage private risk
5) Clarify roles and responsibilities to avoid duplication

Research suggested that there is a significant opportunity for co developing strategies for community engagement in conjunction with already existing social and environmental community initiatives, and to strengthen structures of deliberative decision making and participatory action on climate change adaptation. Facilitating exchange and mutual understanding between community sections and government authorities and other administrative agencies can help avoid community confusion and frustration with top-down planning processes.

Working with local Stakeholders

Succeeding in adapting to climate change at the local level requires gaining a thorough understanding of the **local socio-economic, environmental and institutional context**. For governments and their agencies working in local contexts, it is important to combine top-down adaptation planning processes that result from statutory government responsibilities with a concerted effort towards understanding which aspects of climate change matter to local people, businesses and civil society groups.

Ensuring early and active engagement of local stakeholders is critical to allow for truly place-based adaptation, where local stakeholders take co-ownership and share responsibility in the directions being taken. Stakeholder participation should reflect the ethnic, cultural, political and socio-economic diversity of local communities

Due to the complexity of climate change adaptation, it may not always be obvious to community members what adaptation means in real terms and why adaptation is a priority for governments. Planning adaptation interventions as participatory processes from the outset allows for stakeholders to contribute to important aspects of the adaptation process, such as goal setting, exploring different adaptation options, and designing and agreeing on adaptation interventions suited to the local context and values existing in the community.

Communicating Climate Change Adaptation

Climate change adaptation policy can greatly benefit from working closely with a **number of community agencies** in order to identify and reduce social vulnerabilities. However, for place-based adaptation efforts to be effective and successful, government and other administrative agencies need to ensure they develop their capabilities to communicate issues relating to

climate change in an appropriate way and provide people with the experience of being genuinely listened to.

Knowledge exchange and shared learning between government authorities and the community, as well as between culturally and socio-economically diverse community sections, can strengthen the community's ability to develop informed opinions, take responsibility and build the capacity to act. In particular, this means developing and strengthening communication structures that allow for discussion, knowledge exchange and consensus building.

Credible information and accessible, salient language, storylines, 'tangible' examples, and scenarios are needed to better engage the community with adaptive actions in the face of possible climate change impacts.

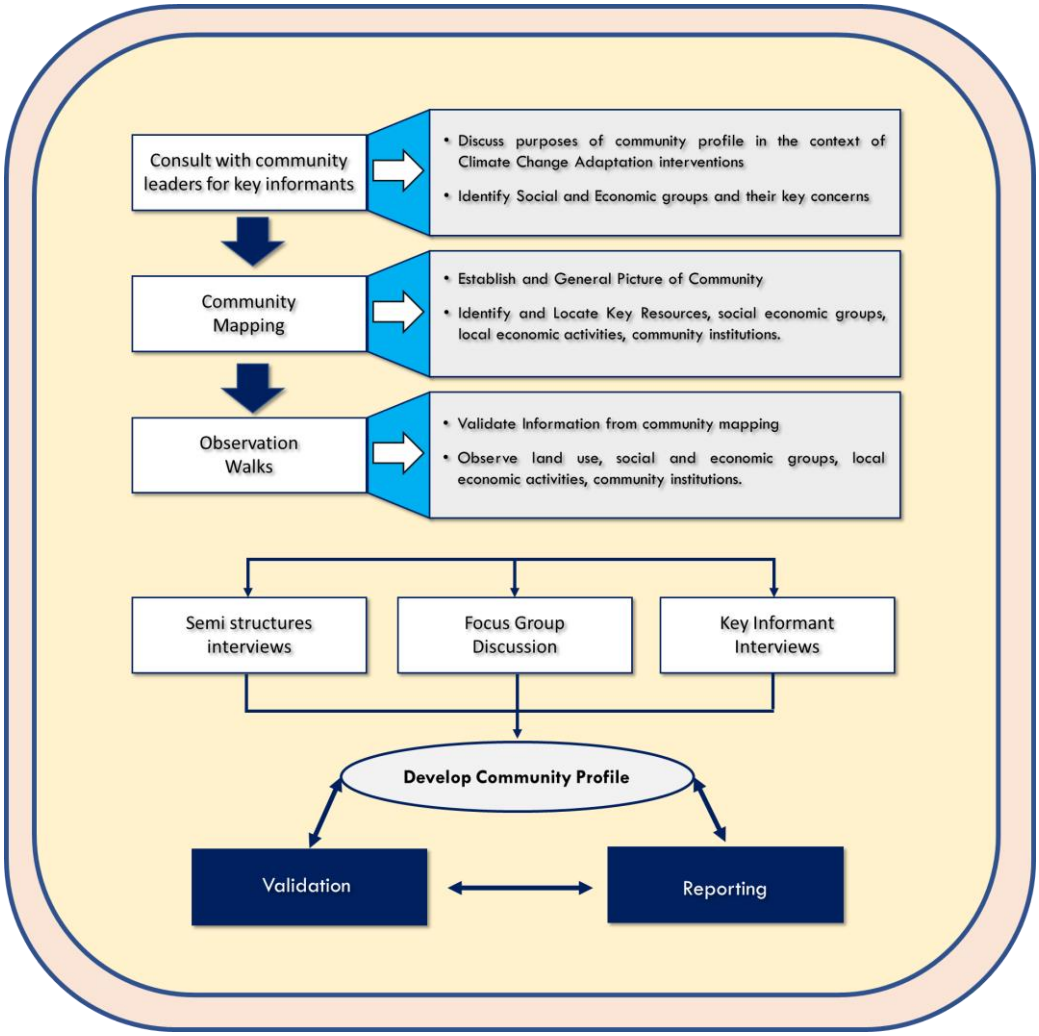
A good understanding of local communities' everyday lives, needs and concerns must be the basis of a critical and responsive reframing of climate change adaptation concepts for successful policy and practice.

Developing a Community Profile

To articulate community perceptions, values and concerns regarding climate change impacts, it can be useful to develop a community profile as part of a participatory, collaborative adaptation planning process.

"*A community profile is a summary of the history, present conditions and anticipated future of a local area. It is a bottom-up process for establishing the local context for an adaptation initiative, which can help to kick-start conversations about climate change impacts and visions of the future held by members of a community or group*."

Community profiling has a strong tradition in community-based adaptation and community development work in developing countries, and is also used in community impact assessment practices in some industrialized countries. For adaptation planning, community profiling can be carried out using the process outlined in following Figure.



Process of Developing a Community Profile

Source: Mod/fledfrom Messer N. and Ph. Townsley; 2003; Local Institutions and Ihle//hoods: Gulde/Ines for Analysis. Food and Agrlcultul'f! Organization of the United Nations. Rome: FAD.

Community maps can provide invaluable insights and a visual reference for discussions on climate change adaptation priorities with local stakeholders. Existing official maps can be used (e.g. topographical maps, land use and zoning maps, flood risk maps, tourist maps, etc.) and modified during discussions to capture concerns about climate change impacts. Alternatively, mental maps can be created by individuals or groups. Often a combination of factual official maps and mental maps created by local stakeholders are best suited to effectively capture and convey climate change adaptation issues. Maps should capture a range of local issues, including:

- population distribution and density, including socio-economic distribution
- key sites of local economic activity (industrial areas, shopping centers, agricultural land, etc.)
- locations of community services (health facilities, schools and childcare centers, council services, essential services)
- areas considered most at risk of suffering from climate change impacts (sea level rise, flooding, heat waves, cold snaps, flash flood, droughts, thunderstorms, monsoon flood etc.)

Table below provides a checklist that can be used throughout the development of a community profile, to ensure that the main aspects that characterize a community are captured. This checklist should be constantly updated and used as a source for developing more detailed checklists for individual interviews or questionnaires. Despite not asking about the impacts of climate change specifically, it can be expected that the key questions listed in the checklist will elicit information on climate variability and change, as well as social, economic and other environmental drivers of change.

Local Natural Resources

- What are the principal natural resources available to the community?
- Who uses them and how are they used?
- Where are they located?

Local Economic Activity

- What are the different local economic activities in the community?
- Who is involved in those activities (men/women, young/old, different social and economic groups) and how many people and households depend on them?
- When do those activities take place (time of day/month/seasons) and where?

Community Structure

- How many people and households live in the community?
- What is the gender composition and age structure of the community?
- What different social, economic, ethnic, cultural and political groups are there in the community?
- How are those groups defined?
- Where do those different social, economic, ethnic, cultural and political groups live?

Local Institutions

- What formal organizations and associations are there in the community?
- What rules, regulations and customs are in place?
- Who is affected by these rules, regulations and customs, and how?

Community Infrastructures

- What services are available in the community (transport, power and water supply, markets, rural extension, health, education, etc.)?
- Who has access to these services?
- How expensive are the user fees for these services?

Community History

- How long has the community been in existence and how was it founded?
- When did different social, economic, ethnic and cultural groups settle in the community?
- How has the community changed over time and what has caused those changes?

Source: Modified 'fromMesser *N. and Ph. Townsley (2003): Local instftutions and livelihoods: Guidelines for Analysis.* Food*and Agriculture Organization* of *the United Nations. Rome: FAD.*

10.3.2 Capacity Development for Climate Change Adaptation

The Capacity to Address Change

The institutional capacity of an organization affects its ability to anticipate, prepare for, detect, and respond to changes affecting species and ecosystems (Armsworth, et al., 2015). Capacity development refers to actions that increase the organization's ability to effectively enact climate adaptation. Here, we present recommendations capacity development that are the most important for planning and management in the face of a changing climate.

Capacity development is the process by which individuals, groups and organizations, institutions and countries develop, enhance and organize their systems, resources and knowledge; all reflected in their abilities, individually and collectively, to perform functions, solve problems and achieve objectives (OECD, 2006).

Wilby and Vaughan (2011) note that organizations capable of adapting to climate change typically:

- Exhibit strong and visionary leadership;
- Set clear climate adaptation objectives;
- Develop risk and vulnerability assessments of high-priority resources and adaptation guidance for practitioners;
- Employ organizational learning and integrate climate into routine management, as well as adopt low-regret, anticipatory, adaptive management;
- Routinely work on projects with a variety of partners, using different working relationships;
- Emphasize monitoring and reporting progress; and
- Ensure effective communication.

Start where you are

The best advice is to simply get started with the information and resources already have. More than anything, building capacity to address climate change requires a commitment to initiate, follow through, connect, and communicate ideas, successes, and failures.

- **Raise awareness:** Development countries like Bangladesh have an important role in raising awareness of how climate change is affecting the essential natural features and services of the planet as well as demonstrating how these systems can contribute as natural solutions to mitigation, adaptation, and hazards reduction. Many governments and NGOs are already working actively to raise awareness on climate change, but the magnitude of the change and the vast number of people and interests involved calls for engagement at a much greater scale.

- **Acknowledge and talk about the issues.** What are the areas of particular concern and who are the people who depend on and care about it? What are the specific health effects, adaptation requirements, or changes in agricultural production that are already affecting the local community? Climate trends may be lengthening the fire season, or perpetuating a drought that influences crop yield in the area. Reach out to other local authority and local communities to learn about their climate change concerns. Simply engaging in conversations with others and acknowledging the issues is an important starting point.

- **Access available information and knowledge:** Information such as climate data, observations of changes over time, projections of future changes, and analyses of expected climate impacts is neded. For most, a key obstacle to getting informed is simply finding time to sort through and read the huge volume of available information. There are an increasing number of internet-based "communities of knowledge" that encourage conversations on climate adaptation questions posted for these forums often elicit informative responses.

These guidelines refer to many kinds of information, tools, and approaches that are needed to plan and adapt to climate change, including:

- **Databases, toolkits, and synthesis reports**: There is a growing number of websites and reports that provide detailed descriptions of likely climate changes and their effects, access to tools and manuals for responding to climate change, and news of the latest research. IPCC regularly publishes extensive regional analyses of climate trends (IPCC, 2013), climate extremes (IPCC, 2012), and impacts and adaptation options (IPCC, 2014a, 2014b). Many local and regional networks also exist.

- **Scientists and researchers:** Universities, government scientists, NGO partners, and other research and conservation groups can help managers understand climate change and its impacts. Natural and social scientists all provide insights into the many elements of climate adaptation and should be considered as resources.

- **Local stakeholders and traditional ecological knowledge:** To build more detailed, first consider what people living on the land have observed about changes in their immediate environment: seasonality, changes in populations or distribution of key species, frequency and seriousness of extreme weather events, etc. Such traditional ecological knowledge (TEK) is an important, and sometimes the only, source of local information for planners and managers (e.g. Menzies, 2006). Many researchers trained in the Western science tradition are now also usefully incorporating elements of TEK into their studies. TEK has often been undervalued or taken for granted, but it can be a valuable and unique resource for managers and planners, as well as extremely cost effective (Danielsen, et al., 2014). It is always a good idea to seek multiple lines of evidence when drawing conclusions or attributing observed trends or events to climate change. Even while recognizing the importance of TEK, scientists need to be very aware of ethical issues and guidelines for engaging Indigenous communities and using their information (CTKW, 2014).

Engage partners and communities

Climate change is a shared problem that affects both ecological systems and the people that rely on them. Implementation of effective adaptation cannot be undertaken alone. The scope of the problem and solutions required are best addressed by including a broad range of people, sectors, and allies. Engagement with scientists, local communities, and others can lead to the development of innovative ideas and opportunities. Leveraging current partnerships can result in broader networks and connections, as well as new information and perspectives .Whether reaching out to the public, local stakeholders and communities, other decision-makers, or academic and NGO partners, it is important to think creatively about who should be at the table and how useful partnerships and perspectives can be cultivated.

Communicate and educate: Turn up the volume

Effective communication and education are at the heart of a strong capacity for climate change response. To be effective, materials must be targeted according to the intended audience. The WCPA Strategic Framework for Capacity Development (IUCN, 2015) identifies three priority focal groups.

1. These are internal audiences that include managers, their employees, and in some cases outside contractors.

2. These are external audiences closely linked to and often sharing goals with PAs, including NGOs, local communities, and other stakeholders and partners.

3. These are external audiences whose policies, decisions, attitudes, political will, and activities indirectly influence capacity development.

Enhancing communication capacity involves both internal communication to ensure all levels of management are familiar with the relevant science and available options, and external communication to share pertinent information among stakeholders. Internal communications include interactions among various personnel and divisions with different responsibilities, as well as targeted training for specific disciplines. External communications should be designed to both engage the general public in developing necessary adaptation alternatives in the present, and to educate specific external audiences, such as young people, who will inherit the responsibility of long-term management in the future. The best engagement strategies use a wide variety of communication techniques and media, and experiment with new outlets and technologies to effectively communicate in ways that reach a range of cultures.

Internal communication with staff and employees Climate change adaptation will be most effective when there is a common understanding of the issues and a culture that encourages discussion of potential responses and solutions.

Plan and act: Become a learning organization

Climate change often in combination with other stressors will create new challenges that require creative solutions. Organizations that promote learning will be more capable of dealing with novel and rapidly changing situations than those that rely on doing “business as usual”. Learning organizations allow people to continually expand their capacity to create the results they are aiming for, while working together for a better future (Senge, 2006). The rationale for such organizations is that in situations of rapid change, only those that are flexible and adaptive will excel. Building a learning organization involves leadership that is credible and open-minded.

Climate change is a complex issue with many variables, and there may be no relevant history or previous experience to guide decisions. Furthermore, adaptation strategies may require prioritizing one important value over another. Alternative courses of action can involve significant trade-offs while presenting no definitive “right” answer. Thus, when dealing with the problem of climate change, will need to recognize the range of thoughts and opinions on future actions, and actively work to maintain flexibility in decision making.

Summary

Climate change adaptation is relatively new, and it is crucial that managers and practitioners communicate and share experiences, best practices, and lessons learned. Protected areas can build capacity for future leaders through new and existing networks and by training staff and reaching out to youth and young professionals. To respond to the challenges of climate change requires that they plan, manage and act in ways that differ from those of the past. Capacity Building will respond to climate change by:

- Starting now and working with what you have;
- Engaging partners and knowledge holders, both professional and local;
- Supporting staff development;
- Committing to ongoing knowledge development and exchange;
- Incorporating forward-looking planning;
- Being flexible and willing to alter plans;
- Thinking at broader scales; and
- Being a “learning organization”.

10.3.3 Assessing Current and Future Climate Change Impacts

There are at least two types of climate information required to undertake a climate change assessment.

Firstly, *information is required on the past and current climate and*

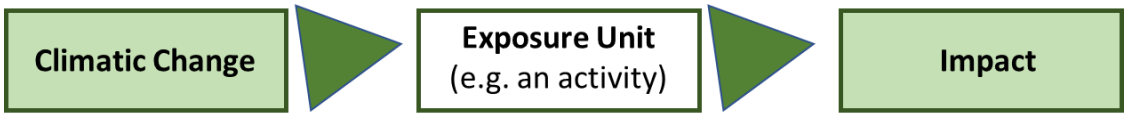
secondly, *information is required on the projected future climate and the likely local and regional effects.*

Both types of information are required to better understand a system’s vulnerability to climatic variability and change.

Climate Change Impact Assessment

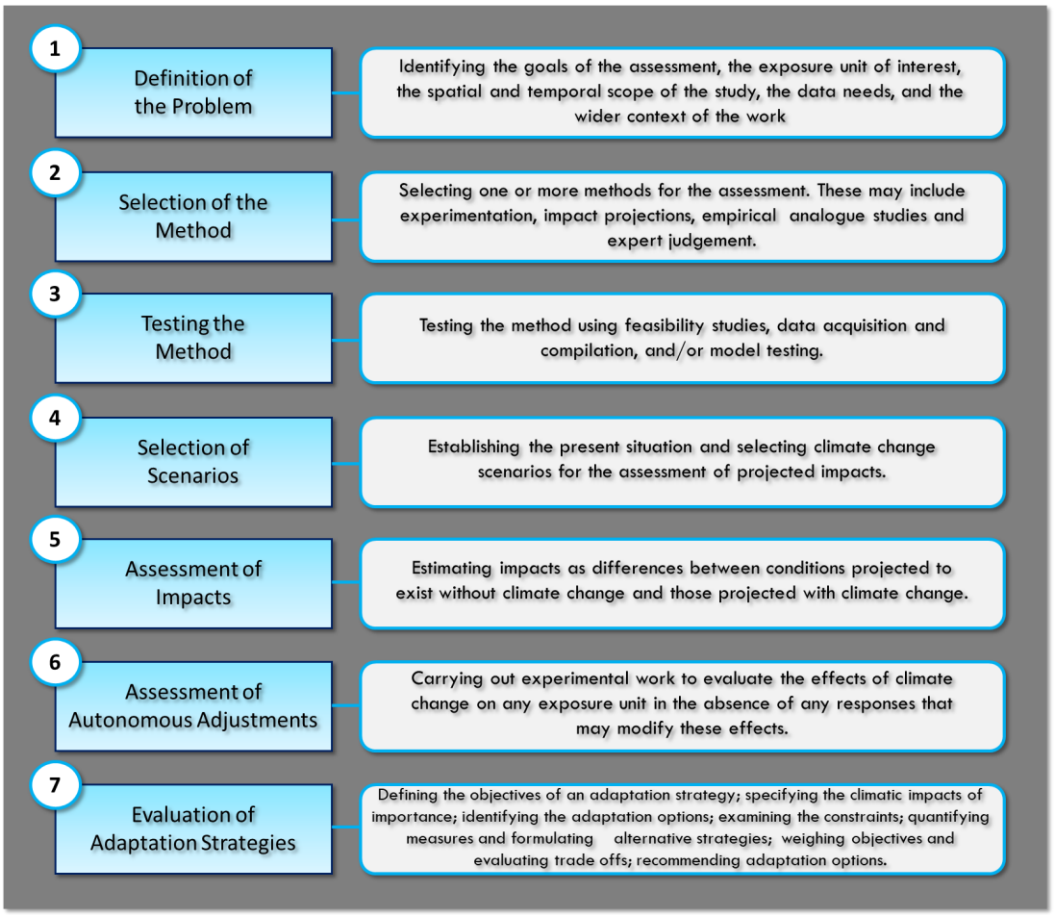
Climate impact assessments focus on how changes in climate affect a particular 'exposure unit'. An exposure unit may be an activity, group, region or resources (human or natural) exposed to significant climatic variations. Impact assessments can be carried out at various scales (national, regional or local) and rely significantly on quantitative data on climatic stimuli and climate change phenomena. This data is typically combination of observational records and projections (or scenarios) derived from Global Climate Models (GCMs).

The approach normally analyses a specific climate change impact and assumes a controlled environment where any non-climate effects are held constant.



Standard Impact Assessment Approach

The climate impact assessment approach has been heavily influenced by the 'seven steps model', published by the IPCC in 1994. Table 4 outlines this impact assessment model.



A weakness in this approach is that multiple climatic and non-climatic stressors coexist in any given system or place, and that is practically very difficult to isolate an impact from such contextual factors. This issue is further complicated by the uncertainty associated with information on climate change and non-climatic stressors (e.g. uncertainty in demographic changes, policy context etc.). Due to these and other limitations of the seven steps model, most impact assessment applications now favor more integrated approach (see 'Integrated assessment' below).

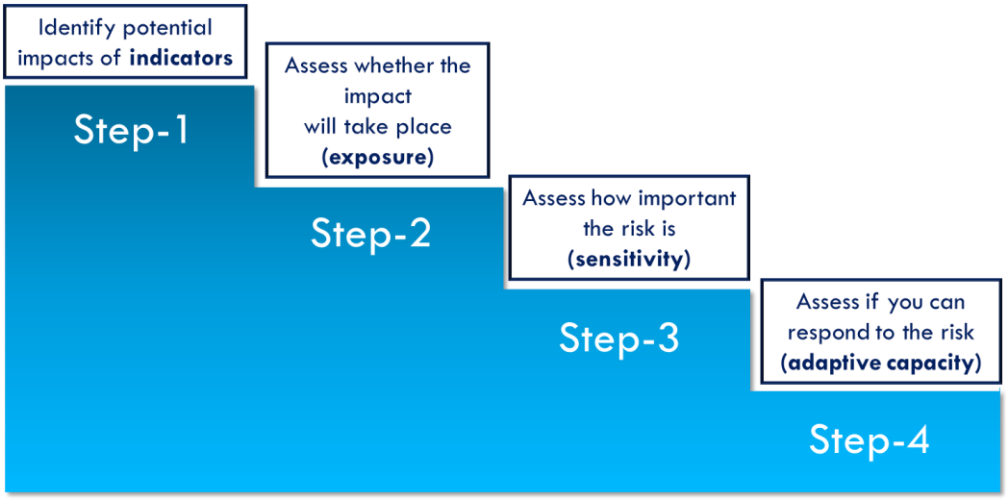
10.3.4 Climate Change Vulnerability Assessment

A climate change vulnerability assessment is a way of identifying and prioritizing impacts from climate change. The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability as:

“Vulnerability to climate change is the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change ” (Parry et al. 2007)

A vulnerability assessment lets you identify these adverse impacts of climate change that are most important to your area.

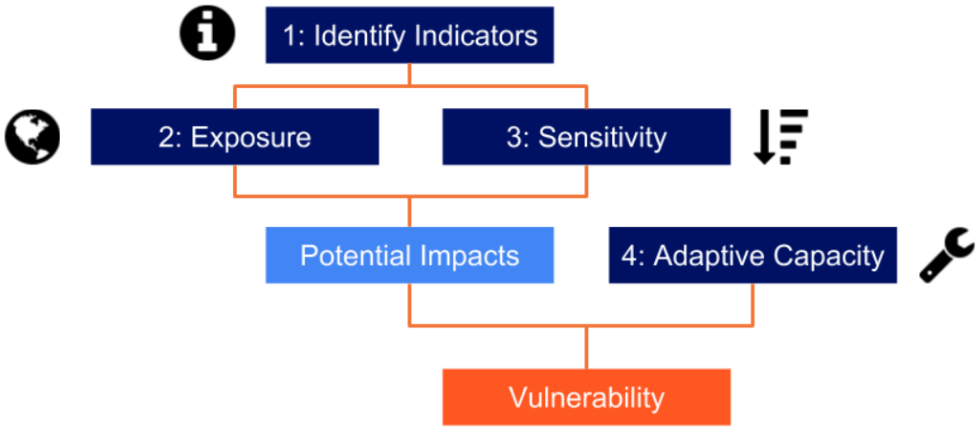
There are four steps to conducting a vulnerability assessment, there are:



Step-1: Identifying Potential Impacts of Indicators

The first step in a Climate Change Vulnerability Assessment is to develop a set of indicators. Indicators are a list of potential impacts that may take place in your area as a result of climate change. The purpose of this list of indicators is to provide a starting point for the Vulnerability Assessment. Probable list of indicators are given below:

- **Agriculture**
- **Biodiversity and Environment**
- **Human Health**
- **Human Settlements and Infrastructure**
- **Water**



Step-2: Assess whether the impact will take place (exposure)

The second step in the climate change vulnerability assessment refers to the concept of "Exposure". Now that it is known what the list of all potential impacts are (Step 1), it is needed to determine whether or not the people of target area are exposed to the particular climate change impact. The question can be asked, "Will this particular impact take place in the targeted area?"

Exposure is usually scored using a **yes/no answer.** Considering an example indicator from

the human settlement sector, increase impacts on Informal Dwellings, for exposure it can be asked: “Do we have informal dwellings in the area?”.

Step-3: Assess how important the risk is (sensitivity)

Once the exposure is assessed (step 2) there comes the sensitivity. Sensitivity refers to the seriousness of the potential impact from climate change. A way to assess sensitivity is to ask the questions, “If the climate change impact will take place in my area, how important will this impact be?”

Sensitivity is usually scored using a **high, medium or low rating.** In the Vulnerability Assessment Tool, each indicator has a proposed way of scoring sensitivity as high medium or low. If we consider an example indicator from the human settlement sector, Increase impacts on Informal Dwellings, for sensitivity we would ask the question: “What percentage of households live in informal dwellings?”. The answer to the sensitivity question may require more recent statistics and local knowledge.

Step-4: Assess if the community can respond to the risk (adaptive capacity)

The fourth step in the climate change vulnerability assessment refers to the concept of “Adaptive Capacity”. Now that it is known what the list of all potential impacts are (Step 1), whether or not the community are exposed (Step 2), if exposed how sensitive is the issue (Step 3), it is required to determine whether or not the community have the systems in place to respond to the climate change impact. Do do this, ask the question, “Do I have systems in place to respond to the impact?”.

The IPCC defines Adaptive Capacity as the *“ability of a system to adjust to climate change to moderate potential damages, to take advantage of opportunities, or to cope with the consequences”.* (Parry et al. 2007)

Adaptive Capacity is usually scored using a high, medium or low rating and we usually consider four different types of systems, namely Research, Policy, Institutional Support, Finance and Community. Consider an example indicator from the human settlement sector, increase impacts on traditional and informal dwellings, for adaptive capacity ask the following questions:

- Is there local research on the particular climate change risk (e.g risks to traditional and informal dwellings)?
- Are there robust policies & programs in place to deal with the particular climate change risk (e.g risks to traditional and informal dwellings)?
- Are there institutional systems to deal with the particular climate change risk (e.g risks to traditional and informal dwellings)?
- Is there financial support for the particular climate change risk (e.g risks to traditional and informal dwellings)?
- Is there adaptive capacity within the community to deal with the particular climate change risk (e.g risks to traditional and informal dwellings)?

The Adaptive Capacity score is a summary of average High, Medium and Low scores of this different question.

Linking Vulnerability Assessment Output with Adaptation Policy

Relating vulnerability assessment outputs to stakeholder decision making, public awareness

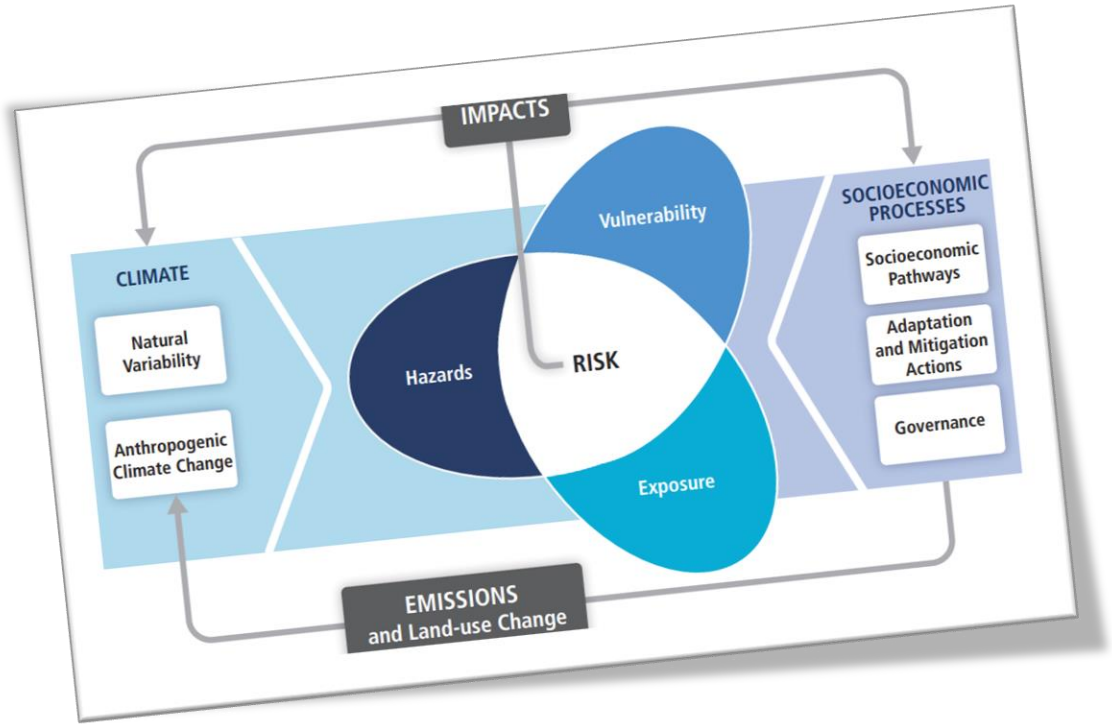
and further assessments.

The strength of vulnerability assessments is that they build the case for climate change adaptation based on local knowledge and bottom-up information, thus helping ensure that adaptation options developed during planning processes are designed in response to actual local needs. Also, through the analysis carried out as part of vulnerability assessments, future climatic change can become directly linked to current social, economic and environmental drivers of vulnerability and help enable the identification of 'starting points' for adaptation.

10.3.5 Detailed Climate Change Risk Assessment

Climate change risk assessment can help organizations identify their climate change related risks or to test their existing risk management strategies under climate change and therefore identify areas where new strategies are needed.

Risk results from the interaction of vulnerability (of the affected system), its exposure over time (to the hazard), as well as the hazard and the likelihood of its occurrence, which can be represented by the three sides of a triangle. If any one of these sides increases, the area of the triangle increases, hence the amount of risk also increases. If any one of the sides reduces, the risk reduces. If we can eliminate one side there is no risk.



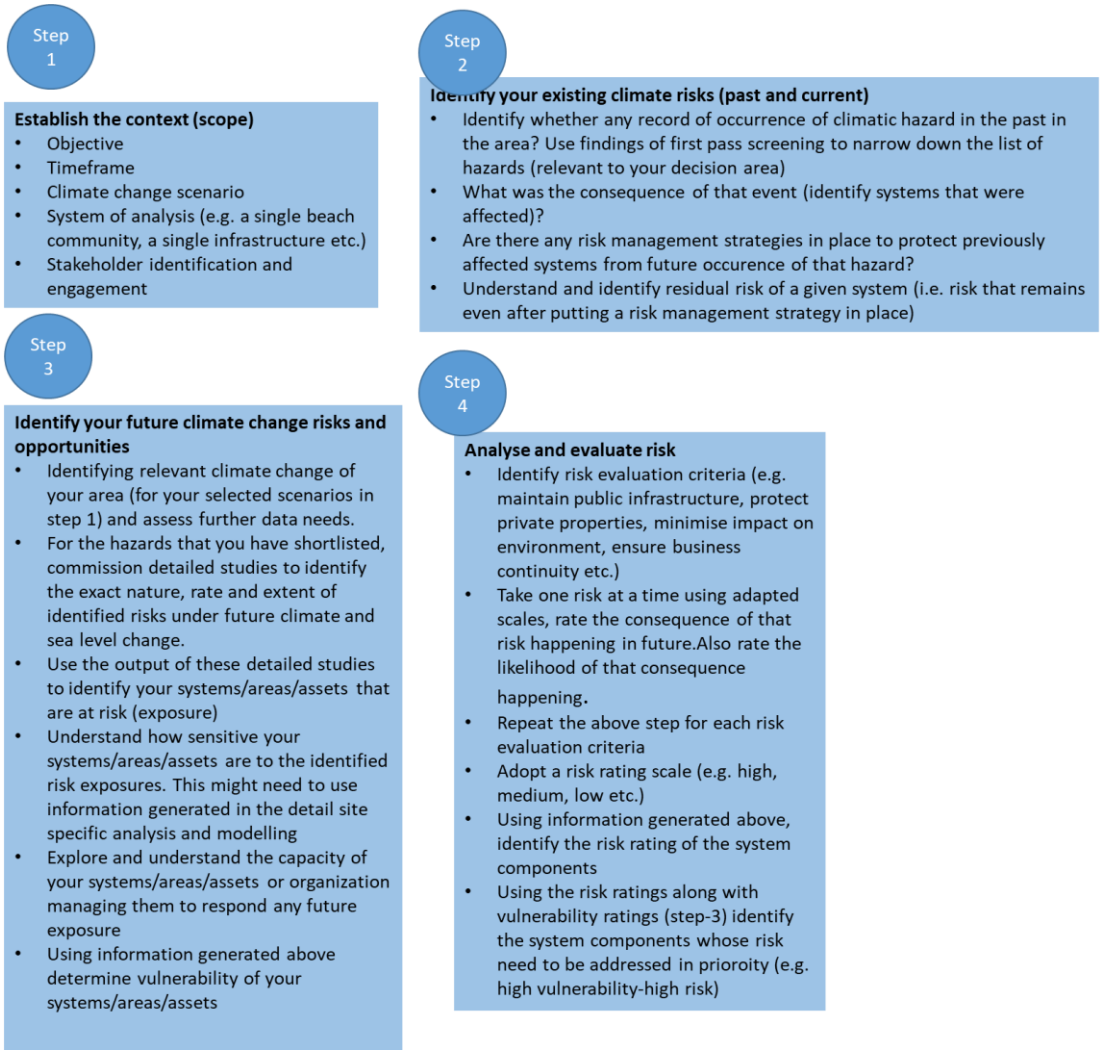
A detailed climate change risk assessment helps users to develop a better understanding of site-specific climate change-related risks. Before conducting a risk assessment that demands this level of detail and resources. Detailed assessment follows a standard risk-based approach (similar to a second-pass assessment). It is not purely quantitative — it also involves incorporating qualitative decisions from stakeholders such as identifying risk evaluation criteria, decisions on relative importance of identified risks etc. However, some elements of this process should be quantitative if the system at risk is critical (for example, if the consequences of system failure are severe) or a higher degree of precision is required for making decisions (e.g. engineering design).

Figure below shows the four steps to a detail assessment. The process may involve engaging with experts or consultants along with stakeholders from your organization.

Risk assessment should be performed in multi-hazard risk assessment approach to facilitet the decision making process holistic.

Risk Evaluation Criteria

Climate change risks need to be evaluated against some criteria. In general, these criteria should be based on the objectives of the risk assessment (defined in Step 1). Selection of criteria also needs to address long-term corporate objectives. For example, if you are a haor local engineer and want to assess how climate change and drought may affect broader issues of your area such as public safety, the local economy and growth, community and lifestyle etc. then these should be your risk evaluation criteria.



Four steps to a detailed assessment.

Adopt scales and rate risk consequence and likelihood

Once the risk evaluation criteria are established, take one risk at a time and, using the consequence information developed in Step 3, rate how much each criterion will be affected by the perceived consequence of that risk. This can be achieved by using your chosen consequence scale. Similarly, you also need to describe how likely a given consequence is to happen. This can be achieved by using your chosen likelihood scale. Here, likelihood refers

to the likelihood of a given hazard under the chosen climate change scenario. In other words, the likelihood of the risk is contingent on this scenario occurring. Repeat this rating of consequence and likelihood for each risk evaluation criteria.

Adopt a risk rating scale (e.g. high, medium, low etc.) and rate the risks.

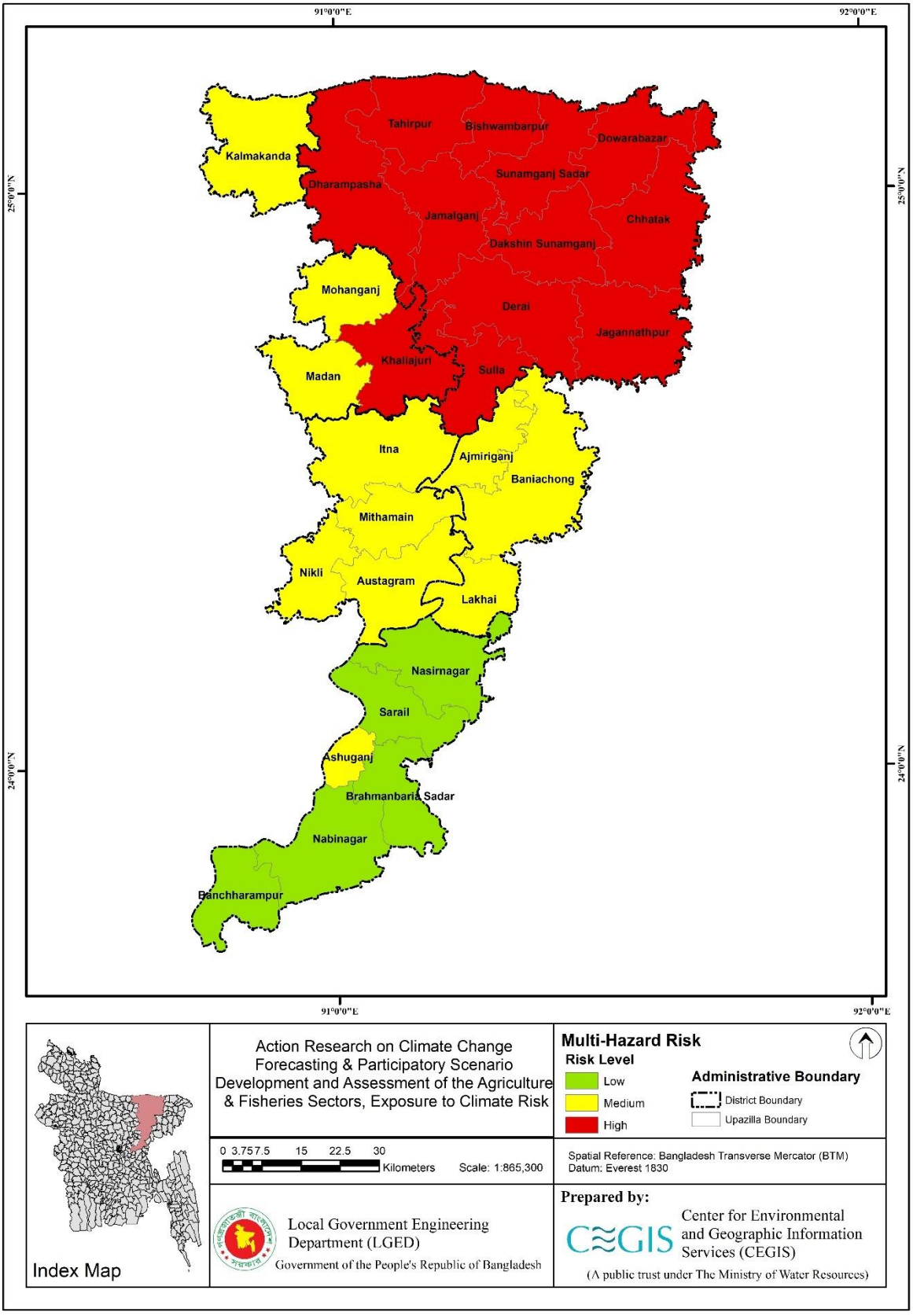
Risk rating scales are qualitative descriptions of the severity of risks. Severity is determined by the potential consequence of a future risk and the likelihood of that risk happening. Take one risk at a time and use the information generated above to come up with a final risk rating. As an example, if a risk (e.g. destabilization of foundation of a coastal infrastructure) arising from a hazard (e.g. increased erosion due to sea level rise) has a consequence rating of 'insignificant' and a likelihood rating of 'rare' then using the example risk rating table below, the risk should have a 'low' rating.

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost	Medium	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Low	Medium	Medium	High	High
Unlikely	Low	Low	Medium	Medium	Medium
Rare	Low	Low	Low	Low	Medium

Using the risk ratings along with vulnerability ratings (Step 3), identify the system components whose risk should be treated as a priority (e.g. high vulnerable-high risk).

The vulnerability (Step 3) and risk (Step 4) assessment for your system components can be used to priorities your planning areas. System components that are at high risk and highly vulnerable should be prioritized. However, be mindful that risks change over time and new information may become available about climate change in your area over the years. Therefore, it is important to periodically review your risks, especially those that are in the intermediate priority category.

	Low Risk	High Risk
Low vulnerability	**Least priority**	**Intermediate priority**
High vulnerability	**Intermediate priority**	**Top priority**



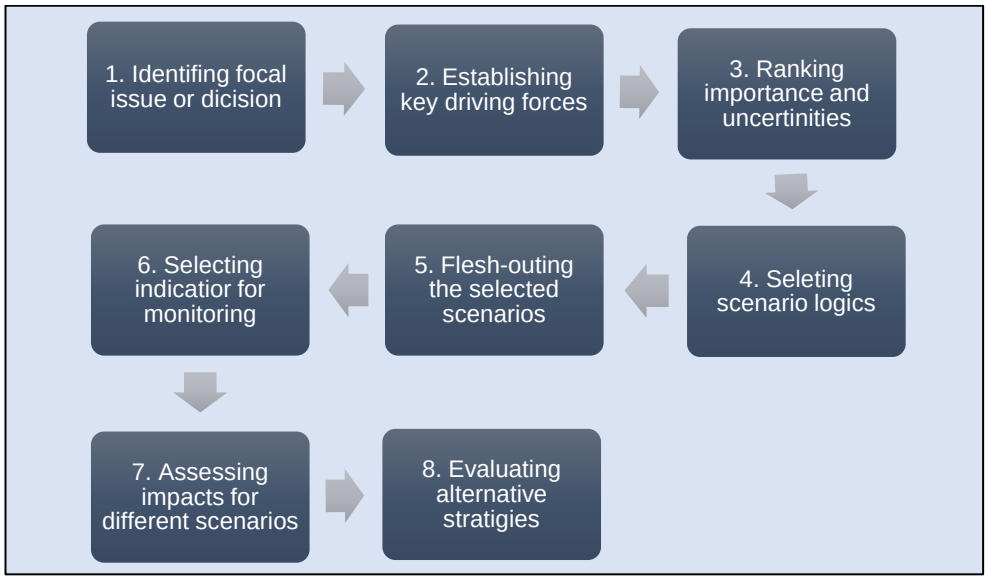
Typical Multi-Hazard Risk Map due to Climate Change Induced Hazards

10.3.6 Planning for Adaptation and Prioritization

Scenario Development

Scenario development is a strategic planning method for thinking creatively about possible complex and uncertain futures and to consider a variety of possible outcome which includes many of the important uncertainties in the system rather than to focus on the accurate prediction of a single outcome that is used to identify long-term goals and actions. It aims to define critical uncertainties and develop plausible scenarios in order to discuss the impacts and the responses to give for each one of them. Scenarios are plausible alternative futures, what might happen under particular assumptions. By focusing on key drivers, complex interactions, and irreducible uncertainties, scenario building generates the futures within which we can assess alternative mitigation strategies including the future without restoration.

Scenario building generally involves following steps,



Identifying focal issue or decision

The focal issue represents the question about the prospect of any event which is currently confronting or will be confronted in near future. Like- “Effect of climate change on the yield of agriculture and fisheries.”

Establishing key driving forces

It’s the most important step of scenario development where the most important factors that will shape the nature of the focal issue which are called as “drivers”. Before specifying the various driver participants should carefully decide the overall assumptions on which the scenarios will be based.

Rank importance & uncertainty

Identified driving forces are ranked in terms of their uncertainty and importance in relation to the focal issue. This step directs the outcome of the final scenarios as the two most important and uncertain drivers define the most divergent and relevant future conditions to be included in the final set.

Select scenario logics

The logics are defined by exploring the interactions of the most uncertain and important drivers such that alternative frames are created, each representing a divergent yet plausible scenario.

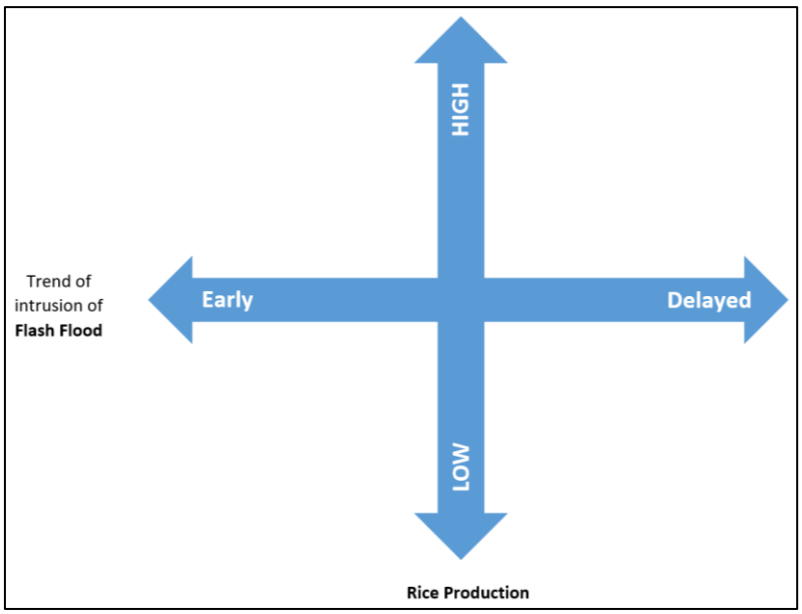
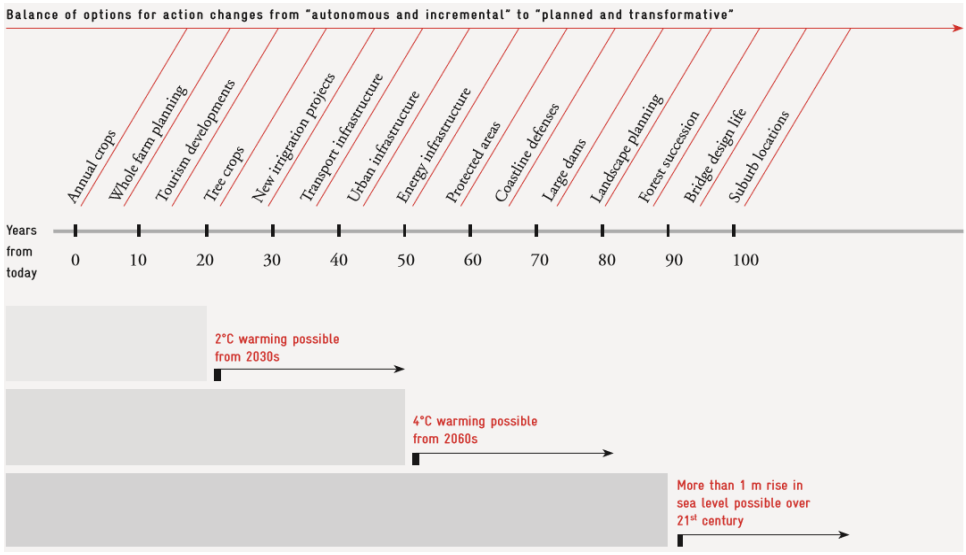


Figure 10.1: Scenario logic for effect of effect of flash flood on rice production

Flesh-out the scenarios

Each scenario is developed by exploring the implications of alternative trajectories on the focal issue under the set parameters defined by the interactions between the key driving forces.



Setting up Planning Horizon

Dynamic Adaptive Policy Pathway approach can be followed to build the alternative trajectories.

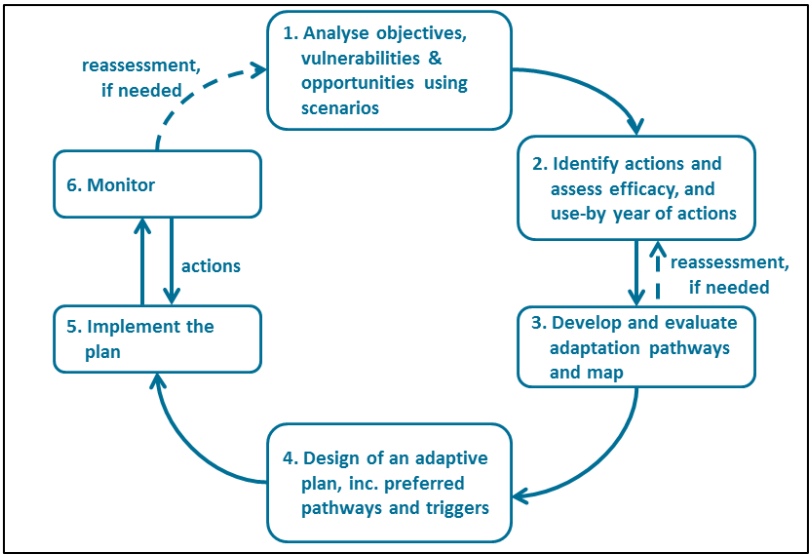


Figure 10.2: Dynamic Adaptive Policy Pathway Approach (Deltares and TU Delft)

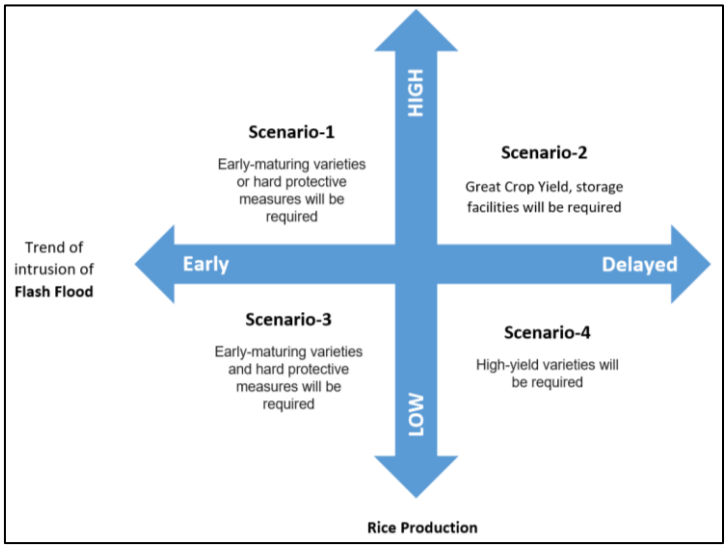


Figure 10.3: Scenarios buildup for previous scenario logic

Select indicators for monitoring

A set of indicators are selected to assess the implications of alternative futures on the focal issue. Metrics refer to a measure used to determine a certain condition.

