Zahidul Islam
Hasan Shafie

# ANTHROPOLOGY OF CLIMATE CHANGE

## Culture and Adaptation in Bangladesh

ANTHROPOLOGY/ CULTURE/ CLIMATE/ ADAPTATION/ BANGLADESH

Anthropology has a long-standing tradition of studying vulnerability, risk and adaptation to environmental changes and modeling the human-environment interactions in terms of real life complexities and cultural conditions. This book is a unique contribution from social science perspectives and foreshadows the beginning of the anthropology of climate change in Bangladesh.

— PROFESSOR ASM MAKSUD KAMAL, Dean, FEES, University of Dhaka.

'Anthropology of Climate Change: Culture and Adaptation in Bangladesh' is an original work of its kind inspiring adaptation efforts at the community level while contributing to the overall global vision of a climate resilient future. The book has sustained relevance to all who are interested in climate change adaptation and sustainable development in Bangladesh.

— AKM MAMUNUR RASHID, Climate Change Specialist, UNDP Bangladesh.

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Climate change emerged as the greatest threat to humanity and the most pressing issue of our time. Recognizing anthropology's potentials for engagement and scholarship in the understanding of contemporary climate variability, and climate change policy and governance, the book made use of cultural analysis and theories to explore the human dimensions of climate change adaptation in the context of Bangladesh. While climate change alters our physical realities, the problem is rooted in specific human actions, choices and a culture of consumerism across the globe. Therefore, climate change is more a human problem than a natural one, which is to be understood in terms of social institutions, cultural beliefs and practices. Again, climate change impacts are experienced, interpreted and explained by people based on their respective cultural knowledge and social positioning. The book is founded upon anthropological research and cultural analysis of human nexus with global environmental changes. Although climate change is a global problem, the distribution of impacts are on local and regional scales, and therefore, the solutions are to be sought on the same levels of complexity with joint production of knowledge involving communities. The book emphasizes the significance of understanding the human dimensions of climate change in exploring equitable and sustainable measures for adaptation in Bangladesh.

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Bangladesh Climate Change Trust (BCCT)
Ministry of Environment and Forests
and
Department of Anthropology
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*Image–01: Tidal Surge during Cyclone Aila (Category 1 Hurricane) on 27 May 2009 (Photograph by Hasan Shafie).*

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# Acknowledgment

Climate change emerged as the greatest threat to humanity and the most pressing issue of our time. Global warming and climate change are unequivocally posing terrible threats to our planet's diversity of life including both human and non-human living systems. Bangladesh experiences all sorts of extreme climatic events such as floods, cyclones, droughts, sea level rise, salinity intrusion, tornadoes, cold waves, lightening etc. Focusing on these adverse effects on local communities, Strategic Environmental Assessment of Climate Change Adaptation Options in Bangladesh (SEACCAOB) project intensively explored local adaptation strategies. Recognizing anthropology's potentials for engagement and scholarship in the understanding of contemporary climate variability, and climate change policy and governance, the book made use of cultural analysis and theories to explore the human dimensions of climate change adaptation in the context of Bangladesh. While climate change alters our physical realities, the problem is rooted in specific human actions, choices and a culture of consumerism across the globe. Therefore, climate change is more a human problem than a natural one, which is to be understood in terms of social institutions, cultural beliefs and practices. Again, climate change impacts are experienced, interpreted and explained by people based on their respective cultural knowledge and social positioning.

The book is founded upon anthropological research and cultural analysis of human nexus with global environmental changes. Although climate change is a global problem, the distribution of impacts are on local and regional scales, and therefore, the solutions are to be sought on the same levels of complexity with joint production of knowledge involving communities. The book emphasizes the significance of understanding the human dimensions of climate change in exploring equitable and sustainable measures for adaptation in Bangladesh. Our ground level field experience gathered from more than 35 villages of Bangladesh show that the community people perceive the nature as part of their socio-cultural life and hence they should be placed at the locus of adaptation policy making to keep nature and culture in great harmony. The present book titled as 'Anthropology of Climate Change: Culture and Adaptation in Bangladesh' is the outcome of the aforesaid project carried out by the Department of Anthropology, University of Dhaka in collaboration with the Bangladesh Climate Change Trust of the Ministry of Environment and Forests, Government of the People's Republic of Bangladesh.

We express our immense gratitude to the funding agency Bangladesh Climate Change Trust (BCCT), Ministry of Environment and Forests for realizing the importance of climate research in academic arena. Additionally, BCCT has patronized to publish outcomes of the research of which this book is a glaring example. Ministry of Education, GoB has played significant roles by providing necessary official guidelines that enormously helped us to turn towards the successful completion of the research and of this book as well.

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Officials of Planning and Development, University of Dhaka instantly cooperated when required.

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We express our heartfelt gratitude to reviewers of the book Prof. Dr. A S M Maksud Kamal, Dean, Faculty of Earth and Environment Science and Chairman, Department of Disaster Science and Management, Prof. Dr. Kazi Maruful Islam, Department of Development Studies, University of Dhaka, and A K M Mamunur Rashid, Climate Change Specialist, CCED, UNDP Bangladesh. Finally, we take the opportunity to express our immense gratitude to experts, government officials, academicians, researchers, and stakeholders whose active cooperation made this project a success. We hope all of our endeavors would be fruitful if this book benefits people who take great interest in climate change and adaptation in order to ensure a better future for the generations to come.

December 2017 | Zahidul Islam
Dhaka | Hasan Shafie

# List of Abbreviations

| | |
|---|---|
| ADB | Asian Development Bank |
| ADP | Annual Development Plan |
| ALGAS | Asia Least Cost Green House Gas Abatement Strategy |
| AOB | Allocation of Business |
| BBS | Bangladesh Bureau of Statistics |
| BCCRF | Bangladesh Climate Change Resilience Fund |
| BCCSAP | Bangladesh Climate Change Action Plan |
| BCCT | Bangladesh Climate Change Trust |
| BCCTF | Bangladesh Climate Change Trust Fund |
| BFRI | Bangladesh Forestry Research Institute |
| BMDA | Barind Multipurpose Development Authority |
| BWDB | Bangladesh Water Development Board |
| CBO | Community Based Organization |
| CCA | Climate Change Adaptation |
| CCC | Climate Change Cell |
| CCU | Climate Change Unit |
| CDM | Clean Development Mechanism |
| CDMP | Comprehensive Disaster Management Program |
| CDS | Coastal Development Strategy |
| COP | Conference of the Parties |
| CZPo | Coastal Zone Policy |
| DMB | Disaster Management Bureau |
| DMC | Disaster Management Committee |
| DDMC | District Disaster Management Committee |
| DNA | Designated National Authority |
| DPPs | Development Plan Proforma |
| DRR | Disaster Risk Reduction |
| ECNEC | Executive Committee of the National Economic Council |
| EIA | Environmental Impact Assessment |
| FGD | Focus Group Discussion |
| FYP | Five Year Plan |
| GDP | Gross Development Product |
| GHG | Green House Gases |
| GIA | Governance and Institutional Analysis |
| GIS | Geographical Information System |
| GoB | Government of Bangladesh |
| HDI | Human Development Index |
| HH | Household Head |
| ICZMP | Integrated Coastal Zone Management Program |
| IFC | International Finance Centre |

| | |
|---|---|
| IPCC | Intergovernmental Panel on Climate Change |
| LCG | Local Consultative Group |
| LDC | Least Developed Countries |
| MoDMR | Ministry of Disaster Management and Relief |
| MDGs | Millennium Development Goals |
| MoEF | Ministry of Environment and Forests |
| MoFDM | Ministry of Food and Disaster Management |
| MoWR | Ministry of Water Resources |
| MTBF | Medium Term Budget Framework |
| NAPA | National Adaptation Program of Action |
| NEC | National Environment Council |
| NGOs | Non-Government Organizations |
| NPDM | National Plan for Disaster Management |
| NSAPR | National Strategies for Accelerating Poverty Reduction |
| NWMP | National Water Management Plan |
| NWRD | National Water Resources Database |
| OPPV | Outline Perspective Plan Vision |
| PIO | Project Implementation Organ |
| PPCR | Pilot Program for Climate Resilience |
| PRS | Poverty Reduction Strategy |
| PRSP | Poverty Reduction Strategy Paper |
| REDD | Reducing Emission from Deforestation and Forest Degradation |
| RHD | Roads and Highway Department |
| SEA | Strategic Environmental Assessment |
| SEIA | Strategic Environmental Impact Assessment |
| SIA | Social Impact Assessment |
| SLR | Sea Level Rise |
| SRDI | Soil Resource Development Institute |
| TRSM | Tidal River and Silt Management |
| UDMC | Union Disaster Management Committee |
| UNDP | United Nation Development Program |
| UNFCCC | United Nations Framework Convention on Climate Change |

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*Image–02: Deposition of Coarse and Sandy Alluvial Silt in Riverbed (Photograph by Mimu Das).*

*Image–03: Wining over Flood (Photograph by Navid bin Sakhawat).*

Chapter One

# Introduction

## SITUATION AND SETTINGS

Bangladesh sustains significant progresses as a developing economy over the years but such escalating growth is being recurrently intercepted by multitudinous natural disasters and socioeconomic processes. Owing to the other concomitant factors like the deltaic formation history and low-lying coastal morphology has turned Bangladesh into the most disaster prone region on earth and is highly susceptible to climate change impacts (Shafie 2009). The country is exposed to natural hazards of all possible sorts, such as, floods, riverbank erosion, cyclones, droughts, water logging, arsenic contamination, salinity intrusion, tornadoes, cold waves, earthquakes etc. The coastal zone of the country is highly vulnerable to climate change driven impacts of cyclone and subsequent storm surge. Inadequate governance, weak institutions, relative deprivation, exploitation and denial of fundamental human rights including highly polarized access to resources through commercial and industrial entities and vested-interest groups are defining characteristics of everyday existence in Bangladesh. The situation becomes increasingly worse due to the multiplying effects of high social vulnerabilities. The (co)occurrence of these natural events are often coupled and multiplied with the high base vulnerabilities of the individuals, households and communities results in disasters that further drive the country towards greater environmental degradation, hunger, poverty, social deprivation and political conflicts, and thereby withholding the socio-economic development of the country.

Bangladesh has achieved 7.24 percent growth in the current fiscal year, which is the highest in the last three decades. Per capita income has increased to 1602 USD in the current fiscal year (GoB 2017b). Poverty and extreme poverty rates have come down to 23.2 and 12.9 per cent respectively, while life expectancy has become 71.6 years. The country has been identified as one of the so-called "next 11 countries with basically promising outlooks for investment and future growth" (GoB 2012a). Current trends of economic development suggests that the country will very likely be a developed country by 2041 (GoB 2017b). Population growth rate has declined but the fertility rate decline seems to have plateaued. Therefore, with increased life expectancy, a reduced mortality rate and improvements in nutrition, a surging population could remain a challenge.

The economy of Bangladesh is highly dependent on agriculture and, at large, natural calamities of different types have made the farmers vulnerable to crop failures and food scarcities accelerating poverty in the country. Climate change threatens to undermine recent economic development in the country. Additionally, a doubling of Bangladesh total population in the last 30 years developed a sharp imbalance in the man–resource (particularly land and water). Poverty, growth, environmental sustainability and vulnerability are inextricably bound together in Bangladesh. However, more than 50 million people still live in poverty and many live in remote or ecologically fragile places (GoB 2012a). The economy is vulnerable to external risks such as a weak global recovery, and a declining new outflow of migrant workers. Besides, power shortage is one of the significant internal risks (Dasgupta, et al. 2010). According to the Climate Change Vulnerability Index of 2015, Bangladesh's economy is more at risk to climate change than any other country. The economic losses due to climate change in Bangladesh over the past 40 years were at an estimated $12 billion, depressing GDP annually by 0.5 to 1 percent.