Assess impacts for different scenarios

Using the selected indicators, scenario planners assess how the focal issue is impacted under each scenario.

Evaluate alternative strategies

The main objective of scenarios is to inform strategic decision-making. Once alternative scenarios are described, managers can evaluate the efficacy of alternative strategies across the suite of scenarios.

Setting Adaptation Goals

Because adaptation is a very broad field of policy action with a wide range of possible directions and outcomes, all adaptation initiatives benefit from having their scope clearly defined at the outset.

WHY CONSIDER ADAPTATION GOALS?

In most climate change adaptation processes, the overarching adaptation goal is described like this: 'to respond to future climate change impacts by reducing climate change related risks and vulnerabilities' .

Below this broad purpose, however, climate change adaptation can have different goals and scopes, such as:

- maintaining an organisation's business continuity and the ability to provide essential services
- enhancing the capacity of vulnerable places to cope with climate variability
- supporting an industry to harness new opportunities presented through a changing climate.

Gaining a clear understanding of the goal(s) and objectives of climate change adaptation is an essential strategic process required at an early stage of adaptation planning and a way of determining the scope for the adaptation activities to follow. The way adaptation goal(s) are framed may influence the adaptation process and its outcomes, including:

- the breadth of climatic and non-climatic information taken into account
- methods and tools used for adaptation planning,(including what type of climate change assessment approach is used - see section 5.2
- range of adaptation options available for consideration.

CHARACTERISTICS OF ADAPTATION GOALS

Goals can either be aspirational and visionary in nature (e.g. 'building community resilience to climate change') or more specific, staking out the boundaries of the adaptation efforts Given that adaptation will need to take place as long as the climate continues to change, it is unrealistic to expect to reach a state of 'being fully adapted'. It is therefore useful for adaptation goals to focus on the process and give less emphasis to a particular predetermined outcome - although some of the adaptation actions may well focus on specific adaptation outcomes. The three goals above are process-driven. They focus on facilitating an active process of 'adapting' in particular organizations, geographic areas, or sectors.

The characteristics of goals and objectives depend to a large degree on the context of the adaptation initiative.). In any case, goals should be aligned with existing organizational objectives. They also need to take available resources and constraints into account, such as financial and human resources.

Identifying Adaptation Options

Identifying or developing adaptation options means coming up with one or more adaptation Interventions that respond to climate change adaptation goals and objectives in an effective,

feasible and meaningful way that is not maladaptive.

The emergent literature on adaptation practice does not recommend any singular method for identifying adaptation options. The method used for Identifying options is likely to be most successful if it is tailor made, to ensure It Is aligned with adaptation goal(s) and objectives.

The following provides a selection of approaches for identifying adaptation on options that are commonly used. It is Important to note that the classification of these is mostly theoretical. The approaches are not mutually exclusive and in practice, are often blended into a customized approach that best suits local needs.

Expert Led Approaches

Purely expert led approaches align well with adaptation objectives that require a high degree of specialist knowledge. skill or experience, such as determining climate change impacts on a rare species, a coastal habitat, or a particular Infrastructure protect. Impact assessment or specialized risk assessments, which are conducted by experts (ecologists, Infrastructure engineers, some planners. etc.), can provide direct recommendations regarding the options for addressing Identified Impacts. These expert recommendations are typically based on scientific consensus of ex stung) and academic peer review.

Note, however, that the term ‘expert ‘can refer to anyone with specialist knowledge on the topic and Include a range of people from local experts and organizational leaders, to scientific experts. For example. If adaptation goals and objectives focus on increasing an organization's understanding of climate change risks, this lends itself well to using experts from within the organization to Identity adaptation options following standard process defined In the risk management literature

Stakeholder and Participatory Approach

Engaging a wide range of stakeholders in the process can help ensure that adaptation options reflect diverse stakeholder needs and are owned by those stakeholders.

Stakeholders may refer to anyone representing the Interests of a sector, discipline or Industry. Stakeholders may also include representative members from the community to ensure adaptation options reflect the diverse views, capacity and needs of the community to which the adaptation intervention is targeted. If the adaptation planning process is well facilitated, having a diverse range of Interests represented in developing adaptation options helps to ensure a balanced and more integrated approach is taken.

For example, if the adaptation goal is to reduce climate-change related community vulnerability, a bottom up participatory approach, where key community stakeholder’s identity priority adaptation options, may best serve this goal. A range of participatory methods exist that can be used for Identifying options such as conceptual modelling, participatory vulnerability mapping, citizens and participatory scenario planning.

Combining Expert Led and Participatory Approach

It is Important to note that participatory approaches do not preclude validation of identified options via experts or by using specific decision support tools. Due to the highly context-specific and pervasive nature of climate change adaptation. active collaboration between experts and ether stakeholders can be a useful approach for identifying adaptation options. Experts can provide Input (In the form of Information opinions and personal experiences) into the process of identifying options, while decision making on priority options can be conducted

in a participatory way.

Type of Adaptive Interventions

There are many different ways of classifying adaptation activities. Typically, the policy and the adaptation literature classify adaptation interventions differently. Broadly speaking, they can be divided into the following categories:

- **Legislation and regulation** – laws and regulation designed to set standards that guide, restrain or reward actions of others
- **Capital works and infrastructure** – new infrastructural projects such as a sea wall, or modification of existing structures such as roads or railways
- **Economic instruments** - taxes, charges, subsidies, grants tradeable permits, government loans, fiscal sector changes
- **Governance –** Reforming the way formal and informal organizations make decisions within themselves with others
- **Research and Innovation –** Investment in research to develop new innovative solutions to emerging policy changes and opportunities
- **Capacity Development –** Process through which individuals, organization, and societies obtain, strengthen and maintain the capabilities to set and achieve their own objectives overtime.
- **Information and Communication –** dissemination of targeted or large-scale information or communication campaign.
- **Education –** using the formal education system for the delivery of particular policy objectives.

Community Recommended Climate Change Adaptation Measures	
• Promotion of HYV (High Yielding Variety) and Ensure Supply of HYV Seeds to the Community • Skill Development Training on Alternative Income Generation Activities (AIGA) • Increase number of Flood Shelters • Construction of Elevated Roads • Promotion of Cold Tolerant Varieties and Ensure Supply of Seeds to the Community • Re-excavation of Khals to Maintain Connectivity of Beels and Rivers • Ensure Community Participation during Project Formulation, Execution and Completion • Regular Dredging of Rivers to Maintain Navigability and Reduce Siltation Problem • Construction and Regular Operation and Maintenance of Submersible Embankments • Ban Use of Current Jal for Fishing • Crop Insurance Mechanism • Flood Insurance Mechanism • Ease of Loan Facilities for Crisis Management and Rehabilitation	• Ensure Adequate Drainage Facilities Constructing Culverts and Bridges • Strengthening Early Warning and Dissemination System for Flash Floods • Engage Community Level Medium (like union parishad, community miking or miking through mosque) etc for Effective Dissemination of Early Warning Information • Slope Protection for Village Settlements through CC Block, Geo Textile Bag and Eco-Friendly Solutions. • Promotion of Boat School. • Emergency Relief Boat/ School Transportation Boat. • Boat Ambulance. • Community Driven Digital Dashboard for Dissemination of Early Warning System • Construction of Seed Store. • Flood Relief Center/Community School • Awareness Raising Program engaging NGOs and local administration • Research and Development and Promotion of Short Duration HYV Varieties

Decision Support tool for Prioritizing Adaptation Options

There are a number of decision support tools that can be used to help determine what adaptation policy, program or intervention are best suited to meet adaptation goals and objectives. Common to all prioritization and decision support tools is that they use certain evaluation criteria for assessing different adaptation options. Some tools rely more strongly on monetary information, which in the case of social and environmental impacts of climate change may not always be readily available. Other tools have the ability to factor in non-monetary information for evaluating adaptation options. In any case, decision support tools need to be tailored to the system under consideration (based on the definition of what adapts see p.15) and to local context and needs, Decision support tools should be able to generate information on the strengths and weaknesses of alternative adaptation options, while also providing mechanisms for dealing With the uncertainties inherent in climate change.

Decision support tools come in many different guises, from simple checklists to complex software applications that can act as all in one, integrated decision support systems. The United Nations Framework Convention on Climate Change (UNFCCC) Compendium on Methods and Tools", for example, lists 48 different adaptation decision support tools some of which are sector specific.

Among this growing list of decision support tools, some stand out as being most commonly used in the Australian context, namely: cost benefit analysis (CBA), cost-effectiveness analysis (CEA) and multi criteria analysis (MCA). These can be very useful in gaining a better understanding of the economic or other benefits of various adaptation options, However, in the context of place-based adaptation it needs to be emphasized that:

- A detailed analysis using tools such as CBA, CEA and MCA is not always necessary, and more informal processes involving dialogue and deliberation at the local level can be more effective in leading to suitable adaptation decisions. This includes processes such as participatory ranking and evaluation. conceptual modelling, and citizens' juries.

- Economic decision support tools other than CBA. CEA and MCA may be equally or more useful for place-based climate change adaptation processes. This includes tools such as Net Present Value (NPV) Analysis, Real Options Analysis and Contingent Valuation.

The following section explores the use of CEA. CEA and MCA in the context of climate change adaptation.

Cost-benefit analysis (CBA)

Cost-benefit analysis is an economic decision support tool that can be used to determine, in monetary terms, whether the total benefits of an adaptation option exceed as total costs. This involves calculating monetary values for all expected costs and beneftts, tor a defined range of stakeholders affected posutiveiy or negatively by the proposed adaptation option.

Using a discount rate, benefits and costs are adjusted for the time bound value of an investment, so that all flows of benefits and costs over time can be expressed on a common

basis as a ‘present value'. Other than through the process of discounting. uncertainty is dealt with in CBA using probabilistic analyses such as sensitivity analysis.

To different degrees, CBA calculations can include assigning monetary values to those costs and benefits that are not traded within a market (e.g. environmental and social goods and services). Based on a CBA, an adaptation option is considered Viable if the aggregate benefits outweigh the costs. Different adaptation options that have been assessed using CBA can be compared and prioritized by their net benefit (i.e. by how much the benefits outweigh the costs).

Cost-effectiveness analysis (CEA)

Cost effectiveness analysis is a commonly used decision support tools that can help identify the least-cost option for achieving a defined, desired benefit (e.g. protecting properties from flooding). Traditionally, CEA has most commonly been applied in the health sector for identifying the least-cost option to achieve a specific non-monetary health outcome, such as increasing life expectancy in mothers. Probabilistic analyses can help address some of the uncertainty involved.

In its most basic form, CEA compares each alternative adaptation option with current practice, resulting in a cost-effectiveness ratio, where the expected benefit or effect of a policy measure is the denominator (e.g. years of expected protection from sea-level rise), and the numerator is the expected cost required to achieve that benefit with a given measure.

CEA is based on the principle of directly comparing the relative costs of alternative options for achieving the same or a very similar desired outcome. In the context of adaptation, CEA could be used to evaluate, for example, the cost effectiveness of different short-term measures to protect coastal properties from erosion and storm surges, where the different options may be: constructing structural barriers, sand replenishment and supportive technological measures to protect existing sand dunes.

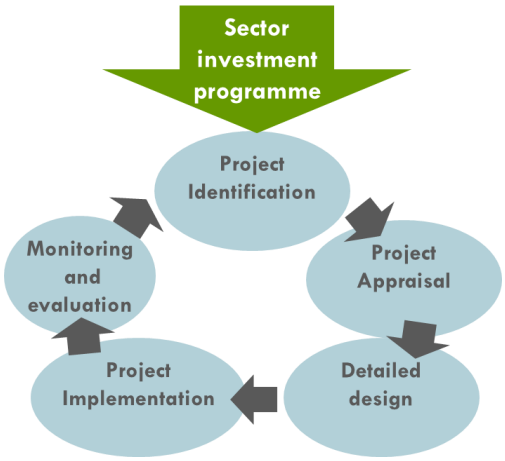
Multi-criteria Analysis (MCA)

Multi-criteria analysis (sometimes referred to as multi-criteria evaluation) represent a suite of decision support tools that are able to include assessing the benefits resulting from adaptation interventions that cannot be measured or costed in quantitative terms. There are many types of multi-criteria analysis (MCA) and no standard definition of what constitutes MCA. Common to all MCAs is that they involve developing and applying a specific framework for integrating a range of quantitative and qualitative, monetary and non- monetary factors into the analysis, which are then weighted and scored against a set of criteria.

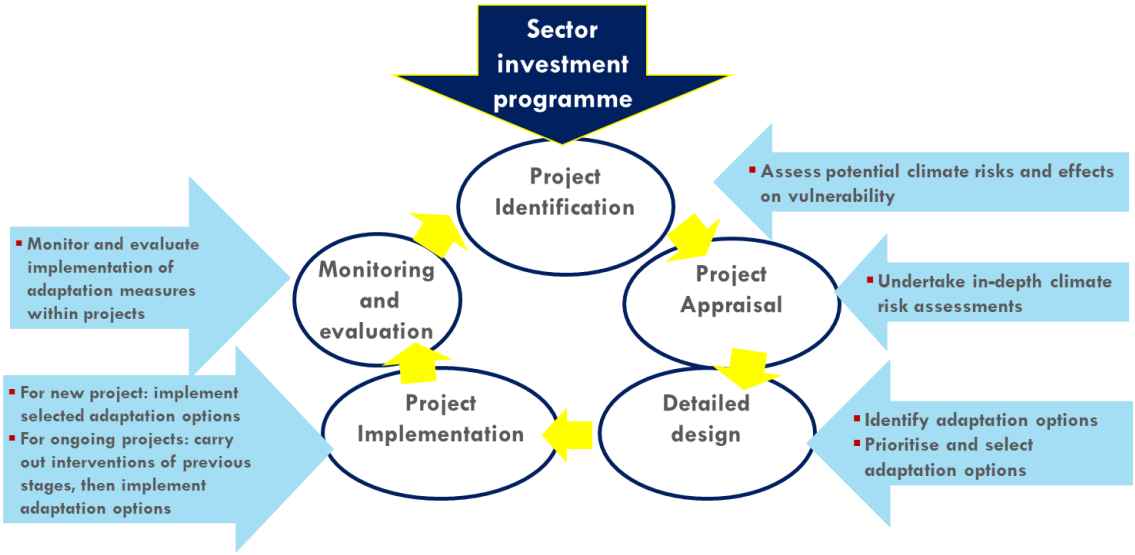
MCA is seen to be able to assist in making decisions by handling large amounts of complex qualitative and quantitative information in a consistent and transparent way. Economic and monetary analyses and MCA are not mutually exclusive. Monetary tools and evaluations such as CBA and CEA are frequently used as part of MCA.

10.3.7 Mainstreaming Climate Change Adaptation into Local Level Planning

Inclusion of CAA into local level government planning process is a very important issue to be done to facilitate successful implementation of CCA measures at local level. In this connection, a logical framework should be developed which should be included into the planning processes during DPP preparation. Existing steps of planning processes are:



Therefore, effort should be made to identify the feasibility of inclusion of different component of CAA measures mainstreaming in every stages of the existing planning process. Following figure shows the different scopes to be considered in different stages of planning process to mainstream CAA measures.



It should be noted that climate change adaptation measures are nothing but the mitigation measures for disaster risk reduction.

Early flash floods in the haor region cause regular damage and destruction to infrastructure, properties and economic activities. Frequently occurring thunderstorm, siltation, erosion have increased the vulnerability in that region. The local governments undertake effective measures to reduce disaster risks within the existing legal framework by formulating and implementing appropriate strategies, action plans and programs to reduce climate change risks. Therefore, Government should introduce a Technical Working Group which will work closely with local communities and other stakeholders including non-governmental organizations and international agencies. A multi-disciplinary group will compose various departments like agricultural department, fisheries department, engineer, planning & development. Local governments and communities play an importan roles in the mainstreaming process by including information on hazard, vulnerability, capacity and risk in local development plans, and by assimilating risk reduction measures into their day-to-day functions and services.

Although, significant progress has been made in terms of reducing the vulnerability of Haor's

people, for example through an upgraded early warning system, efficient preparedness and community-based response capacity. The institutional structure should strengthen of different levels of government, between various line agencies, between other stakeholders and between neighboring localities. Recently established Climate Change Cell in the Local Government Engineering Department (LGED) may be an umbrella which can integrate national level and local level government plan including climate change adaptation measures thorugh formulating similar to Haor Infrastructures and Livelihood Improvement (HILIP) or Calimate Adaptation and Livelihood Improvement Project (CALIP) projects.

10.3.8 Implementation of Adaptive Measures

An effective implementation mechanism for Climate Change Adaptation measures should be formulated to enhance the benefits from the measures in three different stages of Climate Change Adaptation. Exiting institutional arrangement and funding mechanism should be reviewed first to establish the implementation. Following factors need to be considered to establish the effective mechanism.

- Implementation Scheduling
- Strengthening Institutional Arrangement
- Selection of Financing Source
- Considerations for Fund Allocation

Furthermore, ensuring community or local stakeholder's participation is also important to facilitate the successful implementation process. Stakeholder is the process which enables to involve the people who may be affected by any interventions or any decision that can influence their livelihood. Effective engagement helps to reflect the stakeholder's opinion into the implementation level, where each of the stakeholder has a unique perspective about the local disaster characteristics. Therefore, relevant stakeholders should be identified and engaged during implementation of Climate Change Adaptation meaures in different stages, which will make the implementation mechanism more participatory.

There are many funding sources already available for investment in climate change adaptation meaures including Government's Bangladesh Climate Change Trust Fund and international adaptation fund like Green Climate Fund (GCF).

Recognizing the uncertainties and inadequacies of international adaptation finance from both multilateral and bilateral sources, the Government of Bangladesh decided to establish the Bangladesh Climate Change Trust Fund (BCCTF) based on revenue from the national budget, within a legal mandate by the Climate Change Trust Act passed in the Parliament in 2010. "Bangladesh Climate change Trust Fund (BCCTF)" through management across the public and private sector is operating different type of activities to tackle the risks and adverse effects of climate changes.

On the other hand, The Green Climate Fund was established by the 194 countries, who are parties of the United Nations Framework Convention on Climate Change (UNFCCC). Its journey started in 2010, as part of the UNFCCC's financial mechanism. This fund aims to finance equal amounts of funding for mitigation and adaptation by following the Convention's principles and provisions. The main National Designated Authority (NDA) on behalf of the government is the Economic Resources Division (ERD) of the finance ministry who disburse money through two entities i.e. the Infrastructure Development Company Limited (IDCOL), which specialises in renewable energy projects for mitigation, and the Palli Karma Sahayak

Foundation (PKSF), which specialises in adaptation projects, especially for vulnerable communities. Both these agencies are now in the process of submitting different project proposals for funding (but none has been approved yet).

Besides, donors like World Bank, Asian Development Bank (ADB), UNDP, US Aid frequently allocate funds for different climate resilient adaptation projects. Therefore, ample scopes are there for ensuring access to the financing mechanism of climate change adaptation measures. Local level planning and implementating agencies should be trained in a way that they can access these funds to mainstream and implement climate change adaptation measures at local level to improve livelihhods of the community.

10.3.9 Research and Capacity Development

Reaserch and capacity development is a very crucial and vital thing which needs to be considred to integrate climate change adaptation. Specially, short duration varietal development, cold tolerant varietal development, advanced technolocial innovations, mechanization of agriculture, strengthening early warning system etc can be key areas for reaserch and development.

Research and capacity development part cen be done in following three steps:

- Research for Technological Innovation
- Training for Stakeholders
- Awareness Building

Research for technological innovation can be performed mainly with the research groups of different action oriented research organisation and relevant implementing agencies like Center for Environmental and Geographic Information Services (CEGIS), Institute of Water Modeling, IWFM, BUET, Dhaka University, Local Government Engineering Department (LGED), Department of Disaster Management (DDM), Department of Bangladesh Wetlands and Haor Development Board (DBHWD), Bangladesh Water Development Board (BWDB), Ministry of Environment, Forests and Climate Change (MoEFCC) etc.

Furthermore, required training should be be designed to share the research outcomes and transfer the appropriate technologies to relevant stakeholders to facilitate the implementation process strengthening the institutional capacity.

Awareness building programs should be emphasized for local level stakeholder’s to enhance their capacity and knowledge on climate resilience.

10.3.10 Monitoring and Evaluation

Monitoring will enhance the effectiveness of Climate Change Adaptation measures by establishing clear links between past, present and future interventions and results. It helps to achieve comprehension, from past and ongoing activities, relevant information that can subsequently be used as the basis for programmatic fine tuning and planning. Without the monitoring it would be impossible to judge the quality of implementation, maintenance or the effectiveness of any intervention before implementation applying elsewhere. Revision of Climate Change Adaptation measures is a compulsory step before going into full phase implementation of formulated Climate Change Adaptation measures. Monitoring and evaluation should be followed by this course of action.

Therefore, a framework should be developed for monitoring, evaluation and updating of this Climate Change Adaptation guideline, either in a regular or periodical basis. Some M&E indicators shall be identified and targets should be fixed to facilitate the monitoring, evaluation and update of the guideline. Some preliminary identified M&E indicators are:

- Degree of legitimacy/mandate of lead disaster risk reduction organizations
- Existence of operational multi stakeholder mechanisms
- Existence of cooperation among stakeholder groups
- Degree of stakeholders' disaster risk reduction awareness:
- Access and sharing of disaster risk reduction information by stakeholders:
- Extent of inclusion/use of local and traditional knowledge in disaster risk reduction decision-making:
- Existence of disaster risk reduction education programmes:
- Extent of the linkage between disaster risk reduction research/science and policy development:
- Extent of the disaster risk reduction planning and strategy development process
- Existence of policies and regulatory frameworks to support capacity development:
- Adequacy of the information available for climate change adaptation decision-making
- Existence and mobilization of resources by the relevant organizations
- Availability of required technical skills and technology transfer.

11. Guideline on Disaster Risk Reduction

11.1 Introduction

This Chapter describes the guideline for Disaster Risk Reduction in the context of the agriculture and fisheries sectors for the study arera as well as Haor area. The developed guideline will facilitate local engineers and administrations to focus on formulating and implementing sector and location specific disaster risk reduction mitigation measures.

11.2 Principles of DRR Guideline Preparation

This Disaster Risk Reductio guideline follows the implicit principles of the The Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework). This framework is the first major agreement of the post-2015 development agenda, with seven targets and four priorities for action, which was endorsed by the UN General Assembly following the 2015 Third UN World Conference on Disaster Risk Reduction (WCDRR).

The Sendai Framework is a 15-year, voluntary, non-binding agreement which recognizes that the State has the primary role to reduce disaster risk but that responsibility should be shared with other stakeholders including local government, the private sector and other stakeholders, aiming at achieveing

The substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries.

The Sendai Framework focuses on four pritoities for action i.e.

Priority 1. Understanding disaster risk

Disaster risk management should be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment. Such knowledge can be used for risk assessment, prevention, mitigation, preparedness and response.

Priority 2. Strengthening disaster risk governance to manage disaster risk

Disaster risk governance at the national, regional and global levels is very important for prevention, mitigation, preparedness, response, recovery, and rehabilitation. It fosters collaboration and partnership.

Priority 3. Investing in disaster risk reduction for resilience

Public and private investment in disaster risk prevention and reduction through structural and non-structural measures are essential to enhance the economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment.

Priority 4. Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction

The growth of disaster risk means there is a need to strengthen disaster preparedness for response, take action in anticipation of events, and ensure capacities are in place for effective response and recovery at all levels. The recovery, rehabilitation and reconstruction phase is a critical opportunity to build back better, including through integrating disaster risk reduction

into development measures.

Having all these information principles have been set to develop this gideline in line with the main priorities, targets and principles of the Sendari Framework, which are-

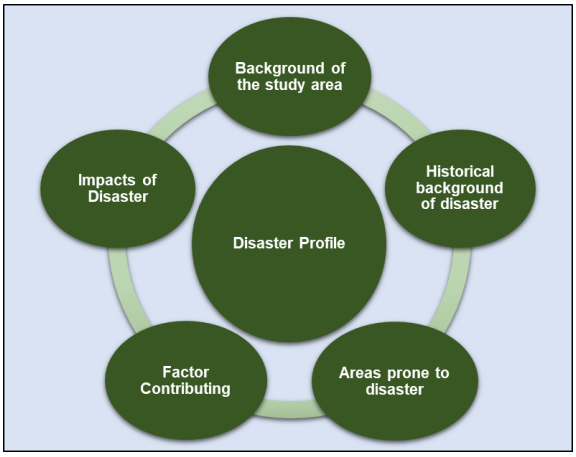
- Responsibility should be shared among authorities, sectors and stakehodlers as appropriate to national ciscumstances
- Protection of persons and their assets while promoting and protecting all human rights including the right to development
- Ensuring full participatory approach from all level of stakeholders
- Decision making considering the integration and coordination of national and local level
- Empowerment of local authorities and communities through resources, incentives and decisionmaking responsibilities as appropriate
- Decision-making to be inclusive and risk-informed while using a multi-hazard approach
- Coherence of disaster risk reduction and sustainable development policies, plans, practices and mechanisms, across different sectors
- Accounting of local and specific characteristics of disaster risks when determining measures to reduce risk
- Addressing underlying risk factors cost-effectively through investment versus relying primarly on postdisaster response and recovery
- Build Back Better for preventing the creation of, and reducing existing disaster risk

11.3 Guidelines for Disaster Risk Reduction

11.3.1 Assessment of Disaster Profile

Disaster profile provides a clear vision for future actions which is inevitably necessary to set the pace for development programmes aiming at risk reduction of the natural hazards. It accommodates an overview of the natural disaster phenomenon. The highlights of the profile is needed to take up a proactive strategy in the management of natural disasters, which would improve the coping capacity of communities, lessen the impact and therefore improve the living condition in the areas of harsh weather conditions. A summary of disaster profiles also should be provided consisting the chorological disaster events with their impacts at least for past 30 years or more if data is available.

Background of the study area as a part of first component of disaster profile means understanding the existing characteristics of the area of interest. Understanding what and how much resources are available and their nature to tackle down the disaster, could be typically called as background. Say for example, measuring extent of rainfall, capacity of river basin, natural disaster prevention system such as natural barrier, green belt, presence of water reservoir and its capacity and so on should be analyzed firstly, to establish a sustainable disaster risk reduction system.



Components of Disaster Profile

Historical background of a disaster includes origin of particular disaster, minimum and maximum return period, extent, damage coverage and so on of past disaster, should be an underlying component of a disaster profile. Proper evaluation and analysis must be needed to make an effect risk reduction system. Meanwhile, understanding and analyzing the impacts from past occurred disaster, could give a functional and comprehensive profile of a particular disaster that will help us to predict and prevent.

Using historical background of a disaster of the study area, vulnerable disaster prone area could easily be identified. Vulnerable disaster prone area is an area which has potentiality to be affected by future disaster and had already been affected by past disasters. Physical, social, economic and environmental vulnerability are the four aspects of disaster vulnerability which must be measured for DRR.

Vulnerability depends on some factors and these factors must be considered for sustainable DRR. Several factors such as poverty, livelihood, Cultural beliefs, Equity, Gender, Weaker social groups are the most affecting and influencing for vulnerability. Therefore, for making a disaster risk mitigation strategies, the socio-economic and demographic characteristics of vulnerable population such as per capita income, earning sources, their cultural beliefs, social resource distribution system, ratio of male and female, number of children and old people living in the vulnerable location, should be considered.

In a disaster, anyone can face the danger of death or physical injury or may also lose his/her home, possessions, and community. Such stressors leads at risk for emotional and physical health problems. That is why, identifying the post disaster impacts and then investigating the mitigation measures for the future disaster impact, is necessary. It helps to prepare for the prevention, mitigation and reduction period of the disaster.

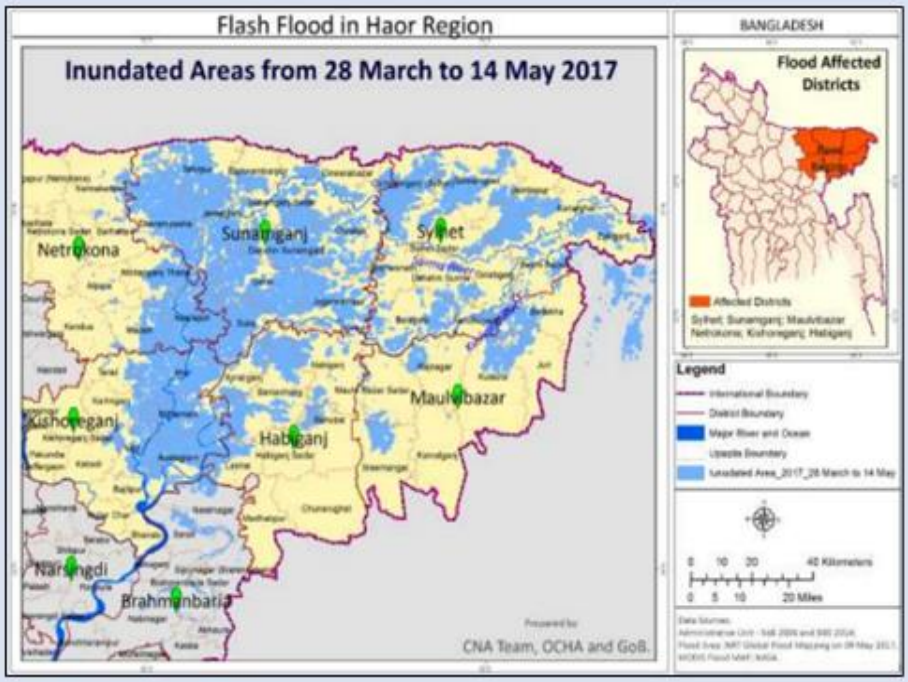
Under these circumstances states above, understanding and analyzing the whole disaster profile, is the prime and preliminary step to mitigating disaster action of a particular area. Some examples of disaster profile with its impacts in Bangladesh are given below.

Disaster Profile

Flash Flood in Haor Region, 2017

Heavy rainfalls as well as onrush of water from the upstream Meghalaya hills in India have led to the inundation of a vast areas of croplands of Haors and low-lying areas of the northeast. Flood started on 28th March affecting six districts (Sylhet, Moulavibazar, Sunamganj, Habiganj, Netrokona and Kishoreganj) in the north east region. Rising water overflow and breeched embankment in many places and inundated vast areas of croplands. It destroyed nearly-ready-for-harvesting boro rice in about 160,170 hectors areas.

Disaster Map



Situation at a Glance

People affected Districts affected	4,667,000 (31% of population in affected area) 6 districts (Habiganj, Kishoreganj, Moulvobazar, Netrokona, Sunamganj, Sylhet) Sunamganj is worst affected.
Upazilas affected	60 (out of 62)
Unions affected Deaths crop Damage	450 (out of 530) 10 Boro rice largely destroyed (estimated to be more than 30,400 million BDT)

Floods in Northeast (Haor) areas of Bangladesh, April-May 2017 (HCCTT CAN)

Table 11.1: Chronology of Major Monsoon Floods in Bangladesh (Past 30 Years)

Events	Impacts
1987	Occurred throughout July and August and affected 57,300 square kilometers (22,100 sq mi) of land, (about 40% of the total area of the country) and was estimated as a once in 30-70 year event.
1988	Occurred throughout August and September. The waters inundated about 82,000 square kilometers (32,000 sq mi) of land, (about 60% of the area) and its return period was estimated at 50–100 years.
1998	Over 75% of the total area of the country was flooded, including half of Dhaka.
2004	This was very similar to the 1988 and 1998 floods with two thirds of the country under water.
2016	Around 3.2 million people have been affected by flooding of 16 districts.

11.3.2 Assessment of Policy and Legal Framework

Policy assessment seeks to inform decision-makers by predicting and evaluating the potential impacts of policy options. The Policy Assessment Framework (PAF) is a tool to assist early appraisal of a number of intervention options and to present outputs in a clear visual format. This will improve the ease of comparing/or prioritizing intervention options and make the assessment against the full range of key objectives more balanced.

Successful DRR results from the combination of top-down, institutional changes and strategies, with bottom-up, local and community-based approaches. In response to formulate sustainable measures for DRR, some necessary steps should be maintained. In Bangladesh, there are benchmarks such as Master Plan of Haor Area 2012, Bangladesh Delta Plan 2100, and National Plan for Disaster Management, 2016-20 and so on, which have some visions or goals that must be considered before formulating measures. Regarding the present disaster problem, some existing national or local written rules and policies are presented which should be investigated for finding out the policy gaps.

A disaster risk assessment profile must be established to identify the nature, location, intensity and likelihood of major disasters prevailing in a community or society by considering all factors. It helps to inform national sustainable development plans so as to avoid the creation of new risk, reduce and manage existing risks, build resilience across various sectors and protect new and existing development from hazardous events. The risk assessment also guide us to identify strengths and gaps in national capacities, and resilience in relation to the risk levels.

Bangladesh has several disaster related polices, rules, guidelines, plan and strategies such as National Disaster Management Policy 2015, Disaster Management Act 2012, National Plan for Disaster Management 2016-20 and so on, which must be assessed and that will help to make sustainable DRR measures. Also, assessing historical profile of past disasters and the policies against the disaster could guide to prepare more comprehensive and sustainable DRR measures, indeed.

Moreover, assessing some international guidelines such as Sendai Framework for Disaster

Risk Reduction 2015-2030, Hyogo Framework for Action 2005-2015 etc. could help to analyze critical factors, guidelines and world's standards regarding sustainable DRR measures.

Furthermore, after analyzing both risk assessment and policy gaps, sustainable measurers should be made by considering national disaster risk reduction and climate change adaptation, including setting risk reduction goals and targets.

Considering the field of interest the related Policy, Plan, Act, Law and Guideline should be acknowledged. If disaster risk reduction of the livelihood in the haor region is the issue then the following disaster related policy documents should be reviewed, but not limited to-

Policy:

- National Environmental Policy, 1992
- National Fisheries Policy, 1998
- National Water Policy, 1999
- National Agriculture Policy, 1999
- National Land Use Policy 2001
- National Jalmohal Management Policy 2009
- National Agriculture Extension Policy, 2012
- National Disaster Management Policy, 2015

Act and Rules:

- Embankment and Drainage Act 1952
- Bangladesh Environmental Conservation Act 1995
- Environmental Conservation Rules 1997
- Bangladesh Water Act 2013
- Bangladesh Water Rule 2018
- Bangladesh Biodiversity Act, 2017
- Disaster Management Act, 2012

Plan and Strategies:

- National Adaptation Programme of Action (NAPA)
- Bangladesh Climate Change Strategy and Action Plan, 2009
- Master Plan of Haor Area, 2012
- Current Five Year Plan
- National Plan for Disaster Management, 2016-20
- Bangladesh Delta Plan 2100
- Sustainable Development Goals
- The National Plan for Disaster Management (2016-2020)
- Standing Orders on Disaster, 2010
- Bangladesh Perspective Plan 2010-2021 (Vision-2021)

Guidelines by UN-DRR:

- Sendai Framework for Disaster Risk Reduction, 2015-2030
- Hyogo Framework for Action, 2005-2015
- Disaster Impact and Risk Assessment Guideline
- Local Disaster Risk Reduction Fund Management Guidelines
- Emergency Fund Management Guidelines
- Indigenous Coping Mechanism Guidebook

- Community Risk Assessment Guidelines
- Damage and Needs Assessment Methodology
- Hazard Specific Risk Assessment Guidelines
- Emergency Response and Information Management Guideline
- National Risk Reduction Fund Management Guideline
- National Disaster Reduction and Emergency Fund Management Guideline
- Local Disaster Management Fund Guideline
- Guideline for Road and Water Safety
- Guideline for Industrial Safety

11.3.3 Impact and Vulnerability Assessment

Disaster Impact Assessment

Impacts of disaster are the effects of disaster on nature and human system which may occur without considering any adaptation. Major natural disasters can and do have severe negative short-run economic impacts. Disasters also appear to have adverse longer-term consequences for economic growth, development and poverty reduction. Although negative impacts are not inevitable, we can take mitigation measures to cope up with the hazard. Steps of Disaster Impact assessment (DIA) are discussed below-

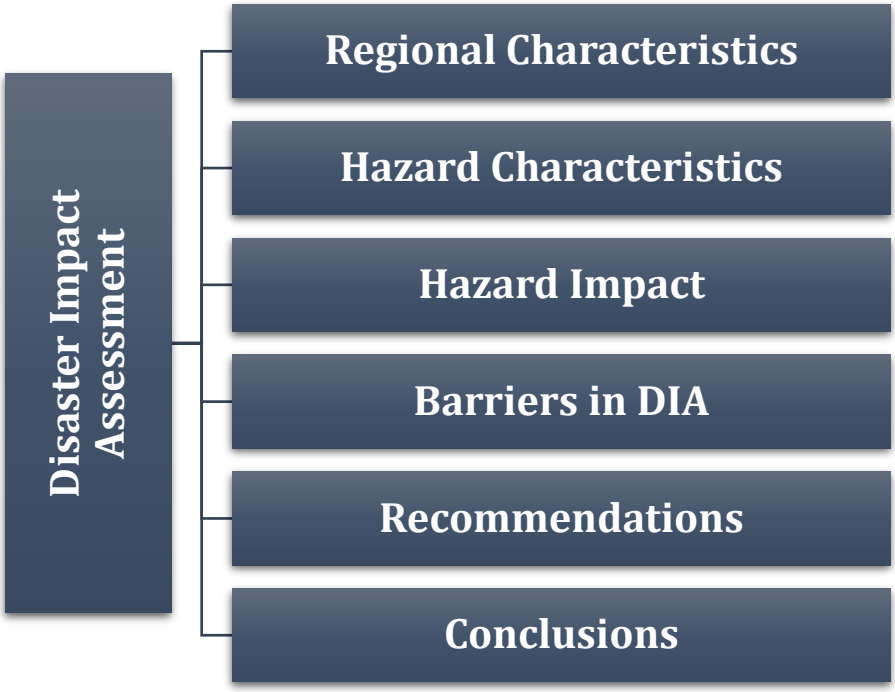


Figure 11.1: Steps of Disaster Impact Assessment

Regional Characteristics

In this section discussion of the geographic characteristics of the region or other features which make the area prone to disasters. For instance the area may be at the junction of several tectonic plates making it prone to earthquakes or it might be a low land which is at the base of hilly area which may cause flash flood during excessive rainfall. Like for the haor area, it is a large bwol shaped depressions area residing just at the foothill of Meghalaya basins, which receive highest amoun of annual rainfall of the year, therefore faces flash floods very

frequently.

Hazard Characteristics

In this step the types of disasters that can occur in the area are considered such as earthquake, floods, tsunamis, land sliding, drought, cyclone, flash flood, hailstorm etc. In addition, discuss the frequency, magnitude, extent and causes of the hazards. To evaluate the degree of risk and the characteristics and scale of possible loss from extreme natural events, it is necessary not only to estimate the probability of occurrence but also to investigate the force and duration of the event.

Potential Impact of Hazards

Potential impacts of hazards on people, houses, infrastructure, crops, livestock (physical impact), social interaction of the people (social impact), business activities (economic impact), behavior, attitude and perceptions of the people (attitudinal impact) should be assessed. This assessment should include about the level of the impact, magnitude of the losses and relevant statistics to support the argument. Inclusion of the preventive, mitigative and preparedness measures taken by the community or other stakeholders to minimize the impact of the disaster e.g. the construction of retaining walls to avoid land sliding, or diversion of channels to reduce overflow of water or the afforestation efforts of the community or even the capacity building and knowledge increasing trainings of the community should be analysed in this step.

Barriers in Disaster Impact Assessment

This section will provide insights into different challenges faced by the research study team during the disaster impact assessment. The challenges can range from the shortage of resources to the difficulty in accessing the area/community.

Recommendations

Include here a list of all the steps required to reduce the future impact of the disasters on the understudy area. Furthermore, the measures required to overcome the challenges faced in the DIA study can also be listed.

Conclusions

This section provides a summary of the whole study including details about the disasters in the area, their causes, impacts on the lives of the people, responsible institutions, challenges in the study of the locality and the areas of improvement.

11.3.4 Assessment of Vulnerability

Vulnerability should be assessed before going into detailed disaster risk assessment. As, vulnerability is the degree to which a system is unable to cope with, the adverse weather condition and natural disaster and Vulnerability is a function of the character, magnitude and rate of hazard and variation to which a system is impacted (Exposed and Sensitive), and its adaptive capacity. Therefore, assessment should be made here on exposure, sensitivity and adaptive capacity.

Exposure × Sensitivity

Exposure and Sensitivity are two very important concept for the assessment of Hazard Impact.

Exposure

The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social or cultural assets in places and settings that could be adversely affected.

Example:

Average temperature rise

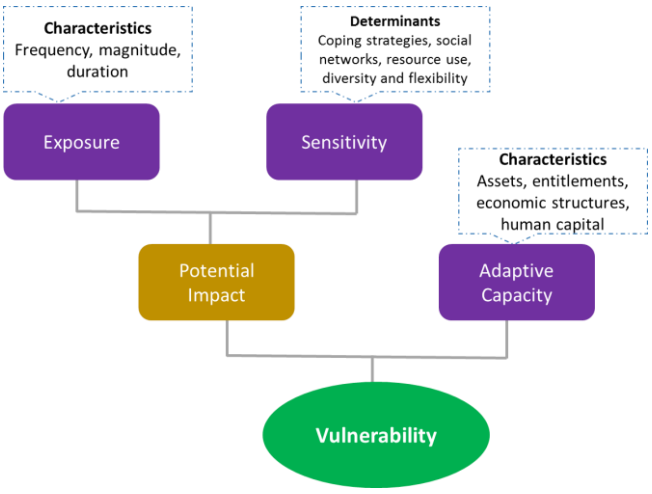
- Regions where average temperatures are high
- Regions where temperature may cross tolerance limit of certain system

Sensitivity

The degree to which a system or species is affected, either adversely or beneficially, by natural disaster. The effect may be direct (damage of life due to thunderstorm) or indirect (scarcity of drinking water due to the reduction of water body during droughts).

Factors that influence sensitivity to climate change

- Physical health and age
- Extent to which physical structure and services are affected by climate hazards
- Health, connectivity and robustness of the ecosystems (for ecosystem)



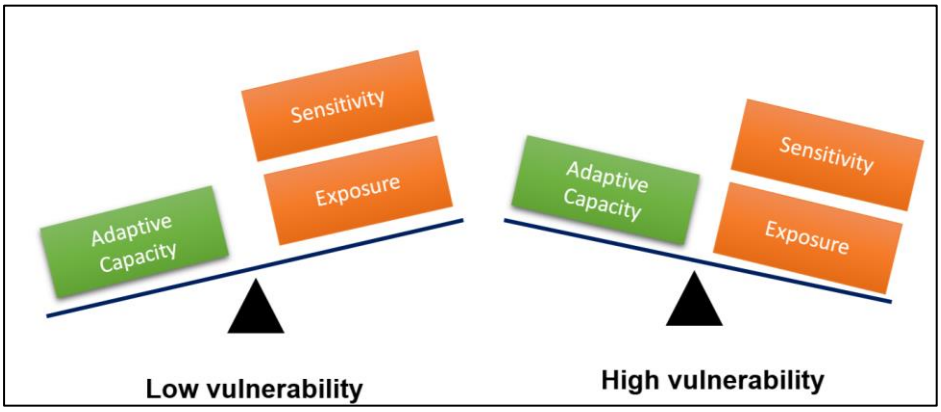
Concept of Vulnerability

Adaptive Capacity

The ability of a system to adjust to climate change (including natural disaster and extremes) to moderate potential damages, to take advantages of opportunities, or to cope with the consequences. Examples: Embankment construction to prevent river bank erosion, building flood shelter to protect livelihood etc.

Factors that influence adaptive capacity

- Access and ability to process information
- Resources to invest in adaptation
- Willingness to change and adapt



Assets with high adaptive capacity and low sensitivity/exposure can tolerate impacts to a greater degree and therefore have an overall low vulnerability. Assets with high sensitivity/exposure and low adaptive capacity are more susceptible to impacts, and therefore have an overall high vulnerability.

Finally, vulnerability can be assessed either quantitiative or qualitive scoring. During scoring of exposure, sensitivity and adaptive capacity normalization should be done on the basis of functional relationship.

11.3.5 Disaster Risk Assessment

Risk is the probability of harmful consequences- casualties, damaged property, lost livelihoods, disrupted economic activity, and damage to the environment, resulting from the interactions between natural or human-induced hazards and vulnerable conditions. Risk assessment is a process to determine the nature and extent of such risk, by analyzing hazards and evaluating the existing condition that together could potentially affect the exposed population, property, services, livelihoods and the environment on which they depend.

In addition, for assessing risk, understanding of risk components and their measurement methods are essential. Basically,

- Risk is the component of Hazard and Probability.
- Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur.
- Risk is often used to refer to the potential for adverse consequences of a climate related hazard.

At a glance,

$$Risk = Hazard \times Probability$$

$$or, \quad Risk = Consequences\ of\ CC\ Impact \times Probability\ of\ that\ Consequences$$

$$Again, \quad Consequences\ of\ CC\ Impact = Exposure \times Sensitivity$$

Under these circumstances stated above, a comprehensive risk assessment consists of exposure of a disaster, sensitivity and probability of that disaster. Following steps guide to assess disaster risk clearly in both qualitative and quantitative way.

1. Qualitative Assessment

Exposure: Besides the estimation of potential losses and their impact, risk assessment allows for the determination of the acceptable level of risk, defined as the level of losses that is acceptable without destroying lives, national economy or personal finances. Once the current and acceptable levels of risk are determined, disaster risk reduction plans and strategies could be revised or developed so that they have the measurable goal of reducing the current risk to acceptable levels.

The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social or cultural assets in places and settings that could be adversely affected. Vulnerable populations are exposed to multiple risks including reduced agricultural productivity, risks to unique and threatened systems, increased exposure to disease vectors and extreme weather events. Simply, exposure is the fact of experiencing something or being affected by it because of being in a particular situation or place. There are some indicators which are accountable for exposure assessment.

- Number of people living in flood prone areas
- Number of properties located in river/coastal floodplain
- Number of hospitals located in areas at risk from flooding/coastal erosion
- Number of households within most deprived communities located in areas of flood/coastal erosion risk
- Historical inundation level and its coverage
- Areas of haor zone at or below mean sea level

Sensitivity: The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g. a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g. damages caused by an increase in the frequency of coastal flooding due to sea level rise).

Indicators that influence the sensitivity to climate change are shown as below.

- Physical health and age
- Extent to which physical structure and services are affected by climate hazards
- Health, connectivity and robustness of the ecosystems (for ecosystem)
- Areas of coastal zone at or below mean sea level
- Number of households within most deprived communities located in areas of flood risk
- Number of hospitals located in areas at risk from flooding

After incorporating all the affecting indicators regarding exposure and sensitivity, the consequence of climate change impact will be measured. Basically, impacts of climate change

are the effects of climate change on natural (e.g. water resources, biodiversity, soil, etc.) and human systems (e.g. agriculture, health, tourism, etc.). Potential impacts are all impacts that may occur given a projected change in climate, without considering adaptation. Intrusion of salinity due to sea level rise is an example of the consequence of climate change impact. Then the consequences of the climate change impacts will be overlaying with probability of that consequences.

Probability of that consequence means probability of occurrence of that disaster. Basically, the probability includes return period of the particular disaster, historical data analysis, disaster prediction analysis and so on. After combining all the above data, the following table will be formed.

The qualitative assessment mainly relies on the descriptive information and expert knowledge and evaluation ranking into qualitative classes such as “High”, “Medium”, “Low”. This information can be gathered from the stakeholder involvement, meeting, interviews, questionnaire etc.

Risk Matrix for Qualitative Assessment

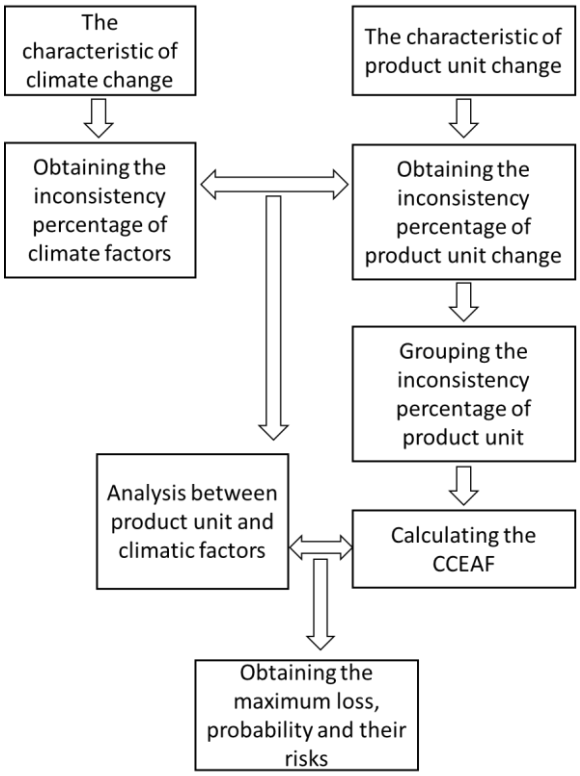
Probability of Disaster event	**Extent of Consequences**		
	Low	**Medium**	**High**
High	Medium	Medium	High
Medium	Low	Medium	Medium
Low	Low	Low	Medium

Using the table a typical qualitative risk assessment can be done and categorize into several classes.