The livelihood base of the people significantly suffers erosion resulting from recurrent and exposure of diverse natural hazards. People, especially poor and marginal, suffer most from these hazards due to high degree of base vulnerabilities and over exposure to natural hazards. The damage scenarios suggest not only of their macroeconomic significance or of implications for longer–term development in Bangladesh, but also imply the severity of indirect and secondary impacts. This has triggered growing awareness of the potential human, structural and economic threats that natural hazards pose. Moreover, as projected in IPCC's fourth assessment report, 70 million people could be affected annually by floods; 8 million by drought; and up to 8% of the low-lying lands may become permanently inundated due to sea level rise– all by 2050. Both in Copenhagen and in Cancun, the world community unanimously agreed that Bangladesh is the country most vulnerable to climate change impacts. However, the situation calls for immediate attention from both national and international communities to develop and undertake measures in counteracting the likely impacts of climate change in Bangladesh.

Human–induced global warming is causing fundamental changes to our climate and turns out to be one of the greatest threats to humanity in the twenty first century. Climate change is a complex, multifaceted, multidimensional, long-term, slow onset phenomenon with enormous impacts that touches almost all spheres of human society including most of its production–consumption processes (Rahman, et al. 2007a). Climate change threatens settlements and the number of people displaced from their land due to riverbank erosion, permanent inundation and sea level rise is increasing rapidly every year. It is also likely to threaten many development investments and efforts. Besides, the risks of climate variability are likely to be accentuated manifolds by the ensuing and extended climate change. For example, food security, water security and energy security are key elements of development. The impacts of climate change are likely to impede the process of achieving those securities in many affected communities.

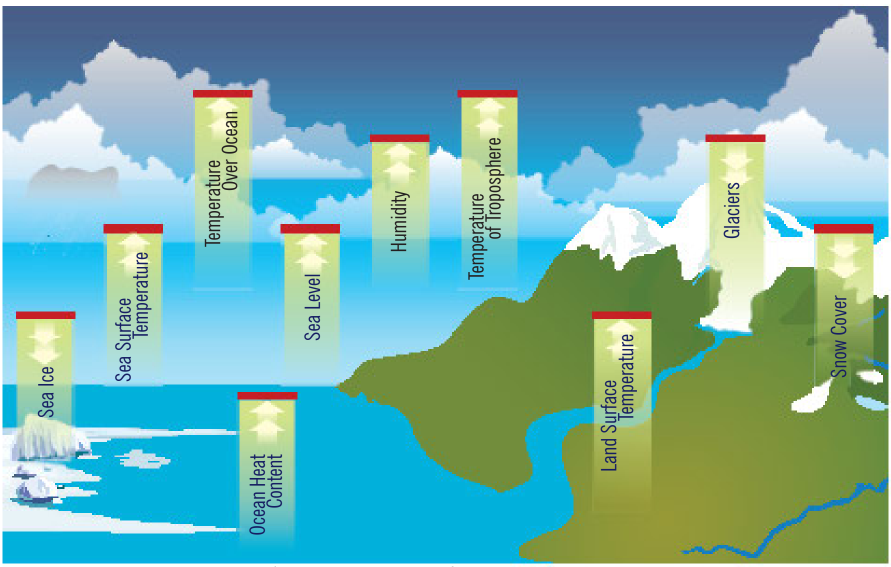
Climate change has received relatively less attention from social sciences until recent time (Haunschild, et al. 2016; Locatelli, et al. 2017). Only around 5% of the scientific papers published on climate change before 2010 were written from a social science perspective, while the rest of them were written from natural sciences perspective (Grieneisen and Zhang 2011). The research trend on the social and policy dimensions of climate change is gradually increasing (Härtel and Pearman 2010). A recent study on the literature on climate change policies showed a dominance of publications in journals with thematic and interdisciplinary orientations, as well as in journals focusing on economics, and a dominance of empirical case studies without theory development (Rykkja, et al. 2014 cf. Locatelli, et al. 2017). Given this backdrop, Stern suggest that climate change research must be interdisciplinary "because human–environment relations are natural and technological as well as behavioral and because the relevant human actions are those not only of industries, but also of communities, organizations and political-economic institutions" (Stern 1992). However, to complement this analysis of journals and disciplines, this book intends to focus on climate change policy research from anthropological perspective. The book would provide the policy makers with reliable data to make informed decisions on adaptation options in Bangladesh as a decision-aiding tool for onward planning at various stages of the policy-making cycle. Under this broad perspective, the present SEA study encompasses assessments of both broad policy initiatives and more concrete programs and plans that have physical and spatial references. The book emphasizes the significance of understanding the human dimensions of climate change in exploring equitable and sustainable measures for adaptation in Bangladesh.

## LIKELY IMPACTS OF CLIMATE CHANGE IN BANGLADESH

Bangladesh is a disaster-prone country. Due to climate change, hydro-meteorological disasters (cyclone, flood, drought, etc.) will be more frequent with increased magnitude. Almost every year, the country experiences disasters causing heavy loss of life and property and jeopardizing the development activities. The country is already beset with many problems like increasing population density, food security, human health, illiteracy, and so forth. These disasters erode the livelihood base of the inhabitants. Bangladesh is likely to be one of the most vulnerable countries of the world to climate change impacts. The global warming due to the increase in greenhouse gas concentrations in the earth's atmosphere and the consequent sea level rise (SLR) are going to exacerbate the situation (Ahmed and Chowdhury 2006). Almost every sector of socio-economic life in Bangladesh is likely to be affected by climate change (Karim and Mimura 2008; Khan, et al. 2011; Pouliotte, et al. 2009; Rahman 2008). In order to appreciate the future vulnerabilities to climate change, it is necessary to understand the interrelationship between climatic regime and associated risks of disasters (Ahmed, et al. 2009; Rahman 2008).

Over the next 25 years, however, with the increase in the absolute size of the population, the per capita water availability in Bangladesh will progressively be reduced (Ahmad, et al. 2001). However, such reduction

**Figure– 1.1: Ten Key Climate Indicators of a Warming World**




*(Note: These are just some of the indicators measured globally over many decades, The data shows that the Earth's climate is warming. Figure source: NOAA NCDC, based on data updated from Kennedy et al. 2010).*

in water availability will only affect the country's huge population during the dry season, where the current availability is already very low. Under general climate variability, the annual per capita water availability in 2025 will become 7,670 cubic meters as against 12,162 cubic meters in 1991. Keeping in view the poor water availability in the dry season, the per capita available supply will be much less, while demand for irrigation and other purposes (i.e., industrial process water, domestic & municipal water supply etc.) will continue to rise (Ahmed 2006). In agricultural sector, the present production activities are impeded by too much water during the wet season and too little during the dry season. The total irrigated area is 4.4 million ha which is being presently irrigated through surface and ground water resource. The over exploitation of subsurface water and erratic rainfall patterns have caused significant decline in the groundwater table in Bangladesh and thereby resulting the STWs to become non-operational in many parts of the country during dry period. Lack of surface water during the dry season limits the function of Low Lift Pumps (Mirza, et al. 2003; Rahman, et al. 2007; Rahman 2011). Figure – 1.1 shows an understanding of climate change impacts in the context of Bangladesh.

The social impacts, though generally not well–understood, are likely to be profound and climate change will affect humans through a variety of direct (changes in climate variables) and indirect pathways (pests and diseases; degradation of natural resources; food price and employment risks; displacement; conflicts, negative spirals) (Heltberg, et al. 2009b). Risks and uncertainties, associated with the impact of climate shocks and stresses, are typically embedded in agricultural practices in rural areas. The agriculture sector is reportedly more vulnerable to climate variations. Therefore, it is important to understand climatic impacts on agroecosystems and the farmer perceptions of climate change and its implications. Climate change is likely to have severe impacts on the food and livelihood securities, human capital and wellbeing of the poor people because of their reliance on subsistence agriculture in rural areas of Bangladesh. On the other hand, in urban areas, informal settlements are mostly built illegally and without formal planning. Limited availability of water, high child and infant mortality rates compounded with a very high morbidity rate (malaria, tuberculosis, diarrhea etc) are common characteristics of such informal settlements (Dodman and Satterthwaite 2008). Climate change also has implications for the urban poor and for rural–urban change. With climate change negatively affecting rural livelihoods, migration from rural to urban areas is increasingly likely to become the favored adaptation strategy of the mobile, rural poor. This will further exacerbate the problem of people living in urban fringe hazardous environments with potential risks of social unrest. However, the likely impacts of climate change across sectors in Bangladesh are represented in the Table– 1.1.

**Table– 1.1: Likely Sectoral Impacts of Climate Change in Bangladesh**

| Direction of Trends | Likelihood of Trend | Agro-ecosystems | Water Resources | Human Health | Settlement and Society |
|---|---|---|---|---|---|
| Fewer cold days and more frequent hot days | Virtually certain | Decreased yields and increased insect outbreaks. | Effects on water resources based on Himalayan snow-melt. | Reduced human mortality from decreased cold exposure. | Increased demand for cooling; declining air quality in cities; effects on winter tourism. |
| Increasing heat waves | Very likely | Reduced yields due to heat stress. | Increased water demand and decreased water quality. | Increased risk of heat related mortality. | Reduction in quality of life for people without appropriate housing; impacts on elderly, very young and poor. |
| Increasing heavy precipitation events | Likely | Damage to crops; soil erosion; inability to cultivate land due to water logging and flood. | Decreased quality of surface and groundwater and contamination of water supply. | Increased risk of deaths, injuries and infectious, respiratory and skin diseases. | Disruption of settlements, commerce, and transport due to flooding; pressures on urban and rural infrastructures; loss of property. |
| Increasing drought affected area | Likely | Land degradation; lower yields, crop damage and failure; increased livestock deaths. | Widespread water stress. | Increased risk of food and water shortage; increased risk of malnutrition; increased risk of water– and food–borne diseases. | Water shortages for settlements, industry and societies; reduced hydropower generation potentials; potential for population migration. |
| Increasing tropical cyclone activity | Likely | Damage to crops; uprooting of trees. | Power outages causing disruption of public water supply. | Increased risk of deaths, injuries, water– and food–borne diseases; post-traumatic stress disorder. | Disruption by flood and high winds; potential for population migrations; loss of property. |
| Increasing incidence of extreme high sea level | Likely | Salinization of irrigation water, estuaries and fresh water ecosystems. | Decreased fresh water availability due to salt–water intrusion. | Increased risk of deaths, injuries by drowning in floods; migration–related health effects. | Costs of coastal production versus costs of land-use relocation; potential for movement of populations and loss of infrastructure. |

*Note: Likelihood of trend is based on SRES Scenarios.*
*Source: Modified and adopted from the Fifth Assessment Report (IPCC 2014).*

Extreme climatic events and recurrent disasters have swept the development achievements of Bangladesh from time to time over the centuries and imposed much havoc on the well-being and socio-economic situation of the people. Impacts and shocks caused by natural disasters have contributed significantly to the pauperization processes in Bangladesh. Researchers often argue that, frequent devastation by natural disasters have been one of the major causes for the country being so poverty stricken (Mirza 2003). It is believed that managing disasters is a vital prerequisite for the country's step towards any long–term development goals. The Government of Bangladesh has attached high importance to disaster management in pursuit to achieve and sustain its development efforts (Mirza, et al. 2003). It is evident that vulnerability of the country to climate change is the result of a complex interrelationship among biophysical, social, economic and technological factors of the country. Many anticipated adverse impacts of climate change would in fact aggravate many of the existing stresses that already pose a serious impediment to economic development of Bangladesh. The climate change policy, particularly adaptation, thus becomes a part and parcel of the development policy of the country (Ali 1999).

## CHALLENGES TO SUSTAINABLE DEVELOPMENT AND CLIMATE CHANGE

Climate change threatens to undermine recent economic development in the country. Through good macroeconomic policies and a vigorous private sector, the country is maintaining a solid GDP growth rate 5.5 to 6 percent annually. Bangladesh has been identified as one of the so-called next 11 countries with promising outlooks for investment and future growth. GDP has more than tripled in real terms and food production has increased three fold. Population growth rate has declined but the fertility rate decline seems to have been plateaued. Therefore, with increased life expectancy complemented by a reduced mortality rate and improvements in nutrition, a swelling population continues to be an outstanding challenge. HDI significantly improved and the percentage of people living below poverty declined from 59 percent to 32 percent between 1991 and 2012. However, more than 50 million people still live in poverty and many live in remote or ecologically fragile places. The economy is vulnerable to external risks such as a weak global recovery from recession, and a declining new outflow of migrant workers. Power shortage is one of the significant internal risks. Given this background, in Bangladesh, climate change impacts are likely to erode the achievements of Millennium Development Goals (MDGs) and pose threats on achieving SDGs in several ways.