2. Quantitative Assessment of Risk

Zhiqiang Dong and his colleagues proposed a quantitative way to the specific steps for risk assessment by addressing a new concept named climate change effect-accumulated frequency (CCEAF), which can be followed for this context too. CCEAF calculates the probability of occurrence due to climate change. The probability of occurrence is equivalent to the sum of frequency or reliability of a threshold value occurrence. Some specific steps have been addressed to assess the risk of agriculture and fisheries production based on the above concept.

The following steps give an overview of Dong’s risk assessment which can be applied in Haor region also.



The flowchart of the specific steps for risk assessment

Step 1. Based on climatic data, the characteristics of climate change of the haor region will be described, such as precipitation change. In haor region, the climate has different and own climetic characteristics, which will be addressed firstly.

Step 2. The inconsistency percentage of product unit for both agricultural crops and fisheries will be calculated from historic data, and the degree of loss in the sectors will be obtained in this step. In pervious climatic adverse effects, say for example occurrence of flood, percentage of agricultural crops and fisheries production loss/inconsistency will be needed to evaluate using historical data.

Step 3. Inconsistency percentage of unit product will be divided into several groups. If the number of groups is denoted as N, then the group interval will be, D = (Maximum inconsistency percentage – Min inconsistency percentage) / (N-1) (Qu 1991). Say for example, calculated maximum inconsistency percentage is 80 and minimum is -40 and the number of group will be 7. The by following above equation, the group interval will be 20. That means, the group will be ranged from -40, -20, 0, 20, 40, 60 and 80.

Step 4. In this step, the probability of increasing or decreasing change in product unit will be calculated. The frequency of inconsistency percentage will be calculated for the different groups (found in step 3). Increasing or decreasing changes in crop unit yield correspond to a specific value of frequency, namely CCEAF and this is the probability of increasing or decreasing change in product unit.

Step 5. Analysis between inconsistency percentage of different climatic factors and product unit will be performed according to the characteristics of climate change. The analysis will be used to calculate maximum values of product change caused by different climatic factors.

Step 6. A quantitative equation will be calculated between inconsistency percentages of multi-

climatic factors and unit product. The maximum value will indicate the maximum product change caused by multi-climatic factors.

Step 7. The CCEAF of maximum yield change caused by separate and multi-climatic factors will be calculated. Then the corresponding risk will be obtained by maximum product change and it's CCEAF.

An example of quantitative disaster risk assessment in crop yield due to precipitation is shown as below.

Risk Assessment **Example**

If, the maximum yield decrease is **14.1%** (consequence) (CC impact) of precipitation and its probability is **56.1%**

Then its Risk = 14.1X 0.561 = 7.9 (Max Risk Value)

If, the maximum yield decrease is **2.1 %** (consequence) (CC impact) of precipitation and its probability is **80%**

Then its Risk = 2.1X 0.8 = 1.7 (Min Risk Value)

Taking ranges of risk value risk level can be fixed like Low, Medium, high and presented with risk matrix, risk map etc.

Probability of Disaster event	Extent of Consequences		
	Low	Medium	High
High	Medium	Medium	High
Medium	Low	Medium	Medium
Low	Low	Low	Medium

11.3.6 Existing DRR Capacities

To conduct analysis of the vulnerability of affected people and area, and formulate adequate DRR measures, assessment of existing disaster risk reduction capacity is mandatory. Considering the capacity assessment framework of UNDP, following issues needed to be analyzed for assessing existing disaster risk reduction capacity-

Institutional arrangements

It is a core issue relevant across most aspects of governance, public sector management and development activities. It addresses the policies, act, procedures, systems and processes that the country have in place to functionalize their political mandates, development policies and objectives as a way to reduction of disaster risk. Sectoral ministries and local governments which have a role in integrating DRR into development planning (land-use, safer construction, rangeland management, water conservation and management, awareness and education); e.g. agriculture, environment, education, urban development, water, transport, gender/ women's affairs/ social affairs. In some countries, almost all governmental ministries may have an existing or potential role in DRR.

Leadership/ Community based arrangement

Effective leadership can transcend individual-to-individual capacity level to organisational capacity level and thus help to advance a strategic planning and an agenda that is vision-driven. Leadership capacities can be enhanced through strategies like strengthening the abilities of the organisation regarding vision setting, transparency, a sense of readiness,

systems thinking, assessment of potential risks and managing them through establishing collective management systems that encourage learning.

Knowledge

It is considered as the foundation of capacity and it includes measures for creating and enhancing knowledge using different teaching approaches and in all educational settings. Developing disaster risk reduction knowledge through improvement in expertise and organisational learning strategies occurs at organisational level. Professional training, experience sharing and knowledge management systems in the organisations are some of the approaches to strengthen DRR capacity at this level.

Accountability

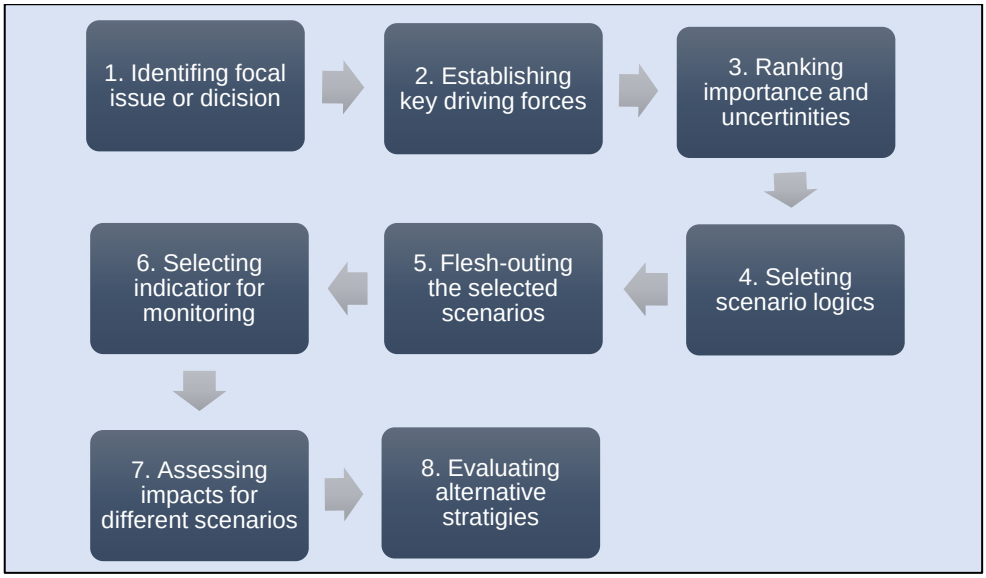
Provision of oversight, monitoring and evaluation is needed to guarantee that processes and programmes are leading to the expected objectives, and providing mechanisms to overcome obstacles and identify shortcomings when necessary.

11.3.7 Development of DRR Mitigation Measures

Scenario Development

Scenario development is a stratigic planning method for thinking creatively about possible complex and uncertain futures and to consider a variety of possible outcome which includes many of the important uncertinties in the system rather than to focus on the accurate prediction of a single outcome that is used to identify long-term goals and actions. It aims to define critical uncertinities and develop plausible scenarios in order to discuss the impacts and the responses to give for each one of them. Scenarios are plausible alternative futures, what might happen under particular assumptions. By focusing on key drivers, complex interactions, and irreducible uncertainties, scenario building generates the futures within which we can assess alternative mitigation strategies including the future without restoration.

Scenario building generally involves following steps,



Identifing focal issue or decision

The focal issue represents the question about the prospect of any event which is currently confronting or will be confronted in near future. Like- “Effect of climate change on the yield of agriculture and fisheries.”

Establishing key driving forces

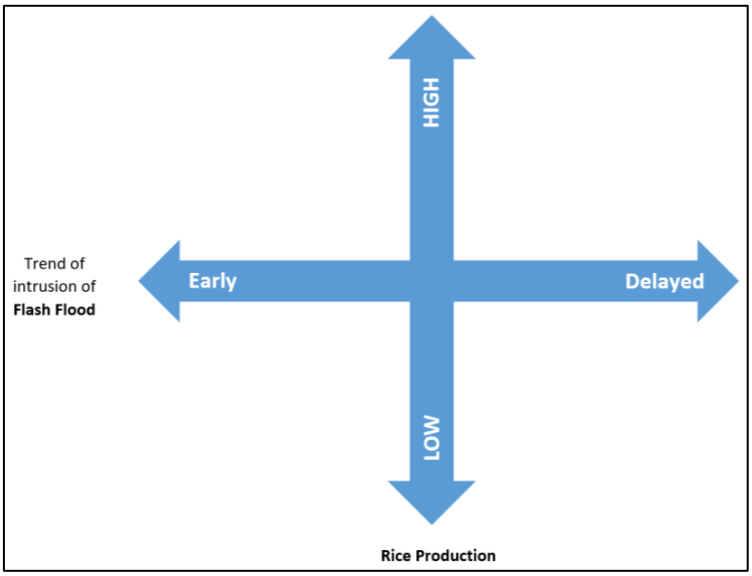
It’s the most important step of scenario development where the most important factors that will shape the nature of the focal issue which are called as “drivers”. Before specifing the various drivers participents should carefully decide the overall assumptions on which the scenarios will be based.

Rank importance & uncertaity

Identified driving forces are ranked in terms of their uncertainty and importance in relation to the focal issue. This step directs the outcome of the final scenarios as the two most important and uncertain drivers define the most divergent and relevant future conditions to be included in the final set.

Select scenario logics

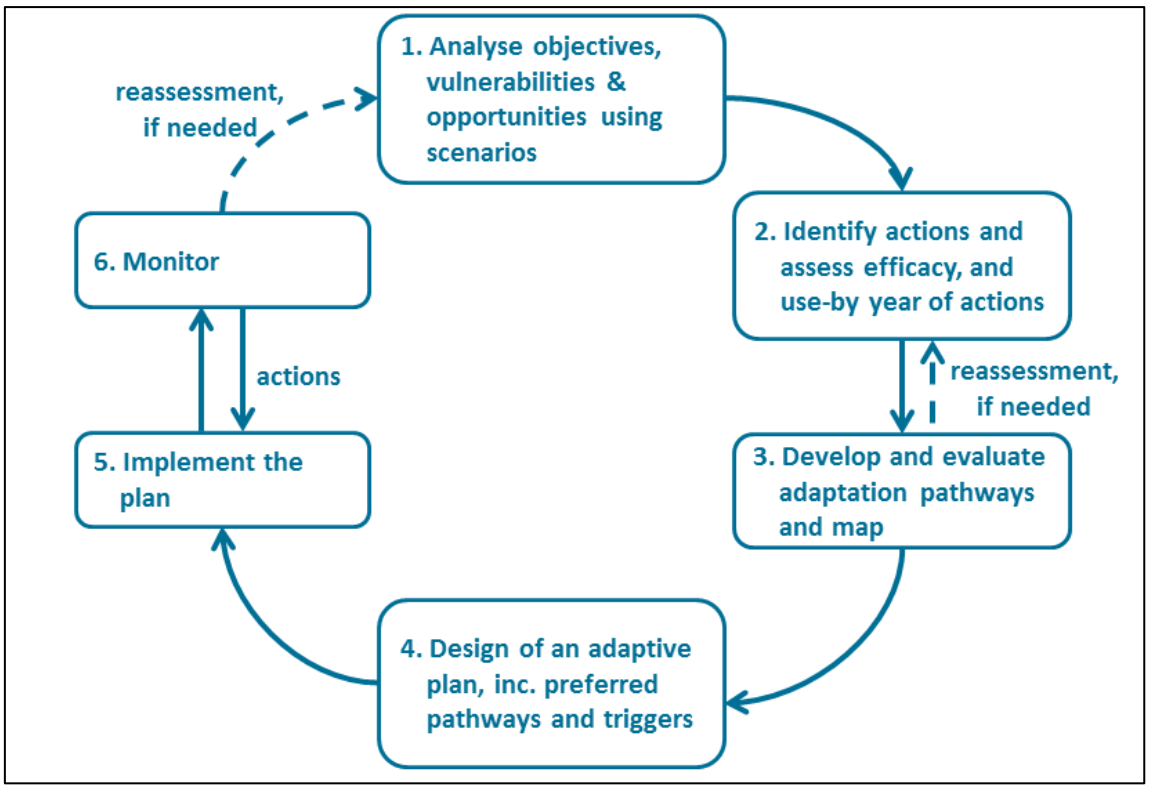
The logics are defined by exploring the interactions of the most uncertain and important drivers such that alternative frames are created, each representing a divergent yet plausible scenario.



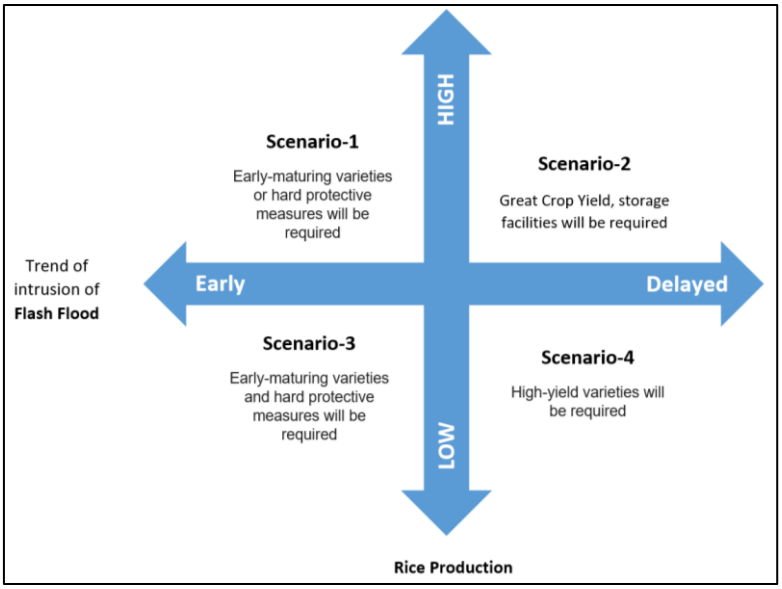
Scenario logic for effect of effect of flash flood on rice production

Flesh-out the scenarios

Each scenario is developed by exploring the implications of alternative trajectories on the focal issue under the set parameters defined by the interactions between the key driving forces. Dynamic Adaptive Policy Pathway approach can be followed to build the alternative trajectories.



Dynamic Adaptive Policy Pathway Approach (Deltares and TU Delft)



Scenarios buildup for previous scenario logic

Select indicators for monitoring

A set of indicator are selected to assess the implications of alternative futures on the focal issue. Metrics refer to a measure used to determine a certain condition.

Assess impacts for different scenarios

Using the selected indicators, scenario planners assess how the focal issue is impacted under

each scenario.

Evaluate alternative strategies

The main objective of scenarios is to inform strategic decision-making. Once alternative scenarios are described, managers can evaluate the efficacy of alternative strategies across the suite of scenarios.

11.3.8 Formulation of DRR Measures

Disaster risk reduction measures formulation involves identification of such intervention which are capable of reducing the adverse effect of disaster by risk mitigation, capacity development and building back better. Mitigation and building back better/ recovery generally indicates hard measures, where capacity development measures are soft measures which are part of the preparedness and response stage of the disaster risk reduction. The identified impact, vulnerability and risk should be emphasized to formulate the DRR measures. Most importantly, the DRR measures should be contextualized in the context of Haor area considering the indigenous mitigation measures currently practicing by community as well as evaluated performance of previously taken measures. Technological innovations and advancement should also be taken into consideration.

Consideration and Identification of Future DRR Measures

Disaster Risk Reduction is the conceptual framework considered to minimize vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards, within the broad context of sustainable development. Disaster Risk Reduction (DRR) encompasses four stages of activities:

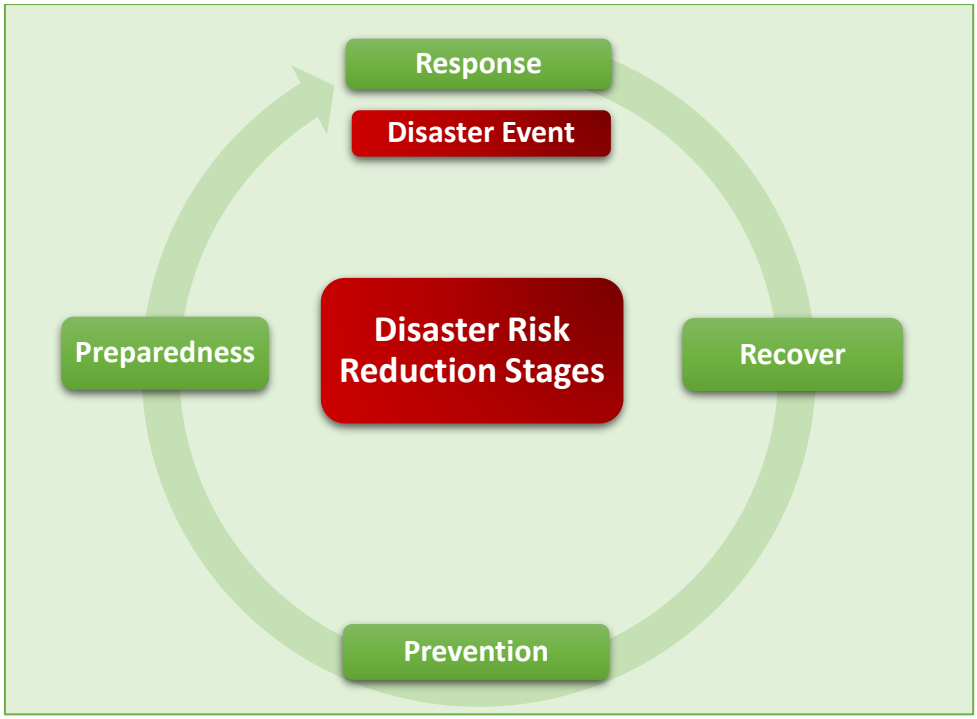
Prevention or mitigation of hazards- sustained actions that decrease the risk of a hazard (probability of occurrence) of a hazard, or to reduce the potential negative consequences suffered by people and/or property.

Preparedness of vulnerabilities to hazards plans or procedures designed to minimize physical and property damage when an event occurs. These activities ensure that when a disaster strikes, disaster (emergency) managers will be able to provide the best response possible.

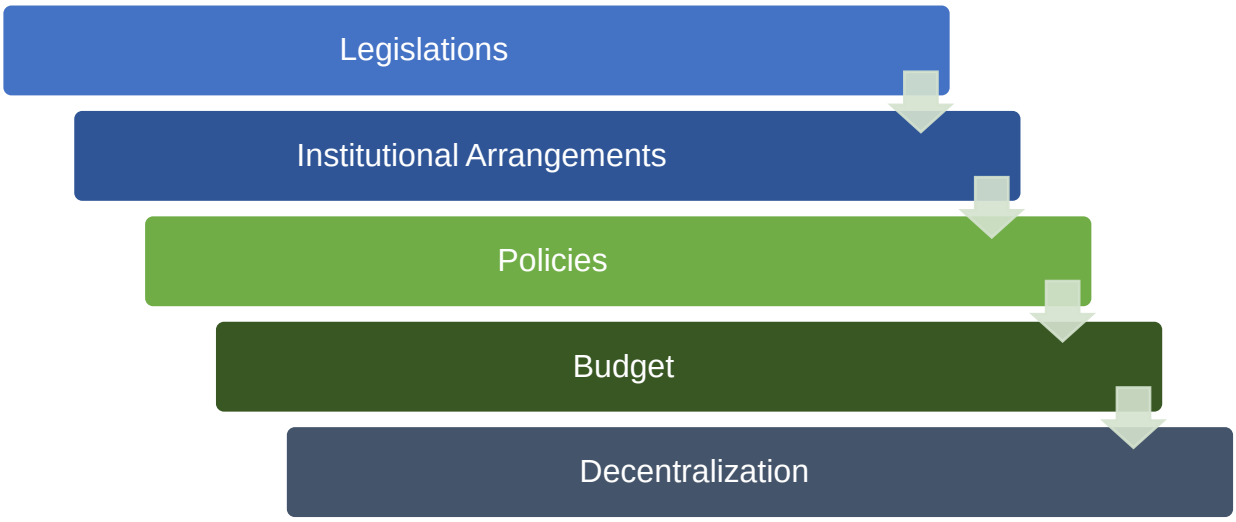
Response- the actions taken to decrease mortality and morbidity, and to prevent further property damage when the hazard occurs. Response is putting preparedness plans into action.

Recover- Recovery is defined as the actions taken to return to normalize the situation following an event.

Dynamic Adaptive Policy Pathway is recommended for the implementation of any hard measures as DRR measures, as they have significant and most of the time long term consequence. The Dynamic Adaptive Policy Pathways (DAPP) approach aims to support the development of an adaptive plan that is able to deal with conditions of deep uncertainties.



Following elements should be considered for DRR measures-



Furthermore, following six key thematic areas should be considered specifically for thre haor areas for formulation of DRR mitigation measures, e.g.

- Protection from early flash floods, drought, wave action, siltation, thunderstorm and other climate change induced hazards
- Strengthening early warning and dissemination system
- Emergency preparedness and response
- Capacity development for Disaster Risk Reduction
- Awareness raising
- Enhance resilience against Climate Change Risk

11.3.9 DRR Measures for Haor Area

Protection from Wave Action and Flash Floods

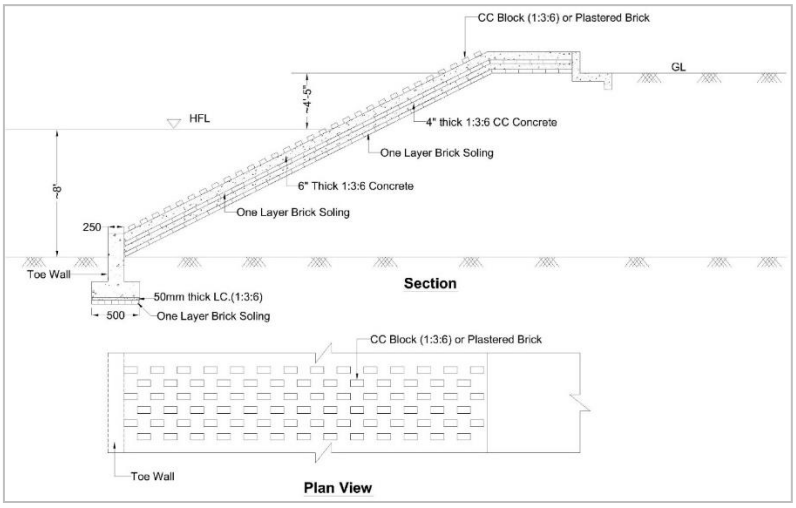
Wave action or Afaal and flash floods are the major risks of the haor area, which occur very frequently, damage or inundate settlements, create havoc to life, livelihood and properties. Protection from these hazards are thus essential and three interventions have been identified accordingly, which are:

- Slope protection through brick soling around the Urban Settlement
- Slope Protection through Greenbelt Development, Geo-bag and CC block around Rural Settlement

Construction of Brick Soling around the Urban Settlement

Afaal or severe wave action generated by wind hit the settlement area or mounds and erode side slope embankment gradually. This phenomena creates huge difficulties for local people especially in the urban area, as urban areas are the focal of all economic activities as well as all basic facilities like markets, medical centers or hospitals etc. It was learnt that in the worst case, wave action could reduce the homestead by 15 to 20% in a particular year. In some village, it is reported that 25% of the homestead area have been lost in the last few years. Therefore, protection of these urban areas from wave action through hard engineering measures are of utmost important.

As engineering measures, slope protection through multi-layered brick soling is suggested as it is sustainable measures yet economically viable in the direction of wave action around the urban settlement instead of local practice of using bamboo with Chailla grass, stone or concrete blocks. Figure 6.5 illustrates thus measure. In this case the sloped surface is covered with a layer of brick, followed by a 4 inch layer of CC concrete at 1:3:6. This is then again topped by a brick layer with another 6 inch of CC layer. This is supported thorough an RCC toe wall at the bottom of the slope. The surface is covered by either CC block or brick which is plastered and in formation as shown in following Figure. The irregular layout contributes to the reduction of wave force. As the more cost-cutting solution, this option is selected for implementation with 68 km coverage.

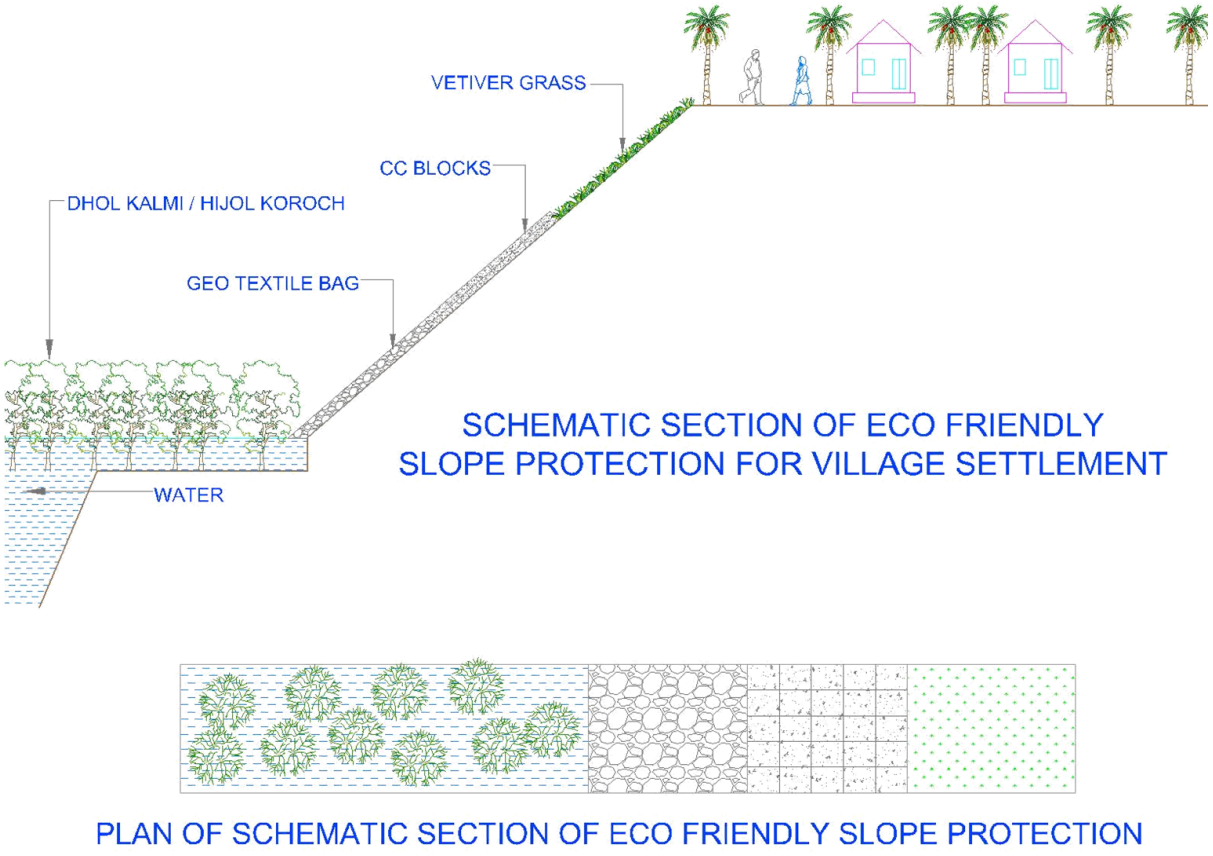


Typical Section and Plan view of slope protection through brick soling

Slope Protection through Greenbelt Development and Geobag

Wave action generated by wind is also a severe problem for discrete villages or settlement inside the haor. While the people of these villages become isolated during full monsoon, erosion of side slope of mounds due to wave action make the situation worse. In this case, eco-slope protection using bio-engineering techniques can be more cost effective and sustainable solution.

Figure below shows the schematic design section of eco-slope protection encircled the discrete villages inside the haor. It can provide long-term sustainable low-cost and maintenance free solution for slope protection. It has been widely recognized that plant root systems can improve the soil shear strength significantly.



Schematic section of eco-slope protection using Dhol-kolmi, Hijol-Karach, geo textile bag, CC block and vetiver grass

In proposed interventions, locally available materials i.e., vetiver grass, dholkalmi, Hijol or Karach, geo textile bags (filled with sand) and CC block will be used for village side slope protection. Vetiver grass has been chosen for its attributes like longer life, strong and long finely structured root system and high tolerance of extreme climatic condition. CC block has been chosen to give initial support to withstand the wave action induced erosion until the vetiver grass is fully grown. Geo textile bags have been used as a support at the toe of side slope and, Dholkalmi and Hijol-Karach has been used as a secondary vegetation at the end

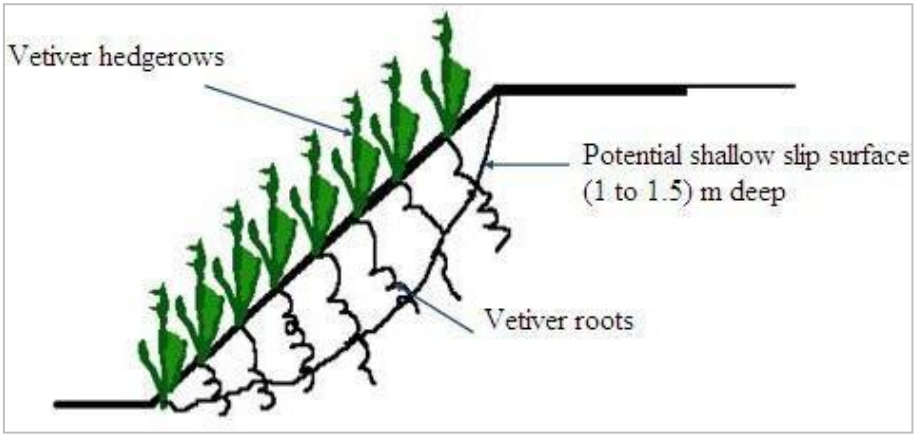
of geo textile bag lining. 182 rural settlements of 4 haor districts Sunamganj, Netrokona, Sylhet and Kishoreganj has been identified which cover an area of 1396 ha.

Vetiver Grass

Vetiver belongs to the same part of the grass family as maize, sorghum, sugarcane, lemon grass and Cymbopogon. Vetiveria zizanioides is a kind of plant that can suitably and rapidly adapt to the environment. The leaf of Vetiveria zizanioides is 45-90 (100) cm. long and 0.6-0.9 (1.2) cm. wide. Vetiveria zizanioides at one year of age can produce the roots penetrating more than 1 meter deep. This somehow, depends on the conditions of the soil and health of the grass. The roots will be longest if the grass is grown in loose clay soil with good water drainage potential.

Root system of vetiver grass

The combination of deep roots with tensile strength of 75 MPa that improve the shear strength of soil by as much as 40% makes vetiver grass an ideal plant for stabilizing steep and unstable slopes. The Vetiver System when applied to such slopes significantly reduces the probability of land slippage and reduces the need for “hard solutions”.



Root system of vetiver grass

Applications include highway, railway, riverbanks, public utility right of ways, canal, dikes, and levee slopes. The Vetiver System can also be used to reduce potential disasters caused by extreme rainfall events. Stabilization of levees and sea dikes reduces the chance of breaching

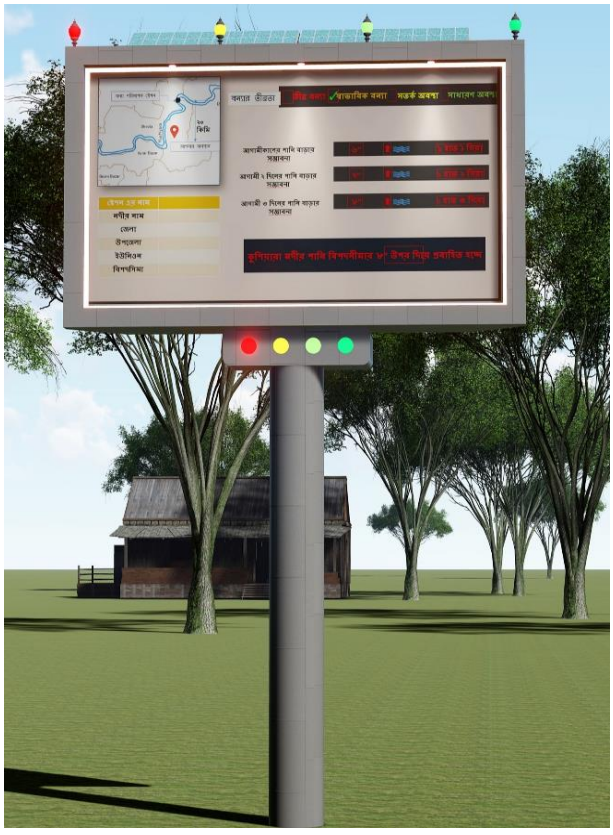
and subsequent devastating flooding. Steep slope protection by vetiver grass reduces potential land slippage caused by high rainfall events. In most developing countries many of the Vetiver System applications can be applied at minimum cost to poor rural communities to enhance quality of life through protection of water supplies, improving soils and increasing farm benefits.

Early Warning System

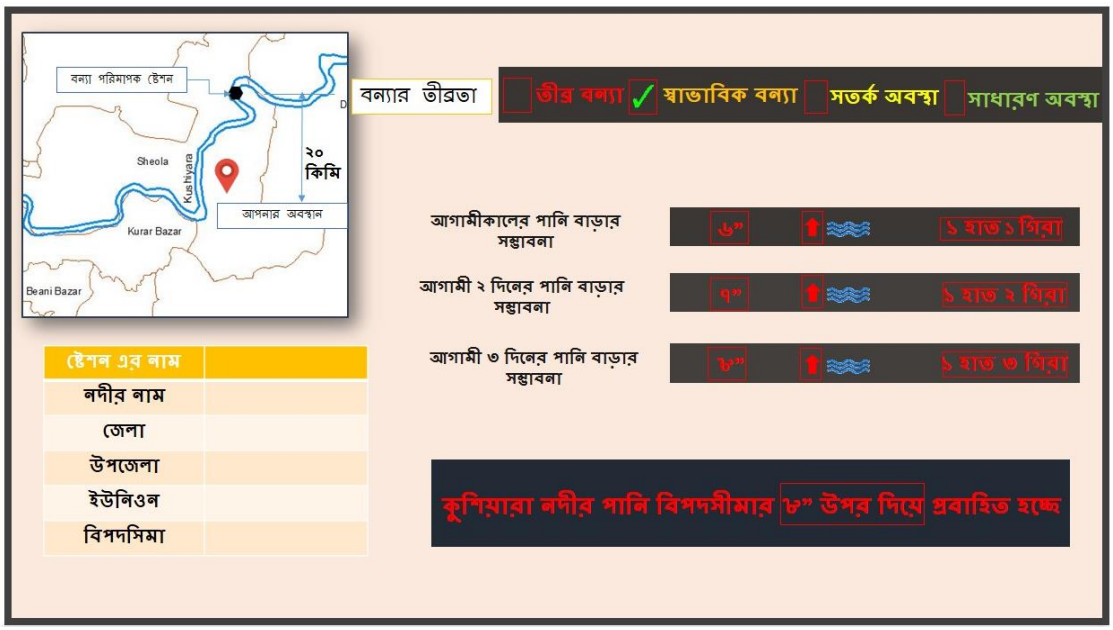
Community driven Digital Dash Board

Flood Forecasting and Warning Center (FFWC) is responsible for early warning information generation and dissemination. However, it is merely ensured yet that the warning information can reach up to community level. Therefore, a community based dissemination of early waning information can be established using Digital Dash Board, where early warning information will be displayed during flood prone time.

The display of the Digital Dash Board will be at least 5ft by 3ft in size and both way display boards will be combined in a rectangular frame, founded on truss structured pole. The poles will have sufficient CC foundation from inside the ground. These type of truss structured pole with foundation will make the Digital Dash Board sustainable against severe wind action during storm. The Digital Dash Board should also be rainwater resistant. According to Haor Master Plan, 2012 around 44% of the haor area is under electricity coverage, which is quite low in compared to national electricity coverage. Therefore, a mini solar panel will be integrated with each digital dash board which will supply the power to operate the Digital Dash Board. This mini solar panel (at least 100W) will be mounted on top of the middle pole of the Digital Dash Board. Figures below show the plan view and display of Digital Dash Board.



Community driven Digital Dash Board



Display of Community driven Digital Dash Board

The Digital Dash Board will be functional for 6 months from April to September of a year, rest of the years it will be remained inactive. A selected person from the community will be responsible for operation (on or off) of solar panel.

This proposed Digital Dash Board will display the early warning information generated by FFWC for respective nearest Rivers and Haors of the Dash Board. The geocoded early warning information with warning symbols will be automatically sent to the Digital Dash Board from FFWC using network of mobile operators or SIM card. The early warning information should contain at least following message and features:

- Water level of which adjacent Rivers are in danger level and how much?
- Which haors are going to be inundated within next 24, 48, 72 hours?
- What is the status of adjacent haors of that location?
- Probability of tipping point of rainfall in upstream or in Meghalaya.
- Size is recommended as 8ft by 6ft.
- Total 1700 no of digital dash board is suggested which will have LED panels, 4 different color light for warning and will be connected with the server through SIM card.

Inter-agency cooperation among FFWC, DDM, Mobile operators and local government should be ensured to disseminate the information properly. Regular inspection of functionality of Digital Dash Board or repair if become damaged due to any hazards should also be performed for full functionality of this dissemination system.

This community driven Digital Dash Board will be very effective and sustainable early warning information dissemination system for not only flood warning but also lightning warning.

Emergency Preparedness and Response

Flood Relief Center/Community School

Flash Flood is the most devastating and costly natural hazards in the world that leads to significant economic and social damages in haor region. In order to mitigate the risk of this

devastating natural disaster Flood relief center can play a vital role as part of disaster response and recovery in providing optimum security, personal safety, and protection from climate and improve resistance to ill health and diseases for victims who lost their accommodations as a result from the disaster itself. When a disaster happened, most of the evacuees particularly the elderly and low income communities rely on the Flood relief center for their temporary house or shelters. However, some of the evacuees were either stayed in hotels, relatives' houses, or even reluctant to leave their own houses in the times of flooding. Living in sheltered places with unfamiliar people may lead to invasion of personal space and privacy of the evacuees.

Flood relief center is not only function as immediate and short-term shelter for the victims but also help them to recover from trauma of the disaster as well as provide a base to start rehabilitation process. Victims from disasters are not only require financial support due to losses and property damages, but some of them may need physical and emotional support after experiencing unexpected situations. Since Flood relief center may be used for several weeks or even months after a disaster period, numerous factors should be taken into account in planning and designing the shelters such as physical location and needs of likely users. As a long-term flood disaster management strategy, a series of dedicated and well-designed Flood relief center should be seriously considered. This Flood shelter will also be used as community school also.

Table 6.2 shows the minimum standards in emergency management according to the standards specified in the Handbook for Emergencies by UNHCR. Figuress below show the 3-d view and corresponding floor plans for the shelters.

Table 11.2: Minimum Standard of a Flood Center

Minimum Standard	Description
Type of Shelter	Tents, plastic sheeting, prefabricated buildings, temporary or transitional shelters, permanent public buildings.
Living Area	Covered area of 3.5 m^2 per person.
Sanitation	Family latrines are preferred. Start with 50 persons per latrine and lower to maximum of 20 persons per latrine (segregated by sex).
Water Availability	Basic water needs are 7.5-15 litres/person/day. Maximum distance to nearest water point is 500 metres.
Health Facilities	Essential health services including control of communicable diseases, child health, sexual and reproductive health, injury, mental health and non-communicable diseases. One health centre/50,000 people with qualified health workers (medical doctors, nurses, midwifes).
Food and Nutrition	Minimum nutritional requirements of 2,100 kcal/person/day consists of 10 % protein, 17 % fat and adequate micronutrient intake.
Non-Food Items	Rapid market analysis can determine whether goods can be sourced locally or in neighbouring, non-affected areas.

Minimum Standard	Description
Accessibility	Access road should consider proximity to transport hubs for the supply of relief assistance, seasonal constraints, hazards and security risks. Escape routes should avoid isolated or screened areas that could pose a threat to users' safety.
Transportation	Primary storage and food distribution accessible by heavy trucks from an all-weather road. Other facilities accessible by light vehicles.
Climate and Environmental Condition	Shelter should provide protection from seasonal climate. Need to minimize adverse impact on the local natural environment resources when providing shelter to the affected population.
Education and Activities	Encourage community to organize structured and supportive educational activities for children. Access to community-based social support and self-help activities that promote psychosocial well-being.

Additional Recommendation

- Flood relief center should be constructed in an elevated land.
- At least one elevated tube well should be constructed within the region.
- Separated place should be kept for livestock and ramp provision should be provided for them.
- 158 Flood Shelter has been suggested in the deeply flooded haor region of Sunamganj and Netrokona districts
- Separate floors for man and woman.
- Roof will be covered through solar panel.
- Each flood shelter should consist of a floor area of 2000 sqft.
- Shelter will be 3 storied.

A Typical Flood Relief Center with a Provision for Livestock

Emergency Relief Boat/School Transportation Boat

Emergency relief boat cum School boats can be used as an emergency measures as this can be most effective option to provide aid to the people in distress and also to provide a safe traveling medium for the children during the monsoon flood. These boats will be designed to carry 35-40 people at any emergency situation. These boats will be lightweight and equipped with a lot of features. These boats will also have other applications other than for just emergency rescues and transportation of students. They can be used as recreational boats, rafting and for fishing due to their efficiency and size. 120 no of location has been identified as vulnerable where the Emergency Relief Boat/School Transportation Boat has been suggested. Some features of Emergency relief boats are illustrated below:

Features

- Eco-friendly materials such as Bamboo and Fiber polymer.
- There should be at least one first aid kit box in the boat.
- Enough life jacket and buoy should be stored for the rescued people or children going to school.
- Bottom of the boat should be as flat as possible with detachable floating wing and should be made of rigid materials to ensure the stability of the boat during storm incident.
- To absorb the wave generated force the boat may have floating wing in the both side, which can be folded during entering narrow channel. This will prevent it from capsizing.
- Hooks of good quality and durability must be carried on a rescue boat. The metal fittings should be galvanized and at least two boat hooks and a few spares must be mandatorily carried aboard every boat.
- Crutches must be made of galvanized iron and should be attached to the boat by a chain secured at the neck of each crutch. If any crutch is damaged or broken, the entire thing must be replaced with the spare crutches that are to be carried on a rescue boat at all times.
- Fire extinguishing appliances, such as portable fire extinguishers must be provided in accordance with the safety regulations. They must be kept on easily accessible spots

on the vessel and must be sealed and regularly checked.

- Lights of an approved type must be available at boat. Internal and external lights, which is powered through Solar Panel. Electric torches and other such portable waterproof equipment must be available with spare batteries.

A Typical Emergency Relief Boat/School Transportation Boat

Boat Ambulance

There are certain remote areas in haor region where it is very difficult to access due to the lack of roads and other routes in emergency condition due to flash flood or other natural disaster. These Regions that are primarily surrounded by water bodies or rough terrains usually have inaccessible routes and can be easily accessed by alternative transportations. This is where alternative methods of providing medical assistance come into picture. There have been several instances globally, where people had to ditch the traditional ambulances and take the aid of aerial ambulances or ambulance boats. For areas that have substantial water bodies, the most efficient option in cases like these is that of ambulance boats.

Ambulance boats are very similar to the traditional ambulances and are equipped with all the necessary gadgets including ventilators, surgery equipment, a team of paramedics, and other necessary equipment to provide aid to the victims. In cases of emergencies, some lifeguard vessels or lifeboats can also be used as ambulances to transport victims or casualties. If the number of casualties is very high, the fishermen community pitched in the rescue operation, turning fishing boats into temporary rescue boats and makeshift ambulances.

The International Convention for the Safety of Life at Sea (SOLAS) and International Maritime Organization (IMO) have set a few specific rules that engineers must adhere to while designing ambulance boats. Considering those rules and our existing condition we propose some features of an ambulance boat:

Features

- Ambulance boats will be equipped with medical lockers, surgical equipment, medical beds, nursing rooms and paramedics. It will become easier and more efficient for people in need to get the required medical assistance.
- The paramedical staff on board the vessel will be trained to work in the field as well and the medical supplies will be regularly updated.
- Ambulance boat will have access to remote areas.
- This boat will have Two (2) – Four (4) separate bed for women and men for the emergency patient.
- General Treatment area for regular patient will be separated from the cabin.
- Storage cabinet for medicine and equipment will be included.
- Shock absorbing stretcher will be included.
- Installation of Solar panel for electricity.
- Some Priority Boat Ambulance for Women, Children and Physically Challenged should be included with some extra features like wheel chair, trained volunteer, Shock absorbing stretcher etc.

A Typical Boat Ambulance

Capacity development for Disaster Risk Reduction

School Boat

To ensure uninterrupted education system in remote area those are highly vulnerable to flash flood school boat can play an effective role to transport students especially up to primary school students. School boat should have following features:

Features

- Each boat will have adequate space to carry 20-25 students excluding the operator.
- There should be at least one first aid kit box in the boat to provide any kind of emergency assistance.
- Enough life jacket and buoy should be stored for the children.
- Bottom of the boat should be as flat as possible and should be made of rigid materials to ensure the stability of the boat during storm incident.
- To absorb the wave generated force the boat may have floating wing in the both side, which can be folded during entering narrow channel. This will prevent it from capsizing.
- Hooks of good quality and durability must be carried on a rescue boat. The metal fittings should be galvanized and at least two boat hooks and a few spares must be mandatorily carried aboard every boat.
- Crutches must be made of galvanized iron and should be attached to the boat by a chain secured at the neck of each crutch. If any crutch is damaged or broken, the entire thing must be replaced with the spare crutches that are to be carried on a rescue boat at all times.
- Fire extinguishing appliances, such as portable fire extinguishers must be provided in accordance with the safety regulations. They must be kept on easily accessible spots on the vessel and must be sealed and regularly checked.

Boat School

To ensure qualitative primary education for the isolated and most deprived children in low lying/ haor areas boat school can be the best option. It is observed that as a flood prone area filled with water for almost six to 7 months in a year. During this time, no education activities are actually carried out as people's basic living conditions are conspicuously disturbed (Ahmed 2013). So boat school can be introduced and already run by BRAC which Schools can being used as an alternative shelter of emergency during disasters. Therefore, children who remain away from education for a long period of time to maintain continuity in learning. Boat school may have some features which illustrated below.

Features

- The school hours will be flexible or can be fixed according to needs
- Children do not have to pay any fees and there are no long holidays.
- Little or no homework as most of their parents are unable to assist them
- Children with special needs receive corrective surgeries along with devices like wheelchairs, hearing aids, glasses and ramps
- The Boat School should contain library and separate wash room facilities for girls and

boys.

- Dimension of the two storied boat school is recommended to be 40 ft by 13 ft.
- Solar panel should be installed for electricity.
- 110 boat schools are suggested for 733 nos. vulnerable schools
- 60 Boat School can be introduced to 120 most vulnerable school lying under deeply flooded haor.

A Typical boat school

Seed Store

Food security can be broadly defined as the condition of having access to adequate nutrients in order to lead a healthy life. The concept of food security has evolved over time, with earlier definitions looking at the availability of food at the aggregate level to recent, more disaggregated definitions, both static and dynamic, that take household and individual-level access to food into account. To ensure food security during lean season and after natural disaster seed store can play an important role to the affected people.

Seed Store concept in India

In India all the seed stores are managed by a group of people who belong to the same village. If the villages are small and homogenous, one grain bank will serve the whole village and all villagers may be members. If the village is large and / or consists of communities / people with different socioeconomic status, separate grain banks can be established for each group. The immediate management responsibility lies with the grain bank committee. In some cases, this committee is only concerned with the management of the grain bank, and in other cases it also deals with other matters related to village development like watershed works, village fund, etc. The committee calls village meetings to decide how much grain will be given to each person, and how much interest should be charged. The committee is also responsible for record keeping. Committee members are elected by the community, who also decides about the spacing of elections. Their main operation has started with Collection of grain from individual households which is done after harvesting the kharif crop in December or January. Initially, the same amount was collected from each household (first collection). After some time, with the grain bank getting established, people started borrowing varying amounts, and thus have to pay back varying amounts. Generally a woman is responsible for walking from house to house to collect the grain. She also checks the quality (moisture, stones, etc.). Another committee member will keep the record book and will fill and seal the bins. Generally both work without any remuneration. In some cases, literate village youth keep the records voluntarily. Then the grain is stored in seed store and according to the decision of committee distribution process is initiated. Interest is calculated per year and is 25%. Initially interest rates were in some villages as high as those paid to the money lender – the reason being that the grain bank will increase faster with high interest. Later on, as the stock increased, most communities decided to decrease to 50 or 25% per annum. Repayment is done after the harvest in December / January. Defaulting is common, and it is recognized that some people are unable to pay back after a poor harvest. They are expected to pay the following year and are charged double interest (for two years). This concept used in Orissa.

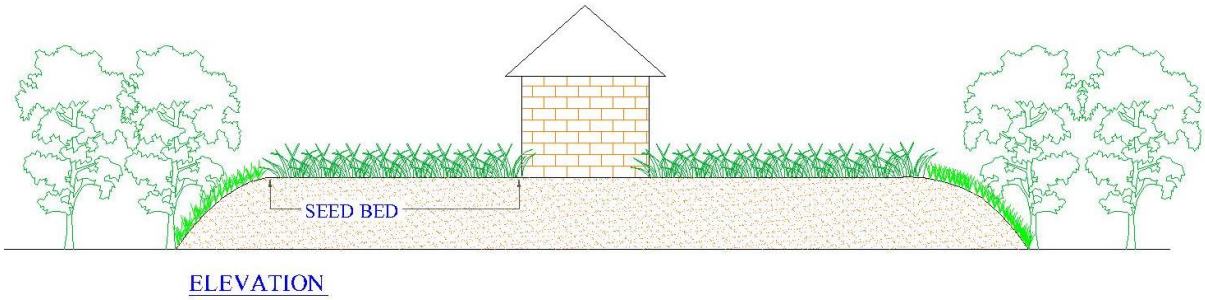
Seed Store concept in Africa

In Africa villagers receive a start-up grant or loan from an external agency (usually an NGO) to purchase grains after the harvest, when prices are low (CRS 1998). During the lean season when prices are high, the cereal bank sells its stock in the village above the original purchase price but below the prevailing market price, using the revenues generated as a revolving fund to refinance its operation in the following year. Apart from providing the start-up grant or loan, the external agency also finances the construction of a storage facility. The cereal bank also assists producers to market their grains in urban markets where consumer prices are higher. Thus, the main objectives of cereal banks appear to be the provision of better marketing services for grain producers and consumers at the village level, the reduction of post-harvest losses, the creation of local emergency stocks as well as building organizational capacity at

the village-level. This concept used in the Sissala East District of the Upper West Region of Ghana.