Initial impression on Bangladesh's potential to adapt to climate change may be gained based on the readings of some key indicators. The gross secondary and tertiary school enrollment stood at 47.5% and 4.8%, respectively, while the rate of literacy is 53% in 2008. A relatively low literacy rate suggests that the public are less capable of adapting to climate change impacts, and thus has high vulnerability. Table– 1.2 provide an overview of Bangladesh in terms of key indices of development.

**Table– 1.2: Bangladesh in Terms of Key Indices of Development**

| Sr. No. | Economic Indicators | Bangladesh | Year |
|---|---|---|---|
| 01 | GDP Growth Rate | 7.05% | 2015 –2016 |
| 02 | GDP Per Capita Income | 1466 US$ | 2015 –2016 |
| 03 | Inflation Rate (Point to Point) | 5.65 | 2015 –2016 |
| 04 | Investment Contribution to GDP | 29.38% | 2015 – 2016 |
| | Public | 07.60% | 2015 – 2016 |
| | Private | 21.78% | 2015 – 2016 |
| 05 | FDI Inflows | 2235.39 Million US$ | FY 2015–16 |
| 06 | Export | 31198.45 Million US$ | FY 2015–16 |
| 07 | Import | 40685.00 Million US$ | FY 2015–16 |
| 08 | Population | 1,60,578,266 | |

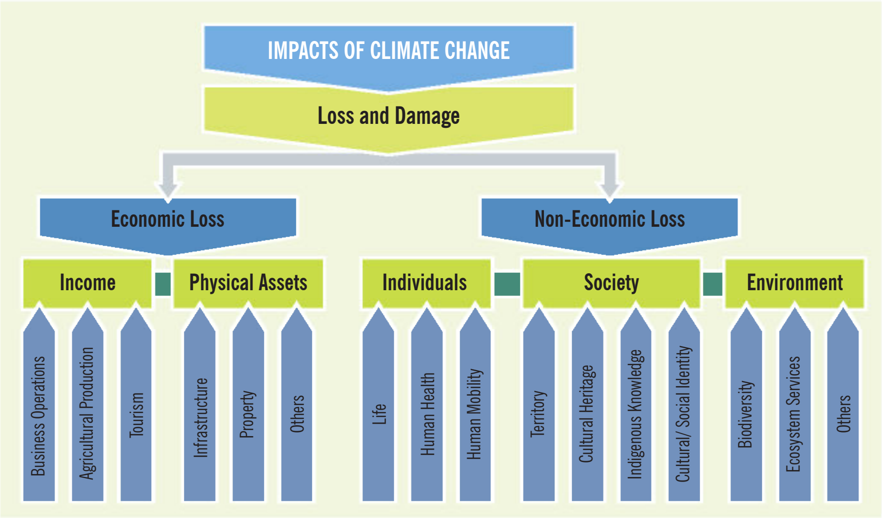
*Source: BIDA 2017, Bangladesh Bureau of Statistics (BBS), Bangladesh Bank (BB)*

The increase in environmental and health risks due to ongoing and future climate changes make it important to scale up interventions to reduce household vulnerability (Heltberg, et al. 2009a). Livelihoods in rural and urban areas are already affected by shocks that are threatening their sustainability, with negative implications for the poor and marginal people. People's livelihood strategies in many areas are expected to change significantly over the next 20 to 30 years. People dependent on agricultural livelihoods are like to become increasingly vulnerable to even small shocks (Cipryk 2009). Bangladesh is one of the most vulnerable countries in the world to climate change impacts, which poses a significant risk to the economic development of the country. The Climate Change Vulnerability Index of 2015 suggests that Bangladesh's economy is more at risk to climate change than that of any other country. The economic losses due to climate change in Bangladesh over the past 40 years are estimated to be $12 billion depressing GDP annually by 0.5 to 1 percent.

## NON–ECONOMIC LOSSES FROM CLIMATE CHANGE

Climate change is expected to bring about a wide range of affects on social, economic and environmental systems. The total costs of climate change, therefore, should account for: mitigation costs (+) adaptation costs (+) the residual costs of loss and damage. The residual costs of loss and damage, which cannot be avoided through adaptation and mitigation, can be further divided into: (1) Economic loss, and (2) Non–economic loss. In recent time, however, the concept of non–economic losses (NELs) has emerged in the context of negotiations on loss and damage under UNFCCC (Serdeczny, et al. 2017). The UNFCCC work program on loss and damage was established at COP 16 (decision 1/CP.16) and after that at COP 18, Parties requested the "preparation of a technical paper on noneconomic losses" (decision 3/ CP.18, para. 10) as part of the work program on loss and damage. NELs are losses of values that are not commonly traded in markets, e.g. loss of life, biodiversity and cultural heritage. Assessing the NELs are challenging mainly because of the absence of a market price. There is a logical connection between the magnitude of adaptation cost, mitigation cost and loss and damage. Increasing the mitigation effort (higher mitigation costs) will reduce loss and damage and might make adaptation cheaper (Fankhauser and Dietz 2014). In Bangladesh, non–economic losses are no less significant than economic losses. Recognizing and managing the risk of NEL should therefore be a central aspect of climate change policy (Fankhauser and Dietz 2014). Non–economic losses occur in three distinct levels: private individuals, society and the environment. NELs may be resulted from of both slow onset impacts (e.g. the loss of territory due to sea level rise) and extreme weather events (e.g. loss and damage in a cyclone) associated to climate change. The NEL may be directly connected to adverse climate change impacts (e.g. loss of ecosystems) or may also occur indirectly (e.g. malnutrition because of impacts in the agriculture sector). The UNFCCC

**Figure– 1.2: Economic and Non-Economic Losses from Climate Change Impacts**




*(Source: Adopted from UNFCCC 2013)*

identifies nine categories of NELs (see Figure– 1.2): life, human health, human mobility, territory, biodiversity, ecosystem services, indigenous/ local knowledge, cultural/ social identity, and cultural heritage (Fankhauser and Dietz 2014).

There are significant challenges for policymakers while addressing the risks of non–economic losses. These challenges are of two–folds: (1) value assessment of NELs, and (2) adaptation decision-making. The first challenge is the identification and quantification of non–economic value and its inclusion in decision-making, using the techniques of value assessment for economic decision-making. NELs encompass both intrinsic and instrumental values (Serdeczny, et al. 2016). While human life is mostly considered to be of intrinsic value, the loss of indigenous knowledge or cultural heritage has been observed to correlate with loss of social cohesion and a decreasing resilience to climate change, implying the instrumental value of these losses (Morrissey and Oliver-Smith 2013; Serdeczny, et al. 2017). The second challenge is related to adaptation to climate change at large. Making good adaptation decisions will reduce the risk of economic and non–economic losses alike, as the two are often connected. Flood protection, for instance, would help to avoid loss related to production interruptions (an economic loss) as well as distress and the outbreak of disease (a non–economic loss).

## CLIMATE CHANGE POLICYSCAPE IN BANGLADESH

Bangladesh has made a significant progress at policy level along with a series of policy and institutional changes had been undertaken by the Government in addressing the natural disasters and climate change impacts. Bangladesh has long been active in the UNFCCC process. There has also been a series of policy and institutional changes undertaken by the Government in recent years influenced by transformations in ideas, knowledge, actors and incentives (Alam, et al. 2011; Shaw, et al. 2013). These generated an increase in political commitment for climate change, emergence of new climate change actors in the decision-making, influenced by international climate change politics and finance (Urry 2015). There is a widespread awareness about the inter–relationship of climate change and development, at the national level, which has been reflected in the new 7$^{th}$ Five Year Plan (2016). The present Government is firmly committed, expressed in their election pledge, for an adoption of integrated policy and plan to protect the country from the adverse effects of global warming and environmental change. It is aligned with the national vision of becoming a middle–income country by 2021.

Policy proposals on climate change issues in Bangladesh requires significant analysis focusing on how the choices are actually made from the large set of possible policy alternatives in the context of Bangladesh (Dietz, et al. 2007; Urwin and Jordan 2008). The policy and strategy making process in Bangladesh suggests that most polices are driven by experts and bureaucrats, again following a top–down process (Alam et al 2010). Climate change policy-making involves many actors and it is a multi-faceted problem, requiring insights from climate science, economics, social sciences, the humanities and engineering (Leiserowitz 2006; Turnpenny, et al. 2005). These include emitters of greenhouse gases, those who make climate change policy and those who will be affected directly and indirectly by climate change (McCright and Dunlap 2003; Rabe 2004). This covers organizations from the national and international research community; national, regional and local government; non–governmental organizations (NGOs); multinational corporations and the huge range of local communities and concerned citizens (Aldy, et al. 2003; Giddens 2009).

Public policy-making can be seen as a process occurring in several domains including problem identification, policy formulation, advocacy, implementation, and evaluation. Although these domains of activities ‘ought to’ happen sequentially, in reality many of these processes are interactive and may occur simultaneously. In this study, data were collected on climate change policy development processes in Bangladesh and the Kingdon framework was made relevant to explain why things happened the way they did (Kingdon and Thurber 1984; Sabatier 1988). At first, the study would analyze the policy processes that tend to create particular ‘policy entrepreneurs and communities’ related to climate change issues, that is, specific constellations of actors, activities, and influences that had shaped climate change policies in Bangladesh. In the case of climate change, challenges of designing research to be ‘policy–relevant’ largely remains with the responsiveness of the scientific process to the needs of policy managers for particular clarity or understanding lying behind scientific assessments, projections or predictions. This book, however, highlights the relevance of anthropological research to climate change policy-making. It suggests that culture and community are central to the factors that mediate the interaction among society, humans and climate.

Political economy and political ecology approaches can bring science and policy closer to the needs of vulnerable groups. The problem, policy and politics streams together converge into the overall policy process to open up policy windows (Giddens 2009). These three streams are important and decisive to the overall policy process to transform an issue from a mere topic and/or problem into a concrete policy. In addressing a compelling problem like climate change, the policy entrepreneurs had played key roles in connecting the streams, and the different types of couplings between them. The Government of Bangladesh (GoB) has taken many initiatives for addressing climate change issues. The key policy instruments include:

**Table– 1.3: Climate Change Policy Instruments in Bangladesh**

| Policy Instrument | Target Year | Climate Objective | Sectoral Scope |
|---|---|---|---|
| **National Policy Instruments** | | | |
| Bangladesh Seventh Five Year Plan– 2016 | 2020 | Supportive Policy | Multisectoral |
| National Perspectives Plan– 2010 | 2021 | Supportive Policy | Multisectoral |
| Medium-Term Budgetary Framework– 2013 | 2018 | Supportive Policy | Multisectoral |
| National Sustainable Development Strategy– 2010 | 2020 | Adaptation & Mitigation | Multisectoral |
| **Climate Change Policy Instruments** | | | |
| Bangladesh Climate Change Strategy and Action Plan (BCCSAP)– 2009 | Onward | Adaptation & Mitigation | Multisectoral |
| National Adaptation Program of Action (NAPA)– 2005 (revised in 2009) | Onward | Adaptation & Mitigation | Multisectoral |
| Bangladesh Climate Change and Gender Action Plan– 2013 | Onward | Gender Equity | Cross–Sectoral |
| Country Investment Plan for Climate Change (CIPCC)– 2016 | Onward | Adaptation & Mitigation | Multisectoral |
| Bangladesh Climate Fiscal Framework– 2014 | Onward | Adaptation & Mitigation | Multisectoral |
| Climate Protection and Development Budget– 2017 | 2018 | Adaptation & Mitigation | Multisectoral |
| Intended Nationally Determined Contributions (INDC)– 2015 | Onward | Adaptation & Mitigation | Multisectoral |
| Nationally Determined Contributions– 2017 | 2030 | Adaptation & Mitigation | Multisectoral |
| **Supportive Sectoral Policies** | | | |
| National Environment Policy– 1992 | Onward | Supportive Policy | Cross–Sectoral |
| National Environment Management Action Plan– 1995 | Onward | Supportive Policy | Cross–Sectoral |
| Energy Efficiency and Conservation Master Plan– 2015 | Onward | Mitigation | Energy |
| Renewable Energy Policy– 2008 | Onward | Mitigation | Energy |
| Master Plan of Haor Areas– 2012 | Onward | Supportive Policy | Cross–Sectoral |
| National Aquaculture Development Strategy and Action Plan– 2013 | 2020 | Supportive Policy | Aquaculture |
| National Forest Policy– 1994 (updated in 2015) | Onward | Supportive Policy | Forest |
| Integrated Resources Management Plans for the Sundarbans– 2010 | 2020 | Supportive Policy | Forest |
| National Wetland Policy– 1998 | Onward | Supportive Policy | Environment |
| National Water Policy– 1999 | Onward | Supportive Policy | Water |
| National Biodiversity Strategy and Action Plan– 2004 (updated in 2016) | Onward | Supportive Policy | Biodiversity |