Recommended Features

- A committee need to form with a concern of respected villagers. Election could be a best option to avoid any kind of inconvenience.
- Women can be involved for collecting grains and checking their qualities. Involving them in the management of the Seed store appears to be beneficial, because they have a vested interested in making it work.
- Initially surplus production for at least some years may be required to build up a grain reserve. Linking seed store to production enhancing / stabilizing measures therefore makes sense.
- Grain needs to be stored for almost a year. If storage practices are low cost and effective, and can be managed by the community on its own, the GB is more likely to sustain.
- As seed store is a new concept in Bangladesh an appropriate initial support initially including training in record keeping, grain storage, and conflict resolution, can enable people to eventually manage the seed store on their own.
- Size of seed store can be- 10 ft. x 10 ft.
- Seed store should be stored in an elevated location so that it is not at risk during the disaster period, with proper sheltering and controlled environment.
- Total 800 Seed Sores are suggested in the Haor region where 235 of them are for 232 most vulnerable mouzas and 565 stores are for 1126 vulnerable mouzas. One seed storage should cover 50-75 households. So therefore large village may have several seed storage, while small village may have one.
- The committee should have 6-8 members, out of them at least 4 should be women.



Elevation View of Seed Store

Elevation View of Seed Store

Awareness Raising Programs

In addition to the above discussed hard, semi-hard and soft measures, various awareness raising programs and campaigns can be organized in the local level for the project districts. Committees such as Relief Distribution Committee, Disaster Risk Reduction Committee etc. cam be formed in localities where they are currently non-existent and can be of substantial contribution. Existing committees can be further strengthened especially for management purposes of many of the proposed measures. Workshops, seminars and skill development trainings can be organized in upazila level for knowledge dissemination regarding disaster preparedness and risk reduction.

11.3.10 Prioritizing DRR Measures

Prioritization of Disaster Risk Reduction (DRR) measure should be done to facilitate the investment planning process under government funding mechanism. In addition of allocation of fund and government priority, local needs should also be taken into consideration. Therefore, prioritization of DRR measures should be performed following three steps:

- Selection of Prioritization Criteria
- Multi-Criteria Analysis
- Prioritization

While selecting the prioritization criteria for the Haor region, the following aspects should be kept in mind:

- Technical viability
- Social suitability
- Environmental affability
- Financial security &
- Operational sustainability

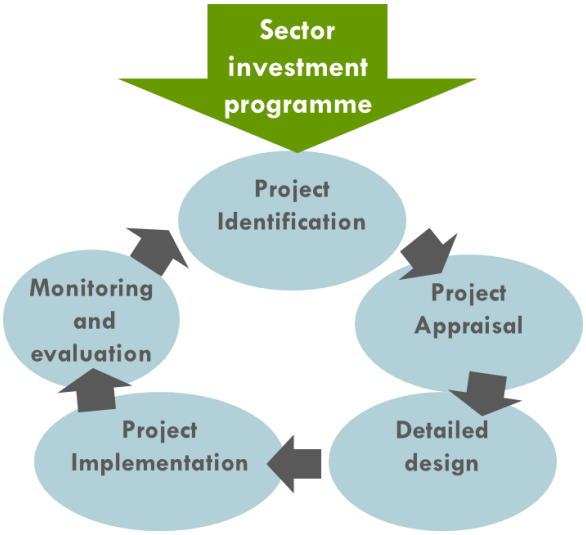
Furthermore, following elements need to considered explicitly as prioritization criteria:

- Fund requirement (amount)
- Role of timely availability of fund
- Resources Optimization
- Scope of Community Engagement
- Adequate Capacity
- Coordination among multi-level stakeholders and implementing agencies
- Enabling Environment
- Need from Community
- Benefit level

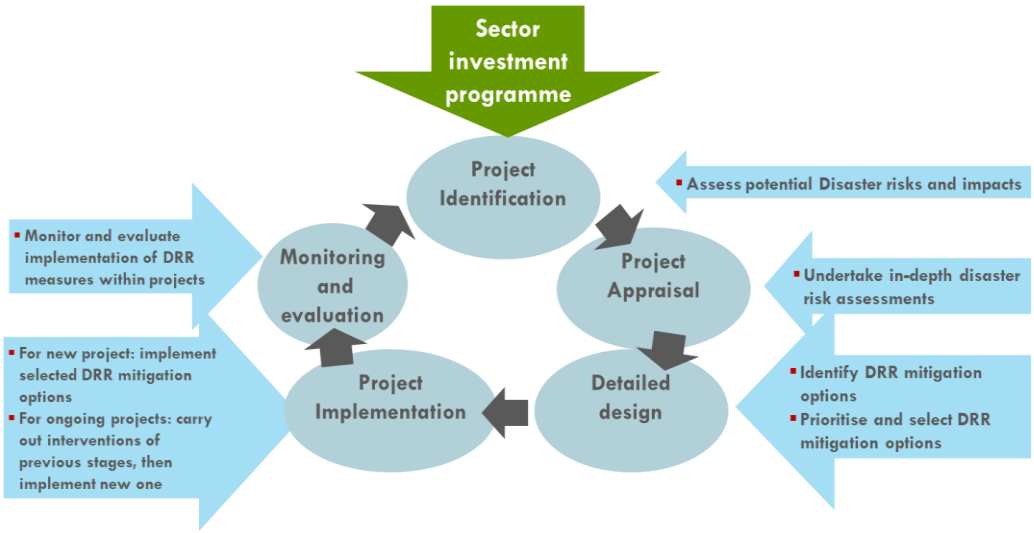
Both qualitative or quanitative multi-criteria analysis can be performed to complete the prioritization process. However, this analysis should always keep in consideration the perceptions and engagement of community to ensure the proposed pprioritized measures are based on the community needs, apart from cost benefit analysis. Inclusive operation and maintenance plan is also an important criteria need to be evaluated extensively to ensure the operational sustainability of the proposed DRR mitigation measures.

11.3.11 Mainstreaming DRR Measures

Inclusion of DRR into government planning process is a very important issue to be done to facilitate successful implementation of DRR measures at local level. In this connection, a logical framework should be developed which should be included into the planning processes during DPP preparation. Existing steps of planning processes are:



Therefore, effort should be made to identify the feasibility of inclusion of different component of DRR measures mainstreaming in every stages of the existing planning process. Following figure shows the different scopes to be considered in different stages of planning process to mainstream DRR measures.



Early flash floods in the haor region cause regular damage and destruction to infrastructure, properties and economic activities. Frequently occurring thunderstorm, siltation, erosion have increased the vulnerability in that region. The local governments undertake effective measures to reduce disaster risks within the existing legal framework by formulating and implementing appropriate strategies, action plans and programs to reduce disaster risks. Government should introduce a Technical Working Group which will work closely with local communities and other stakeholders including non-governmental organizations and international agencies. A multi-disciplinary group will compose various departments like agricultural department, fisheries department, engineer, planning & development. Local governments and communities play an importan roles in the mainstreaming process by including information on hazard, vulnerability, capacity and risk in local development plans, and by assimilating risk reduction measures into their day-to-day functions and services.

Bangladesh has taken an aggregate approach towards disaster management, where emphasis has been given to working together with all stakeholders to build strategic, scientific and implementation partnerships with all relevant government departments and agencies, and other key non-government players including NGOs, academic and technical institutions, the private sector and donors that is able to bring together the knowledge and skill sets, concerns and ideas of relevant stakeholders would work toward mainstreaming DRR . Significant progress has been made in terms of reducing the vulnerability of Haor's people, for example through an upgraded early warning system, efficient preparedness and community-based response capacity. The institutional structure should strengthen of different levels of government, between various line agencies, between other stakeholders and between neighboring localities

Government and non-government disaster risk reduction projects and programs should to be aligned with the objectives in this plan. Moreover, the plan should indicate specific entry points in relevant sectors. An important milestone in mainstreaming is the integration of the DRM plan into the social and economic development plan. A number of international and UN agencies are providing technical and financial support to national government in mainstreaming DRR in development. They include: The United Nations Development Programme's Global Mainstreaming Initiative for Disaster Risk Reduction, with support from UNDP, Bangladesh developed a flood action plan initiating a culture of disaster management and risk reduction. UNDP helped Bangladesh to develop the physical assets, knowledge and human capacity — and the planning, coordination, finance and implementation mechanisms

— that underpin its disaster management and risk reduction system. These investments contribute to a transformed disaster scenario and using this knowledge and financial source in haor region, we can improve scenario when disaster takes place.

11.3.12 Implementation Mechanism

An effective implementation mechanism for DRR measure should be formulated to enhance the benefits from DRR measures in three different stages of DRR. Exiting institutional arrangement and funding mechanism should be reviewed first to establish the implementation. Following factors need to be considered to establish the effective mechanism.

- Implementation Scheduling
- Strengthening Institutional Arrangement
- Selection of Financing Source
- Considerations for Fund Allocation

The Government of Bangladesh has increased the budget allocation for the education sector over the last few years. However, dedicated budget for children affected by climate change or living in disaster prone areas has been prioritised. Budget lines should be created at the level of local government to support the basic functioning of DRM offices and their activities. In reality, most local governments still do not have a budget line for mitigation and preparedness, although some do have a calamity fund for emergency response. Moreover, in most cases, local governments are expected to finance mitigation and preparedness activities out of existing budget heads. We may therefore consider a dedicated budget line for mitigation and preparedness as another important milestone for a local government. Local government also needs to explore other sources of disaster-related funding.

Furthermore, ensuring community or local stakeholder's participation is also important to facilitate the successful implementation process. Stakeholder is the process which enables to involve the people who may be affected by any interventions or any decision that can influence their livelihood. Effective engagement helps to reflect the stakeholder's opinion into the implementation level, where each of the stakeholder has a unique perspective about the local disaster characteristics. Therefore, relevant stakeholders should be identified and engaged during implementation of DRR measures in different stages, which will make the implementation mechanism more participatory.

11.3.13 Research and Capacity Development

Research and capacity development part cen be done in following three steps:

- Research for Technological Innovation
- Training for Stakeholders
- Awareness Building

Research for technological innovation can be performed mainly with the research groups of different action oriented research organisation and relevant implementing agencies like Center for Environmental and Geographic Information Services (CEGIS), Institute of Water Modeling, IWFM, BUET, Dhaka University, Local Government Engineering Department (LGED), Department of Disaster Management (DDM), Department of Bangladesh Wetlands and Haor Development Board (DBHWD), Bangladesh Water Development Board (BWDB) etc.

Furthermore, required training will be designed to share the research outcomes and transfer the appropriate technologies to relevant stakeholders to facilitate the implementation process strengthening the institutional capacity.

Awareness building programs should be emphasized to local level stakeholder's to enhance their capacity also.

11.3.14 Monitoring, Evaluation and Update

Monitoring will enhance the effectiveness of DRR measures by establishing clear links between past, present and future interventions and results. It helps to achieve comprehension, from past and ongoing activities, relevant information that can subsequently be used as the basis for programmatic fine tuning and planning. Without the monitoring it would be impossible to judge the quality of implementation, maintenance or the effectiveness of any intervention before implementation applying elsewhere. Revision of DRR measures is a compulsory step before going into full phase implementation of formulated DRR measures. Monitoring and evaluation should be followed by this course of action.

Therefore, a framework should be developed for monitoring, evaluation and updating of this DRR guideline, either in a regular or periodical basis. Some M&E indicators shall be identified and targets should be fixed to facilitate the monitoring, evaluation and update of the guideline. Some noteworthy M&E indicators are:

- Degree of legitimacy/mandate of lead disaster risk reduction organizations
- Existence of operational multi stakeholder mechanisms
- Existence of cooperation among stakeholder groups
- Degree of stakeholders' disaster risk reduction awareness:
- Access and sharing of disaster risk reduction information by stakeholders:
- Extent of inclusion/use of local and traditional knowledge in disaster risk reduction decision-making:
- Existence of disaster risk reduction education programmes:
- Extent of the linkage between disaster risk reduction research/science and policy development:
- Extent of the disaster risk reduction planning and strategy development process
- Existence of policies and regulatory frameworks to support capacity development:
- Adequacy of the information available for disaster risk reduction decision-making
- Existence and mobilization of resources by the relevant organizations
- Availability of required technical skills and technology transfer

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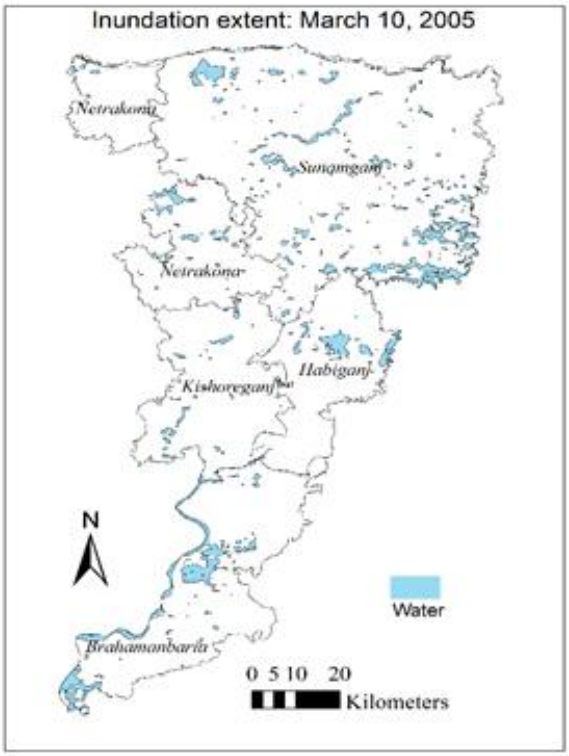
Appendix A: Hydro-meteorological Analysis

Table A.1: Summary statistics of minimum and maximum temperatures at Sreemangal and Sylhet

Station Id	Data types	Minimum	Maximum	Median	Variance
10704	Mean annual Maximum	29.88	31.62	30.65	0.23
10704	Mean annual Minimum	19.18	20.49	19.59	0.086
10705	Mean annual Maximum	29.12	31.47	30.32	0.37
10705	Mean annual Minimum	19.38	21.62	20.85	0.22

Note: Median denotes or relates to a value or quantity lying at the midpoint of a dataset Variance represents degree of variability of dataset distributions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Sunamganj
Netrakona
Habiganj
Kishoreganj
N
Water
Brahamanbaria
0 5 10 20
Kilometers

Inundation extent: March 7, 2006
Netrakona
Sunamganj
Netrakona
Habiganj
Kishoreganj
N
Water
Brahamanbaria
0 5 10 20
Kilometers

Inundation extent: March 5, 2007
Netrakona
Sunamganj
Netrakona
Habiganj
Kishoreganj
N
Water
Brahamanbaria
0 5 10 20
Kilometers

Inundation extent: March 17, 2008
Netrakona
Sunamganj
Netrakona
Habiganj
Kishoreganj
N
Water
Brahamanbaria
0 5 10 20
Kilometers

Inundation extent: March 12, 2009
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Habiganj
Kishoreganj
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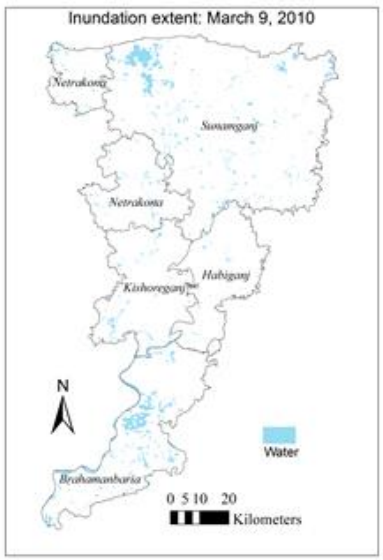
Brahamanbaria
0 5 10 20
Kilometers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Kishoreganj
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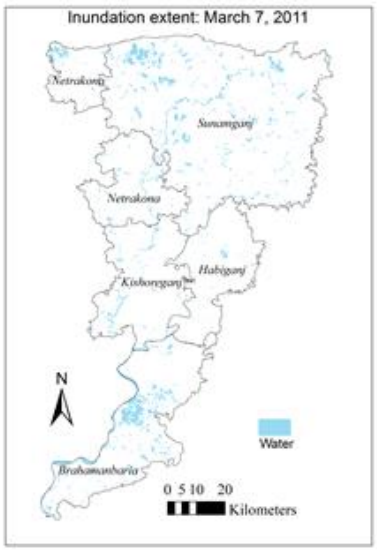
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Habiganj
Kishoreganj
N
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Brahamanbaria
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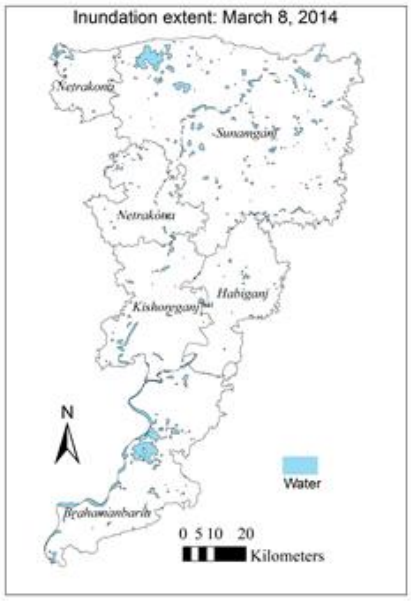
Kilometers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Habiganj
Kishoreganj
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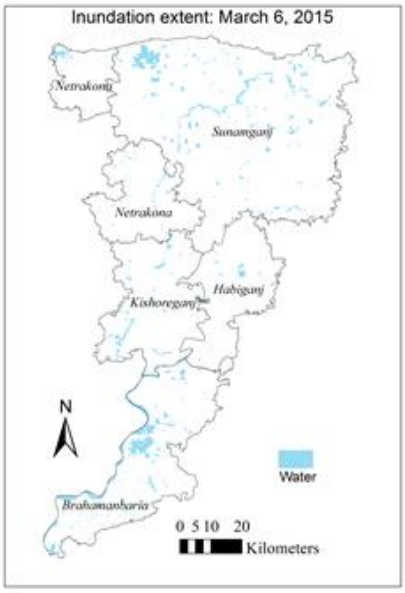
Water
Brahamanbaria
0 5 10 20
Kilometers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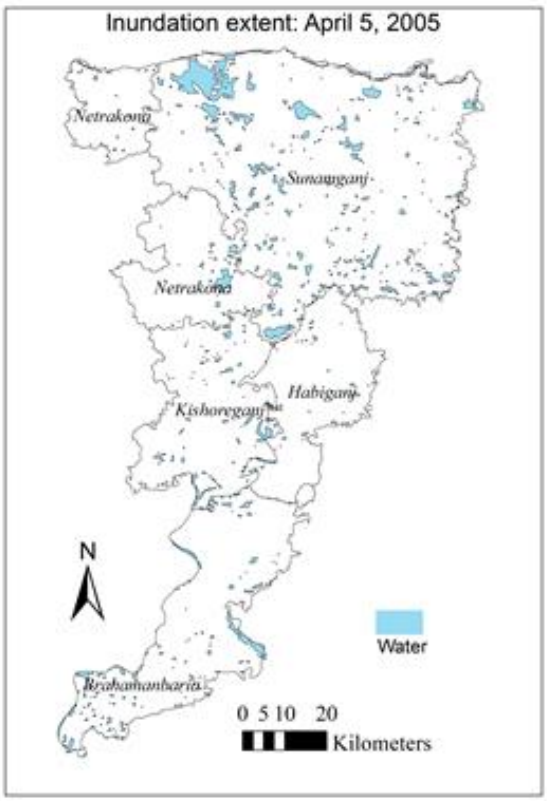
Habiganj
Kishoreganj
N
Water
Brahamanbaria
0 5 10 20
Kilometers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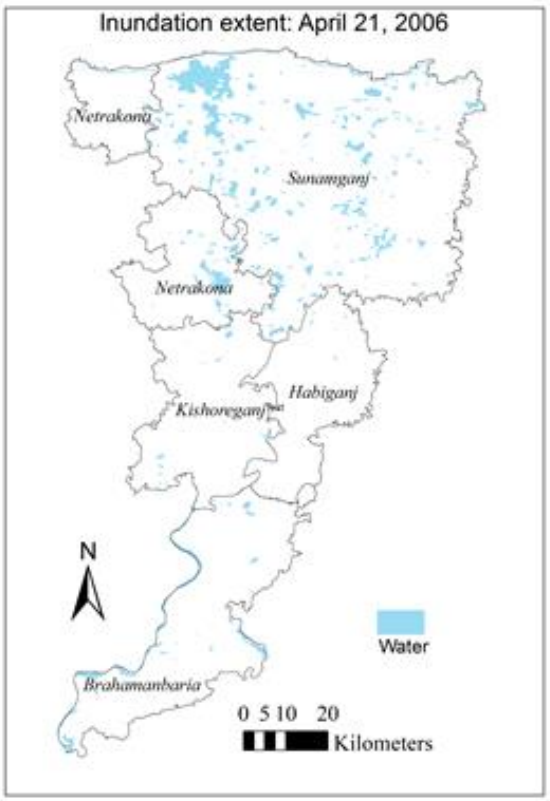
Habiganj
Kishoreganj
Brahamanbaria
N
Water
0 5 10 20
Kilometers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Kishoreganj
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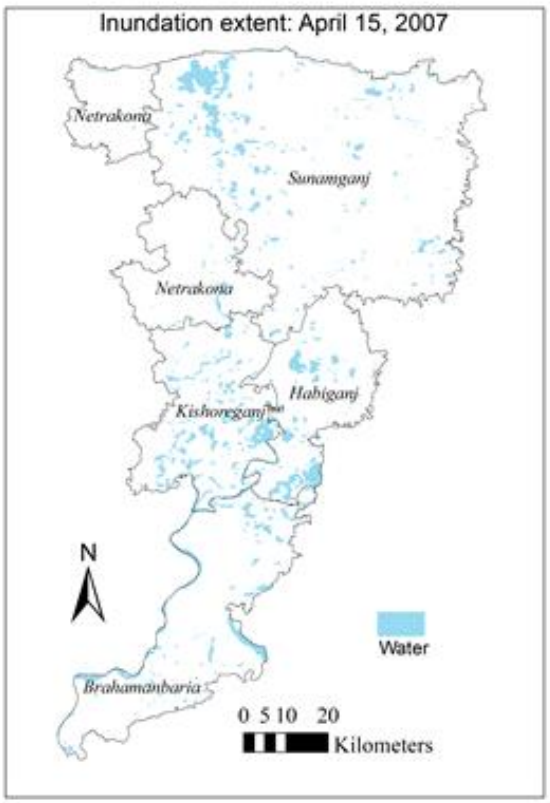
Kilometers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Habiganj
Kishoreganj
Brahamanbaria
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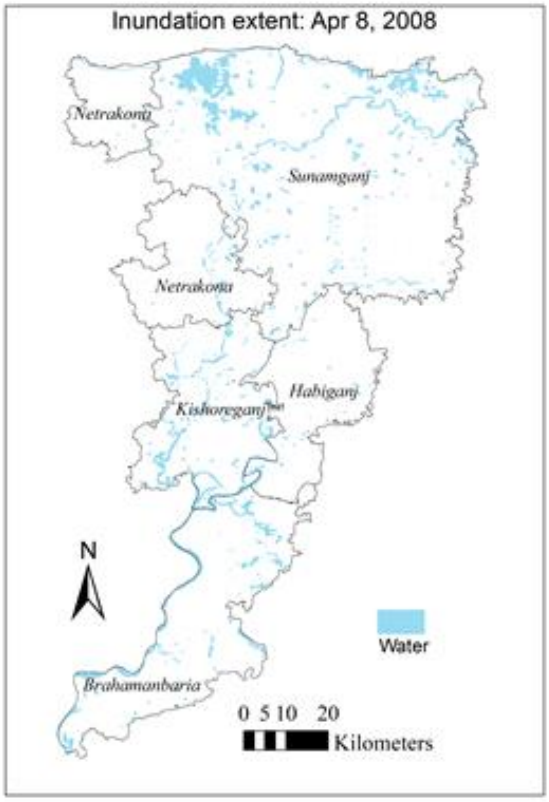
Kilometers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Kishoreganj
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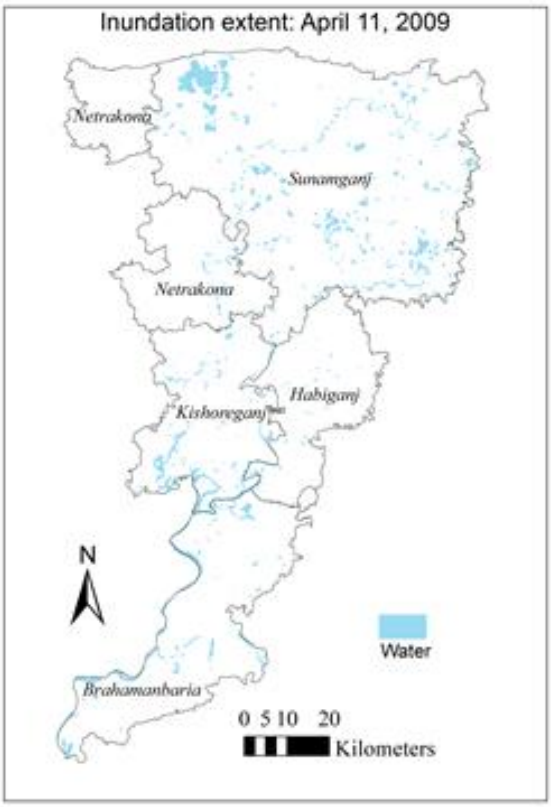
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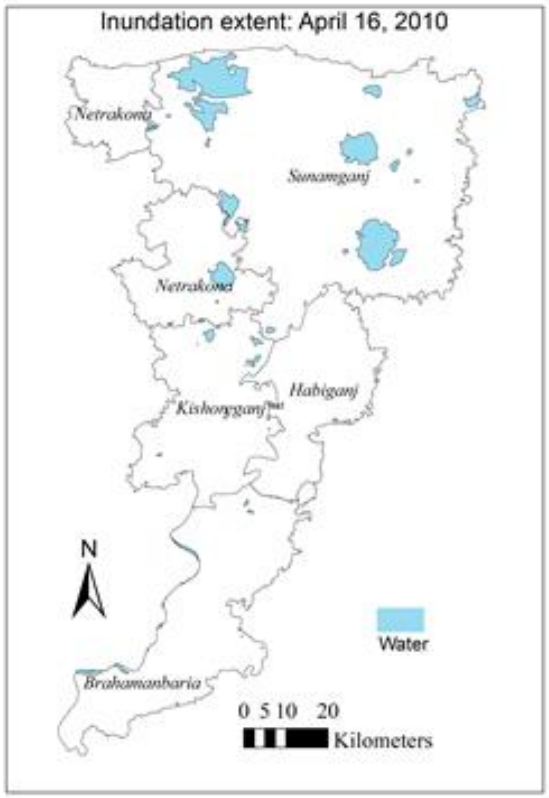
Kilometers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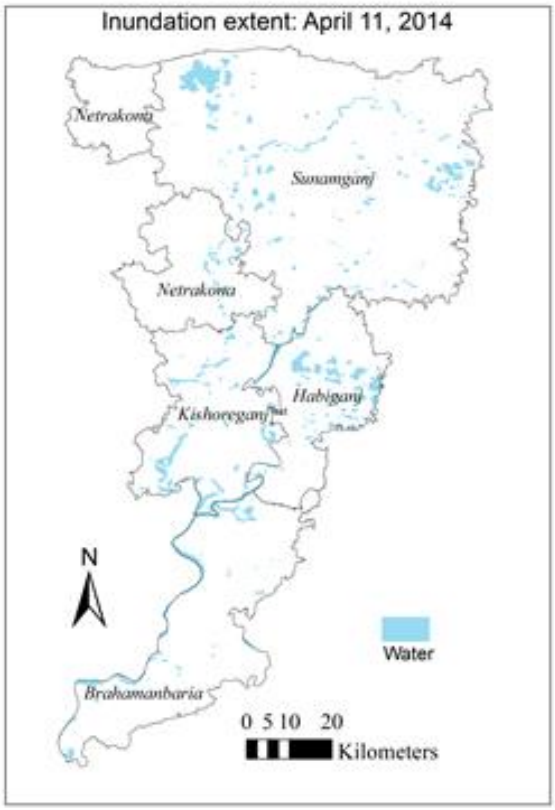
Kishoreganj
N
Water
Brahamanbaria
0 5 10 20
Kilometers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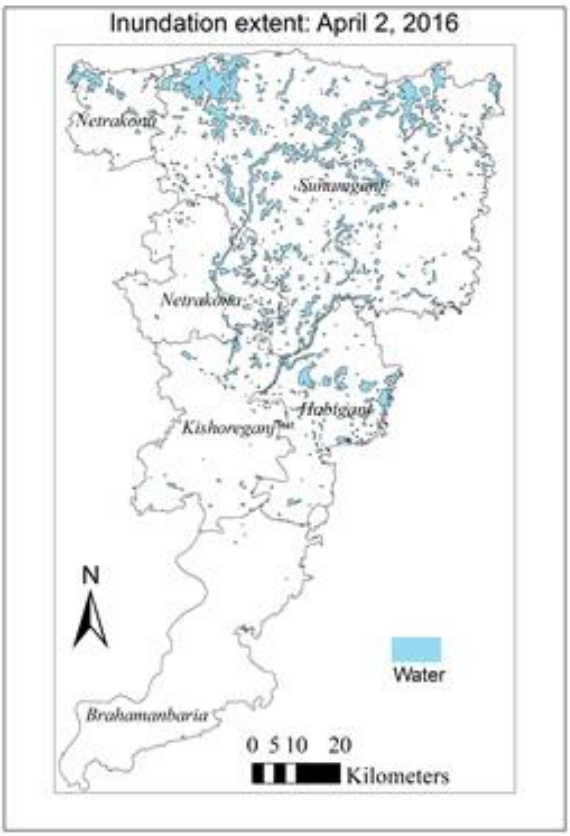
Netrakona
Habiganj
Kishoreganj
N
Water
Brahamanbaria
0 5 10 20
Kilometers


Inundation extent: April 2, 2016
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Netrakona
Habiganj
Kishoreganj
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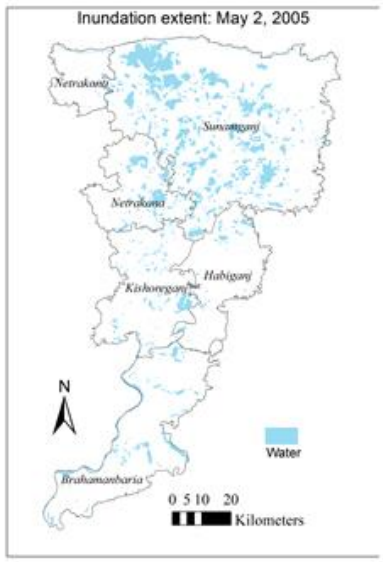
Water
Brahamanbaria
0 5 10 20
Kilometers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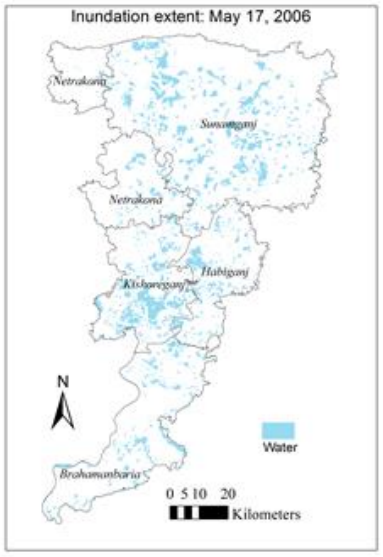
Kishoreganj
N
Water
Brahamanbaria
0 5 10 20
Kilometers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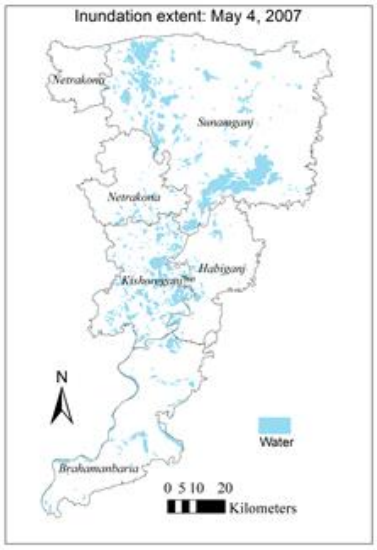
Habiganj
Kishoreganj
N
Water
Brahamanbaria
0 5 10 20
Kilometers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Kishoreganj
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Water
Brahamanbaria
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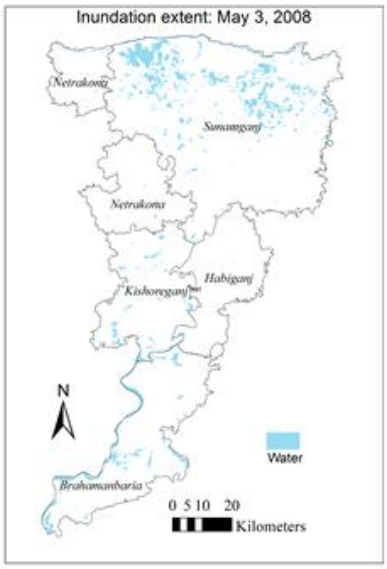
Kilometers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Habiganj
Kishoreganj
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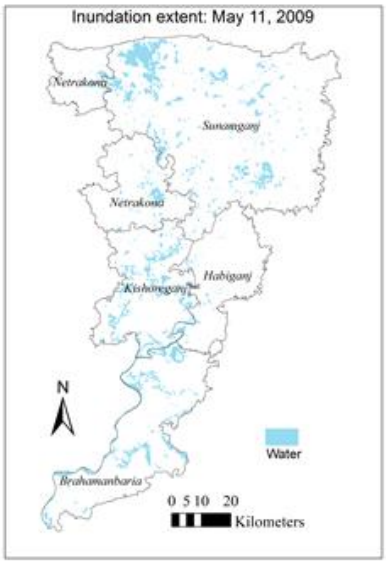
Water
Brahamanbaria
0 5 10 20
Kilometers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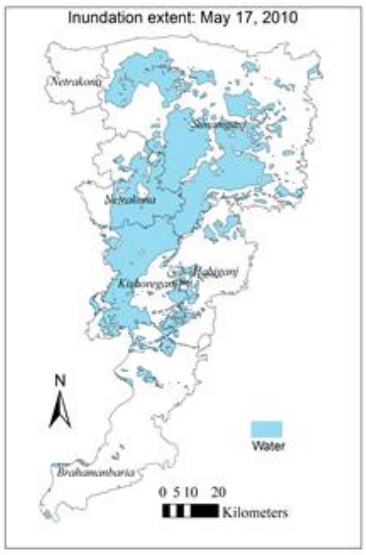
Kilometers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Kilometers

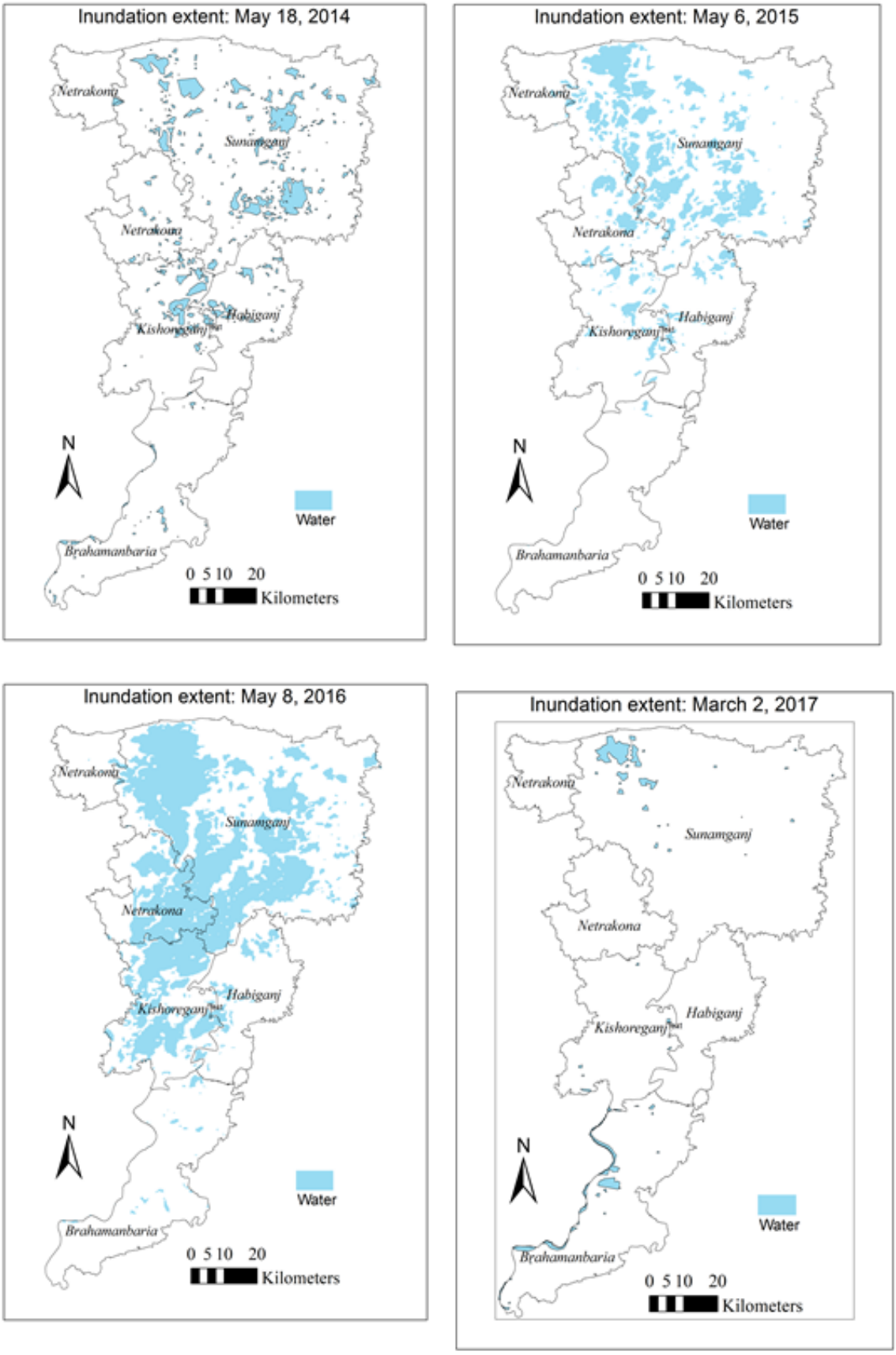
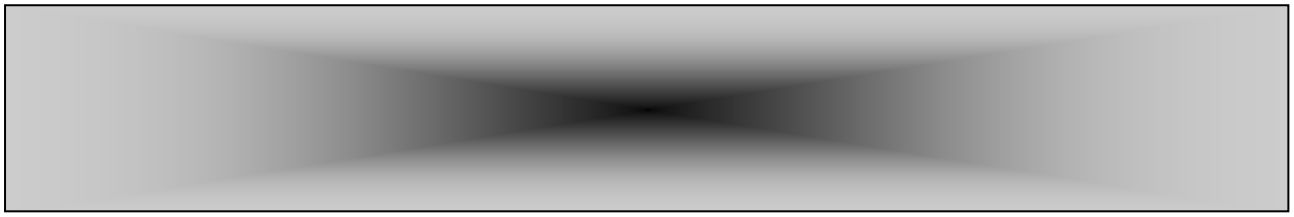


Figure A.1: Inundation Extent in Haor Regions

Appendix B: Household Survey Questionnaire

Action Research on Climate Change Forecasting & Participatory Scenario Development and Assessment of the Agriculture & Fisheries Sectors, Exposure to Climate Risk

CEGIS



কেস নং				
তারিখ				
সাক্ষাৎকার গ্রহণের স্থান			জি পি এস	

বিভাগঃ.....

জেলাঃ.....

উপজেলাঃ.....

ইউনিয়ন পরিষদের নামঃ .....

গ্রামঃ.....

পাড়াঃ.....

ওয়ার্ড নংঃ.....

বাড়ী নং (যদি থাকে) .....

সাক্ষাৎকার গ্রহণকারীর নামঃ.....

স্বাক্ষরঃ.....

সুপারভাইজার/কোয়ালিটি কন্ট্রোল অফিসারের নামঃ.....

স্বাক্ষরঃ.....
তারিখঃ.....

ভূমিকা ও সম্মতিঃ

আস্সালামু আলাইকুম। সম্প্রতি বাংলাদেশ সরকারের স্থানীয় সরকার ও প্রকৌশল অধিদপ্তর জলবায়ু পরিবর্তনের কারনে হাওড় অঞ্চলের মানুষের স্বাভাবিক অবস্থা ধরে রাখার জন্য ঐওখওচ প্রকল্পের আওতায় "অপঃরড়হ জবংবধৎপয ড়হ ঈষরসধঃব ঈযধহমব ঋড়ৎবপধংঃরহম ধহফ চধৎঃরপরঢ়ধঃড়ু ঝপবহধৎরড় উবাবষড়ঢ়সবহঃ ধহফ অংংবংংসবহঃ ড়ভ ঃযব অমৎরপঁষঃঁৎব ধহফ ঋরংযবৎরবং ঝবপঃড়ৎং, ঊীঢ়ড়ংঁৎব ঃড় ঈষরসধঃব জরংশচ নামে একটি গবেষনা পরিচালনা করছে। এই গবেষনার উদ্দেশ্য হল হাওড় অঞ্চলের জলবায়ু পরিবর্তনের জন্য সৃষ্ট ঝুঁকি ও প্রভাব সম্পর্কে জনসচেতনতা তৈরী এই সকল ঝঁকি মোকাবিলা এবং ভবিষ্যতে জলবায়ু পরিবর্তনশীলতার অভিযোজনের উপায়সমূহ চিহ্নিত করা। এই কাজের অংশহিসেবে আপনাদের বর্তমান আর্থ-সামাজিক অবস্থা, জলবায়ু পরিবর্তনের অবস্থা, ঝুকি এবং অভিযোজনের সম্পর্কে জানবো এবং আপনাদের দেয়া তথ্যের ভিত্তিতে পরবর্তীতে জলবায়ু পরিবর্তনের কারনে হাওড় অঞ্চলের মানুষের কৃষি এবং মৎস্যভিত্তিক জীবিকা টিকিয়ে রাখা এবং এর সার্বিক ব্যবস্থাপনার জন্য কি কি ব্যবস্থা গ্রহণ করা যায় তা বোঝার চেষ্টা করবো। আপনার মতামত শুধুমাত্র গবেষণার কাজে ব্যবহৃত হবে, এবং আপনার প্রদত্ত তথ্যের এর গোপনীয়তা নিশ্চিত থাকবে। আপনি অনুমতি দিলে আমি সাক্ষাৎকার গ্রহণ শুরু করতে পারি।

উত্তরদাতা/উত্তরদাত্রীরনামঃ.....মোবাইলঃ.....

বয়সঃ.....বছর (পূর্ণ বছরে)

শিক্ষাগত যোগ্যতাঃ.....(সর্বোচ্চ যে শ্রেণী পাস করেছে)

বৈবাহিক অবস্থাঃ ১. বিবাহিত ২. অবিবাহিত ৩. বিধবা ৪. আলাদা/পরিত্যক্তা ৫. তালাকপ্রাপ্তা

উত্তরদাতা/উত্তরদাত্রীরপারিবারিক অবস্থানঃ

খানা প্রধান ২. খানা প্রধান নন

খানার মোট সদস্য সংখ্যাঃ ক. মোট.....জন খ. পুরুষ.....গ. মহিলাঃ.....জন ঘ. শিশু .....

বর্তমানে খানার কতজন স্কুল/কলেজ/ বিশ্ববিদ্যালয়ে যায় উল্লেখ করুন ।

....

খানার প্রধান পেশা কি*২? .....

আপনার মোট মাসিক আয় কত (প্রধান)? ঃ.....

আপনি এই পেশা ছাড়া আর অন্য কোন আয়মূলক পেশায় নিয়োজিত আছেন কিনা?

১.হ্যাঁ ২. না

এই আয়মূলক পেশা থেকে আপনার মোট মাসিক আয় কত? ঃ.....

বছরে কত মাস আপনি এই কাজে নিয়োজিত থাকেন?.....মাস

এই পেশা (অপ্রধান) থেকে আপনার মোট মাসিক আয় কত? ঃ.....

খানার মোট মাসিক আয় (নেট আয়) ও সঞ্চয়ঃ

ক. আয়	খ. ব্যয়	গ. সঞ্চয়
টাকা=	টাকা=	টাকা=

**কোড: ১. গৃহিনী ২. মাঝি/জেলে ৩. ভিক্ষাবৃত্তি ৪. কৃষি ৫.সরকারী চাকুরী/প্রাইভেট চাকুরী ৬. বাসাবাড়িতে কাজ করে ৭. ঘএঙ প্রকল্পে কাজ করে ৮. বড়/মাঝারী ব্যবসায়ী ৯. ছাত্র ১০. দিনমজুর ১১. ক্ষুদ্র ব্যবসায়ী/ফড়িয়া ১৪. হস্ত শিল্প, সেলাই, কারিগর, কাঠমিস্ত্রি, রাজমিস্ত্রি সহ অন্যান্য স্ব-নিয়োজিত কর্ম ১৫. গবাদী/হাঁস-মুরগী পালন ১৬. অটো ড্রাইভার ১৭. বিদেশে চাকুরী/অন্য কোন কাজে নিয়োজিত ১৮. অন্যান্য (নির্দিষ্ট করুন).

বসত বাড়ির আঙিনায় পুকুরের হিসাব ঃ

পুকুরের সংখ্যা (সংখ্যায়)	পুকুরের জন্য ব্যবহৃত জমির পরিমাণ (শতাংশে)

খানার জ্বালানীর উৎসগুলো কি কি?

লাকড়ি ২. সিলিন্ডার গ্যাস ৩. কেরোসিন ৪. অন্যান্য (নির্দিষ্ট করুন)... . . . .

আপনার এলাকায় ১৯৯১-২০১৮ পর্যন্ত কি ধরনের দুর্যোগের সম্মুখীন হয়েছেন? (শুধু টিক চিহ্ন দিন)

দুর্যোগের নামসমূহ	১৯৯১-২০১৮																											
	১৯৯১	১৯৯২	১৯৯৩	১৯৯৪	১৯৯৫	১৯৯৬	১৯৯৭	১৯৯৮	১৯৯৯	২০০০	২০০১	২০০২	২০০৩	২০০৪	২০০৫	২০০৬	২০০৭	২০০৮	২০০৯	২০১০	২০১১	২০১২	২০১৩	২০১৪	২০১৫	২০১৬	২০১৭	২০১৮
ঋষধংয ঋষড়ড়ফ (আকস্মিক বন্যা)																												
ঝবধংড়হধষ ঋষড়ড়ফ (মৌসুমী বন্যা)																												
ঈুপষড়হব (ঘূর্ণিঝড়)																												
ডধাব অপঃরড়হ (আফাল)																												
ঐবধু জধরহভধষষ (ভারী বৃষ্টিপাত)																												
উৎড়ঁমযঃ (খরা)																												
উৎড়ংরড়হ (ভূমিক্ষয়)																												
এঃযঁহফবৎংঃড়ৎস (বজ্রপাত)																												

এলাকায় ১৯৯১-২০১৮ পর্যন্ত সংঘটিত কোন দুর্যোগসমূহের ব্যাপকতা[3] নিরূপন (শুধু কোড বসান)

সাল	আকস্মিক বন্যা	মৌসুমী বন্যা	ঘূর্ণিঝড়	আফাল /ঢেউ	ভারী বৃষ্টিপাত	খরা	ভূমিক্ষয়	বজ্রপাত
১৯৯১								
১৯৯২								
১৯৯৩								
১৯৯৪								
১৯৯৫								
১৯৯৬								
১৯৯৭								
১৯৯৮								
১৯৯৯								
২০০০								
২০০১								
২০০২								
২০০৩								
২০০৪								
২০০৫								
২০০৬								
২০০৭								
২০০৮								
২০০৯								
২০১০								
২০১১								
২০১২								
২০১৩								
২০১৪								
২০১৫								
২০১৬								
২০১৭								
২০১৮								

আপনি প্রতি বছর সাধারণত কি বিপদের মুখোমুখীন হোন?

১. আকস্মিক বন্যা ২. মৌসুমী বন্যা ৩. শিলাবৃষ্টি ৪. ঠান্ডা আবহাওয়া ৫. ঢেউয়ের কারনে ভাংগন ৬. আফাল ৭. অন্যান্য(নির্দিষ্ট করুন)...
.....

আপনার বসতবাড়ী/ফসলী জমি কি বাঁধ দ্বারা সুরক্ষিত?

১. হ্যাঁ ২. না

আপনি কি গ্রাম প্রতিরক্ষা/কার্যক্রম দ্বারা উপকৃত হয়েছেন?

১. হ্যাঁ ২. না

আপনি জলবায়ু পরিবর্তন সংক্রান্ত বা বিপর্যয়ের হ্রাস, ইত্যাদির জন্য কোন প্রশিক্ষণ পেয়েছেন?

১. হ্যাঁ ২. না

[3] *কোড: ১. অনেকবেশী যা পরিমাপযোগ্য নয় ২. অনেকবেশী কিন্তু পরিমাপযোগ্য ৩. পরিমাপযোগ্য এবং ক্ষতির পরিমাণ কম ৪. ক্ষতির পরিমাণ সহনীয় ৫. নেই বললেই চলে ৬. কোন প্রভাব নেই

আপনি কি ২০১৬, ২০১৭ সনে বন্যা পূর্বাভাস এর তথ্য পেয়েছেন বা পেয়ে উপকৃত হয়েছেন?

১. হ্যাঁ ২. না

কোন দুর্যোগের কারনে আপনার ক্ষতি বেশী হয়েছে বলে আপনি মনে করেন? সালের ও নামসহ উল্লেখ করুনঃ

ক্রমিক নং	দুর্যোগের নাম	সাল	ক্ষতির পরিমান (শতকরায় উল্লেখ করুন)			
০১.	ঋষধংয ঋষড়ড়ফ (আকস্মিক বন্যা)		কৃষি	মৎস্য	প্রণীসম্পদ	অন্যান্য
০২.	ঝবধংড়হধষ ঋষড়ড়ফ (মৌসুমী বন্যা)					
০৩.	ঈুপষড়হব (ঘূর্ণিঝড়)					
০৪.	ডধাব অপঃরড়হ (আফাল)					
০৫.	ঐবধু জধরহভধষষ (ভারী বৃষ্টিপাত)					
০৬.	উৎড়ঁমযঃ (খরা)					
০৭.	উৎড়ংরড়হ (ভূমিক্ষয়)					
০৮.	এঁযঁহফবৎংঃড়ৎস (বজ্রপাত)					

দুর্যোগের কারনে খানার অস্থাবর সম্পত্তির ক্ষতির পরিমাণ সংখ্যায় উল্লেখ করুন (একাধিক উত্তর হতে পারে)ঃ

দুর্যোগের নাম	সাল	সম্পত্তির ধরন	সর্বমোট আনুমানিক মূল্য (টাকায়)
ঋষধংয ঋষড়ড়ফ (আকস্মিক বন্যা)		ফসল	
		গবাদিপশু	
		ঘরবাড়ি	
		মৎস্যসম্পদ	
		অন্যান্য .....(নির্দিষ্ট করুন)	
ঝবধংড়হধষ ঋষড়ড়ফ (মৌসুমী বন্যা)		ফসল	
		গবাদিপশু	
		ঘরবাড়ি	
		মৎস্যসম্পদ	
		অন্যান্য .....(নির্দিষ্ট করুন)	
ঈুপষড়হব (ঘূর্ণিঝড়)		ফসল	
		গবাদিপশু	
		ঘরবাড়ি	
		মৎস্যসম্পদ	
		অন্যান্য .....(নির্দিষ্ট করুন)	
ডধাব অপঃরড়হ (আফাল)		ফসল	
		গবাদিপশু	
		ঘরবাড়ি	
		মৎস্যসম্পদ	
		অন্যান্য .....(নির্দিষ্ট করুন)	
ঐবধু জধরহভধষষ (ভারী বৃষ্টিপাত)		ফসল	
		গবাদিপশু	
		ঘরবাড়ি	
		মৎস্যসম্পদ	
		অন্যান্য .....(নির্দিষ্ট করুন)	
উৎড়ঁমযঃ (খরা)		ফসল	
		গবাদিপশু	
		ঘরবাড়ি	
		মৎস্যসম্পদ	
		অন্যান্য .....(নির্দিষ্ট করুন)	
উৎড়ংরড়হ (ভূমিক্ষয়)		ফসল	

দুর্যোগের নাম	সাল	সম্পত্তির ধরন	সর্বমোট আনুমানিক মূল্য (টাকায়)
		গবাদিপশু	
		ঘরবাড়ি	
		মৎস্যসম্পদ	
		অন্যান্য .....(নির্দিষ্ট করুন)	
ঞযঁহফবৎংঃড়ৎস (বজ্রপাত)		ফসল	
		গবাদিপশু	
		ঘরবাড়ি	
		মৎস্যসম্পদ	
		অন্যান্য .....(নির্দিষ্ট করুন)	

কোন সময়ে কোন দুর্যোগের কারনে বসত বাড়ির গাছপালা বেশী ক্ষতিগ্রস্থ হয়েছিল বলে আপনি মনে করেন?

দুর্যোগের নাম	(✔) চিহ্ন দিন
ঋষধংয ঋষড়ড়ফ (আকস্মিক বন্যা)	
ঝবধংড়হধষ ঋষড়ড়ফ (মৌসুমী বন্যা)	
ঈুপষড়হব (ঘূর্ণিঝড়)	
ডধাব অপঃরড়হ (আফাল)	
ঐবধু জধরহভধষষ (ভারী বৃষ্টিপাত)	
উৎড়ঁমযঃ (খরা)	
উৎড়ংরড়হ (ভূমিক্ষয়)	
ঞযঁহফবৎংঃড়ৎস (বজ্রপাত)	

বর্ষাকালে আপনার খানার জ্বালানীর উৎসসমূহ উল্লেখ করুন।

বাজার থেকে কিনে আনতে হয়২. অনেক দুর থেকে সংগ্রহ করতে হয় ৩. আত্মীয় স্বজনের বাড়ি থেকে আনতে হয় ৪. অন্যান্য (নির্দিষ্ট করুন)

দুর্যোগকালীন সময়ে জ্বালানী পেতে কি ধরনের সমস্যা হয় এবং কিভাবে জ্বালানী সংগ্রহ করা হয় ? উল্লেখ করুন। (নিম্ন বক্সে বাংলায় লিখুন)

....

দুর্যোগকালীন সময়ে গবাদিপশু কোথায় রাখা হয়

উচু বাঁধের উপর

উচু রাস্তার উপর

স্কুল আশ্রয় কেন্দ্রে

অন্যের বাড়িতে

ভেলার উপর

চালের উপর

অন্যান্য (নির্দিষ্ট করুন).....

দুর্যোগকালীন সময়ে গবাদিপশু খাবারের উৎসসমূহ উল্লেখ করুন

উঁচু মাঠ যেখান থেকে খড়, লতাপাতা সংগ্রহ করা হয় ২. বাড়ির উচু স্থানে (যেখানে খড় গাদা করে রাখা হয়) ৩. বাজার থেকে ক্রয়কৃত (চাউলের কুড়া, ভূষি ইত্যাদি কেনা হয়) ৪. কচুরীপানা ৫. অন্যান্য (নির্দিষ্ট করুন).....

দুর্যোগের কারনে আপনাকে কতবার পেশা পরিবর্তন করতে হয়েছে ? (সংখ্যা উল্লেখ করুন)

.....

আপনার প্রধান পেশা ব্যতিরেকে আপনি পরবর্তিতে কোন কোন পেশায়*৪নিয়োজিত হয়েছিলেন (নিম্ন লিখিত কোড বসাতে হবে)

....

প্রচলিত পেশাগত ক্যালেন্ডার উল্লেখ করুন ঃ(✔) চিহ্ন দিন

পেশার নাম	গ্রীষ্ম				বর্ষা				শীত			
	মার্চ	এপ্রিল	মে	জুন	জুলাই	আগস্ট	সেপ্টেম্বর	অক্টোবর	নভেম্বর	ডিসেম্বর	জানুয়ারী	ফেব্রুয়ারী
কৃষি												
মৎস্যশিকার												
দিনমজুর												
ব্যবসা												
রিক্সাচালনা												
অন্যান্য (উল্লেখ করুন)												

আকস্মিক বন্যার দূর্যোগের পূর্বেই ফসল কাটা যায় এ ধরণের প্রচলিত/স্থানীয় উন্নত জাত এলআইভি/উচ্চ ফলনশীল জাত এইচওয়াইভি ইত্যাদি ধানের জাত আছে কি? আকস্মিক বন্যা সহনশীল, ঠান্ডা আবহাওয়া সহনশীল ধানের জাত সম্পর্কে আপনার জানা আছে কি?

১ হ্যাঁ ২. না উত্তর হ্যাঁ হলে ঃ

ক্র. নং	মৌসুম	জাতের নাম	সহনশীলতার ধরণ	রোপণ সময়	কাটার সময়	বীজ প্রাপ্যতা	উৎপাদন কেজি/বিঘায়

দুর্য়োগের কারনে কোন কোন সময়ে আপনার আয় কমেছে ? সাল সহ উল্লেখ করুন।

....

আয় কমে যাওয়ার কারনে তা আপনার পারিবারিক কি ধরনের প্রভাব ফেলেছে?

আর্থিক অনটনে পড়তে হয়েছিল ২. এনজিও থেকে লোন নেওয়া হয়েছিল ৩. খাবার সংকট দেখা দিয়েছিল ৪. ঋণ নিতে হয়েছিল ৫. দরিদ্র হয়ে পড়েছিল ৬. চিকিৎসা নিতে সমস্যা হয়েছিল ৭. অন্যান্য (নির্দিষ্ট করুন)এই ব্যয় নির্বাহের জন্য আপনি কোন কোন পন্থা অবলম্বন করেছিলেন? উল্লেখ করুন।

অধিক সুদে ঋণ নিতে হয়েছিল ২. এনজিও থেকে লোন নেওয়া হয়েছিল ৩. গবাদি পশু বিক্রি করতে হয়েছিল ৪. জমি বন্ধক দেওয়া হয়েছিল ৫. বসত ভিটা বিক্রি করতে হয়েছিল ৬. কৃষি জমি বিক্রি করতে হয়েছিল ৭. আত্মীয় স্বজনের কাছ থেকে নিতে হয়েছিল ৮. অন্যান্য (নির্দিষ্ট করুন).....

আপনার আর্থিক সক্ষমতা বাড়ানোর জন্য দুর্যোগকালীন সময়ে কোন কোন সংস্থা কাজ করেছিল ?

আশা ২. ওর্য়াল্ড ভিশন ৩. রেড ক্রিসেন্ট সোসাইটি ৪. ব্র্যাক ৫. গ্রামীন ব্যাংক ৬. ঢাকা আহ্সানিয়া মিশন ৭. সরকারি সংস্থা ৮. অন্যান্য (নির্দিষ্ট করুন)

এই সকল সংস্থাগুলো কোন কোন পদক্ষেপ গ্রহণ করেছিল? উল্লেখ করুন

ত্রাণ দিয়েছিল ২. শুকনো খাবার বিতরণ ৩. নগদ অর্থ প্রদান ৪. সার বীজ প্রদান ৫.অর্থের বিনিময়ে খাদ্য বিতরণ কর্মসূচি ৬.অন্যান্য (নির্দিষ্ট করুন)

নিয়মিত ফসল ক্যালেন্ডার উল্লেখ করুন?

[৪]*কোড: ১. মাঝি/জেলে ২. সরকারী চাকুরী ৩. প্রাইভেট চাকুরী ৪. গার্মেন্টসে কাজ করা ৫. বাসাবাড়িতে কাজ করে ৬. ঘএঙ প্রকল্পে কাজ করে ৮. বড়/মাঝারী ব্যবসায়ী ৯. দিনমজুর ১০. ক্ষুদ্র ব্যবসায়ী/ফড়িয়া ১১. হস্ত শিল্প, ১২. দর্জির কাজ ১৩. কাঠমিস্ত্রি, ১৪. রাজমিস্ত্রি ১৫. গবাদী পশু পালন ১৬. হাঁস-মুরগী পালন ১৭. অটো ড্রাইভার ১৮. বিদেশে কাজ / চাকুরী ১৯. অন্যান্য (নির্দিষ্ট করুন).

ফসলের নাম	গ্রীষ্ম				বর্ষা				শীত			
	মার্চ	এপ্রিল	মে	জুন	জুলাই	আগস্ট	সেপ্টেম্বর	অক্টোবর	নভেম্বর	ডিসেম্বর	জানুয়ারী	ফেব্রুয়ারী

নিয়মিত মাছের ক্যালেন্ডার উল্লেখ করুন?

মৎস্যের উৎস	গ্রীষ্ম				বর্ষা				শীত			
	মার্চ	এপ্রিল	মে	জুন	জুলাই	আগস্ট	সেপ্টেম্বর	অক্টোবর	নভেম্বর	ডিসেম্বর	জানুয়ারী	ফেব্রুয়ারী

দুর্যোগ পরবর্তী সময়ে ফসল ক্যালেন্ডার উল্লেখ করুন?

দুর্যোগের নাম	ফসলের নাম	গ্রীষ্ম				বর্ষা				শীত			
		মার্চ	এপ্রিল	মে	জুন	জুলাই	আগস্ট	সেপ্টেম্বর	অক্টোবর	নভেম্বর	ডিসেম্বর	জানুয়ারী	ফেব্রুয়ারী
ঋষধৎয ঋষড়ড়ফ (আকস্মিক বন্যা)													
ঝবধৎড়হধষ ঋষড়ড়ফ (মৌসুমী বন্যা)													
ঈুপষড়হব (ঘূর্ণিঝড়)													
ডধাব অপঃরড়হ (আফাল)													
ঐবধু জধরহভধষষ (ভারী বৃষ্টিপাত)													
উৎড়ঁময়ঃ (খরা)													
উৎড়ংরড়হ (ভূমিক্ষয়)													
এঁযহফবৎংঃড়ৎস (বজ্রপাত)													

দূর্যোগ পরবর্তী সময়ে মাছের ক্যালেন্ডার উল্লেখ করুন?

দুর্যোগের নাম	মৎস্যের উৎস	গ্রীষ্ম				বর্ষা				শীত			
		মার্চ	এপ্রিল	মে	জুন	জুলাই	আগস্ট	সেপ্টেম্বর	অক্টোবর	নভেম্বর	ডিসেম্বর	জানুয়ারী	ফেব্রুয়ারী
ঋষধৎয ঋষড়ড়ফ (আকস্মিক বন্যা)													
ঝবধৎড়হধষ ঋষড়ড়ফ (মৌসুমী বন্যা)													
ঈুপষড়হব (ঘূর্ণিঝড়)													
ডধাব অপঃরড়হ (আফাল)													
ঐবধু জধরহভধষষ (ভারী বৃষ্টিপাত)													
উৎড়ঁমযঃ (খরা)													
উৎড়ংরড়হ (ভূমিক্ষয়)													
এঃযঁহফবৎৎঃড়ৎস (বজ্রপাত)													

ফসলের এবং মৎস্যের ক্ষতি এড়ানোর জন্য সরকারী এবং বেসরকারী পর্যায়ে কি ধরনের পদক্ষেপ গ্রহন করা হয়েছিল ? উল্লেখ করুন

১.বেড়ীবাঁধ নির্মান করা হয়েছিল ২.জাল বিতরণ করা হয়েছিল ৩.অন্যান্য (নির্দিষ্ট করুন)

কৃষি উৎপাদন বাড়ানোর জন্য কি কি ধরনের বীজ সরবরাহ করা হয়েছিল ?

১.হাইব্রীড বীজ বিতরণ ২.এইচ ওয়াইভি বীজ ০৩. ঠান্ডা সহনশীল ধন বীজ বিতরন ০৪. অন্যান্য (নির্দিষ্ট করুন)

দুর্যোগকালীন সময়ে মহিলারা কি কি ধরনের সমস্যার সম্মুখীন হয়ে থাকেন?

রান্না করতে সমস্যা হয় ২. লাকড়ির অভাব দেখা দেয় ৩. খাবার পানি সংগ্রহ করতে সমস্যা হয় ৪. বাচ্চা লালন পালনে সমস্যা হয় ৫. চলাচলে অসুবিধা হয় ৬. ঘরের আশপাশ পরিষ্কার করতে হয় ৭. পানি বাহিত রোগে আক্রান্ত হয় ৮. প্রশাব পায়খানা করতে অসুবিধা হয় ৯. গর্ভকালীন চিকিৎসা নিতে অসুবিধা হয় ১০. অন্যান্য (নির্দিষ্ট করুন)

দুর্যোগকালীন সময়ে মহিলারা কি কি ধরনের কাজ করে এসকল সমস্যার মোকাবিলা করে থাকে ?

১. টিনের চুলা তৈরী করে রান্না করতে হয় ২. লাকড়ি সংগ্রহ করে মজুত রাখতে হয় ৩. অনেক দূর থেকে পানি সংগ্রহ করে আনতে হয় ৪. শুকনো খাবার তৈরী করে মজুত রাখতে হয় ৫. প্রশাব পায়খানার জন্য উন্মুক্ত জায়গা খুজতে হয় ৬.অস্থায়ী ল্যাট্রিন স্থাপন করতে হয় ৭. অন্যান্য (নির্দিষ্ট করুন)

অতীত থেকে বর্তমান সময় পর্যন্ত বাড়িতে খাবার পানির উৎস কি?

১। টিউবওয়েল ২। কুয়া/ইন্দিরা ৩। পুকুর/ডোবা

৪। নদী ৫। খাল/বিল ৬। অন্যান্য (নির্দিষ্ট করুন).....

দুর্যোগকালীন সময়ে কোন কোন উৎস থেকে খাওয়ার পানি সংগ্রহ করতেন ? উল্লেখ করুন।

১। টিউবওয়েল ২. হাওড়ের পানি ফুটিয়ে পান করা হয় ৩. দূর থেকে সংগ্রহ করতে হয় ৪. অন্যান্য (নির্দিষ্ট করুন).....

কোন কোন দুর্যোগের সময় খাওয়ার পানির সংকট সবচেয়ে বেশী হয়েছিল ? সাল ও দুর্যোগের নামসহ উল্লেখ করুন। (নিচের বক্সে লিখুন)

দুর্যোগের নাম	সাল
ঋষধংয ঋষড়ড়ফ (আকস্মিক বন্যা)	
ঝবধংড়হধষ ঋষড়ড়ফ (মৌসুমী বন্যা)	
ঈুপষড়হব (ঘূর্ণিঝড়)	
ডধাব অপঃরড়হ (আফাল)	
ঐবধু জধরহভধষষ (ভারী বৃষ্টিপাত)	
উৎড়ঁমযঃ (খরা)	
উৎড়ংরড়হ (ভূমিক্ষয়)	
এঃযঁহফবৎংঃড়ৎস (বজ্রপাত)	

দুর্যোগকালীন সময়ে কোন কোন রোগের প্রার্দুভাব বেশী হয়েছিল ? উল্লেখ করুন।

১. ডায়রিয়া
২. চিকেন পক্স
৩. টিবি
৪. টাইফয়েড
৫. জন্ডিস
৬. সাধারণ জ্বর
৭. গ্যাস্ট্রিক
৮. বাতের ব্যাথা
৯. চর্মরোগ
১০. উচ্চ রক্ত চাপ
১১. অন্যান্য(নির্দিষ্ট করুন).....

বাড়িতে বিদ্যুৎ ব্যবস্থা ক্ষতিগ্রস্থ কোন সময়ে বেশী হয়েছিল? উল্লেখ করুন।

....

দুর্যোগকালীন সময়ে পয়নিষ্কাশন ব্যবস্থায় কি কি সমস্যা দেখা দেয়? উল্লেখ করুন।

পায়খানা ডুবে যায় ২. খোলা জায়গায় পায়খানা করতে হয় ৩. পানির উপরে পায়খানা করে ৪. বাঁশের মাচা বানিয়ে পায়খানা করতে হয় ৫. অন্যান্য (নির্দিষ্ট করুন).....

দুর্যোগকালীন ও দুর্যোগ পরবর্তীসময়ে যাতাযাত ও যোগাযোগের মাধ্যমগুলো*[৫] কি কি? উল্লেখ করুন।

দুর্যোগকালীন	দুর্যোগ পরবর্তী

ঐতিহ্যগতভাবে প্রচলিত রাস্তা/বাঁধের ঢাল রক্ষার পদ্ধতি সম্পর্কে আপনি জানেন কি? ১. হ্যাঁ ২. না (উত্তর হ্যাঁ হলে কোনটি)

১. ভটিবার রোপণের মাধ্যমে

২. ঢোল কলমি রোপণের মাধ্যমে

৩. অন্যান্য ঘাস রোপণ/বপনের মাধ্যমে

৪. অন্যান্য গাছ রোপণের মাধ্যমে

আকস্মিক বন্যার ফলে দুর্যোগ মোকাবেলায় কার্যকরী পূর্বাভাস কি ভাবে দূর্গত এলাকার জনগণের কাছে পৌছনো যায়?

[৫] *কোডসমূহঃ ১. নৌকা ২. রিকশা ৩. ভ্যান ৪. অটো (ব্যাটারি চালিত রিকশা),৫. পায়ে হেঁটে ৬. বাইক ৭. সি এন জি ৮. কলা বা বাঁশের ভেলা ৯. অন্যান্য (নির্দিষ্ট করুন)

মোবাইলের মাধ্যমে এসএসএস বা ফোন করে ২. পুরো এলাকায় মাইকিং করে ৩. মসজিদের মাধ্যমে মাইকিং করে ৪. ইউনিয়ন পরিষদের মাধ্যমে ৫. রেডিও বা টেলিভিশনের মাধ্যমে ৬. অন্যান্য (নির্দিষ্ট করুন).....

হাওড় এলাকার জনগণকে আকস্মিক/ফ্লাসফ্লাড এর প্রভাব থেকে রক্ষা করার জন্য কি করা যেতে পারে বলে আপনি মনে করেন?

বেড়িবাঁধ নির্মান করতে হবে ২. খাল খনন করতে হবে ৩. নদী খনন করতে হবে ৪. অন্যান্য (নির্দিষ্ট করুন).....

আপনারা স্থানীয় পর্যায়ে দুর্যোগ ঝুকি মোকাবিলা এবং অভিযোজনের কি কি পদ্ধতি অনুসরণ করে থাকেন?

ক্ষতিগ্রস্থ বাঁধের অংশে মাটি ফেলা হয় ২. স্থানীয় ভাবে মাটি দিয়ে বসত ভিটা উচু করা ৩. বাড়ির চারপাশে পাথর চড়িয়ে রাখা ও গাছ লাগানো হয় ৪. বর্ষার সময় পানি নিষ্কাশনের জন্য বাঁধ কেটে দেওয়া হয় ৫. বিল খনন করে অভয়াশ্রম তৈরীর করে একটা অংশে পানি আটকে রাখা ৫. অন্যান্য (নির্দিষ্ট করুন)

আপনারা স্থানীয় পর্যায়ে দুর্যোগ ঝুকি মোকাবিলা এবং অভিযোজনের পদ্ধতি গুলোর সুবিধাসমূহ কি কি? (কৃষি ও মৎস্য ভিত্তিক)

স্বল্পকালীন সময়ের জন্য ফসল রক্ষা করা যায় ২. ঘরবাড়ির ক্ষয় ও ভাঙ্গন রোধ করা যায় ৩. সাময়িকভাবে পানি প্রবাহ ঠেকানো যায় ৪. সাময়িক ভাবে পুকুওে চাষকৃত মাছ রক্ষা করা যায় ৫. অন্যান্য (নির্দিষ্ট করুন).....

আপনার মতে, আপনারা স্থানীয় পর্যায়ে দুর্যোগ ঝুকি মোকাবিলা এবং অভিযোজনের পদ্ধতি গুলোর চিরস্থায়ী করার জন্য সুপারিশগুলো কি কি? (কৃষি ও মৎস্য ভিত্তিক)

সারাবছর ব্যবহারপযোগী বাঁধ নির্মাণ করতে হবে ২. বাঁধের দুইপাশ বর্ষার আগে ব্লক দিতে হবে ৩. স্লুইসগেট নির্মান করতে হবে ৪. বাঁধ আরো উঁচু করতে হবে ৫. ঠাণ্ডা সহিষ্ণু ধানের বীজ সরবরাহ করতে হবে ৬. আগাম জাতের ধানের বীজ সরবরাহ করতে হবে ৭. আয়মূলক কাজের প্রশিক্ষণ দিতে হবে ৮. বন্যা পূর্বাভাস ব্যবস্থা জোরদার করতে হবে ৯. উচু রাস্তা নির্মাণ করতে হবে ১০. আশ্রয়কেন্দ্রের পরিমাণ বাড়াতে হবে ১১. নিয়মিত মনিটরিং এর মাধ্যমে বাঁধ ও রাস্তা মেরামত করতে হবে ১২. বেটিবার ঘাস ও বিভিন্ন গাছ রোপনের মাধ্যমে বাঁধ ও রাস্তা শক্তিশালী করতে হবে ১৩. পানি নিস্কাশনের জন্য পর্যাপ্ত কালভার্ট নির্মান করতে হবে ১৪. সেচ পাম্পের মাধ্যমে পানি নিস্কশন করতে হবে ১৫. খাল খনন করতে হবে ১৬. নদী খনন করতে হবে ১৭. বর্ষার আগ দিয়ে সকল মেরামত কাজ সম্পন্ন করতে হবে ১৮. নেট জালের ব্যবহার বন্ধ করতে হবে ১৯. মৎস্য ও কৃষিজীবীদের মধ্যে বিদ্যমান সম্পর্ক উন্নয়নে ব্যবস্থা গ্রহণ করতে হবে ২০. স্থানীয় পানি ব্যবস্থাপনা কমিটিগুলোকে শক্তিশালীকরণ এবং পর্যাপ্ত ট্রেনিংয়ের ব্যবস্থা করতে হবে ২১. নতুন প্রকল্প বাস্তবায়নের আগে ও পরে স্থানীয় মানুষের মতামতকে গুরুত্ব দিতে হবে ২২. যেথানে পানি ব্যবস্থাপনা কমিটি নেই সেখানে পাড়া, মহল্লা বা ইউনিয়নভিত্তিক পানি ব্যবস্থাপনা কমিটি করতে হবে ২৩. অন্যান্য (নির্দিষ্ট করুন).....

বিভিন্ন দুর্যোগ মোকাবেলায় নির্মিত বিভিন্ন অবকাঠামোগুলো কৃষিক্ষেত্রে কেমন ভুমিকা রাখে ?

ফসলের ক্ষতির হাত থেকে রক্ষা করে ২. হঠাৎ পানি প্রবেশের হাত থেকে রক্ষা করে ৩. কৃষি উৎপাদন বৃদ্ধি পায় ৪. কৃষি ভিত্তিক আয় বাড়ে ৫. অন্যান্য (নির্দিষ্ট করুন).....

অবকাঠামো নির্মাণের ফলে আপনারা কতটুকু উপক্রিত হয়েছি

নির্মিত অবকাঠামোগুলো কি সঠিকভাবে ক্রিয়াশীল রয়েছে ?

হ্যাঁ ২. না

সকল অবকাঠামোর সঠিক সময়ে মেরামত করা হয় কিনা?

হ্যাঁ ২. না

উত্তর না হলে, মেরামত না হওয়ায় কিকি ক্ষতির সম্মুখীন হয়েছেন ?

অবকাঠামোগুলো উন্নয়নের ব্যাপারে আপনাদের যদি কোন মতামত থাকে উল্লেখ করুন

Appendix C: FGD/Workshop Checklist for PSD

জরংশ অংংবংংসবহঃ (ঝুঁকি মূল্যায়ন প্রশ্নপত্র(

উপজেলার নামঃ	তারিখঃ
অংশগ্রহণকারীর নামঃ	মোবাইল নম্বরঃ

জলবায়ু পরিবর্তন জনিত আপদ গুলো সনাক্তকরণ

আপদের নাম	আপনার এই উপজেলায় সবচেয়ে বেশী প্রভাব রাখে এমন আপদের মাত্রা নির্ধারণ করুন (০ = কোনো প্রভাব নেই, ১= স্বল্প প্রভাব, ২= মাঝারি প্রভাব, ৩= বেশী প্রভাব)	Vulnerable Groups							
		মহিলা	ভূমিহীন কৃষক	কৃষক (প্রান্তিক/ক্ষুদ্র/ মাঝারী)	মাছচাষী	দিনমুজুর	বৃদ্ধ (৬০ তদূর্ধ্ব) /প্রতিবন্ধী	শিশু (৭ বছরের নিচে)	আপনি এখানে আরও vulnerable groups নাম বলতে পারেন (যদি থাকে)
তাপমাত্রা বৃদ্ধি									
বৃষ্টিপাত বৃদ্ধি									
আগাম বন্যা									
ঢেউ (আফাল)									
শিলাবৃষ্টি									
শৈত্যপ্রবাহ									
বজ্রপাত									
খরা									

আপদের নাম	আপনার এই উপজেলায় সবচেয়ে বেশী প্রভাব রাখে এমন আপদের মাত্রা নির্ধারণ করুন (০ = কোনো প্রভাব নেই, ১= স্বল্প প্রভাব, ২= মাঝারি প্রভাব, ৩= বেশী প্রভাব)	Vulnerable Groups							
		মহিলা	ভূমিহীন কৃষক	কৃষক (প্রান্তিক/ক্ষুদ্র/ মাঝারী)	মাছচাষী	দিনমুজুর	বৃদ্ধ (৬০ তদূর্ধ্ব) /প্রতিবন্ধী	শিশু (৭ বছরের নিচে)	আপনি এখানে আরও vulnerable groups নাম বলতে পারেন (যদি থাকে)
নদী ভাঙ্গন									
পলিকরন (Siltation)									
সর্বমোট	১০০								

জলবায়ু পরিবর্তন ফলে আপদের সম্ভাবনা

আপদের নাম	সম্ভাবনার মাত্রা									
	প্রতি বছর	২ বছর পর	৩ বছর পর	৫ বছর পর	১০ বছর পর	২০ বছর পর	৩০ বছর পর	৫০ বছর পর	১০০ বছর পর	আপনার মন্তব্য (বিশেষ কিছু থাকলে উল্লেখ করুন)
তাপমাত্রা বৃদ্ধি										
বৃষ্টিপাত বৃদ্ধি										
আগাম বন্যা										
ঢেউ (আফাল)										
শিলাবৃষ্টি										
শৈত্যপ্রবাহ										
বজ্রপাত										
খরা										
নদী ভাঙ্গন										
পলিকরন (Siltation)										

জলবায়ু পরিবর্তন ফলে আপদের প্রভাব) অতীত- ২০০০ থেকে ২০১৫ পর্যন্ত(

আপদের নাম	সম্ভাব্য ফলাফল (প্রয়োজন অনুপাতে স্তরায়ন করুন ০= কোনো পড়োভাব নেই, ১= খুব কম প্রভাব, ২= মাঝারি প্রভাব এবং ৩= বেশী প্রভাব)								
	ফসলের ক্ষতি	মৎস্য উৎপাদন ক্ষতি	কৃষি জমি হ্রাস	বাসস্থান নষ্ট	কম আয়	পানির গুনগত মান নষ্ট	শিক্ষার ক্ষতি	স্বাস্থ্য সমস্যা বৃদ্ধি	এমনিভাবে, আপনি আরও নেতিবাচক প্রভাব গুলোর নাম বলতে পারেন (১-৩) এর মধ্যে
তাপমাত্রা বৃদ্ধি									
বৃষ্টিপাত বৃদ্ধি									
আগাম বন্যা									
ঢেউ (আফাল)									
শিলাবৃষ্টি									
শৈত্যপ্রবাহ									
বজ্রপাত									
খরা									
নদী ভাঙ্গন									
পলিকরন (Siltation)									

জলবায়ু পরিবর্তন ফলে আপদের প্রভাব) বর্তমান সময়ে -২০১৫ থেকে এখন পর্যন্ত(

আপদের নাম	সম্ভাব্য ফলাফল (প্রয়োজন অনুপাতে স্তরায়ন করুন ০= কোনো পড়োভাব নেই, ১= খুব কম প্রভাব, ২= মাঝারি প্রভাব এবং ৩= বেশী প্রভাব)								
	ফসলের ক্ষতি	মৎস্য উৎপাদন ক্ষতি	কৃষি জমি হ্রাস	বাসস্থান নষ্ট	কম আয়	পানির গুনগত মান নষ্ট	শিক্ষার ক্ষতি	স্বাস্থ্য সমস্যা বৃদ্ধি	এমনিভাবে, আপনি আরও নেতিবাচক প্রভাব গুলোর নাম বলতে পারেন (১-৩) এর মধ্যে
তাপমাত্রা বৃদ্ধি									
বৃষ্টিপাত বৃদ্ধি									
আগাম বন্যা									
ঢেউ (আফাল)									
শিলাবৃষ্টি									
শৈত্যপ্রবাহ									
বজ্রপাত									
খরা									
নদী ভাঙ্গন									
পলিকরন (Siltation)									

Participatory Scenario Development) অংশগ্রহণ মূলক ভবিষ্যৎ জলবায়ু পরিবর্তন ও এর প্রভাব নিরূপণ(

উপজেলার নাম: তারিখ:

উত্তর দাতার নাম: মোবাইল নম্বর: পেশা:

১ .আপনি কি মনে করেন প্রতি বছর জলবায়ু পরিবর্তন জনিত আপদের সংখ্যা ও মাত্রা বাড়ছে? যদি বাড়ে ,তাহলে বছরের কোন সময়ে এই আপদ গুলো ঘটছে এবং কয়বার ঘটছে ,সে ব্যপারে আপনার মতামত দিন

আপদের নাম	সময় (Time of Occurrence)	ভবিষ্যত ক্ষতির মাত্রা অনুধাবন
তাপমাত্রা বৃদ্ধি		
বৃষ্টিপাত বৃদ্ধি		
আগাম বন্যা		
ঢেউ (আফাল)		
শিলাবৃষ্টি		
শৈত্যপ্রবাহ		
বজ্রপাত		
খরা		
নদী ভাঙ্গন		
পলিকরন (Siltation)		
অন্যান্য (দয়া করে উল্লেখ করুন)		

)স্বল্প মাত্রা= ২০৩০, মাঝারি মাত্রা= ২০৫০ এবং দীর্ঘ মাত্রা= ২০৮০(

২ .জলবায়ু পরিবর্তন জনিত কারনে কি ধরনের প্রভাব পড়ে বিশেষ করে কৃষি ও মৎস্য খাতে উল্লেখ করুন।

আপদের নাম	বর্তমান প্রভাব	ভবিষ্যত প্রভাবসমুহ অনুধাবন
তাপমাত্রা বৃদ্ধি		
বৃষ্টিপাত বৃদ্ধি		
আগাম বন্যা		
ঢেউ (আফাল)		
শিলাবৃষ্টি		
শৈত্যপ্রবাহ		
বজ্রপাত		
খরা		
নদী ভাঙ্গন		
পলিকরন (Siltation)		
অন্যান্য (দয়া করে উল্লেখ করুন)		

৩ .জলবায়ু পরিবর্তনের কারনে নেতিবাচক প্রভাবসমুহ বিশেষত কৃষি ও মৎস্য ক্ষেত্রে মোকাবিলা করার জন্য কি ধরনের অভিযোজন ব্যবস্থা গ্রহন করা হয়ে থাকে ? অগ্রাধিকার ভিত্তিক অভিযোজন ব্যবস্থা সমুহের র ্যাঙ্কিং করুন –

আপদের নাম	বর্তমান অভিযোজন ব্যবস্থা	স্বল্প মেয়াদী অভিযোজন ব্যাবস্থা	মাঝারী মেয়াদী অভিযোজন ব্যবস্থা	দীর্ঘ মেয়াদী অভিযোজন ব্যবস্থা
তাপমাত্রা বৃদ্ধি				
বৃষ্টিপাত বৃদ্ধি				
আগাম বন্যা				
ঢেউ (আফাল)				
শিলাবৃষ্টি				
শৈত্যপ্রবাহ				
বজ্রপাত				
খরা				
নদী ভাঙ্গন				
পলিকরন (Siltation)				
অন্যান্য (দয়া করে উল্লেখ করুন)				

Appendix D: KII Checklist

1. Name of key informant:
2. Age: Sex:
3. Village: Union:
4. Upazila: Zila:

Situation	Before 20 years	Present
Risks		
Major Risks/ Hazard (Drought/ Hail Strom/Flash Flood) Most vulnerable area of this upazila in terms of risk and hazard Local perceptions on risks (i.e. drought/hail storm/flash flood) Frequency, intensity of risks Specific month/season/time for each risks Causes of the risks		
Organizations support for Climate Change		
What are the most Important organizations What are the activities/plan for mitigating the risks? What are the roles of these organizations What information/Assistance do they provide on the risk How could the different organizations be improved		
Risk management		
Participatory Scenario Development What are the stakeholders for PSD Which activities can be followed for PSD Risk prevention Risk prevention measures or preparedness initiatives (by own/others) The ways for access to information on risks Engaged Stakeholders/institute/organizations for access to information on risks Availability of information based on the risks prevailed in the vulnerable area Risk mitigation Name of assigned stakeholders/institutions for risks mitigation Risk mitigation measures and initiatives (previous and existing) Access to formal / informal credit and savings for risks mitigation Risk coping: Risk coping measures Change in major crops		

Situation	Before 20 years	Present
Introduction of new varieties Change in irrigation system Shifting of planting time Reduction of consumption/ expenditure Sell assets Child labor Intensify use of natural resources Off-farm employment Change in livelihood activities Migration Credit (Crop insurance)		
Change in crop cultivation system		
Month of (name of the crop): Seedbed preparation Ploughing Sowing Fertilizer application Weeding Irrigation Harvesting		
Change in fishing (i.e. capture and culture)		
Fish production Fish verities Rare Fishes Conflict between fishers and farmers		
Lessons leant and other issues		
What initiatives has worked/not and why Support received from government, NGOs or community itself during prevention, mitigation and coping Needs Local initiatives/ use of traditional local knowledge		

Appendix E: Field Photographs

Participatory Scenario Development (PSD)

PSD at Mollapara Union, Sunamganj Sadar

PSD at Badaghat Dakhin, Bishwambarpur

PSD at Dowarabazar Sadar, Dowarabazar

PSD at Fatehpur, Bishwambarpur

PSD at Islampur, Chatak

PSD at Jaykalas, Dakshin Sunamganj

PSD at Nowarai, Chatak

PSD at Paschim Birgaon, Dakshin Sunamganj

PSD at Surma, Dowarabazar

PSD at Tahirpur Sadar, Tahirpur

PSD at Uttar Sreepur, Tahirpur

PSD at Suair, Mohanganj

PSD at Borkhafan, Kalmakanda

PSD at Chanduail, Kalmakanda

PSD at Ghulua, Dharmapasha

PSD at Gobindasree, Madan

PSD at Islampur, Dharmapasha

PSD at Kaittal, Madan

PSD at Khaliajuri Sadar, Khaliajuri

PSD at Magan Siyadhar, Mohanganj

PSD at Mendipur, Khaliajuri

Key Informant Interveiw (KII)

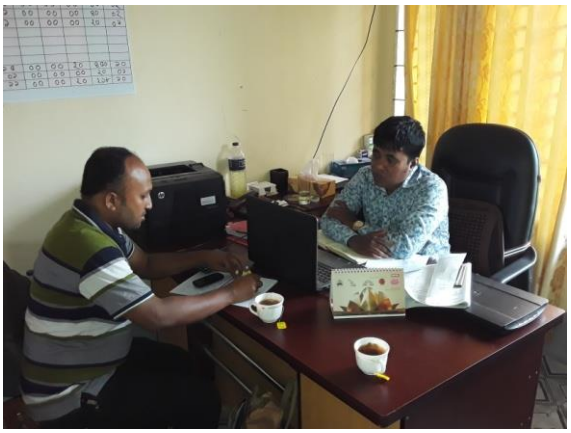
KII with fisheries officer Nikli, Kishoreganj

Meeting with Upazila LGED Engineer, Nikli, Kishoreganj

KII with Agriculture Officer, Madan, Netrakona

Consultation with HILIP concern person at Nikli, Kishoreganj

KII with Fisheries officer, Chatok



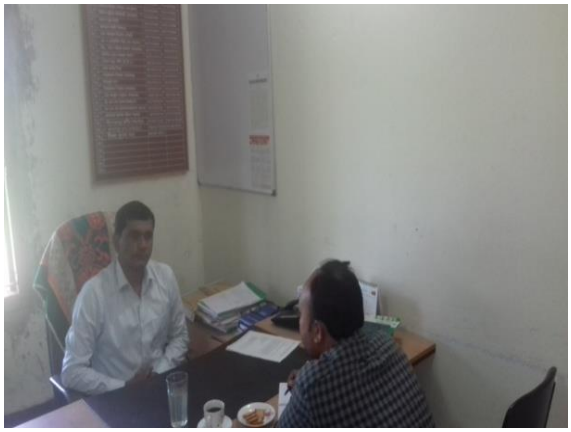
KII with Agriculture officer, Mithamain

KII with Agriculture officer, Itna

KII with Fisheries officer, Aushtagram

KII with Fisheries officer, Sulla

KII with Agriculture officer, Lakhai



KII with Fisheries Officer, Ajmiriganj

KII with Agriculture officer, Baniachang

KII with Agriculture officer, Bishwamvarpur

KII with Fisheries Officer, Jagannathpur

KII with Agriculture officer, Tahirpur

KII with Fisheries Officer, Tahirpur

Household Survey

Household Survey at Mollapara, Sunamganj Sadar

Household Survey at Bancharampur

Household Survey at Kandapara, Dharampasha

Household Survey at Baniachang

Household Survey at Ashtagaram

Household Survey at Derai

Household Survey at Kalmakanda

Household Survey at Sulla

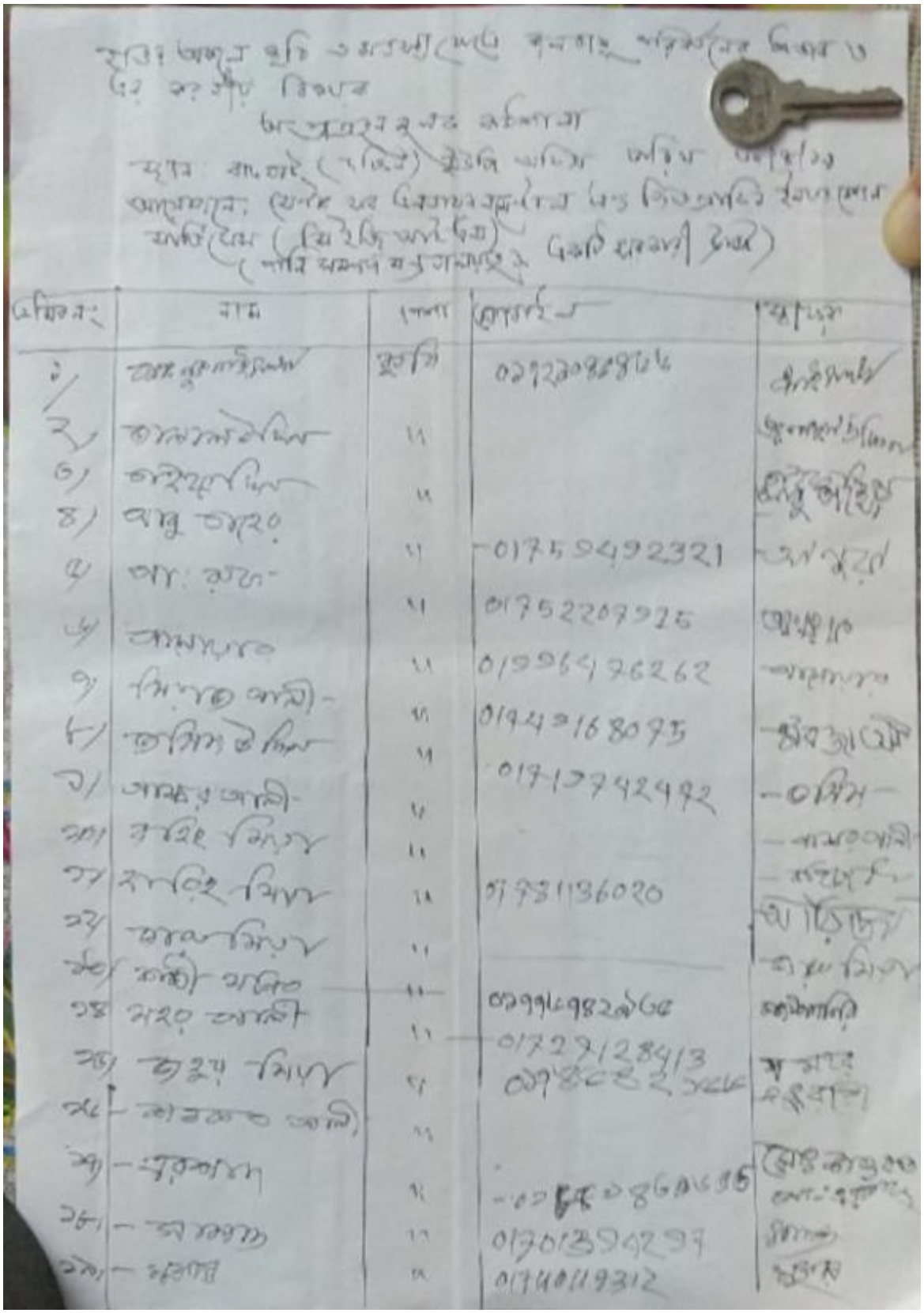
Household Survey at Ajmiriganj

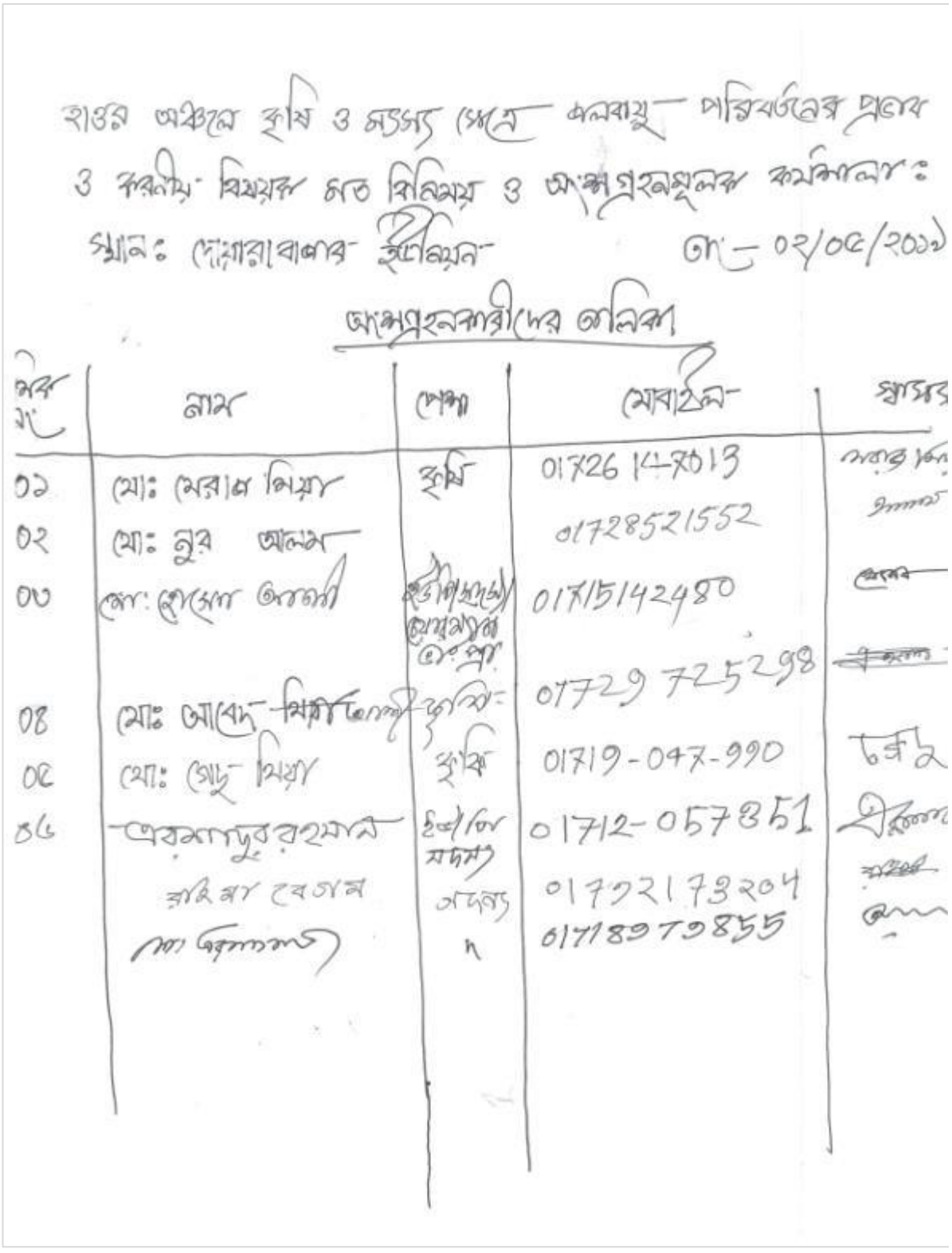
Household Survey at Madan

Household Survey at Dharampasha

Household Survey at Mithamain

Appendix F: Participant List of PSD

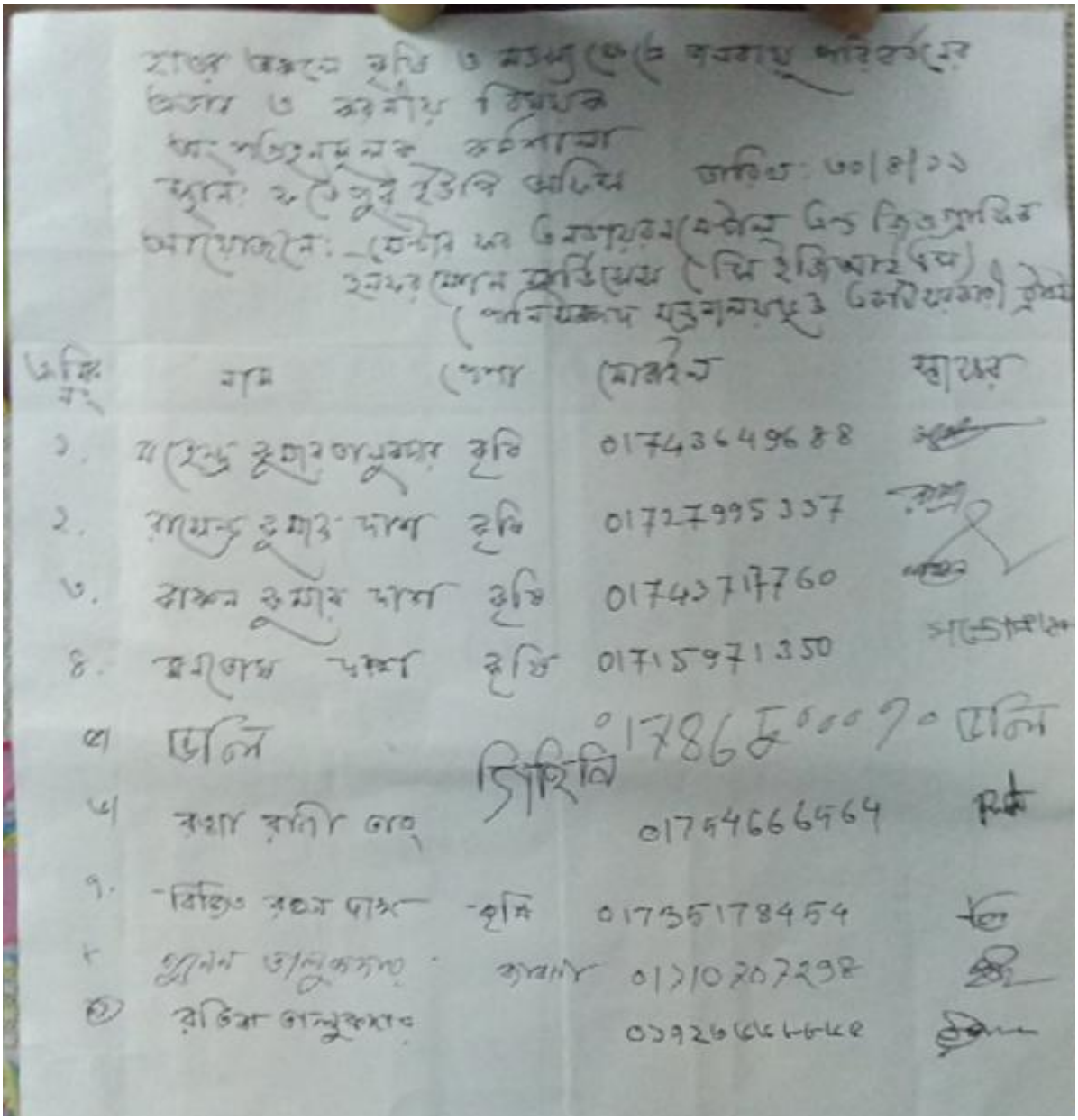


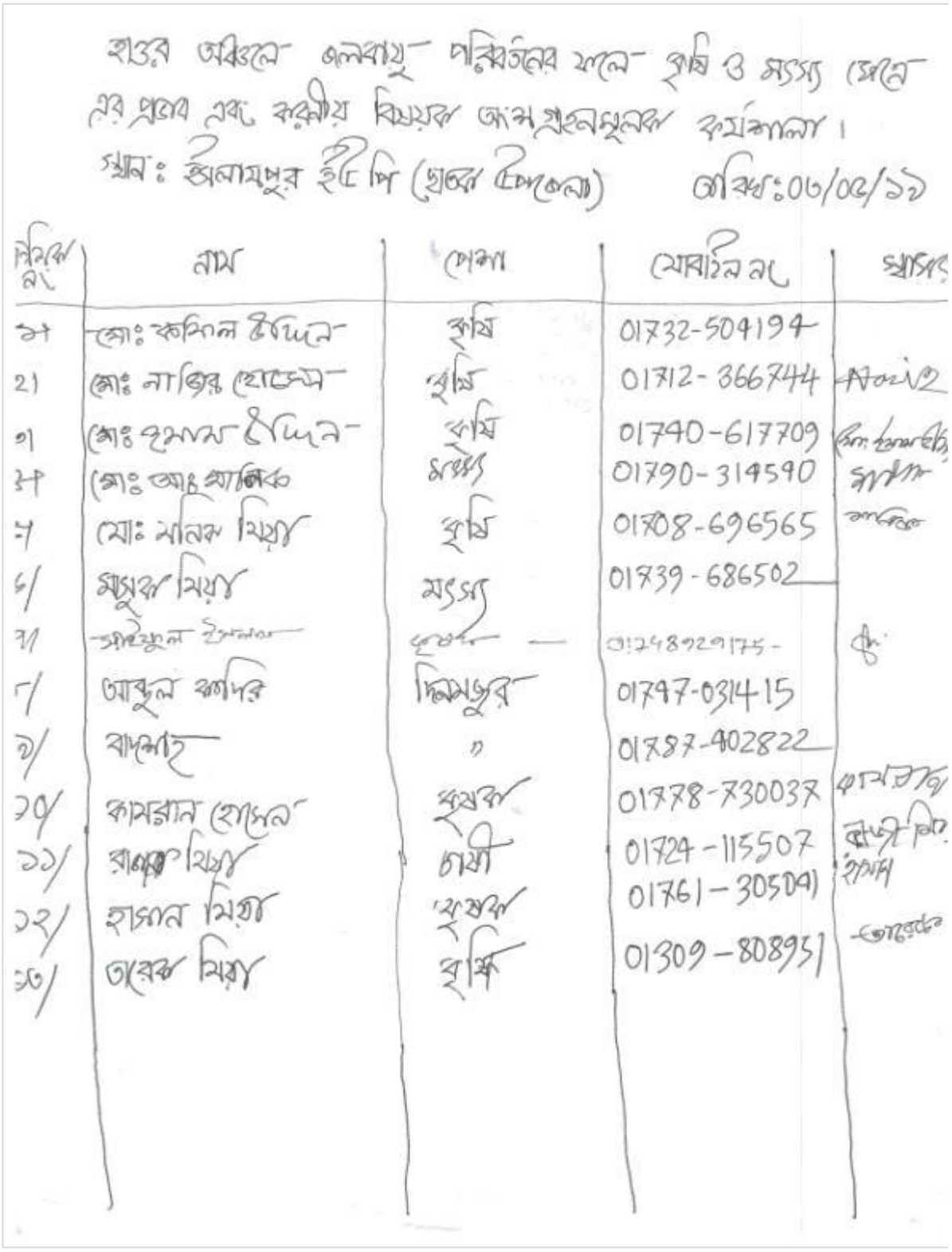


হাওর অঞ্চলে কৃষি ও অন্যান্য খাতে জলবায়ু পরিবর্তনের প্রভাব
ও করণীয় বিষয়ক মত বিনিময় ও অংশগ্রহণমূলক কর্মশালা:
স্থান: দোয়ারাবাজার ইউনিয়ন তাং- ০২/০৫/২০১৯