| | Policy Instrument | Target Year | Climate Objective | Sectoral Scope |
|---|---|---|---|---|
| | Bangladesh Delta Plan– 2016 | 2100 | Supportive Policy | Multisectoral |
| | National Land Use Policy– 2001 | Onward | Supportive Policy | Land-Use |

The Ministry of Environment and Forests (MoEF) has taken the lead in setting policy agenda for climate change in Bangladesh, although climate change impinges on the responsibilities of a wide range of other Ministries and agencies. Accordingly, in recent years a large number of investments have been made by a range of Ministries, for example, in coastal infrastructure and crop development, which provide a base from which to improve climate resilience. The Government led the development of the Bangladesh Strategic Action Plan on climate Change (BCSSAP) which also included low carbon energy dimensions (BCCSAP 2009). Coupled with renewed efforts of coherent development planning, in which climate change is now being embedded, the country is moving ahead on climate change and is a lead player for the Least Developed Countries (LDC) internationally. Implementation of plans and strategies on climate change has a long way to go and there will need to be a continuing national effort at all levels and sectors of civil society.

## STRATEGIC ENVIRONMENTAL ASSESSMENT OF ADAPTATION POLICY

At present, there is no concrete commitment for mitigating climate change through reducing GHG emissions by the major polluters, and therefore, the hope remains on the possibility of large investments on various adaptation plans and programs to address climate change–induced hazards. The global development agencies including even the private sector insurance companies are up for 'climate–proofing' of development particularly in the developing and least–developed countries. In the context of Bangladesh, adaptation is of high significance as recurring climate hazards undo the investments and development efforts particularly in risky areas including coastal zone. Research on adaptation policies can contribute to policy development by building an understanding of barriers in policy processes, and by providing knowledge needed throughout policy cycles (Locatelli, et al. 2017).

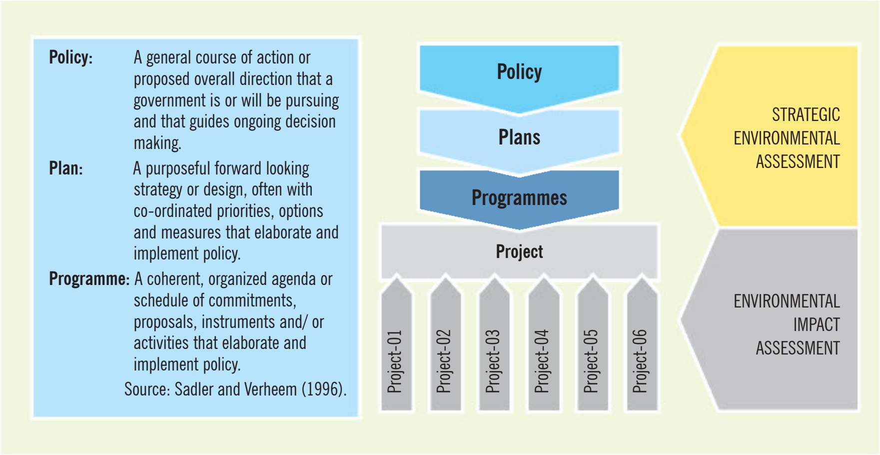
The environmental implications of policies, plans and programs are of significant concerns of present time. In this context, Strategic Environmental Impact Assessment (SEIA) or simply as Strategic Environmental Assessment (SEA) emerged as a recent approach and method towards understanding the changes in the environment (Ahmed and Sánchez-Triana 2008; Alshuwaikhat 2005; Partidário 1999; Short, et al. 2013; Therivel and Partidario 1996). SEA has therefore evolved, complementary to EIA, in order to conduct environmental assessments of development policies, plans or programs (Alshuwaikhat 2005; Goodland 2005; Loayza and Shima 2012). While, the primary purpose of Environmental Impact Assessment (EIA) is to determine and evaluate the environmental implications of development, to inform decision-making at the project level, SEA is used to make strategic decisions at the planning, programming and policy level influencing the nature of development (Brown and Thérivel 2000; Donnelly, et al. 2007; Fischer 2010; Sadler and Dalal-Clayton 2012).

SEA, unlike EIA, focuses on analyzing the potential environmental consequences of proposed policies, plans and programs, and their alternatives (Pintér, et al. 2004; Sadler and Dalal-Clayton 2012). SEA indicates a systematic and comprehensive process of evaluating at the earliest possible stage the environmental effects of a policy, plan or program and its alternatives (Fischer 2010; Loayza and Shima 2012; Therivel and Partidario 1996). SEA can be defined as "a systematic process for evaluating the environmental consequences of proposed policy, plan or program initiatives in order to ensure they are fully included and appropriately addressed at the earliest appropriate stage of decision making on par with economic and social considerations" (Sadler and Verheem 1996). More precisely, SEA is an approach for mainstreaming and upstreaming environmental sustainability in the decision-making hierarchy (Caple 2014; Fundingsland Tetlow and Hanusch 2012; OECD 2006). A hierarchy exists among policies, plans and programs with policies at the top level of conceptualization. The programs make plans more specific by including a time schedule for specific activities. Implementation of a program involves carrying out specific projects, which is subjected to traditional EIA (Fundingsland Tetlow and Hanusch 2012; Loayza and Shima 2012) .