অংশগ্রহনকারীদের তালিকা

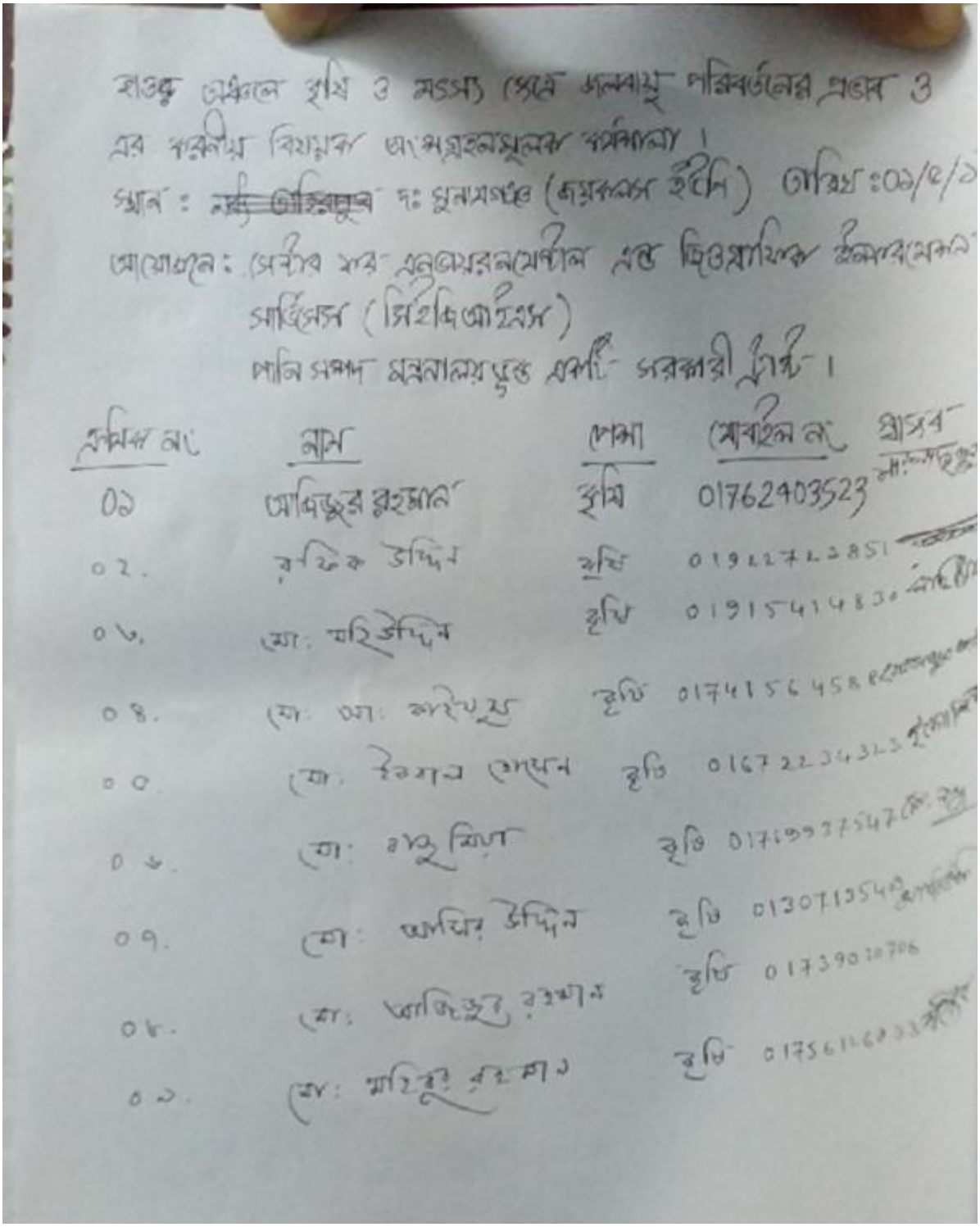
ক্রমিক নং	নাম	পেশা	মোবাইল	স্বাক্ষর
০১	মো: মেরাজ মিয়া	কৃষি	01726 147013	
০২	মো: নুর আলম		01728521552	
০৩	মো: হোসেন আলী	[illegible]	01715142480	
		[illegible]	01729 725298	
০৪	মো: আবেদ মিয়া	[illegible]		
০৫	মো: মোছু মিয়া	কৃষি	01719-047-990	
০৬	[illegible]	[illegible]	01712-057851	
	[illegible]	[illegible]	01722173204	
	[illegible]	[illegible]	01718979855	





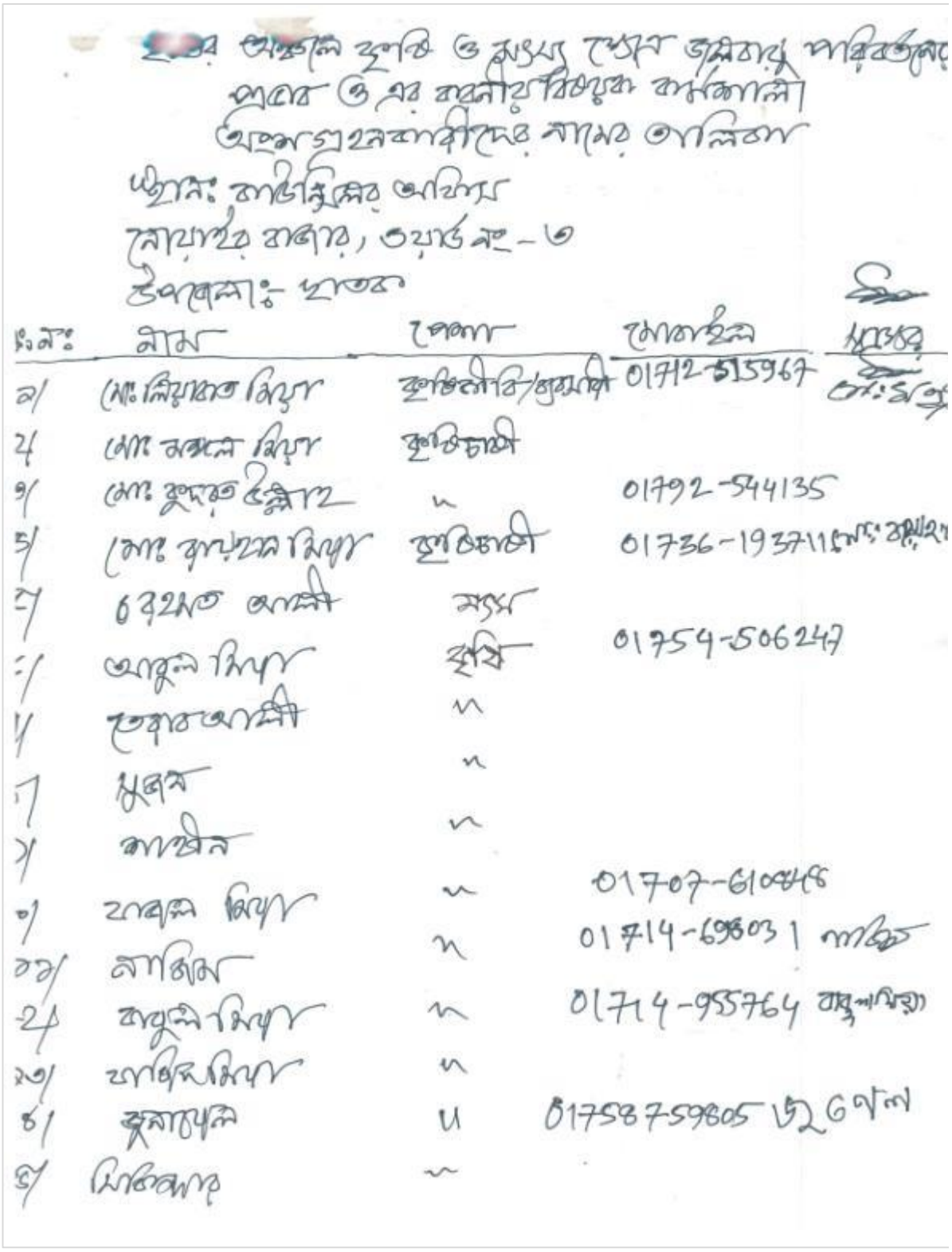
হাওর অঞ্চলে জলবায়ু পরিবর্তনের ফলে কৃষি ও মৎস্য খাতে
এর প্রভাব এবং করণীয় বিষয়ক অংশগ্রহণমূলক কর্মশালা।
স্থান: জামালপুর ইউপি (হলের উপজেলা) তারিখ: ০৬/০৫/১৬

ক্রমিক নং	নাম	পেশা	মোবাইল নং	স্বাক্ষর
১।	মোঃ কফিল উদ্দিন	কৃষি	01732-504194	
2।	মোঃ নাজির হোসেন	কৃষি	01712-366744	
৩।	মোঃ ফুসসর উদ্দিন	কৃষি	01740-617709	
৪।	মোঃ আঃ খালেক	মৎস্য	01790-314590	
৫।	মোঃ মনির মিয়া	কৃষি	01708-696565	
৬।	মধুকর মিয়া	মৎস্য	01739-686502	
৭।	সাইফুল ইসলাম	কৃষক	01748929175	
৮।	আবুল কাদির	দিনমজুর	01797-031415	
৯।	বাদশাহ	"	01787-402822	
১০।	কামরান হোসেন	কৃষক	01778-730037	
১১।	রাকেশ মিয়া	চাষী	01724-115507	
১২।	হাসান মিয়া	কৃষক	01761-305091	
১৩।	তারেক মিয়া	কৃষি	01309-808951	



খাওড় অঞ্চলে কৃষি ও মৎস্য খাতে জলবায়ু পরিবর্তনের প্রভাব ও
এর করণীয় বিষয়ক অংশগ্রহণমূলক কর্মশালা।
স্থান : ~~নড়াইল~~ ঃ খুলনাগড় (জয়কলস ইউনি) তারিখ : ০৯/২/১
আয়োজনে : সেচ্ছায় মরা প্রতিরোধমূলক এন্ড ডিওয়ার্ফিক উন্নয়নমেলন
সার্ভিসেস (সিইডিআইএস)
পানি সম্পদ মন্ত্রণালয় যুক্ত একটি সরকারী ট্রাস্ট।

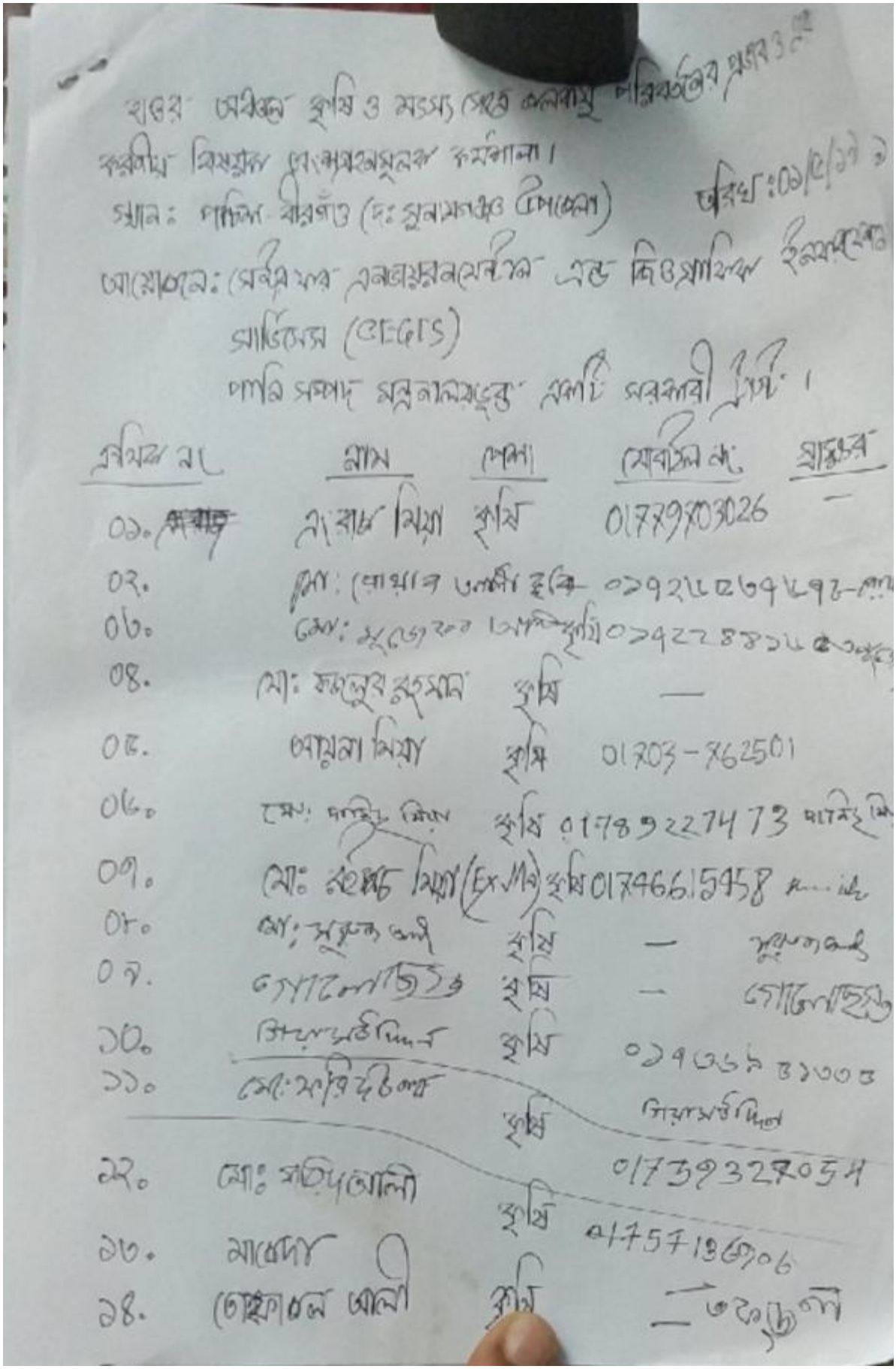
ক্রমিক নং	নাম	পেশা	মোবাইল নং	স্বাক্ষর
০১	আজিজুর রহমান	কৃষি	01762403523	
০২.	রফিক উদ্দিন	কৃষি	01922742851	
০৩.	মো: মহিউদ্দিন	কৃষি	01915414830	
০৪.	মো: আ: কাইয়ুম	কৃষি	01741564582	
০৫.	মো: ইমাম হোসেন	কৃষি	01672234323	
০৬.	মো: রাজু মিয়া	কৃষি	01719937547	
০৭.	মো: আফির উদ্দিন	কৃষি	01307135483	
০৮.	মো: আজিজুর রহমান	কৃষি	01739012706	
০৯.	মো: মহিবুর রহমান	কৃষি	01756116033	



[redacted] অঞ্চলে কৃষি ও মৎস্য খেয়া তরিবন্ধু সারিবদ্ধভাবে
স্থাপন ও এর রক্ষণাবেক্ষণ কার্যক্রমে
অংশগ্রহণকারীদের নামের তালিকা

স্থান: কাউনিয়ার অফিস
নোয়াপাড়া বাজার, ওয়ার্ড নং - ৩
উপজেলা: হাতিয়া

ক্রঃনং	নাম	পেশা	মোবাইল	স্বাক্ষর
১/	মোঃ শিহাবুদ্দিন মিয়া	কৃষিশ্রমিক/মৎস্যজীবী	01712-515967	
২/	মোঃ সফিউল মিয়া	কৃষিচাষী		
৩/	মোঃ কুদ্দুস ঠিকাদার	"	01792-544135	
৪/	মোঃ কামাল মিয়া	কৃষিচাষী	01736-193711	
৫/	[illegible] আক্তার	মহিলা		
৬/	আবুল মিয়া	কৃষি	01754-506247	
৭/	[illegible] আক্তার	"		
৮/	[illegible]	"		
৯/	[illegible]	"		
১০/	[illegible]	"		
১১/	[illegible]	"	01707-610446	
১২/	[illegible]	"	01714-696031	
১৩/	[illegible]	"	01714-955764	
১৪/	[illegible]	"		
১৫/	[illegible]	"	01758-759805	
১৬/	[illegible]	"		



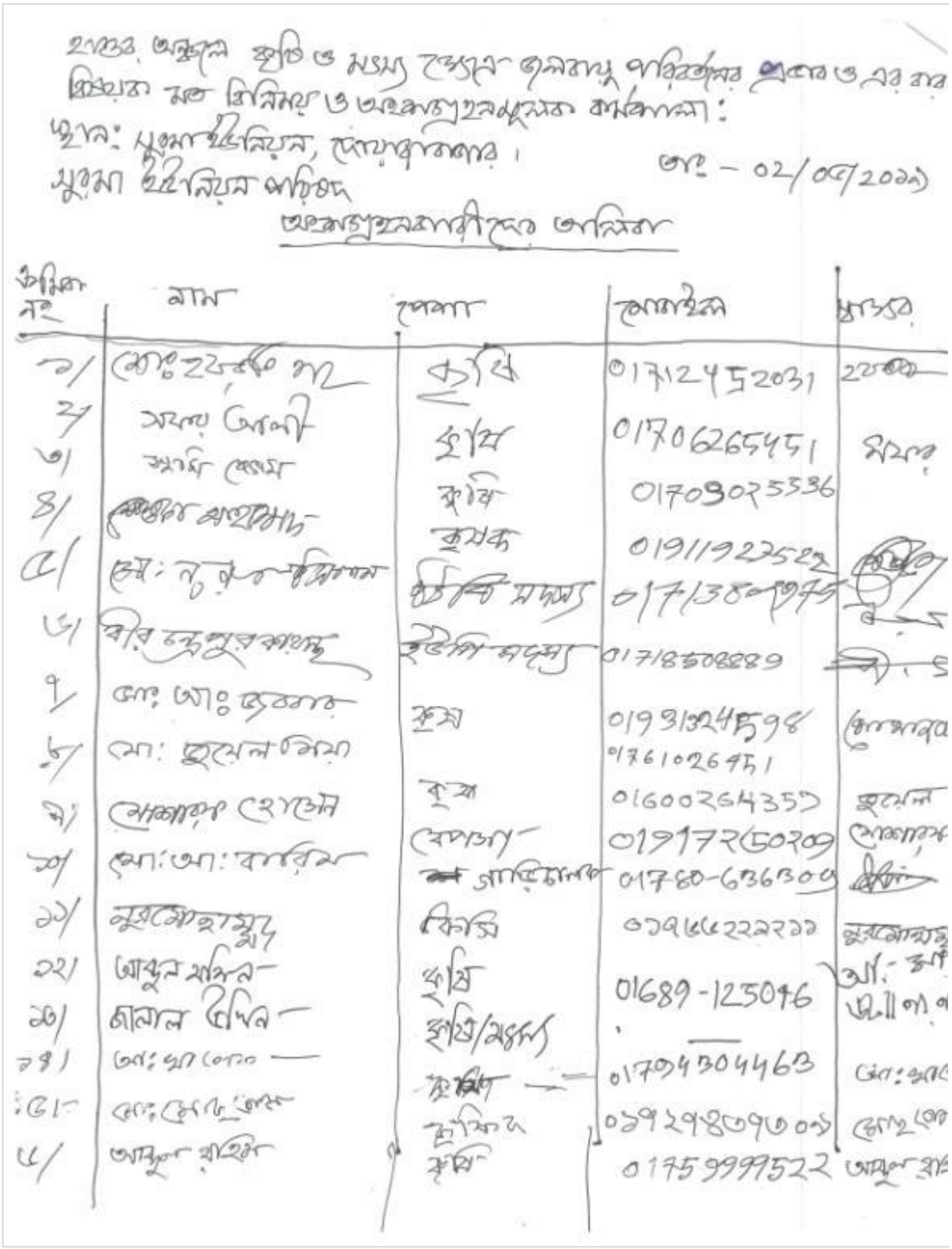
শ্রেণীর অধীনে কৃষি ও মৎস্য খাতে জলবায়ু পরিবর্তনের প্রভাব ও করণীয় বিষয়ক মোবাইলভিত্তিক কর্মশালা।

স্থান: পাবলি বীরগঞ্জ (দঃ সুনামগঞ্জ টেপোলো) তারিখ: ০৯/০৫/১৭ ই

আয়োজনে: সেন্টার ফর এনভায়রনমেন্টাল এন্ড জিওগ্রাফিক ইনফরমেশন সার্ভিসেস (CEGIS)

পাবি সম্পাদ মন্ত্রনালয়ের একটি সরকারী সংস্থা।

ক্রমিক নং	নাম	পেশা	মোবাইল নং	স্বাক্ষর
০১.	[illegible]	কৃষি	01779703026	—
০২.	[illegible]	[illegible]	[illegible]	[illegible]
০৩.	[illegible]	[illegible]	[illegible]	[illegible]
০৪.	মোঃ ফজলুর রহমান	কৃষি	—	
০৫.	আয়না মিয়া	কৃষি	01703-762501	
০৬.	মোঃ [illegible]	কৃষি	01789227473	[illegible]
০৭.	মোঃ [illegible]	কৃষি	01746615458	[illegible]
০৮.	[illegible]	কৃষি	—	[illegible]
০৯.	[illegible]	কৃষি	—	[illegible]
১০.	[illegible]	কৃষি	[illegible]	[illegible]
১১.	মোঃ [illegible]	কৃষি	[illegible]	[illegible]
১২.	মোঃ [illegible]	কৃষি	01759327054	
১৩.	[illegible]	কৃষি	01757196906	
১৪.	[illegible]	কৃষি	—	[illegible]



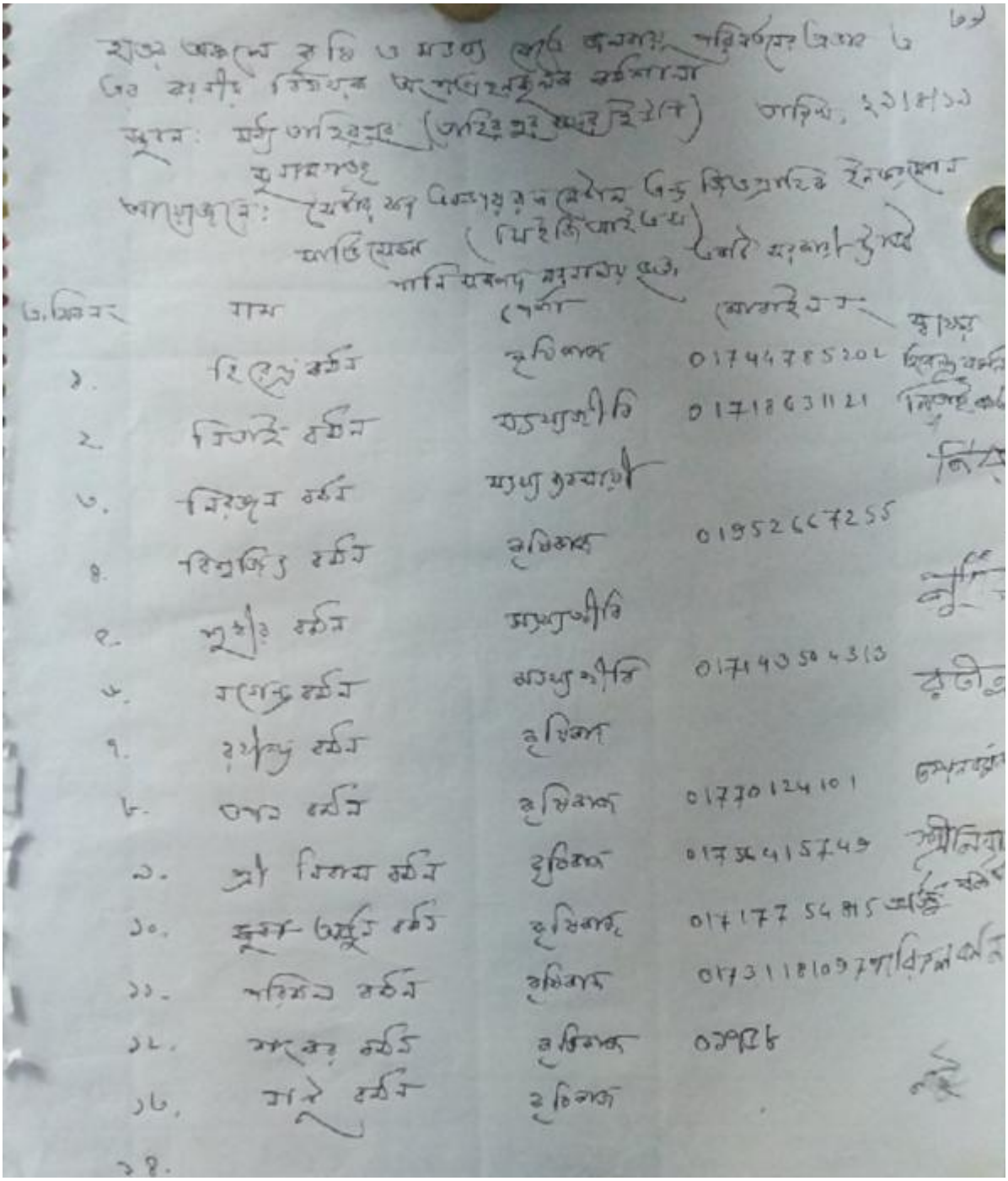
প্রস্তাবিত অনুকূল কৃষি ও মৎস্য উপযোগী ভূমিব্যবহার পরিবর্তনের প্রভাব ও এর ব্যবস্থাপনা বিষয়ক মত বিনিময় ও অংশগ্রহণমূলক কর্মশালা:

স্থান: সুরমা ইউনিয়ন, সেচ্ছাকারকান্দা। তারিখ – 02/06/2024

সুরমা ইউনিয়ন পরিষদ

অংশগ্রহণকারীদের তালিকা

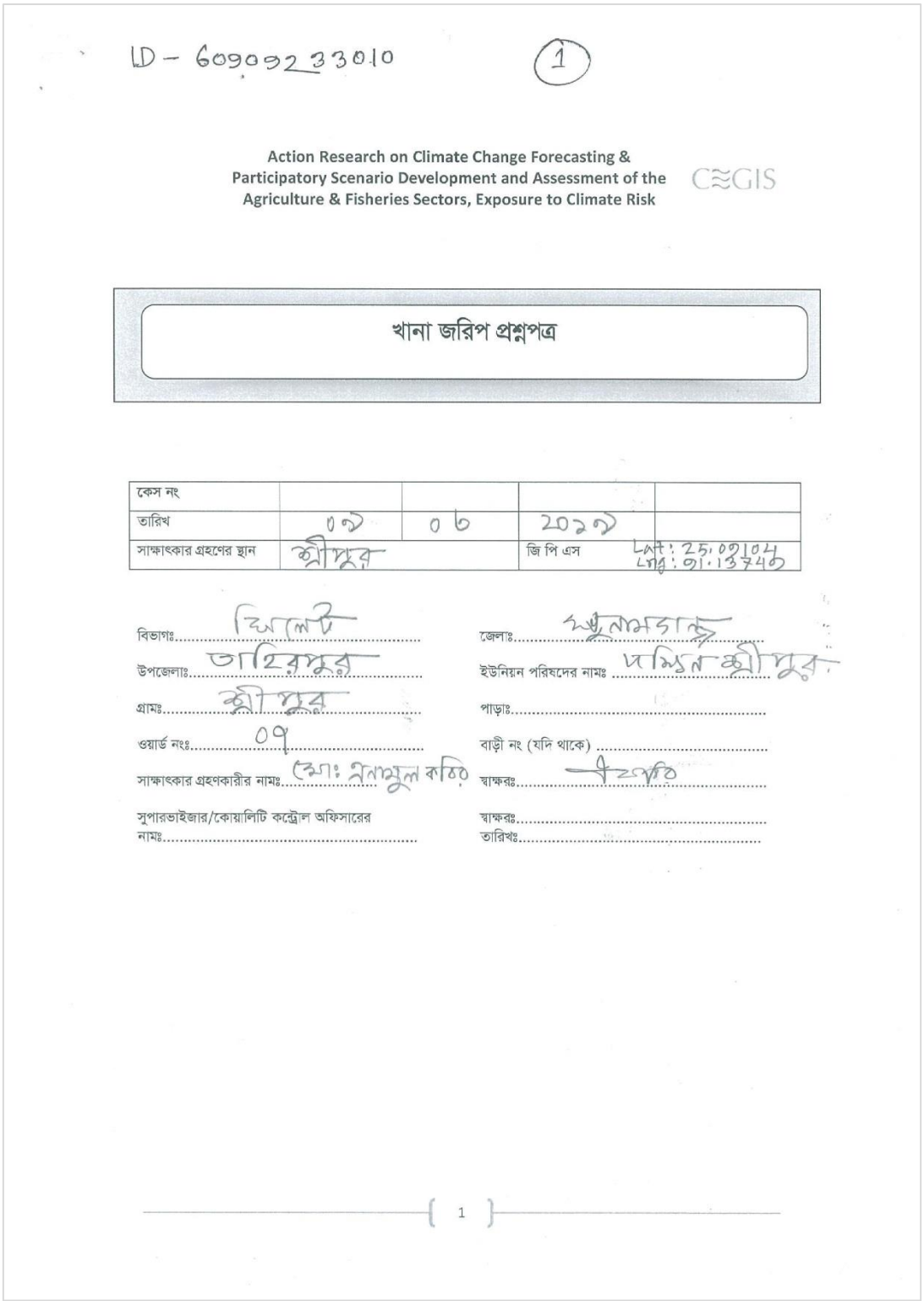
ক্রমিক নং	নাম	পেশা	মোবাইল	স্বাক্ষর
১।	মোঃ হুমায়ুন কবির	কৃষি	01712452031	
২।	সফল আলী	কৃষি	01706265451	
৩।	শফিক মেম্বার	কৃষি	01709025336	
৪।	[illegible]	কৃষক	01911922522	
৫।	[illegible]	[illegible] সদস্য	01713[illegible]	
৬।	বীর বাহাদুর কার্বারী	ইউপি সদস্য	01718508889	
৭।	মোঃ আঃ রহমান	কৃষি	01931245948	
৮।	মোঃ হুসেন মিয়া		01761026451	
৯।	মোকাদ্দস হোসেন	কৃষি	01600264357	
১০।	মোঃ আঃ বারিক	ব্যবসা	01917250209	
১১।	নুরমোহাম্মদ	গাড়িচালক	0178[illegible]636305	
১২।	আবুল হাসিম	কিসান	01916222222	
১৩।	জামাল উদ্দিন	কৃষি	01689-125046	
১৪।	মোঃ [illegible]	কৃষি/মৎস্য		
১৫।	মোঃ [illegible]	[illegible]	01709304463	
১৬।	[illegible]	[illegible]	01[illegible]	
১৭।	আবুল হাসিম	কৃষি	01759999522	



ক্রমিক নং	নাম	পেশা	মোবাইল নং	স্বাক্ষর
১.	[illegible]	কৃষিকর্ম	01744785204	
২.	[illegible]	ব্যবসায়ী	01718631121	
৩.	[illegible]	ব্যবসা		
৪.	[illegible]	কৃষিকর্ম	01952667255	
৫.	[illegible]	ব্যবসায়ী		
৬.	[illegible]	ব্যবসায়ী	01714050 4313	
৭.	[illegible]	কৃষিকর্ম		
৮.	[illegible]	কৃষিকর্ম	01770124101	
৯.	[illegible]	কৃষিকর্ম	01735415749	
১০.	[illegible]	কৃষিকর্ম	017177 54815	
১১.	[illegible]	কৃষিকর্ম	01731181097	
১২.	[illegible]	কৃষিকর্ম	01[illegible]8	
১৩.	[illegible]	কৃষিকর্ম		
১৪.				

Appendix G: Scanned Copy of Filled up Surveyed Forms
House Hold Survey: Tahirpur, Sunamganj

Household



LD – 6090923010 (1)

Action Research on Climate Change Forecasting & Participatory Scenario Development and Assessment of the Agriculture & Fisheries Sectors, Exposure to Climate Risk

CEGIS

খানা জরিপ প্রশ্নপত্র

কেস নং				
তারিখ	০৭	০৬	২০২৫	
সাক্ষাৎকার গ্রহণের স্থান	শ্রীপুর		জি পি এস	Lat: 25.09104 Lng: 91.13740

বিভাগঃ সিলেট
জেলাঃ সুনামগঞ্জ
উপজেলাঃ তাহিরপুর
ইউনিয়ন পরিষদের নামঃ দক্ষিন শ্রীপুর
গ্রামঃ শ্রীপুর
পাড়াঃ
ওয়ার্ড নংঃ ০৭
বাড়ী নং (যদি থাকে)
সাক্ষাৎকার গ্রহণকারীর নামঃ মোঃ এনামুল কবির
স্বাক্ষরঃ
সুপারভাইজার/কোয়ালিটি কন্ট্রোল অফিসারের নামঃ
স্বাক্ষরঃ
তারিখঃ

1

ভূমিকা ও সম্মতিঃ

আস্‌সালামু আলাইকুম। সম্প্রতি বাংলাদেশ সরকারের স্থানীয় সরকার ও প্রকৌশল অধিদপ্তর জলবায়ু পরিবর্তনের কারনে হাওড় অঞ্চলের মানুষের স্বাভাবিক অবস্থা ধরে রাখার জন্য HILIP প্রকল্পের আওতায় *"Action Research on Climate Change Forecasting and Participatory Scenario Development and Assessment of the Agriculture and Fisheries Sectors, Exposure to Climate Risk"* নামে একটি গবেষনা পরিচালনা করছে। এই গবেষনার উদ্দেশ্য হল হাওড় অঞ্চলের জলবায়ু পরিবর্তনের জন্য সৃষ্ট ঝুঁকি ও প্রভাব সম্পর্কে জনসচেতনতা তৈরী ,এই সকল ঝুঁকি মোকাবিলা এবং ভবিষ্যতে জলবায়ু পরিবর্তনশীলতার অভিযোজনের উপায়সমূহ চিহ্নিত করা। এই কাজের অংশহিসেবে আপনাদের বর্তমান আর্থ-সামাজিক অবস্থা, জলবায়ু পরিবর্তনের অবস্থা, ঝুকি এবং অভিযোজনের সম্পর্কে জানবো, এবং আপনাদের দেয়া তথ্যের ভিত্তিতে পরবর্তীতে জলবায়ু পরিবর্তনের কারনে হাওড় অঞ্চলের মানুষের কৃষি এবং মৎস্যভিত্তিক জীবিকা টিকিয়ে রাখা এবং এর সার্বিক ব্যবস্থাপনার জন্য কি কি ব্যবস্থা গ্রহণ করা যায় তা বোঝার চেষ্টা করবো। আপনার মতামত শুধুমাত্র গবেষণার কাজে ব্যবহৃত হবে, এবং আপনার প্রদত্ত তথ্যের এর গোপনীয়তা নিশ্চিত থাকবে। আপনি অনুমতি দিলে আমি সাক্ষাৎকার গ্রহণ শুরু করতে পারি।

১. উত্তরদাতা/উত্তরদাত্রীরনামঃ ..... মোবাইলঃ 02982-209662

২. বয়সঃ ৫৫ বছর (পূর্ণ বছরে)

৩. শিক্ষাগত যোগ্যতাঃ নবম (সর্বোচ্চ যে শ্রেণী পাস করেছে)

৪. বৈবাহিক অবস্থা ১. বিবাহিত ২. অবিবাহিত ৩. বিধবা ৪. আলাদা/পরিত্যক্তা ৫. তালাকপ্রাপ্তা

৫. উত্তরদাতা/ উত্তরদাত্রীর পারিবারিক অবস্থানঃ
১. খানা প্রধান ২. খানা প্রধান নন

৬. খানার মোট সদস্য সংখ্যাঃ ক. মোট ৬ জন খ. পুরুষ. ৬ গ. মহিলাঃ ৬ জন ঘ. শিশু .....

৭. বর্তমানে খানার কতজন স্কুল/কলেজ/ বিশ্ববিদ্যালয়ে যায় উল্লেখ করুন ।
২

৮. খানার প্রধান পেশা কি*? ৪

৯. আপনার মোট মাসিক আয় কত (প্রধান)? ঃ ..... ৬,০০০/=

১০. আপনি এই পেশা ছাড়া আর অন্য কোন আয়মূলক পেশায় নিয়োজিত আছেন কিনা?
১. হ্যাঁ ২. না

১১. এই আয়মূলক পেশা থেকে আপনার মোট মাসিক আয় কত? ঃ ..... ৮০০০/=

১২. বছরে কত মাস আপনি এই কাজে নিয়োজিত থাকেন? ..... ৬ মাস

১৩. এই পেশা (অপ্রধান) থেকে আপনার মোট মাসিক আয় কত? ঃ ..... ৮০০০/=

---

[1] *কোডঃ ১. গৃহিনী ২. মাঝি/জেলে ৩. ভিক্ষাবৃত্তি ৪. কৃষি ৫.সরকারী চাকুরী/প্রাইভেট চাকুরী ৬. বাসাবাড়িতে কাজ করে ৭. NGO প্রকল্পে কাজ করে ৮. বড়/মাঝারী ব্যবসায়ী ৯. ছাত্র ১০. দিনমজুর ১১. ক্ষুদ্র ব্যবসায়ী/ফড়িয়া ১৪. হস্ত শিল্প, সেলাই, কারিগর, কাঠমিস্ত্রি, রাজমিস্ত্রি সহ অন্যান্য স্ব-নিয়োজিত কর্ম ১৫. গবাদী/হাঁস-মুরগী পালন ১৬. অটো ড্রাইভার ১৭. বিদেশে চাকুরী/অন্য কোন কাজে নিয়োজিত ১৮. অন্যান্য (নির্দিষ্ট করুন).

১৪. খানার মোট মাসিক আয় (নেট আয়) ও সঞ্চয় ঃ

ক. আয়	খ. ব্যয়	গ. সঞ্চয়
টাকা= ২৪,০০০/=	টাকা= ২৪,০০০/=	টাকা= ০

১৫. বসত বাড়ির আঙিনায় পুকুরের হিসাব ঃ N/A

পুকুরের সংখ্যা	পুকুরের জন্য ব্যবহৃত জমির পরিমাণ (শতাংশে)

১৬. খানার জ্বালানীর উৎসগুলো কি কি?

ক) লাকড়ি খ) সিলিন্ডার গ্যাস গ) কেরোসিন ঘ) অন্যান্য (নির্দিষ্ট করুন)..... .

১৭. আপনার এলাকায় ১৯৯১-২০১৮ পর্যন্ত কি ধরনের দুর্যোগের সম্মুখীন হয়েছেন?

দুর্যোগের নামসমূহ	1991-2018																												
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Flash Flood (আকস্মিক বন্যা)														✓												✓	✓	
Seasonal Flood (মৌসুমী বন্যা)															✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Cyclone (ঘূর্ণিঝড়)																												
Wave Action (আফাল)														✓												✓	✓	
Heavy Rainfall (ভারী বৃষ্টিপাত)																												
Drought (খরা)																												
Erosion (ভূমিক্ষয়)																												

১৮. এলাকায় ১৯৯১-২০১৮ পর্যন্ত সংঘটিত কোন দুর্যোগসমূহের ব্যাপকতা- নিরূপন

সাল	আকস্মিক বন্যা	মৌসুমী বন্যা	ঘূর্ণিঝড়	আফাল /ঢেউ	ভারী বৃষ্টিপাত	খরা	ভূমিক্ষয়
১৯৯১							
১৯৯২							
১৯৯৩							

[2] *কোড: 1. অনেকবেশী যা পরিমাপযোগ্য নয় ২. অনেকবেশী কিন্তু পরিমাপযোগ্য ৩. পরিমাপযোগ্য এবং ক্ষতির পরিমাণ কম ৪. ক্ষতির পরিমাণ সহনীয় ৫. নেই বললেই চলে ৬. কোন প্রভাব নেই

সাল	আকস্মিক বন্যা	মৌসুমী বন্যা	ঘূর্ণিঝড়	আফাল /ঢেউ	ভারী বৃষ্টিপাত	খরা	ভূমিক্ষয়
১৯৯৪							
১৯৯৫							
১৯৯৬							
১৯৯৭							
১৯৯৮							
১৯৯৯							
২০০০							
২০০১							
২০০২							
২০০৩							
২০০৪	২			২			
২০০৫		৬					
২০০৬		৬					
২০০৭		৬					
২০০৮		৬					
২০০৯		৬					
২০১০		৬					
২০১১		৬					
২০১২		৬					
২০১৩		৬					
২০১৪		৬					
২০১৫		৬					
২০১৬	২			৬			
২০১৭	২			২			
২০১৮		৬					

১৯. আপনি প্রতি বছর সাধারণত কি বিপদের মুখোমুখীন হোন?
ক) আকস্মিক বন্যা (খ) মৌসুমী বন্যা গ) শিলাবৃষ্টি ঘ) ঠান্ডা আবহাওয়া ঙ) ঢেউয়ের কারনে ভাংগন চ) আফাল (AFAL) ছ) অন্যান্য

২০. আপনার বসতবাড়ী/ফসলী জমি কি বাঁধ দ্বারা সুরক্ষিত?
(১) হ্যাঁ ২. না

২১. আপনি কি গ্রাম প্রতিরক্ষা/কার্যক্রম দ্বারা উপকৃত হয়েছেন?
১. হ্যাঁ (২) না

২২. আপনি জলবায়ু পরিবর্তন সংক্রান্ত বা বিপর্যয়ের হ্রাস, ইত্যাদির জন্য কোন প্রশিক্ষণ পেয়েছেন?
১. হ্যাঁ (২) না

২৩. আপনি কি ২০১৬, ২০১৭ সনে বন্যা পূর্বাভাস এর তথ্য পেয়েছেন বা পেয়ে উপকৃত হয়েছেন?

১. হ্যাঁ (২) না

কোন দুর্যোগের কারনে আপনার ক্ষতি বেশী হয়েছে বলে আপনি মনে করেন? সালের ও নামসহ উল্লেখ করুনঃ

ক্রমিক নং	দুর্যোগের নাম	সাল	ক্ষতির পরিমান (শতকরায়)			
০১.			কৃষি	মৎস্য	প্রাণীসম্পদ	অন্যান্য
০২.	আকস্মিক বন্যা	২০২৭	৭০০%	—	৪০%	২০%
০৩.						
০৪.						
০৫.						
০৬.						
০৭.						

২৪. দুর্যোগের কারনে খানার অন্যান্য সম্পত্তির ক্ষতির পরিমাণ সংখ্যায় উল্লেখ করুন (একাধিক উত্তর হতে পারে)ঃ

দুর্যোগের নাম	সাল	সম্পত্তির ধরন	সর্বমোট আনুমানিক মূল্য
আকস্মিক বন্যা	২০২৭	ফসল	২০০০০৳=
		গবাদিপশু	৪০,০০০৳=
		ঘরবাড়ি	২০,০০০৳=
		অন্যান্য .....(নির্দিষ্ট করুন)	

পেশার নাম	গ্রীষ্ম				বর্ষা				শীত			
	মার্চ	এপ্রিল	মে	জুন	জুলাই	আগস্ট	সেপ্টেম্বর	অক্টোবর	নভেম্বর	ডিসেম্বর	জানুয়ারী	ফেব্রুয়ারী
কৃষি	✓	✓								✓	✓	✓
মৎস্যশিকার												
দিনমজুর				✓	✓	✓	✓	✓				
ব্যবসা												
রিক্সাচালনা												
অন্যান্য (উল্লেখ করুন)												

৩৩. আকস্মিক বন্যার দুর্যোগের পূর্বেই ফসল কাটা যায় এ ধরণের প্রচলিত/স্থানীয় উন্নত জাত এলআইভি/উচ্চ ফলনশীল জাত এইচওয়াইভি ইত্যাদি ধানের জাত আছে কি? আকস্মিক বন্যা সহনশীল, ঠান্ডা আবহাওয়া সহনশীল ধানের জাত সম্পর্কে আপনার জানা আছে কি? ১ হ্যাঁ ২ না উত্তর হ্যাঁ হলে ঃ

ক্র. নং	মৌসুম	জাতের নাম	সহনশীলতার ধরণ	রোপণ সময়	কাটার সময়	বীজ প্রাপ্যতা	উৎপাদন কেজি/বিঘায়

৩৪. দুর্যোগের কারনে কোন কোন সময়ে আপনার আয় কমেছে ? সাল সহ উল্লেখ করুন।

2008 2016 2019

৩৫. আয় কমে যাওয়ার কারনে তা আপনার পারিবারিক কি ধরনের প্রভাব ফেলেছে?

আর্থিক অনটন দেখা দিয়েছিল

৩৬. এই ব্যয় নির্বাহের জন্য আপনি কোন কোন পন্থা অবলম্বন করেছিলেন? উল্লেখ করুন।

পোষা পরিবর্তন করতে হয়েছিল
জমি বিক্রি করা হয়েছিল

৩৭. আপনার আর্থিক সক্ষমতা বাড়ানোর জন্য দুর্যোগকালীন সময়ে কোন কোন সুবিধা কাজ করেছিল ?

ব্যাংক, আত্মীয়, আত্মীয় স্বজন, ঋণ দেওয়া

৩৮. এই সকল সংস্থাগুলো কোন কোন পদক্ষেপ গ্রহণ করেছিল? উল্লেখ করুন

১. ঋণ বিতরণ, ২. নগদ অর্থ বিতরণ ৩. খাদ্য বিতরণ কর্মসূচী
৪. খাদ্য ও টাকা বিতরণ

৩৯. নিয়মিত ফসল ক্যালেন্ডার উল্লেখ করুন?

ফসলের নাম	গ্রীষ্ম				বর্ষা				শীত			
	মার্চ	এপ্রিল	মে	জুন	জুলাই	আগস্ট	সেপ্টেম্বর	অক্টোবর	নভেম্বর	ডিসেম্বর	জানুয়ারী	ফেব্রুয়ারী
বিভিন্ন	✓	✓								✓	✓	✓

৪০. নিয়মিত মাছের ক্যালেন্ডার উল্লেখ করুন? N/A

মৎস্যের উৎস	গ্রীষ্ম				বর্ষা				শীত			
	মার্চ	এপ্রিল	মে	জুন	জুলাই	আগস্ট	সেপ্টেম্বর	অক্টোবর	নভেম্বর	ডিসেম্বর	জানুয়ারী	ফেব্রুয়ারী

৪১. দুর্যোগ পরবর্তী সময়ে ফসল ক্যালেন্ডার উল্লেখ করুন? N/A

দুর্যোগের নাম	ফসলের নাম	গ্রীষ্ম				বর্ষা				শীত			
		মার্চ	এপ্রিল	মে	জুন	জুলাই	আগস্ট	সেপ্টেম্বর	অক্টোবর	নভেম্বর	ডিসেম্বর	জানুয়ারী	ফেব্রুয়ারী

৪২. দুর্যোগ পরবর্তী সময়ে মাছের ক্যালেন্ডার উল্লেখ করুন? N/A

দুর্যোগের নাম	মৎস্যের উৎস	গ্রীষ্ম				বর্ষা				শীত			
		মার্চ	এপ্রিল	মে	জুন	জুলাই	আগস্ট	সেপ্টেম্বর	অক্টোবর	নভেম্বর	ডিসেম্বর	জানুয়ারী	ফেব্রুয়ারী

৪৩. ফসলের এবং মৎস্যের ক্ষতি এড়ানোর জন্য সরকারী এবং বেসরকারী পর্যায়ে কি ধরনের পদক্ষেপ গ্রহন করা হয়েছিল ? উল্লেখ করুন

হাওড় রক্ষা বাঁধ নির্মান করা হয়েছে

৪৪. কৃষি উৎপাদন বাড়ানোর জন্য কি কি ধরনের বীজ সরবরাহ করা হয়েছিল ?

না

৪৫. দুর্যোগকালীন সময়ে মহিলারা কি কি ধরনের সমস্যার সম্মুখীন হয়ে থাকেন?

১. .....২. .....৩. .....৪. .....

২. রান্না করার সমস্যা দেখা দেয়
২. ছোট বাচ্চাদের নিয়ে সমস্যায় পড়েন
৩. চলাচলের সমস্যা হয়

দুর্যোগকালীন	দুর্যোগ পরবর্তী
নৌকা	পায়ে হেটে
ভেলা	

৫৪. ঐতিহ্যগতভাবে প্রচলিত রাস্তা/বাঁধের ঢাল রক্ষার পদ্ধতি সম্পর্কে আপনি জানেন কি? ১. হ্যাঁ ২. না (উত্তর হ্যাঁ হলে কোনটি)

১. ভটিবার রোপণের মাধ্যমে
২. ঢাল কলমি রোপণের মাধ্যমে
৩. অন্যান্য ঘাস রোপণ/বপনের মাধ্যমে
৪. অন্যান্য গাছ রোপণের মাধ্যমে

৫৫. আকস্মিক বন্যার ফলে দুর্যোগ মোকাবেলায় কার্যকরী পূর্বাভাস কি ভাবে দূর্গত এলাকার জনগণের কাছে পৌছনো যায়?

১. মাইক মোগে প্রচার
২. রেডিও টেলিভিশনের মাধ্যমে

৫৬. হাওড় এলাকার জনগণকে আকস্মিক/ফ্লাসফ্লাড এর প্রভাব থেকে রক্ষা করার জন্য কি করা যেতে পারে বলে আপনি মনে করেন?

১. রেডিয়াম নিশ্চিত করা
২. নদী ও সরু খনন করা

৫৭. আপনারা স্থানীয় পর্যায়ে দুর্যোগ ঝুকি মোকাবিলা এবং অভিযোজনের কি কি পদ্ধতি অনুসরণ করে থাকেন?

১. চলতি ভিটার পাশে মাটি দিয়ে উচু করা

৫৮. আপনারা স্থানীয় পর্যায়ে দুর্যোগ ঝুকি মোকাবিলা এবং অভিযোজনের পদ্ধতি গুলোর সুবিধাসমূহ কি কি? (কৃষি ও মৎস্য ভিত্তিক)

১. চলতি ভিটার পাশে বেশি হয়।

৫৯. আপনার মতে, আপনারা স্থানীয় পর্যায়ে দুর্যোগ ঝুকি মোকাবিলা এবং অভিযোজনের পদ্ধতি গুলোর চিরস্থায়ী করার জন্য সুপারিশগুলো কি কি? (কৃষি ও মৎস্য ভিত্তিক)

৪৬. দুর্যোগকালীন সময়ে মহিলারা কি কি ধরনের কাজ করে এসকল সমস্যার মোকাবিলা করে থাকে?

১. নারকেল আহরণ ও রান্না করে খাওয়া হয়।
২. কর্মসংস্থান হারিয়ে বাড়িতে সময় কাটান।

৪৭. অতীত থেকে বর্তমান সময় পর্যন্ত বাড়িতে খাবার পানির উৎস কি?

১। টিউবওয়েল ২। কুয়া/ইন্দিরা ৩। পুকুর/ডোবা
৪। নদী ৫। খাল/বিল ৬। অন্যান্য (নির্দিষ্ট করুণ).....

৪৮. দুর্যোগকালীন সময়ে কোন কোন উৎস থেকে খাওয়ার পানি সংগ্রহ করতেন ? উল্লেখ করুন।

নলকূপ

৪৯. কোন কোন দুর্যোগের সময় খাওয়ার পানির সংকট সবচেয়ে বেশী হয়েছিল ? সাল ও দুর্যোগের নামসহ উল্লেখ করুন।

2008 2019

৫০. দুর্যোগকালীন সময়ে কোন কোন রোগের প্রার্দুভাব বেশী হয়েছিল ? উল্লেখ করুন।

ডায়রিয়া, জন্ডিস, টাইফয়েড

৫১. বাড়িতে বিদ্যুৎ ব্যবস্থা ক্ষতিগ্রস্থ কোন সময়ে বেশী হয়েছিল? উল্লেখ করুন।

2008

৫২. দুর্যোগকালীন সময়ে পয়নিষ্কাশন ব্যবস্থায় কি কি সমস্যা দেখা দেয়? উল্লেখ করুন।

পায়খানা হতে সংক্রামক রোগের ছড়ানোর সম্ভাবনা বেশী হয়।

৫৩. দুর্যোগকালীন ও দুর্যোগ পরবর্তী সময়ে যাতায়াত ও যোগাযোগের মাধ্যমগুলো কি কি? উল্লেখ করুন।

২. বাড়িঘর নির্মান করতে হবে।

২. নদী ও খাল খনন করতে হবে।

(দয়া করে তথ্য সংগ্রহকালীন ছবি সংযুক্ত করুন)

বিভিন্ন দুর্যোগ মোকাবেলায় নির্মিত বিভিন্ন অবকাঠামো গুলো কৃষি ক্ষেত্রে কেমন ভুমিকা রাখে?

১. হাওড় কৃষকদের চাষ যুলো হটাৎ পানি আসায় ফসলের দাম যুলোকে কৃষা করে।
২. কৃষি ভিত্তিক আয় বেড়েছে।

অবকাঠামো নির্মাণ এর ফলে আপনরা কতটুকু উপক্রিত হয়েছেন?

আমরা অনেক উপকৃত হয়েছি

নির্মিত অবকাঠামো গুলো কি সঠিক ভাবে ক্রিয়াশীল রয়েছে?

হ্যাঁ।

সকল অবকাঠামোর সঠিক সময়ে মেরামত করা হয় কিনা? উত্তর না হলে মেরামত না হওয়ায় কি কি ক্ষতির সম্মুখীন হয়েছেন?

হ্যাঁ।

আপ্নাদের যদি কোন মতামত অবকাঠামো এর বেপারে থেকে থাকে?

১. বেড়িবাধের দুইপাশা পাকা ব্লক দিলে ভালো হত
২. বেড়ি বাধ আরও উচু করে দিতে হবে।
৩.

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Action Research on Climate Change Forecasting & Participatory Scenario Development and Assessment of the Agriculture & Fisheries Sectors, Exposure to Climate Risk

CEGIS

খানা জরিপ প্রশ্নপত্র

কেস নং				
তারিখ	২২	০৩	২০২১	
সাক্ষাৎকার গ্রহণের স্থান	ঝিনাইগাতী বাজার		জি পি এস	Lat 25.09215 Long 90.29454

বিভাগঃ ময়মনসিংহ

জেলাঃ শেরপুর

উপজেলাঃ ঝিনাইগাতী

ইউনিয়ন পরিষদের নামঃ ঝিনাইগাতী

গ্রামঃ বাঘানগর

পাড়াঃ

ওয়ার্ড নংঃ ০৬

বাড়ী নং (যদি থাকে)

সাক্ষাৎকার গ্রহণকারীর নামঃ মোঃ এনামুল কবির

স্বাক্ষরঃ

সুপারভাইজার/কোয়ালিটি কন্ট্রোল অফিসারের নামঃ

স্বাক্ষরঃ

তারিখঃ

ভূমিকা ও সম্মতিঃ

আস্সালামু আলাইকুম। সম্প্রতি বাংলাদেশ সরকারের স্থানীয় সরকার ও প্রকৌশল অধিদপ্তর জলবায়ু পরিবর্তনের কারনে হাওড় অঞ্চলের মানুষের স্বাভাবিক অবস্থা ধরে রাখার জন্য HILIP প্রকল্পের আওতায় *"Action Research on Climate Change Forecasting and Participatory Scenario Development and Assessment of the Agriculture and Fisheries Sectors, Exposure to Climate Risk"* নামে একটি গবেষনা পরিচালনা করছে। এই গবেষনার উদ্দেশ্য হল হাওড় অঞ্চলের জলবায়ু পরিবর্তনের জন্য সৃষ্ট ঝুঁকি ও প্রভাব সম্পর্কে জনসচেতনতা তৈরী ,এই সকল ঝুঁকি মোকাবিলা এবং ভবিষ্যতে জলবায়ু পরিবর্তনশীলতার অভিযোজনের উপায়সমূহ চিহ্নিত করা। এই কাজের অংশহিসেবে আপনাদের বর্তমান আর্থ-সামাজিক অবস্থা, জলবায়ু পরিবর্তনের অবস্থা, ঝুকি এবং অভিযোজনের সম্পর্কে জানবো, এবং আপনাদের দেয়া তথ্যের ভিত্তিতে পরবর্তীতে জলবায়ু পরিবর্তনের কারনে হাওড় অঞ্চলের মানুষের কৃষি এবং মৎস্যভিত্তিক জীবিকা টিকিয়ে রাখা এবং এর সার্বিক ব্যবস্থাপনার জন্য কি কি ব্যবস্থা গ্রহণ করা যায় তা বোঝার চেষ্টা করবো। আপনার মতামত শুধুমাত্র গবেষণার কাজে ব্যবহৃত হবে, এবং আপনার প্রদত্ত তথ্যের এর গোপনীয়তা নিশ্চিত থাকবে। আপনি অনুমতি দিলে আমি সাক্ষাৎকার গ্রহণ শুরু করতে পারি।

১. উত্তরদাতা/উত্তরদাত্রীরনামঃ আবুসুফিয়ান মিয়া মোবাইলঃ 01926096026

২. বয়সঃ ৫০ বছর (পূর্ণ বছরে)

৩. শিক্ষাগত যোগ্যতাঃ উচ্চ (সর্বোচ্চ যে শ্রেণী পাস করেছে)

৪. বৈবাহিক অবস্থাঃ ১. বিবাহিত ২. অবিবাহিত ৩. বিধবা ৪. আলাদা/পরিত্যক্তা ৫. তালাকপ্রাপ্তা

৫. উত্তরদাতা/ উত্তরদাত্রীর পারিবারিক অবস্থানঃ
১. খানা প্রধান ২. খানা প্রধান নন

৬. খানার মোট সদস্য সংখ্যাঃ ক. মোট ৪ জন খ. পুরুষ. ২ গ. মহিলাঃ ৬ জন ঘ. শিশু .....

৭. বর্তমানে খানার কতজন স্কুল/কলেজ/ বিশ্ববিদ্যালয়ে যায় উল্লেখ করুন ।
২

৮. খানার প্রধান পেশা কি[১]? ৪

৯. আপনার মোট মাসিক আয় কত (প্রধান)? ঃ ৬০০০/=

১০. আপনি এই পেশা ছাড়া আর অন্য কোন আয়মূলক পেশায় নিয়োজিত আছেন কিনা?
১. হ্যাঁ ২. না

১১. এই আয়মূলক পেশা থেকে আপনার মোট মাসিক আয় কত? ঃ ২০০০/=

১২. বছরে কত মাস আপনি এই কাজে নিয়োজিত থাকেন? ২২ মাস

১৩. এই পেশা (অপ্রধান) থেকে আপনার মোট মাসিক আয় কত? ঃ ২০০০/=

[১] *কোড: ১. গৃহিনী ২. মাঝি/জেলে ৩. ভিক্ষাবৃত্তি ৪. কৃষি ৫.সরকারী চাকুরী/প্রাইভেট চাকুরী ৬. বাসাবাড়িতে কাজ করে ৭. NGO প্রকল্পে কাজ করে ৮. বড়/মাঝারী ব্যবসায়ী ৯. ছাত্র ১০. দিনমজুর ১১. ক্ষুদ্র ব্যবসায়ী/ফড়িয়া ১৪. হস্ত শিল্প, সেলাই, কারিগর, কাঠমিস্ত্রি, রাজমিস্ত্রি সহ অন্যান্য স্ব-নিয়োজিত কর্ম ১৫. গবাদী/হাঁস-মুরগী পালন ১৬. অটো ড্রাইভার ১৭. বিদেশে চাকুরী/অন্য কোন কাজে নিয়োজিত ১৮. অন্যান্য (নির্দিষ্ট করুন).

১৪. খানার মোট মাসিক আয় (নেট আয়) ও সঞ্চয় ঃ

ক. আয়	খ. ব্যয়	গ. সঞ্চয়
টাকা= ২৫০০০/=	টাকা= ২৪০০০/=	টাকা= ২০০০/=

১৫. বসত বাড়ির আঙিনায় পুকুরের হিসাব ঃ N/A

পুকুরের সংখ্যা	পুকুরের জন্য ব্যবহৃত জমির পরিমাণ (শতাংশে)

১৬. খানার জ্বালানীর উৎসগুলো কি কি?

ক) লাকড়ি খ) সিলিন্ডার গ্যাস গ) কেরোসিন ঘ) অন্যান্য (নির্দিষ্ট করুন)..... .

১৭. আপনার এলাকায় ১৯৯১-২০১৮ পর্যন্ত কি ধরনের দুর্যোগের সম্মুখীন হয়েছেন?

দুর্যোগের নামসমূহ	1991-2018																										
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Flash Flood (আকস্মিক বন্যা)														✓												✓	✓	
Seasonal Flood (মৌসুমী বন্যা)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Cyclone (ঘূর্ণিঝড়)																							✓					
Wave Action (আফাল)														✓												✓	✓	
Heavy Rainfall (ভারী বৃষ্টিপাত)																												
Drought (খরা)																												
Erosion (ভূমিক্ষয়)																												

১৮. এলাকায় ১৯৯১-২০১৮ পর্যন্ত সংঘটিত কোন দুর্যোগসমূহের ব্যাপকতা[2] নিরূপন

সাল	আকস্মিক বন্যা	মৌসুমী বন্যা	ঘূর্ণিঝড়	আফাল /ঢেউ	ভারী বৃষ্টিপাত	খরা	ভূমিক্ষয়
১৯৯১		৩					
১৯৯২		৩					
১৯৯৩		৩					

[2] *কোড: ১. অনেকবেশী যা পরিমাপযোগ্য নয় ২. অনেকবেশী কিন্তু পরিমাপযোগ্য ৩. পরিমাপযোগ্য এবং ক্ষতির পরিমাণ কম ৪. ক্ষতির পরিমাণ সহনীয় ৫. নেই বললেই চলে ৬. কোন প্রভাব নেই

সাল	আকস্মিক বন্যা	মৌসুমী বন্যা	ঘূর্ণিঝড়	আফাল /ঢেউ	ভারী বৃষ্টিপাত	খরা	ভূমিক্ষয়
১৯৯৪		৩					
১৯৯৫		৩					
১৯৯৬		৩					
১৯৯৭		৩					
১৯৯৮		৩					
১৯৯৯		৩					
২০০০		৩					
২০০১		৩					
২০০২		৩					
২০০৩		৩					
২০০৪	২	৩		৩			
২০০৫		৩					
২০০৬		৩					
২০০৭		৩					
২০০৮		৩					
২০০৯		৩					
২০১০		৩					
২০১১		৩					
২০১২		৩					
২০১৩		৩	২				
২০১৪		৩					
২০১৫		৩					
২০১৬	২	৩		৩			
২০১৭	২	৩		৩			
২০১৮		৩					

১৯. আপনি প্রতি বছর সাধারণত কি বিপদের মুখোমুখীন হোন?
ক) আকস্মিক বন্যা (খ) মৌসুমী বন্যা গ) শিলাবৃষ্টি ঘ) ঠান্ডা আবহাওয়া ঙ) ঢেউয়ের কারনে ভাংগন চ) আফাল (AFAL) ছ) অন্যান্য

২০. আপনার বসতবাড়ী/ফসলী জমি কি বাঁধ দ্বারা সুরক্ষিত?
(১. হ্যাঁ) ২. না

২১. আপনি কি গ্রাম প্রতিরক্ষা/কার্যক্রম দ্বারা উপকৃত হয়েছেন?
১. হ্যাঁ (২. না)

২২. আপনি জলবায়ু পরিবর্তন সংক্রান্ত বা বিপর্যয়ের হ্রাস, ইত্যাদির জন্য কোন প্রশিক্ষণ পেয়েছেন?
১. হ্যাঁ (২. না)

২৩. আপনি কি ২০১৬, ২০১৭ সনে বন্যা পূর্বাভাস এর তথ্য পেয়েছেন বা পেয়ে উপকৃত হয়েছেন?

১. হ্যাঁ (২. না)

কোন দুর্যোগের কারনে আপনার ক্ষতি বেশী হয়েছে বলে আপনি মনে করেন? সালের ও নামসহ উল্লেখ করুনঃ

ক্রমিক নং	দুর্যোগের নাম	সাল	ক্ষতির পরিমান (শতকরায়)			
			কৃষি	মৎস্য	প্রাণীসম্পদ	অন্যান্য
০১.						
০২.	আকস্মিক বন্যা	২০২৯	২৫%	–	৩০%	২০%
০৩.	ঘূর্ণিঝড়	২০২৬	–	–	২০%	৩০%
০৪.						
০৫.						
০৬.						
০৭.						

২৪. দুর্যোগের কারনে খানার অস্থাবর সম্পত্তির ক্ষতির পরিমাণ সংখ্যায় উল্লেখ করুন (একাধিক উত্তর হতে পারে)ঃ

দুর্যোগের নাম	সাল	সম্পত্তির ধরন	সর্বমোট আনুমানিক মূল্য
আকস্মিক বন্যা	২০২৯	ফসল	৬০,০০০/=
		গবাদিপশু	৩০,০০০/=
		ঘরবাড়ি	২০,০০০/=
		অন্যান্য .....(নির্দিষ্ট করুন)	
ঘূর্ণিঝড়	২০২৬	ঘরবাড়ি	৮০০০/=
		চাষের যন্ত্রপাতি	২০,০০০/=

২৫. কোন সময়ে কোন দুর্যোগের কারনে বসত বাড়ির গাছপালা বেশী ক্ষতিগ্রস্থ হয়েছিল বলে আপনি মনে করেন?

২০২৬ - ঘূর্ণিঝড় ২০০৪, ২০২৯ - আকস্মিকবন্যা

২৬. বর্ষাকালে আপনার খানার জ্বালানীর উৎসসমূহ উল্লেখ করুন।

১. বাজার থেকে কিনতে হয়।

2. আত্মীয় স্বজনের বাড়ি থেকে আনতে হয়

২৭. দুর্যোগকালীন সময়ে জ্বালানী পেতে কি ধরনের সমস্যা হয় এবং কিভাবে জ্বালানী সংগ্রহ করা হয় ? উল্লেখ করুন।

১. উচু মুল্যে কাঠ/বাজার থেকে ক্রয় করতে হয়

২৮. দুর্যোগকালীন সময়ে গবাদিপশু কোথায় রাখা হয় বাড়ীর উচুস্থান

২৯. দুর্যোগকালীন সময়ে গবাদিপশু খাবারের উৎসসমূহ উল্লেখ করুন ১. বাড়ী-খড়ও কুড়াচ্ছড়।

৩০. দুর্যোগের কারনে আপনাকে কতবার পেশা পরিবর্তন করতে হয়েছে ?

২ বার

৩১. আপনার প্রধান পেশা ব্যতিরেকে আপনি পরবর্তিতে কোন কোন পেশায় নিয়োজিত হয়েছিলেন

শ্রমিক, চাষাবাদ

৩২. প্রচলিত পেশাগত ক্যালেন্ডার উল্লেখ করুনঃ

পেশার নাম	গ্রীষ্ম				বর্ষা				শীত			
	মার্চ	এপ্রিল	মে	জুন	জুলাই	আগস্ট	সেপ্টেম্বর	অক্টোবর	নভেম্বর	ডিসেম্বর	জানুয়ারী	ফেব্রুয়ারী
কৃষি	✓	✓								✓	✓	✓
মৎস্যশিকার												
দিনমজুর												
ব্যবসা ক্ষুদ্র	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
রিক্সাচালনা												
অন্যান্য (উল্লেখ করুন)												

৩৩. আকস্মিক বন্যার দুর্যোগের পূর্বেই ফসল কাটা যায় এ ধরণের প্রচলিত/স্থানীয় উন্নত জাত এলআইভি/উচ্চ ফলনশীল জাত এইচওয়াইভি ইত্যাদি ধানের জাত আছে কি? আকস্মিক বন্যা সহনশীল, ঠান্ডা আবহাওয়া সহনশীল ধানের জাত সম্পর্কে আপনার জানা আছে কি? ১ হ্যাঁ (২. না) উত্তর হ্যাঁ হলে ঃ

ক্র. নং	মৌসুম	জাতের নাম	সহনশীলতার ধরণ	রোপণ সময়	কাটার সময়	বীজ প্রাপ্যতা	উৎপাদন কেজি/বিঘায়

৩৪. দুর্যোগের কারনে কোন কোন সময়ে আপনার আয় কমেছে ? সাল সহ উল্লেখ করুন।
২০০৪, ২০১৬, ২০২৯

৩৫. আয় কমে যাওয়ার কারনে তা আপনার পারিবারিক কি ধরনের প্রভাব ফেলেছে?
১. অর্থনৈতিক সংকট দেখা দিয়েছিল

৩৬. এই ব্যয় নির্বাহের জন্য আপনি কোন কোন পন্থা অবলম্বন করেছিলেন? উল্লেখ করুন।
১. ঋণ করে চলতে হয়েছিল
২. খরচ নিয়ন্ত্রণ করা

৩৭. আপনার আর্থিক সক্ষমতা বাড়ানোর জন্য দুর্যোগকালীন সময়ে কোন কোন সংস্থা কাজ করেছিল ?

ব্রাক, আশা, কেয়ার, সমকাী

৩৮. এই সকল সংস্থাগুলো কোন কোন পদক্ষেপ গ্রহণ করেছিল? উল্লেখ করুন

১. ঋন বিতরন ২. অর্থনৈতিক কর্মসূচী

৩. ঘর তৈরি বিতরন

৩৯. নিয়মিত ফসল ক্যালেন্ডার উল্লেখ করুন?

ফসলের নাম	গ্রীষ্ম				বর্ষা				শীত			
	মার্চ	এপ্রিল	মে	জুন	জুলাই	আগস্ট	সেপ্টেম্বর	অক্টোবর	নভেম্বর	ডিসেম্বর	জানুয়ারী	ফেব্রুয়ারী
বি-২৮	✓	✓								✓	✓	✓
বি-২৯	✓	✓								✓	✓	✓

৪০. নিয়মিত মাছের ক্যালেন্ডার উল্লেখ করুন?

N/A

মৎস্যের উৎস	গ্রীষ্ম				বর্ষা				শীত			
	মার্চ	এপ্রিল	মে	জুন	জুলাই	আগস্ট	সেপ্টেম্বর	অক্টোবর	নভেম্বর	ডিসেম্বর	জানুয়ারী	ফেব্রুয়ারী

৪১. দুর্যোগ পরবর্তী সময়ে ফসল ক্যালেন্ডার উল্লেখ করুন?

N/A

দুর্যোগের নাম	ফসলের নাম	গ্রীষ্ম				বর্ষা				শীত			
		মার্চ	এপ্রিল	মে	জুন	জুলাই	আগস্ট	সেপ্টেম্বর	অক্টোবর	নভেম্বর	ডিসেম্বর	জানুয়ারী	ফেব্রুয়ারী

৪২. দুর্যোগ পরবর্তী সময়ে মাছের ক্যালেন্ডার উল্লেখ করুন?

N/A

দুর্যোগের নাম	মৎস্যের উৎস	গ্রীষ্ম				বর্ষা				শীত			
		মার্চ	এপ্রিল	মে	জুন	জুলাই	আগস্ট	সেপ্টেম্বর	অক্টোবর	নভেম্বর	ডিসেম্বর	জানুয়ারী	ফেব্রুয়ারী

৪৩. ফসলের এবং মৎস্যের ক্ষতি এড়ানোর জন্য সরকারী এবং বেসরকারী পর্যায়ে কি ধরনের পদক্ষেপ গ্রহন করা হয়েছিল ? উল্লেখ করুন

না

৪৪. কৃষি উৎপাদন বাড়ানোর জন্য কি কি ধরনের বীজ সরবরাহ করা হয়েছিল ?

না

৪৫. দুর্যোগকালীন সময়ে মহিলারা কি কি ধরনের সমস্যার সম্মুখীন হয়ে থাকেন?

১. .....২. .....৩. .....৪. .....

১. স্যানিটারি ন্যাপকিন নিয়ে সমস্যায় পড়তে হয়

২. অন্যান্য পুরুষ সদস্যদের কাছে বলতে সমস্যা হয়

৪৬. দুর্যোগকালীন সময়ে মহিলারা কি কি ধরনের কাজ করে এসকল সমস্যার মোকাবিলা করে থাকে ?

১. লাকড়ি, আগুন থেকে প্রস্তুত, ৪. রান্না করা হয়।
২. অন্যান্য পরিবার থেকে দিয়ে দূর থেকে রান্না আনা হয়।

৪৭. অতীত থেকে বর্তমান সময় পর্যন্ত বাড়িতে খাবার পানির উৎস কি?

১। টিউবওয়েল ২। কুয়া/ইন্দিরা ৩। পুকুর/ডোবা
৪। নদী ৫। খাল/বিল ৬। অন্যান্য (নির্দিষ্ট করুণ).....

৪৮. দুর্যোগকালীন সময়ে কোন কোন উৎস থেকে খাওয়ার পানি সংগ্রহ করতেন ? উল্লেখ করুন।

নলকূপ

৪৯. কোন কোন দুর্যোগের সময় খাওয়ার পানির সংকট সবচেয়ে বেশী হয়েছিল ? সাল ও দুর্যোগের নামসহ উল্লেখ করুন।

2008 2026 2029 = অসংক্রান্ত বন্যা

৫০. দুর্যোগকালীন সময়ে-কোন কোন রোগের প্রাদুর্ভাব বেশী হয়েছিল ? উল্লেখ করুন।

ডায়রিয়া, চর্মরোগ, জন্ডিস

৫১. বাড়িতে বিদ্যুৎ ব্যবস্থা ক্ষতিগ্রস্থ কোন সময়ে বেশী হয়েছিল? উল্লেখ করুন।

2008 সালে

৫২. দুর্যোগকালীন সময়ে পয়নিষ্কাশন ব্যবস্থায় কি কি সমস্যা দেখা দেয়? উল্লেখ করুন।

পয়ঃনালা পানিতে ডুবে যায়। মল
ডোবা খাল নালা ভরাট হয়ে যায়।

৫৩. দুর্যোগকালীন ও দুর্যোগ পরবর্তী সময়ে যাতায়াত ও যোগাযোগের মাধ্যমগুলো কি কি? উল্লেখ করুন।

দুর্যোগকালীন	দুর্যোগ পরবর্তী
নৌকা	হিউ এন ডি
হেঁটে	মটর সাইকেল
	অটো

৫৪. ঐতিহ্যগতভাবে প্রচলিত রাস্তা/বাঁধের ঢাল রক্ষার পদ্ধতি সম্পর্কে আপনি জানেন কি? ১. হ্যাঁ ২. না (উত্তর হ্যাঁ হলে কোনটি)

১. ভটিবার রোপণের মাধ্যমে
২. ঢালে কলমি রোপণের মাধ্যমে
৩. অন্যান্য ঘাস রোপণ/বপনের মাধ্যমে
৪. অন্যান্য গাছ রোপণের মাধ্যমে

৫৫. আকস্মিক বন্যার ফলে দুর্যোগ মোকাবেলায় কার্যকরী পূর্বাভাস কি ভাবে দূর্গত এলাকার জনগণের কাছে পৌছনো যায়?

১ মোবাইল ফোন সাহায্যে

৫৬. হাওড় এলাকার জনগণকে আকস্মিক/ফ্লাসফ্লাড এর প্রভাব থেকে রক্ষা করার জন্য কি করা যেতে পারে বলে আপনি মনে করেন?

১. বেড়ি বাধ নির্মান করতে হবে।
২. নদী ও খাল খনন করতে হবে।

৫৭. আপনারা স্থানীয় পর্যায়ে দুর্যোগ ঝুকি মোকাবিলা এবং অভিযোজনের কি কি পদ্ধতি অনুসরণ করে থাকেন?

১. বসত ভিটা উচু করে মাটি দিয়ে ভরাট করা হয়।

৫৮. আপনারা স্থানীয় পর্যায়ে দুর্যোগ ঝুকি মোকাবিলা এবং অভিযোজনের পদ্ধতি গুলোর সুবিধাসমূহ কি কি? (কৃষি ও মৎস্য ভিত্তিক)

১. বসত ভিটা উচু হওয়ায় সহজে রক্ষা পায়।

৫৯. আপনার মতে, আপনারা স্থানীয় পর্যায়ে দুর্যোগ ঝুকি মোকাবিলা এবং অভিযোজনের পদ্ধতি গুলোর চিরস্থায়ী করার জন্য সুপারিশগুলো কি কি? (কৃষি ও মৎস্য ভিত্তিক)

N/A

(দয়া করে তথ্য সংগ্রহকালীন ছবি সংযুক্ত করুন)

বিভিন্ন দুর্যোগ মোকাবেলায় নির্মিত বিভিন্ন অবকাঠামো গুলো কৃষি ক্ষেত্রে কেমন ভুমিকা রাখে?

১. প্রাথমিক পর্যায় হটাৎ বন্যা বে সময় আমরা ছোটা থেকে ফসলের শেষ কে সময়ের কমানো বন্যা বন্ধ হয়ে যাওয়া।
২. কৃষি উৎপাদনে বৃদ্ধি পেয়েছে।

অবকাঠামো নির্মাণ এর ফলে আপনরা কতটুকু উপক্রিত হয়েছেন?

আমরা অনেক উপকৃত হয়েছি

নির্মিত অবকাঠামো গুলো কি সঠিক ভাবে ক্রিয়াশীল রয়েছে?

হ্যাঁ।

সকল অবকাঠামোর সঠিক সময়ে মেরামত করা হয় কিনা? উত্তর না হলে মেরামত না হওয়ায় কি কি ক্ষতির সম্মুখীন হয়েছেন?

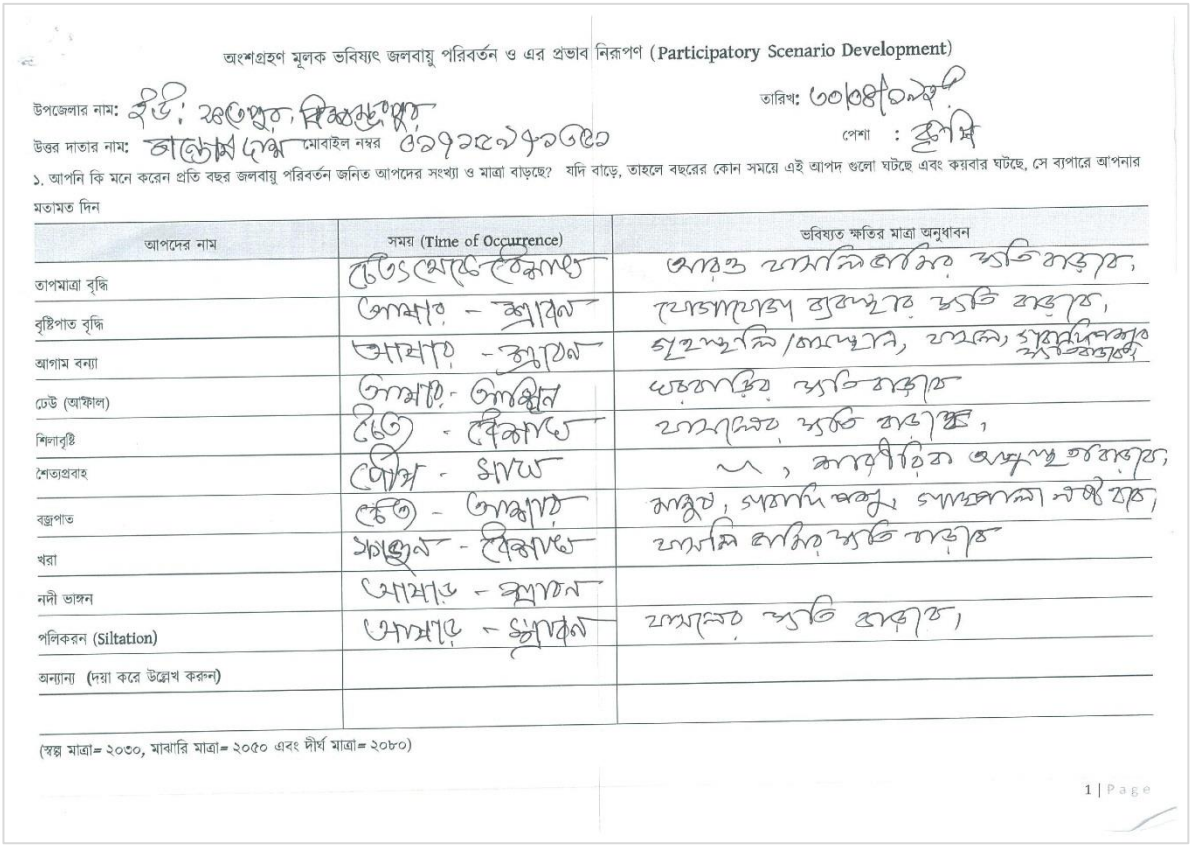
না

১. হটাৎ বন্যা ফসলের সাথে সাথে মাটি ধুয়ে যাওয়া নষ্ট হয়ে যায়।

আপনাদের যদি কোন মতামত অবকাঠামো এর বেপারে থেকে থাকে?

১. বাঁধ আরও উচু করে বেধে দিতে হবে,
২. বাঁধের দুই পাশ্বে পাকা ঘাট দিয়ে বেধে দিতে হবে,
৩. নিয়মিত রক্ষনাবেক্ষনের ব্যবস্থা করতে হবে

Participatory Scenario Development



অংশগ্রহণ মূলক ভবিষ্যৎ জলবায়ু পরিবর্তন ও এর প্রভাব নিরূপণ (Participatory Scenario Development)

উপজেলার নাম: ইউ: [illegible] তারিখ: [illegible]

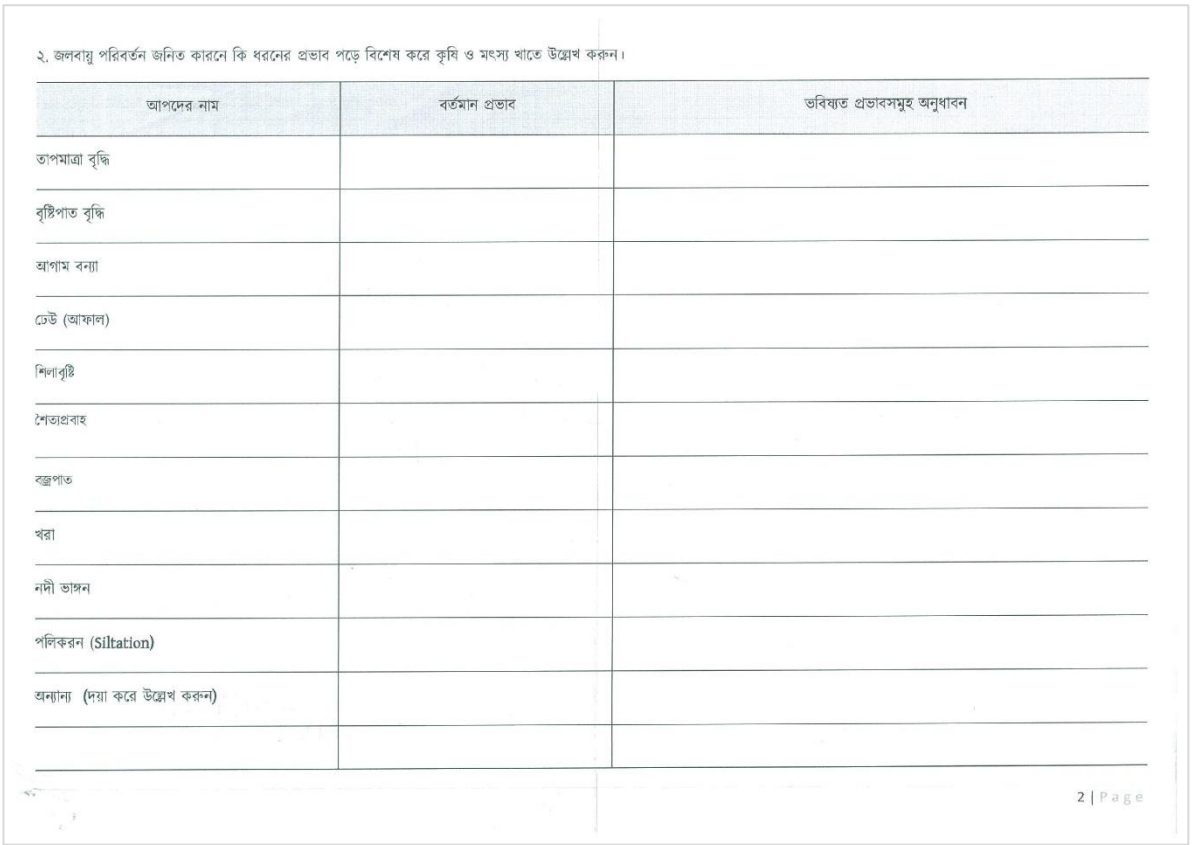
উত্তর দাতার নাম: [illegible] মোবাইল নম্বর [illegible] পেশা : কৃষি

১. আপনি কি মনে করেন প্রতি বছর জলবায়ু পরিবর্তন জনিত আপদের সংখ্যা ও মাত্রা বাড়ছে? যদি বাড়ে, তাহলে বছরের কোন সময়ে এই আপদ গুলো ঘটছে এবং কয়বার ঘটছে, সে ব্যপারে আপনার মতামত দিন

আপদের নাম	সময় (Time of Occurrence)	ভবিষ্যত ক্ষতির মাত্রা অনুধাবন
তাপমাত্রা বৃদ্ধি	[illegible]	[illegible]
বৃষ্টিপাত বৃদ্ধি	[illegible]	[illegible]
আগাম বন্যা	[illegible]	[illegible]
ঢেউ (আফাল)	[illegible]	[illegible]
শিলাবৃষ্টি	[illegible]	[illegible]
শৈত্যপ্রবাহ	[illegible]	[illegible]
বজ্রপাত	[illegible]	[illegible]
খরা	[illegible]	[illegible]
নদী ভাঙ্গন	[illegible]	[illegible]
পলিকরন (Siltation)	[illegible]	[illegible]
অন্যান্য (দয়া করে উল্লেখ করুন)		

(স্বল্প মাত্রা= ২০৩০, মাঝারি মাত্রা= ২০৫০ এবং দীর্ঘ মাত্রা= ২০৮০)

1 | Page



২. জলবায়ু পরিবর্তন জনিত কারনে কি ধরনের প্রভাব পড়ে বিশেষ করে কৃষি ও মৎস্য খাতে উল্লেখ করুন।

আপদের নাম	বর্তমান প্রভাব	ভবিষ্যত প্রভাবসমূহ অনুধাবন
তাপমাত্রা বৃদ্ধি		
বৃষ্টিপাত বৃদ্ধি		
আগাম বন্যা		
ঢেউ (আফাল)		
শিলাবৃষ্টি		
শৈত্যপ্রবাহ		
বজ্রপাত		
খরা		
নদী ভাঙ্গন		
পলিকরন (Siltation)		
অন্যান্য (দয়া করে উল্লেখ করুন)		

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৩. জলবায়ু পরিবর্তনের কারনে নেতিবাচক প্রভাবসমুহ বিশেষত কৃষি ও মৎস্য ক্ষেত্রে মোকাবিলা করার জন্য কি ধরনের অভিযোজন ব্যবস্থা গ্রহন করা হয়ে থাকে ? অগ্রাধিকার ভিত্তিক অভিযোজন ব্যবস্থা সমুহের র‍্যাংকিং করুন–

আপদের নাম	বর্তমান অভিযোজন ব্যবস্থা	স্বল্প মেয়াদী অভিযোজন ব্যবস্থা	মাঝারী মেয়াদী অভিযোজন ব্যবস্থা	দীর্ঘ মেয়াদী অভিযোজন ব্যবস্থা
তাপমাত্রা বৃদ্ধি	[illegible]			✓
বৃষ্টিপাত বৃদ্ধি	[illegible]			
আগাম বন্যা	[illegible]	✓		
ঢেউ (আফাল)	[illegible]	✓		
শিলাবৃষ্টি				
শৈত্যপ্রবাহ				
বজ্রপাত	[illegible]			✓
খরা	[illegible]	✓		
নদী ভাঙ্গন	[illegible]	✓		
পলিকরন (Siltation)				
অন্যান্য (দয়া করে উল্লেখ করুন)				

অংশগ্রহণ মূলক ভবিষ্যৎ জলবায়ু পরিবর্তন ও এর প্রভাব নিরূপণ (Participatory Scenario Development)

উপজেলার নাম: তারিখ:

উত্তর দাতার নাম: [illegible] মোবাইল নম্বর ০১৭১৩-৬৪২১৭২, ০১৭৭২০ ৪৪৭৭১ পেশা :

১. আপনি কি মনে করেন প্রতি বছর জলবায়ু পরিবর্তন জনিত আপদের সংখ্যা ও মাত্রা বাড়ছে? যদি বাড়ে, তাহলে বছরের কোন সময়ে এই আপদ গুলো ঘটছে এবং কয়বার ঘটছে, সে ব্যাপারে আপনার মতামত দিন

আপদের নাম	সময় (Time of Occurrence)	বর্তমান/ভবিষ্যত ক্ষতির মাত্রা অনুধাবন
তাপমাত্রা বৃদ্ধি	[illegible]	[illegible]
বৃষ্টিপাত বৃদ্ধি	[illegible]	[illegible]
আগাম বন্যা	[illegible]	[illegible]
ঢেউ (আফাল)	[illegible]	[illegible]
শিলাবৃষ্টি	[illegible]	[illegible]
শৈত্যপ্রবাহ	[illegible]	[illegible]
বজ্রপাত	[illegible]	[illegible]
খরা	[illegible]	[illegible]
নদী ভাঙ্গন		
পলিকরন (Siltation)	[illegible]	[illegible]
অন্যান্য (দয়া করে উল্লেখ করুন)		

(স্বল্প মাত্রা= ২০৩০, মাঝারি মাত্রা= ২০৫০ এবং দীর্ঘ মাত্রা= ২০৮০)

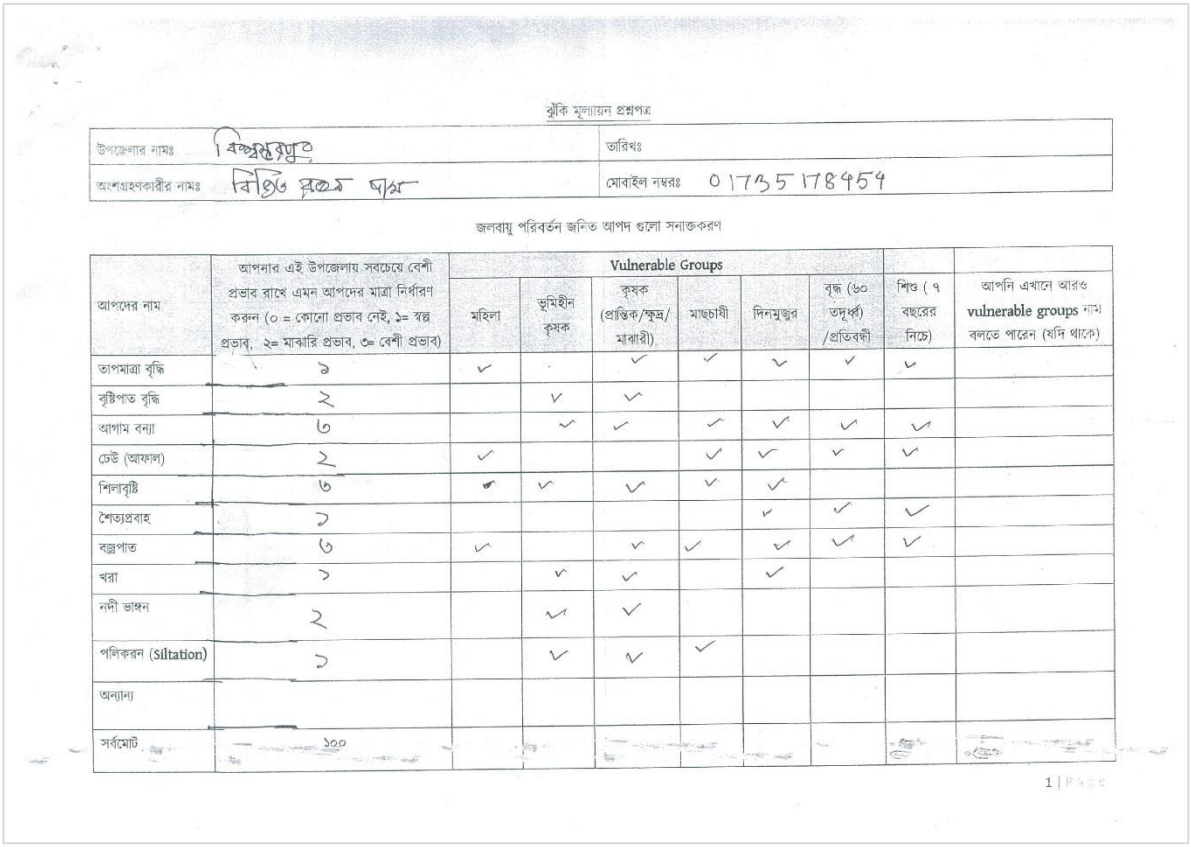
২. জলবায়ু পরিবর্তন জনিত কারনে কি ধরনের প্রভাব পড়ে বিশেষ করে কৃষি ও মৎস্য খাতে উল্লেখ করুন।

আপদের নাম	বর্তমান প্রভাব	ভবিষ্যত প্রভাবসমূহ অনুধাবন
তাপমাত্রা বৃদ্ধি		
বৃষ্টিপাত বৃদ্ধি		
আগাম বন্যা		
ঢেউ (আফাল)		
শিলাবৃষ্টি		
শৈত্যপ্রবাহ		
বজ্রপাত		
খরা		
নদী ভাঙ্গন		
পলিকরন (Siltation)		
অন্যান্য (দয়া করে উল্লেখ করুন)		

৩. জলবায়ু পরিবর্তনের কারনে নেতিবাচক প্রভাবসমূহ বিশেষত কৃষি ও মৎস্য ক্ষেত্রে মোকাবিলা করার জন্য কি ধরনের অভিযোজন ব্যবস্থা গ্রহন করা হয়ে থাকে ? অগ্রাধিকার ভিত্তিক অভিযোজন ব্যবস্থা সমূহের র্যাংকিং করুন–

আপদের নাম	বর্তমান অভিযোজন ব্যবস্থা	স্বল্প মেয়াদী অভিযোজন ব্যবস্থা	মাঝারী মেয়াদী অভিযোজন ব্যবস্থা	দীর্ঘ মেয়াদী অভিযোজন ব্যবস্থা
তাপমাত্রা বৃদ্ধি				
বৃষ্টিপাত বৃদ্ধি				
আগাম বন্যা	—			
ঢেউ (আফাল)				
শিলাবৃষ্টি	—			
শৈত্যপ্রবাহ	—			
বজ্রপাত	—			
খরা				
নদী ভাঙ্গন				
পলিকরন (Siltation)				
অন্যান্য (দয়া করে উল্লেখ করুন)				