SEA is distinguished from EIA in the sense that EIA indicates the impact of certain development on environment, but SEA appraises the impact of environment on development (Caple 2014; Fundingsland Tetlow and Hanusch 2012; Runhaar and Driessen 2007). SEA lays down the macro parameters of environmental resources within which development has to take place in a country, region or sector. The purpose of SEA is to ensure that environmental considerations and alternatives are addressed with economic and social factors in policy, plan or program development. The implementation measures associated with policies and programs cause direct economic and social effects. According to the OECD framework, the Figure– 1.3 shows the up–streaming environmental considerations into the decision-making hierarchy for SEA (OECD 2006).

The scope of SEA cannot be limited to consideration of environmental effects alone. In addition to direct and indirect environmental effects, SEA should also consider "cumulative effects," i.e., impact on the environment that results when the effects of implementing the proposal are added to

**Figure– 1.3: SEA: Up-Streaming Environmental Considerations into Policy-Making**




*(Source: Modified and adapted from OECD 2006)*

analogous effects of other past, present and reasonable foreseeable future actions. Cumulative impacts are important because impacts of individual projects may be minor when considered in isolation, but significant when the projects are viewed collectively (Stoeglehner, et al. 2009; Wallington, et al. 2007). SEA allows for the systematic consideration of cumulative and wider environmental effects. There is often a lack of correspondence between the temporal and spatial scale of cumulative effects and the narrow scope of project–level EIA (Abaza, et al. 2004). SEA can conducted to identify potential environmental problems early so that decision-makers can filter out environmentally damaging projects that might otherwise be the source of costly and protracted delays and controversy (Ahmed and Sánchez-Triana 2008; Buckley 2000; Geneletti 2011; L'Europe, et al. 2014).

The application of strategic environmental assessment (SEA) for identifying and evaluating potential impacts of policies, plans and programs (PPPs) and promoting more sustainable patterns of development (Fundingsland Tetlow and Hanusch 2012; Stinchcombe and Gibson 2001). The present research applies the SEA concepts and methods to explore the likely impacts of adaptation policies of Bangladesh. Climate change–induced hazards are not linear, and variability are often erratic and not often predictable (Hulme 2009). The available scientific knowledge suggests that climate is changing by human activities, but the extent and magnitude are still based on probable assumptions, guesses and scenarios. As climate system is the very foundation of life in this planet, and if we had already brought irreversible changes, then human existence would be at real stake (Beck 2010). Moreover, Bangladesh is a disaster–prone country, mainly because of its geographical location, as being the lowest riparian of the Ganges, Brahmaputra and Meghna basin.

Floodplains occupy 80% of the country. Mean elevations range from less than 1 meter on tidal floodplains, 1 to 3 meters on the main river and estuarine floodplains, and up to 6 meters in the Sylhet basin in the north–east (Rashid 1991). Only in the extreme northwest are elevations greater than 30 meters above the mean sea level. The northeast and southeast portions of the country are hilly, with some tertiary hills over 1000 meters above mean sea level (Huq, et al. 1999). In recent years, climate change impacts have increased the frequency and magnitude of climate disasters, not only in Bangladesh, but also across the globe (Beck 2009). Therefore, we need to have appropriate and effective adaptation policies in place to manage and reduce climate risks in the context of Bangladesh. This book is an outcome of a SEA study, which has immediate relevance to the evolving climate change policyscape in Bangladesh.

## SCOPE OF THE BOOK

The scope of the book is to examine the likely impact of the adaptation options that are likely to be implemented at different regions of Bangladesh through various national and international adaptation funds. The impact assessment critically examined how these selected adaptation options would likely affect physical and biological environment, as well as the economic and social aspects that local communities are dependent on. The book attempted to explore adaptation and adaptive capacity from capability, Sen's sense of the term, perspective. According to Sen, capabilities reflect various 'functionings' a person can potentially achieve and require the access to 'freedoms'– political freedom, economic facilities, social opportunities, transparency guarantees, and protective security (Sen 1992; Sen 1993; Sen 2001; Sen 2005; Sen 1990). However, the present book assesses adaptation options and policies by addressing the following issues:

Firstly, assesses the current vulnerability of livelihood to existing climate change and/or climate variability. This also includes the efficacy assessment of coping mechanisms in the face of current climate variability risks. Second, analyzes the future climate risks by assessing the vulnerability and capacity of the community to respond to developing climate change risks. Third, develops inventory of existing adaptation options and identify the magnitude of barriers (institutional, policy, technological, financial, etc) to climate change adaptation. Fourth, analyzes likely impact(s) of existing adaptation options on the biophysical and social environment and on the livelihoods of the poor and marginalized people. Fifth, assesses the sustainability of the adaptation process and policies by exploring the ability, capacity and willingness of the community to sustain and continue the adaptation interventions. Finally, recommend national and regional level scaling–up of selected climate change adaptation options.

## METHODOLOGY AND STUDY DESIGN

### Approach and Design

The book is based on empirical research conducted over a period of one year during 2015 and 2016. This study is based on both quantitative and qualitative frame of analysis, with both secondary and primary data and information. The published literature, both in print and electronic media that could be made available formed the secondary sources of information. The adaptation options were captured from the field through participatory process. The local communities of the research area, who are long experienced in autonomous adaptation, were the primary actors in the design of the project. The project identified vulnerabilities based on appropriate indicators used internationally (Downing et.al, 2001; Adger, 1998) and nationally. The research design and implementation methodology were participatory and community based. Using a range of quantitative (questionnaire survey and structured interview), and qualitative methods (key informants interview, FGD, village transect, social mapping, hazard mapping, etc.). However, specific methodologies planned for specific strategic aspects of the project are described below.

The strategic environmental assessment (SEA) approach aims at being systematic, analytical and practical. The following methodological steps has been followed to create a logical structure and provide guidance in clarifying the complex issues involved. The following methodological outline has been followed to create a logical structure and provide guidance in clarifying the complex issues involved (please see Figure– 1.4). The major information areas and corresponding methodological steps are discussed below.