Risk Assessment

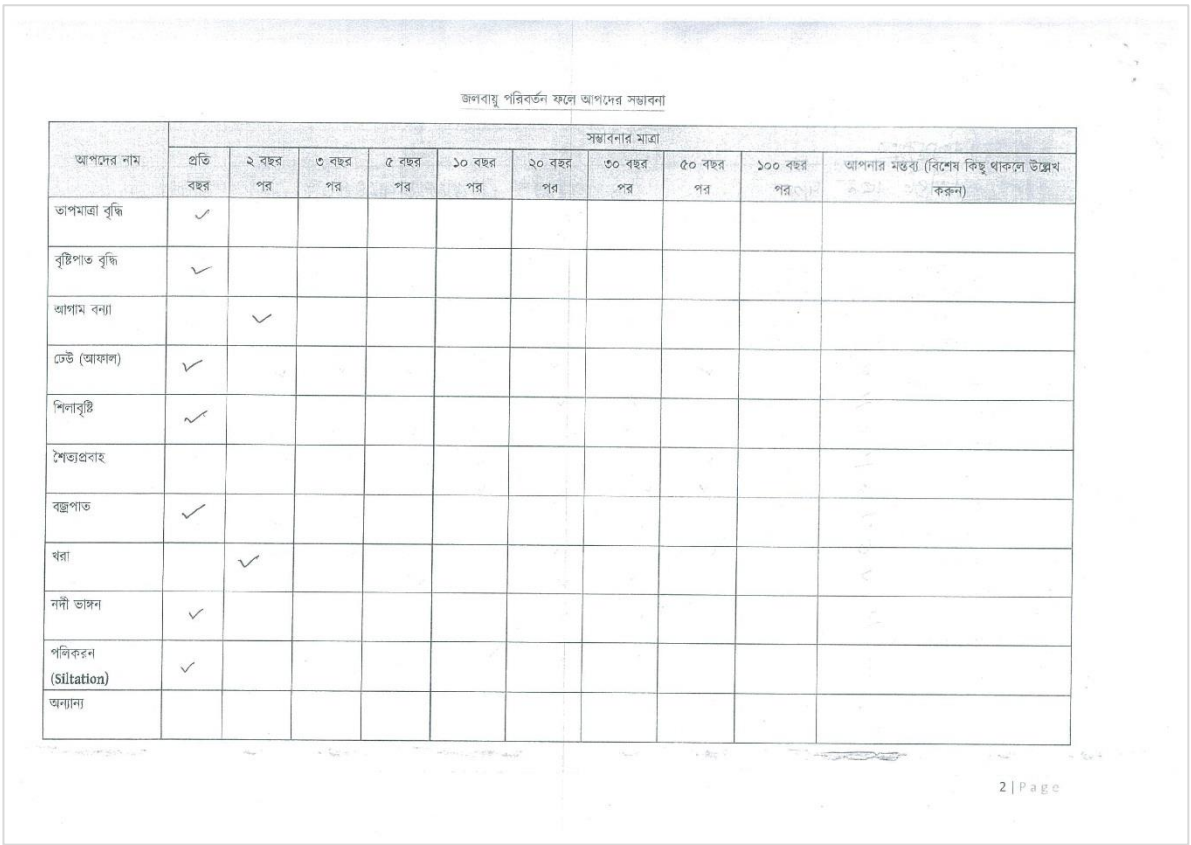


ঝুঁকি মূল্যায়ন প্রশ্নপত্র

উপজেলার নামঃ বিশ্বম্ভরপুর	তারিখঃ
অংশগ্রহণকারীর নামঃ বিপ্লব কুমার ঘোষ	মোবাইল নম্বরঃ ০১৭৩৫১৭৪৯৫৭

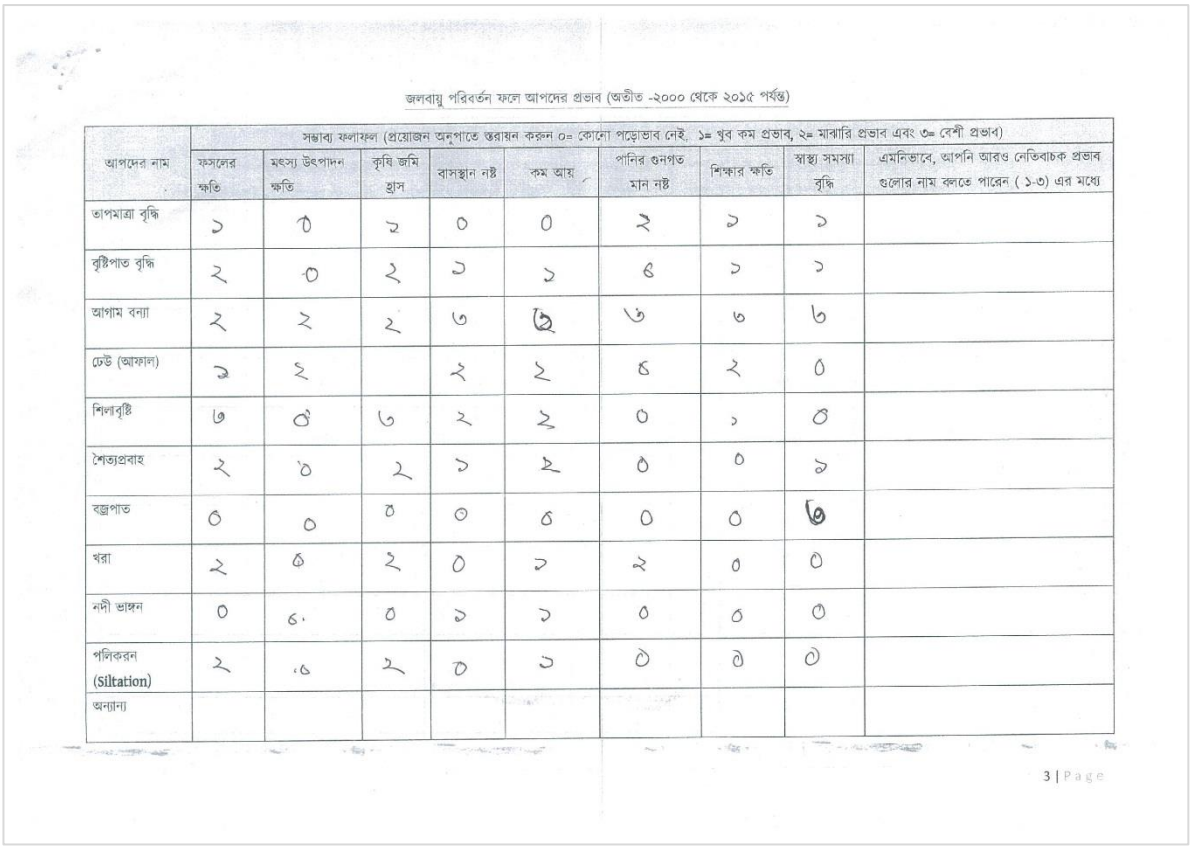
জলবায়ু পরিবর্তন জনিত আপদ গুলো সনাক্তকরণ

আপদের নাম	আপনার এই উপজেলায় সবচেয়ে বেশী প্রভাব রাখে এমন আপদের মাত্রা নির্ধারণ করুন (০ = কোনো প্রভাব নেই, ১= স্বল্প প্রভাব, ২= মাঝারি প্রভাব, ৩= বেশী প্রভাব)	Vulnerable Groups							আপনি এখানে আরও vulnerable groups নাম বলতে পারেন (যদি থাকে)
		মহিলা	ভূমিহীন কৃষক	কৃষক (প্রান্তিক/ক্ষুদ্র/ মাঝারী)	মাছচাষী	দিনমুজুর	বৃদ্ধ (৬০ তদূর্ধ্ব) /প্রতিবন্ধী	শিশু (৭ বছরের নিচে)	
তাপমাত্রা বৃদ্ধি	৯	✓		✓	✓	✓	✓	✓	
বৃষ্টিপাত বৃদ্ধি	২		✓	✓					
আগাম বন্যা	৬		✓	✓	✓	✓	✓	✓	
ঢেউ (আফাল)	২	✓			✓	✓	✓	✓	
শিলাবৃষ্টি	৬	✓	✓	✓	✓	✓			
শৈত্যপ্রবাহ	১					✓	✓	✓	
বজ্রপাত	৬	✓		✓	✓	✓	✓	✓	
খরা	১		✓	✓		✓			
নদী ভাঙ্গন	২		✓	✓					
পলিকরন (Siltation)	১		✓	✓	✓				
অন্যান্য									
সর্বমোট	১০০								



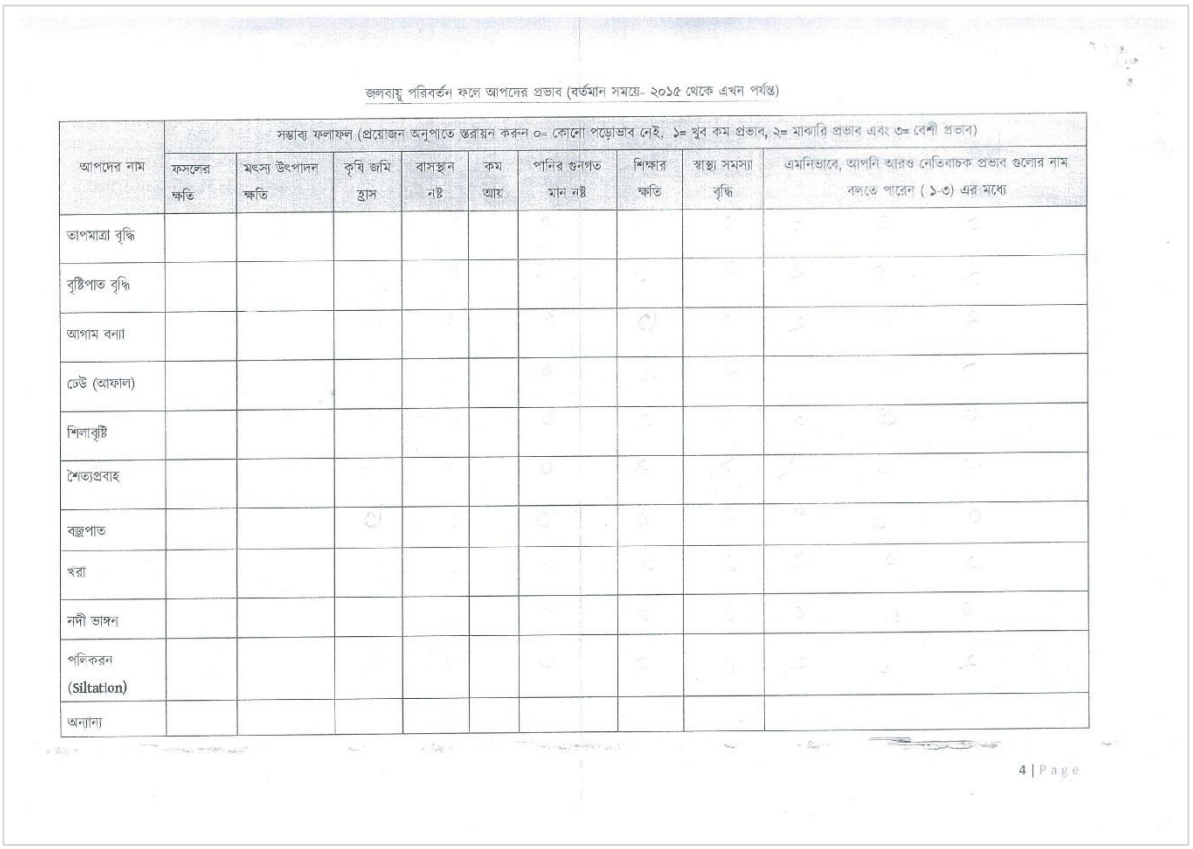
জলবায়ু পরিবর্তন ফলে আপদের সম্ভাবনা

আপদের নাম	সম্ভাবনার মাত্রা									
	প্রতি বছর	২ বছর পর	৩ বছর পর	৫ বছর পর	১০ বছর পর	২০ বছর পর	৩০ বছর পর	৫০ বছর পর	১০০ বছর পর	আপনার মন্তব্য (বিশেষ কিছু থাকলে উল্লেখ করুন)
তাপমাত্রা বৃদ্ধি	✓									
বৃষ্টিপাত বৃদ্ধি	✓									
আগাম বন্যা		✓								
ঢেউ (আফাল)	✓									
শিলাবৃষ্টি	✓									
শৈত্যপ্রবাহ										
বজ্রপাত	✓									
খরা		✓								
নদী ভাঙ্গন	✓									
পলিকরন (Siltation)	✓									
অন্যান্য										



জলবায়ু পরিবর্তন ফলে আপদের প্রভাব (অতীত -২০০০ থেকে ২০১৫ পর্যন্ত)

আপদের নাম	সম্ভাব্য ফলাফল (প্রয়োজন অনুপাতে স্তরায়ন করুন ০= কোনো পড়োভাব নেই, ১= খুব কম প্রভাব, ২= মাঝারি প্রভাব এবং ৩= বেশী প্রভাব)								
	ফসলের ক্ষতি	মৎস্য উৎপাদন ক্ষতি	কৃষি জমি হ্রাস	বাসস্থান নষ্ট	কম আয়	পানির গুনগত মান নষ্ট	শিক্ষার ক্ষতি	স্বাস্থ্য সমস্যা বৃদ্ধি	এমনিভাবে, আপনি আরও নেতিবাচক প্রভাব গুলোর নাম বলতে পারেন (১-৩) এর মধ্যে
তাপমাত্রা বৃদ্ধি	১	০	২	০	০	২	১	১	
বৃষ্টিপাত বৃদ্ধি	২	০	২	১	১	৪	১	১	
আগাম বন্যা	২	২	২	৩	৩	৩	৩	৩	
ঢেউ (আফাল)	১	২		২	২	৪	২	০	
শিলাবৃষ্টি	৩	০	৩	২	২	০	১	০	
শৈত্যপ্রবাহ	২	০	২	১	২	০	০	১	
বজ্রপাত	০	০	০	০	০	০	০	৩	
খরা	২	০	২	০	১	২	০	০	
নদী ভাঙ্গন	০	০	০	১	১	০	০	০	
পলিকরন (Siltation)	২	০	২	০	১	০	০	০	
অন্যান্য									



জলবায়ু পরিবর্তন ফলে আপদের প্রভাব (বর্তমান সময়ে- ২০১৫ থেকে এখন পর্যন্ত)

আপদের নাম	সম্ভাব্য ফলাফল (প্রয়োজন অনুপাতে স্তরায়ন করুন ০= কোনো পড়োভাব নেই, ১= খুব কম প্রভাব, ২= মাঝারি প্রভাব এবং ৩= বেশী প্রভাব)								
	ফসলের ক্ষতি	মৎস্য উৎপাদন ক্ষতি	কৃষি জমি হ্রাস	বাসস্থান নষ্ট	কম আয়	পানির গুনগত মান নষ্ট	শিক্ষার ক্ষতি	স্বাস্থ্য সমস্যা বৃদ্ধি	এমনিভাবে, আপনি আরও নেতিবাচক প্রভাব গুলোর নাম বলতে পারেন (১-৩) এর মধ্যে
তাপমাত্রা বৃদ্ধি									
বৃষ্টিপাত বৃদ্ধি									
আগাম বন্যা									
ঢেউ (আফাল)									
শিলাবৃষ্টি									
শৈত্যপ্রবাহ									
বজ্রপাত									
খরা									
নদী ভাঙ্গন									
পলিকরন (Siltation)									
অন্যান্য									

ঝুঁকি মূল্যায়ন প্রশ্নপত্র

উপজেলার নামঃ তাহিরপুর (জেঃ সুনামগঞ্জ)	তারিখঃ
অংশগ্রহণকারীর নামঃ [illegible] (সদস্য-৩)	মোবাইল নম্বরঃ ০১৭১৪১০৪৫৬

জলবায়ু পরিবর্তন জনিত আপদ গুলো সনাক্তকরণ

আপদের নাম	আপনার এই উপজেলায় সবচেয়ে বেশী প্রভাব রাখে এমন আপদের মাত্রা নির্ধারণ করুন (০ = কোনো প্রভাব নেই, ১= স্বল্প প্রভাব, ২= মাঝারি প্রভাব, ৩= বেশী প্রভাব)	Vulnerable Groups							
		মহিলা	ভূমিহীন কৃষক	কৃষক (প্রান্তিক/ক্ষুদ্র/ মাঝারী)	মাছচাষী	দিনমুজুর	বৃদ্ধ (৬০ তদূর্ধ্ব) /প্রতিবন্ধী	শিশু (৭ বছরের নিচে)	আপনি এখানে আরও **vulnerable groups** নাম বলতে পারেন (যদি থাকে)
তাপমাত্রা বৃদ্ধি	৩					✓			
বৃষ্টিপাত বৃদ্ধি	২								
আগাম বন্যা	৩	✓	✓	✓	✓	✓	✓	✓	প্রবীণ
ঢেউ (আফাল)	১							✓	প্রবীণ
শিলাবৃষ্টি	১		✓	✓					
শৈত্যপ্রবাহ	২						✓	✓	
বজ্রপাত	১	✓	✓	✓			✓	✓	গবাদিপশু
খরা	২		✓	✓		✓			
নদী ভাঙ্গন	২		✓	✓		✓			
পলিকরন (**Siltation**)									
অন্যান্য									
সর্বমোট	১০০								

জলবায়ু পরিবর্তন ফলে আপদের সম্ভাবনা

আপদের নাম	সম্ভাবনার মাত্রা									
	প্রতি বছর	২ বছর পর	৩ বছর পর	৫ বছর পর	১০ বছর পর	২০ বছর পর	৩০ বছর পর	৫০ বছর পর	১০০ বছর পর	আপনার মন্তব্য (বিশেষ কিছু থাকলে উল্লেখ করুন)
তাপমাত্রা বৃদ্ধি		✓								
বৃষ্টিপাত বৃদ্ধি	✓									
আগাম বন্যা		✓								
ঢেউ (আফাল)			✓							
শিলাবৃষ্টি			✓							
শৈত্যপ্রবাহ			✓							
বজ্রপাত			✓							
খরা		✓								
নদী ভাঙ্গন		✓								
পলিকরন (**Siltation**)										
অন্যান্য										

জলবায়ু পরিবর্তন ফলে আপদের প্রভাব (অতীত -২০০০ থেকে ২০১৫ পর্যন্ত)

আপদের নাম	সম্ভাব্য ফলাফল (প্রয়োজন অনুপাতে স্তরায়ন করুন ০= কোনো পড়োভাব নেই, ১= খুব কম প্রভাব, ২= মাঝারি প্রভাব এবং ৩= বেশী প্রভাব)								
	ফসলের ক্ষতি	মৎস্য উৎপাদন ক্ষতি	কৃষি জমি হ্রাস	বাসস্থান নষ্ট	কম আয়	পানির গুনগত মান নষ্ট	শিক্ষার ক্ষতি	স্বাস্থ্য সমস্যা বৃদ্ধি	এমনিভাবে, আপনি আরও নেতিবাচক প্রভাব গুলোর নাম বলতে পারেন (১-৩) এর মধ্যে
তাপমাত্রা বৃদ্ধি	২	০		০	২	২	০	২	
বৃষ্টিপাত বৃদ্ধি	১	২	২		২	০	০	০	
আগাম বন্যা	৩	৩	৩	২	৩	২	২	২	
ঢেউ (আফাল)		২		২	২	০	২	০	
শিলাবৃষ্টি	২	০	২	০	০	০	০	০	
শৈত্যপ্রবাহ									
বজ্রপাত									মানুষের জায়গের অভাব হয়
খরা	২	০	২	০	২	০	০	২	
নদী ভাঙ্গন	২	০	২		২	০	০	০	
পলিকরন (Siltation)									
অন্যান্য									

জলবায়ু পরিবর্তন ফলে আপদের প্রভাব (বর্তমান সময়ে- ২০১৫ থেকে এখন পর্যন্ত)

আপদের নাম	সম্ভাব্য ফলাফল (প্রয়োজন অনুপাতে স্তরায়ন করুন ০= কোনো পড়োভাব নেই, ১= খুব কম প্রভাব, ২= মাঝারি প্রভাব এবং ৩= বেশী প্রভাব)								
	ফসলের ক্ষতি	মৎস্য উৎপাদন ক্ষতি	কৃষি জমি হ্রাস	বাসস্থান নষ্ট	কম আয়	পানির গুনগত মান নষ্ট	শিক্ষার ক্ষতি	স্বাস্থ্য সমস্যা বৃদ্ধি	এমনিভাবে, আপনি আরও নেতিবাচক প্রভাব গুলোর নাম বলতে পারেন (১-৩) এর মধ্যে
তাপমাত্রা বৃদ্ধি									
বৃষ্টিপাত বৃদ্ধি									
আগাম বন্যা									
ঢেউ (আফাল)									
শিলাবৃষ্টি									
শৈত্যপ্রবাহ									
বজ্রপাত									
খরা									
নদী ভাঙ্গন									
পলিকরন (Siltation)									
অন্যান্য									

Appendix H: GHGs Emission Factors

CH4 Emission Factor for Rice Cultivation

Results for Region: Brahmanbaria

LU	Climate	EcoZone	Soil	LUSub	CropClass	MgmtSys	PreWaterReg	WaterReg	OrgAmdType	EFc	SFw	SFp	SFo	SFs	SFr	EFrice
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-Fallow-Spices	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-Fallow-Spices	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46

LU	Climate	EcoZone	Soil	LUSub	CropClass	MgmtSys	PreWaterReg	WaterReg	OrgAmdType	EFc	SFw	SFp	SFo	SFs	SFr	EFrice
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Boro	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Boro	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Pulses	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Pulses	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Pulses	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Pulses	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	BAman-BAman-Boro	Non-flooded pre-season > 180d	Deep water	No Organic Amendments	1.3	0.31	0.68	1	1	1	0.274

LU	Climate	EcoZone	Soil	LUSub	CropClass	MgmtSys	PreWaterReg	WaterReg	OrgAmdType	EFc	SFw	SFp	SFo	SFs	SFr	EFrice
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	BAman-BAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-Fallow-Boro	Flooded pre-season > 30d	Continuously flooded	No Organic Amendments	1.3	1	1.9	1	1	1	2.47
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-Fallow-Boro	Non-flooded pre-season < 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	1	1	1	1	0.676
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-Fallow-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Boro	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248

LU	Climate	EcoZone	Soil	LUSub	CropClass	MgmtSys	PreWaterReg	WaterReg	OrgAmdType	EFc	SFw	SFp	SFo	SFs	SFr	EFrice
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Oilseeds	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Oilseeds	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Jute-TAman-Oilseeds	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Jute-TAman-Oilseeds	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248

Results for Region: Habiganj

LU	Climate	EcoZone	Soil	LUSub	CropClass	MgmtSys	PreWaterReg	WaterReg	OrgAmdType	EFc	SFw	SFp	SFo	SFs	SFr	EFrice
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-Fallow-Wheat	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-Fallow-Wheat	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Boro	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Boro	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248

LU	Climate	EcoZone	Soil	LUSub	CropClass	MgmtSys	PreWaterReg	WaterReg	OrgAmdType	EFc	SFw	SFp	SFo	SFs	SFr	EFrice
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Fallow	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Fallow	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Fallow	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Fallow	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Pulses	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Pulses	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Pulses	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248

LU	Climate	EcoZone	Soil	LUSub	CropClass	MgmtSys	PreWaterReg	WaterReg	OrgAmdType	EFc	SFw	SFp	SFo	SFs	SFr	EFrice
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Pulses	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Spices	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Spices	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Spices	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Spices	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	BAman-BAman-Boro	Flooded pre-season > 30d	Deep water	No Organic Amendments	1.3	0.31	1.9	1	1	1	0.766
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	BAman-BAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46

LU	Climate	EcoZone	Soil	LUSub	CropClass	MgmtSys	PreWaterReg	WaterReg	OrgAmdType	EFc	SFw	SFp	SFo	SFs	SFr	EFrice
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-Fallow-Boro	Flooded pre-season > 30d	Continuously flooded	No Organic Amendments	1.3	1	1.9	1	1	1	2.47
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-Fallow-Boro	Non-flooded pre-season < 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	1	1	1	1	0.676
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-Fallow-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Boro	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Fallow	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46

LU	Climate	EcoZone	Soil	LUSub	CropClass	MgmtSys	PreWaterReg	WaterReg	OrgAmdType	EFc	SFw	SFp	SFo	SFs	SFr	EFrice
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Fallow	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Oilseeds	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Oilseeds	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Jute-TAman-Oilseeds	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Jute-TAman-Oilseeds	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248

Results for Region: Kishoreganj

LU	Climate	EcoZone	Soil	LUSub	CropClass	MgmtSys	PreWaterReg	WaterReg	OrgAmdType	EFc	SFw	SFp	SFo	SFs	SFr	EFrice
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Boro	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Pulses	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Pulses	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Pulses	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Spices	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46

LU	Climate	EcoZone	Soil	LUSub	CropClass	MgmtSys	PreWaterReg	WaterReg	OrgAmdType	EFc	SFw	SFp	SFo	SFs	SFr	EFrice
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Spices	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Spices	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-Fallow-Boro	Flooded pre-season > 30d	Continuously flooded	No Organic Amendments	1.3	1	1.9	1	1	1	2.47
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-Fallow-Boro	Non-flooded pre-season < 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	1	1	1	1	0.676
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-Fallow-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Boro	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248

LU	Climate	EcoZone	Soil	LUSub	CropClass	MgmtSys	PreWaterReg	WaterReg	OrgAmdType	EFc	SFw	SFp	SFo	SFs	SFr	EFrice
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Jute-TAman-Oilseeds	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Jute-TAman-Oilseeds	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Jute-TAman-Others	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Jute-TAman-Others	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	Maize Cultivation	Annual Croplands	Aus-Fallow-Maize	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46

Results for Region: Netrokona

LU	Climate	EcoZone	Soil	LUSub	CropClass	MgmtSys	PreWaterReg	WaterReg	OrgAmdType	EFc	SFw	SFp	SFo	SFs	SFr	EFrice
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-Fallow-Spices	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-Fallow-Spices	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Pulses	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Pulses	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Pulses	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Pulses	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-Fallow-Boro	Flooded pre-season > 30d	Continuously flooded	No Organic Amendments	1.3	1	1.9	1	1	1	2.47
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-Fallow-Boro	Non-flooded pre-season < 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	1	1	1	1	0.676

LU	Climate	EcoZone	Soil	LUSub	CropClass	MgmtSys	PreWaterReg	WaterReg	OrgAmdType	EFc	SFw	SFp	SFo	SFs	SFr	EFrice
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-Fallow-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Boro	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Jute-TAman-Oilseeds	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Jute-TAman-Oilseeds	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248

Results for Region: Sunamganj

LU	Climate	EcoZone	Soil	LUSub	CropClass	MgmtSys	PreWaterReg	WaterReg	OrgAmdType	EFc	SFw	SFp	SFo	SFs	SFr	EFrice
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-Fallow-Spices	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-Fallow-Spices	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Boro	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Boro	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Fallow	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46

LU	Climate	EcoZone	Soil	LUSub	CropClass	MgmtSys	PreWaterReg	WaterReg	OrgAmdType	EFc	SFw	SFp	SFo	SFs	SFr	EFrice
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Fallow	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Fallow	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Fallow	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Pulses	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Pulses	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Pulses	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Aus-TAman-Pulses	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	BAman-BAman-Boro	Flooded pre-season > 30d	Deep water	No Organic Amendments	1.3	0.31	1.9	1	1	1	0.766

LU	Climate	EcoZone	Soil	LUSub	CropClass	MgmtSys	PreWaterReg	WaterReg	OrgAmdType	EFc	SFw	SFp	SFo	SFs	SFr	EFrice
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	BAman-BAman-Boro	Non-flooded pre-season > 180d	Continuously flooded	No Organic Amendments	1.3	1	0.68	1	1	1	0.884
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-Fallow-Boro	Flooded pre-season > 30d	Continuously flooded	No Organic Amendments	1.3	1	1.9	1	1	1	2.47
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-Fallow-Boro	Non-flooded pre-season < 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	1	1	1	1	0.676
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-Fallow-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Boro	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Boro	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Fallow	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46

LU	Climate	EcoZone	Soil	LUSub	CropClass	MgmtSys	PreWaterReg	WaterReg	OrgAmdType	EFc	SFw	SFp	SFo	SFs	SFr	EFrice
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Fallow	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Oilseeds	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Fallow-TAman-Oilseeds	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Jute-TAman-Oilseeds	Non-flooded pre-season > 180d	Intermittently flooded - multiple aeration	No Organic Amendments	1.3	0.52	0.68	1	1	1	0.46
Cropland Remaining Cropland	Tropical Wet	Tropical Rain Forest	High Activity Clay Mineral	General Cropping	Annual Croplands	Jute-TAman-Oilseeds	Non-flooded pre-season > 180d	Regular rainfed	No Organic Amendments	1.3	0.28	0.68	1	1	1	0.248

Annual Amount of Synthetic Fertilizer N Applied to Soils

Year	Fertilizer N Applied to Soils		Total
	Urea	DAP	
Brahmanbaria	26,006	2,104	28,110
Kishoreganj	21,920	5,555	27,475
Netrokona	34,714	3,423	38,137
Habiganj	70,286	5,961	76,247
Sunamganj	26,510	6,330	32,840
Total	179,436	23,373	202,809

Enteric CH4 Emissions Factor: Basic Characterization

Livestock Category	Enteric CH4 Emissions Factor EFt(b)
Dairy Cows	16
Non Dairy Cows	15
Buffalo	37
Goat	4.5
Sheep	2.64

Direct and Indirect N2O Emissions Factors: Basic Characterization

LvstkCat	MAT	ManureSys	MS	EF3	FracGASM	EFv	Nrate	TAM	EFt(b)
Dairy Cows	27 °C (Warm)	Anaerobic Digester	0.05	0	0.35	0.01	0.47	275	6
	27 °C (Warm)	Burned for Fuel	0.37	0.02	0.3	0.01			
	27 °C (Warm)	Liquid/Slurry - with Natural Crust Cover	0.02	0.005	0.4	0.01			
	27 °C (Warm)	Solid Storage	0.56	0.005	0.3	0.01			
Non-Dairy Cattle	27 °C (Warm)	Anaerobic Digester	0.05	0	0.35	0.01	0.34	110	2
	27 °C (Warm)	Burned for Fuel	0.37	0.02	0.3	0.01			
	27 °C (Warm)	Liquid/Slurry - with Natural Crust Cover	0.02	0.005	0.4	0.01			
	27 °C (Warm)	Solid Storage	0.56	0.005	0.45	0.01			
Buffalo	27 °C (Warm)	Burned for Fuel	0.43	0.02	0.3	0.01	0.32	295	5
	27 °C (Warm)	Solid Storage	0.57	0.005	0.45	0.01			
Goats	27 °C (Warm)	Solid Storage	1	0.005	0.12	0.01	1.37	30	0.22
Sheep	27 °C (Warm)	Solid Storage	1	0.005	0.12	0.01	1.17	28	0.20
Poultry	27 °C (Warm)	Daily Spread	1	0	0.3	0.01	0.82	1.8	0.02

Appendix I: Glossary of CCA Guideline

Adaptive Capacity. ability of a system to adjust to climate change to moderate potential damages, to take advantage of opportunities, or to cope with the consequences

Adaptation. In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate

Climate. A statistical description in terms of the mean and variability of relevant indicators, such as those relating to temperature and rainfall, over a period of time. The World Meteorological Organization defines this period as three decades.

Capacity. The combination of all the strengths, attributes and resources available within an organization, community or society to manage and reduce disaster risks and strengthen resilience. Capacity may include infrastructure, institutions, human knowledge and skills, and collective attributes such as social relationships, leadership and management.

Capacity development. It is the process by which people, organizations and society systematically stimulate and develop their capacities over time to achieve social and economic goals. It is a concept that extends the term of capacity-building to encompass all aspects of creating and sustaining capacity growth over time. It involves learning and various types of training, but also continuous efforts to develop institutions, political awareness, financial resources, technology systems and the wider enabling environment.

Climate change. Refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), which defines climate change as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods” (IPCC 2007).

Community Profile. Summary of the history, present conditions and anticipated future of a local area. It is a bottom-up process for establishing the local context for an adaptation initiative, which can help to kick-start conversations about climate change impacts and visions of the future held by members of a community or group.”

Context. the situation within which something exists or happens, and that can help explain it.

Co-ownership. the fact of owning something such as a business together with one or more other people.

Cost–benefit analysis (**CBA**). sometimes called **benefit costs analysis** (**BCA**), is a systematic approach to estimating the strengths and weaknesses of alternatives used to determine options which provide the best approach to achieving benefits while preserving savings (for example, in transactions, activities, and functional business requirements). A CBA may be used to compare completed or potential courses of actions, or to estimate (or evaluate) the value against the cost of a decision, project, or policy. It is commonly used in commercial transactions, business or policy decisions (particularly public policy), and project investments.

Cost-effectiveness analysis (**CEA**) is a form of economic analysis that compares the relative costs and outcomes (effects) of different courses of action. Cost-effectiveness analysis is distinct

from cost–benefit analysis, which assigns a monetary value to the measure of effect.[1] Cost-effectiveness analysis is often used in the field of health services, where it may be inappropriate to monetize health effect.

Multi-criteria analysis (MCA) is a complementary approach to cost-benefit analysis (CBA). It is a two-stage decision procedure. The first stage identifies a set of goals or objectives and then seeks to identify the trade-offs between those objectives for different policies or for different ways of achieving a given policy. The second stage seeks to identify the "best" policy by attaching weights (scores) to the various objectives

Disaster. A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts.

Disaster damage. Occurs during and immediately after the disaster. This is usually measured in physical units (e.g. square meters of housing, kilometers of roads, etc.) and describes the total or partial destruction of physical assets, the disruption of basic services and damages to sources of livelihood in the affected area.

Duplication. the practice of doing the same thing more than once, or having more than one person or thing to do the same task, when this is not necessary:

Focus group discussion (FGD). is a good way to gather together people from similar backgrounds or experiences to discuss a specific topic of interest

Exposure. The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard prone areas.

Exposure Unit. Individuals or property which may be subject to loss or damage on which a monetary value may be placed. When these exposure units have similar characteristics they meet the requirement of insurability as homogeneous exposure units.

Hazard. A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. Multi-hazard means (1) the selection of multiple major hazards that the country faces, and (2) the specific contexts where hazardous events may occur simultaneously, cascading or cumulatively over time, and taking into account the potential interrelated effects. Hazards include (as mentioned in the Sendai Framework for Disaster Risk Reduction 2015-2030, and listed in alphabetical order) biological, environmental, geological, hydrometeorological and technological processes and phenomena.

Intergovernmental Panel on Climate Change (IPCC). is an intergovernmental body of the United Nations that is dedicated to providing the world with objective, scientific information relevant to understanding the scientific basis of the risk of human-induced climate change, its natural, political, and economic impacts

Key informant. refers to the person with whom an interview about a particular organization, social program, problem, or interest group is conducted. In a sense, the **key informant** is a proxy for her or his associates at the organization or group.

Mitigation. The adverse impacts of hazards, in particular natural hazards, often cannot be prevented fully, but their scale or severity can be substantially lessened by various strategies and actions. Mitigation measures include engineering techniques and hazard-resistant construction as well as improved environmental and social policies and public aware- ness. It

should be noted that, in climate change policy, 'mitigation' is defined differently, and is the term used for the reduction of greenhouse gas emissions that are the source of climate change.

NGO. a non-profit organization that operates independently of any government, typically one whose purpose is to address a social or political issue.

Research. A detailed study of a subject, especially in order to discover (new) information or reach a (new) understanding:

Resilience. The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, capacity for self-organization and capacity to adapt to stress and change (IPCC 2007).

Response. Actions taken directly before, during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected.

Risk. The result of the interaction of physically defined hazards with the properties of the exposed systems—i.e., their sensitivity or social vulnerability. Risk can also be considered as the combination of an event, its likelihood and its consequences—i.e. risk equals the probability of climate hazard multiplied by a given system's vulnerability (UNDP 2004).

Scenario. A systemic method for thinking creatively about possible complex and uncertain futures. The central idea is to consider a variety of possible futures that include many of the important uncertainties in the system rather than to focus on the accurate prediction of a single outcome.

Semi-structured interview. is a meeting in which the interviewer does not strictly follow a formalized list of questions. They will ask more open-ended questions, allowing for a discussion with the interviewee rather than a straightforward question and answer format.

Sensitivity. The degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g. a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g. damages caused by an increase in the frequency of coastal flooding due to sea level rise) Sensitivity includes exposure that considers the nature and magnitude of climate change and whether a system would be affected by such change. For example, the low- lying coastal areas of Bangladesh are exposed to sea level rise, whereas the Rift Valley in Africa, because of its elevation, is not. Sensitivity also considers the extent to which an exposed system can be affected by climate change. Some crops such as maize are quite sensitive, while systems such as manufacturing are much less sensitive to climate change, although they can be affected by extreme events, reductions in water supplies and power disruption (IPCC 2001, 2007).

Stakeholder. a person such as an employee, customer, or citizen who is involved with an organization, society, etc. and therefore has responsibilities towards it and an interest in its success

Storyline. The narrative threads experienced by each character or set of characters in a work of fiction

Synthesis. the mixing of different ideas, influences, or things to make a whole that is different, or new:

Vulnerability. The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazard

Appendix J: Glossary of DRR Guideline

Affected. People who are affected, either directly or indirectly, by a hazardous event. Directly affected are those who have suffered injury, illness or other health effects; who were evacuated, displaced, relocated or have suffered direct damage to their livelihoods, economic, physical, social, cultural and environmental assets. Indirectly affected are people who have suffered consequences, other than or in addition to direct effects, over time, due to disruption or changes in economy, critical infrastructure, basic services, commerce or work, or social, health and psychological consequences.

Build back better. The use of the recovery, rehabilitation and reconstruction phases after a disaster to increase the resilience of nations and communities through integrating disaster risk reduction measures into the restoration of physical infrastructure and societal systems, and into the revitalization of livelihoods, economies and the environment.

Building Code. A set of ordinances or regulations and associated standards intended to regulate aspects of the design, construction, materials, alteration and occupancy of structures which are necessary to ensure human safety and welfare, including resistance to collapse and damage.

Climate. A statistical description in terms of the mean and variability of relevant indicators, such as those relating to temperature and rainfall, over a period of time. The World Meteorological Organization defines this period as three decades.

Capacity. The combination of all the strengths, attributes and resources available within an organization, community or society to manage and reduce disaster risks and strengthen resilience. Capacity may include infrastructure, institutions, human knowledge and skills, and collective attributes such as social relationships, leadership and management.

Capacity assessment. It is the process by which the capacity of a group, organization or society is reviewed against de- sired goals, where existing capacities are identified for maintenance or strengthening and capacity gaps are identified for further action.

Capacity development. It is the process by which people, organizations and society systematically stimulate and develop their capacities over time to achieve social and economic goals. It is a concept that extends the term of capacity-building to encompass all aspects of creating and sustaining capacity growth over time. It involves learning and various types of training, but also continuous efforts to develop institutions, political awareness, financial resources, technology systems and the wider enabling environment.

Climate change. Refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), which defines climate change as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods” (IPCC 2007).

Contingency planning. A management process that analyses disaster risks and establishes arrangements in advancements in advance to enable timely, effective and appropriate responses.

Coping capacity. It is the ability of people, organizations and systems, using available skills and resources, to manage adverse conditions, risk or disasters. The capacity to cope requires continuing awareness, resources and good management, both in normal times as well as during disasters or adverse conditions. Coping capacities contribute to the reduction of disaster risks.

Critical infrastructure. The physical structures, facilities, networks and other assets which provide services that are essential to the social and economic functioning of a community or society.

Disaster. A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts.

Disaster damage. Occurs during and immediately after the disaster. This is usually measured in physical units (e.g. square meters of housing, kilometers of roads, etc.) and describes the total or partial destruction of physical assets, the disruption of basic services and damages to sources of livelihood in the affected area.

Disaster impact. It is the total effect, including negative effects (e.g. economic losses) and positive effects (e.g., economic gains) of a hazardous event or a disaster. The term includes economic, human and environmental impacts, and may include death, injuries, disease and other negative effects on human physical, mental and social well-being.

Disaster loss database. A set of systematically collected records about disaster occurrence, damages, losses and impacts, compliant with the Sendai Framework for Disaster Risk Reduction 2015-2030 monitoring minimum requirements.

Disaster management. The organization, planning and application of measures preparing for, responding to and recovering from disasters.

Disaster risk. The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity.

Acceptable risk, or tolerable risk, is therefore an important sub-term; the extent to which a disaster risk is deemed acceptable or tolerable depends on existing social, economic, political, cultural, technical and environmental conditions. In engineering terms, acceptable risk is also used to assess and define the structural and non-structural measures that are needed in order to reduce possible harm to people, property, services and systems to a chosen tolerated level, according to codes or “accepted practice” which are based on known probabilities of hazards and other factors.

Residual risk is the disaster risk that remains even when effective disaster risk reduction measures are in place, and for which emergency response and recovery capacities must be maintained. The presence of residual risk implies a continuing need to develop and support effective capacities for emergency services, preparedness, response and recovery, together with socioeconomic policies such as safety nets and risk transfer mechanisms, as part of a holistic approach.

Disaster risk assessment. A qualitative or quantitative approach to determine the nature and extent of disaster risk by analyzing potential hazards and evaluating existing conditions of

exposure and vulnerability that together could harm people, property, services, livelihoods and the environment on which they depend.

Disaster risk governance. The system of institutions, mechanisms, policy and legal frameworks and other arrangements to guide, coordinate and oversee disaster risk reduction and related areas of policy.

Disaster risk information. Comprehensive information on all dimensions of disaster risk, including hazards, exposure, vulnerability and capacity, related to persons, communities, organizations and countries and their assets.

Disaster risk management. Disaster risk management is the application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses.

Disaster risk reduction. Disaster risk reduction is aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development.

Disaster risk reduction strategies and policies. Define goals and objectives across different timescales and with concrete targets, indicators and time frames. In line with the Sendai Framework for Disaster Risk Reduction 2015-2030, these should be aimed at preventing the creation of disaster risk, the reduction of existing risk and the strengthening of economic, social, health and environmental resilience.

Early warning system. An integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities systems and processes that enables individuals, communities, governments, businesses and others to take timely action to reduce disaster risks in advance of hazardous events.

Economic loss. Total economic impact that consists of direct economic loss and indirect economic loss.

Direct economic loss: the monetary value of total or partial destruction of physical assets existing in the affected area. Direct economic loss is nearly equivalent to physical damage.

Indirect economic loss: a decline in economic value added as a consequence of direct economic loss and/or human and environmental impacts.

Evacuation. Moving people and assets temporarily to safer places before, during or after the occurrence of a hazardous event in order to protect them.

Exposure. The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard prone areas.

Extensive disaster risk. The risk of low-severity, high-frequency hazardous events and disasters, mainly but not exclusively associated with highly localized hazards.

Hazard. A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. Multi-hazard means (1) the selection of multiple major hazards that the country faces, and (2) the specific contexts where hazardous events may occur simultaneously, cascading or cumulatively over time, and taking into account the potential interrelated effects. Hazards include (as mentioned in the Sendai Framework for Disaster Risk Reduction 2015-

2030, and listed in alphabetical order) biological, environmental, geological, hydrometeorological and technological processes and phenomena.

Biological hazards are of organic origin or conveyed by biological vectors, including pathogenic microorganisms, toxins and bioactive substances. Examples are bacteria, viruses or parasites, as well as venomous wildlife and insects, poisonous plants and mosquitoes carrying disease-causing agents.

Environmental hazards may include chemical, natural and biological hazards. They can be created by environmental degradation or physical or chemical pollution in the air, water and soil. However, many of the processes and phenomena that fall into this category may be termed drivers of hazard and risk rather than hazards in themselves, such as soil degradation, deforestation, loss of biodiversity, salinization and sea-level rise.

Geological or geophysical hazards originate from internal earth processes. Examples are earthquakes, volcanic activity and emissions, and related geophysical processes such as mass movements, landslides, rockslides, surface collapses and debris or mud flows. Hydrometeorological factors are important contributors to some of these processes. Tsunamis are difficult to categorize: although they are triggered by undersea earthquakes and other geological events, they essentially become an oceanic process that is manifested as a coastal water-related hazard.

Hydrometeorological hazards are of atmospheric, hydrological or oceanographic origin. Examples are tropical cyclones (also known as typhoons and hurricanes); floods, including flash floods; drought; heat waves and cold spells; and coastal storm surges. Hydrometeorological conditions may also be a factor in other hazards such as landslides, wild land fires, locust plagues, epidemics and in the transport and dispersal of toxic substances and volcanic eruption material.

Technological hazards originate from technological or industrial conditions, dangerous procedures, infrastructure failures or specific human activities. Examples include industrial pollution, nuclear radiation, toxic wastes, dam failures, transport accidents, factory explosions, fires and chemical spills. Technological hazards also may arise directly as a result of the impacts of a natural hazard event.

Hazardous event. The manifestation of a hazard in a particular place during a particular period of time.

Intensive disaster risk. The risk of high-severity, mid- to low-frequency disasters, mainly associated with major hazards.

Mitigation. The adverse impacts of hazards, in particular natural hazards, often cannot be prevented fully, but their scale or severity can be substantially lessened by various strategies and actions. Mitigation measures include engineering techniques and hazard-resistant construction as well as improved environmental and social policies and public aware- ness. It should be noted that, in climate change policy, ‘mitigation’ is defined differently, and is the term used for the reduction of greenhouse gas emissions that are the source of climate change.

Mainstreaming disaster risk reduction. With every disaster, there is a significant impact on various sectors of development like agriculture, housing, health, education and infrastructure. This results in a serious social and economic setback to the development and poverty reduction priorities of the developing countries, and poses a threat for achieving the Millennium

Development goals. To meet with this crisis, the scarce resources that are programmed for development are often diverted for relief and rehabilitation efforts. Thus development activity and disaster risk reduction representing two sides of the same coin have to be dealt with in unison, with mainstreaming disaster risk management into development policy, planning and implementation. On the other hand, the process of development, and the kind of development choices made in many countries, itself, creates disaster risks. With disaster risk reduction considerations not featuring into the project design of the development activities, increases the risks, thus increasing the negative impact of the disasters on the socio economic set up of the country. Thus development activity and disaster risk reduction representing two sides of the same coin have to be dealt with in unison, with mainstreaming disaster risk management into development policy, planning and implementation.

National platform for disaster risk reduction. A generic term for national mechanisms for coordination and policy guidance on disaster risk reduction that are multisectoral and interdisciplinary in nature, with public, private and civil society participation involving all concerned entities within a country.

No-regret measures. Adaptation measures that would be justified under all plausible future scenarios, including the absence of man-made climate change impact (World Bank 2010, GN 7).

Preparedness. The knowledge and capacities developed by governments, response and recovery organizations, communities and individuals to effectively anticipate, respond to and recover from the impacts of likely, imminent or current disasters.

Prevention. Activities and measures to avoid existing and new disaster risks.

Reconstruction. The medium- and long-term rebuilding and sustainable restoration of resilient critical infrastructures, services, housing, facilities and livelihoods required for the full functioning of a community or a society affected by a disaster, aligning with the principles of sustainable development and 'build back better', to avoid or reduce future disaster risk.

Recovery. The restoring or improving of livelihoods and health, as well as economic, physical, social, cultural and environmental assets, systems and activities, of a disaster-affected community or society, aligning with the principles of sustainable development and 'build back better', to avoid or reduce future disaster risk.

Rehabilitation. The restoration of basic services and facilities for the functioning of a community or a society affected by a disaster.

Resilience. The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, capacity for self-organization and capacity to adapt to stress and change (IPCC 2007).

Response. Actions taken directly before, during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected.

Retrofitting. Reinforcement or upgrading of existing structures to become more resistant and resilient to the damaging effects of hazards.

Risk. The result of the interaction of physically defined hazards with the properties of the exposed systems—i.e., their sensitivity or social vulnerability. Risk can also be considered as

the combination of an event, its likelihood and its consequences—i.e. risk equals the probability of climate hazard multiplied by a given system's vulnerability (UNDP 2004).

Risk transfer. The process of formally or informally shifting the financial consequences of particular risks from one party to another, whereby a household, community, enterprise or state authority will obtain resources from the other party after a disaster occurs, in exchange for ongoing or compensatory social or financial benefits provided to that other party.

Structural and non-structural measures. Structural measures are any physical construction to reduce or avoid possible impacts of hazards, or the application of engineering techniques or technology to achieve hazard resistance and resilience in structures or systems. Non-structural measures are measures not involving physical construction which use knowledge, practice or agreement to reduce disaster risks and impacts, in particular through policies and laws, public awareness raising, training and education.

Scenario. A systemic method for thinking creatively about possible complex and uncertain futures. The central idea is to consider a variety of possible futures that include many of the important uncertainties in the system rather than to focus on the accurate prediction of a single outcome.

Sensitivity. The degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g. a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g. damages caused by an increase in the frequency of coastal flooding due to sea level rise) Sensitivity includes exposure that considers the nature and magnitude of climate change and whether a system would be affected by such change. For example, the low- lying coastal areas of Bangladesh are exposed to sea level rise, whereas the Rift Valley in Africa, because of its elevation, is not. Sensitivity also considers the extent to which an exposed system can be affected by climate change. Some crops such as maize are quite sensitive, while systems such as manufacturing are much less sensitive to climate change, although they can be affected by extreme events, reductions in water supplies and power disruption (IPCC 2001, 2007).

Tipping points. A tipping point is reached when global climate changes from one stable state to another stable state. After the tipping point has been passed, the transition to a new state occurs.

Transformative adaptation. Solutions that fundamentally change objectives or ways of doing things (Stafford Smith et al. 2011; UKCIP 2015); transformative and incremental solutions can be compatible.

Underlying disaster risk drivers. Processes or conditions, often development-related, that influence the level of disaster risk by increasing levels of exposure and vulnerability or reducing capacity.

Vulnerability. The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazard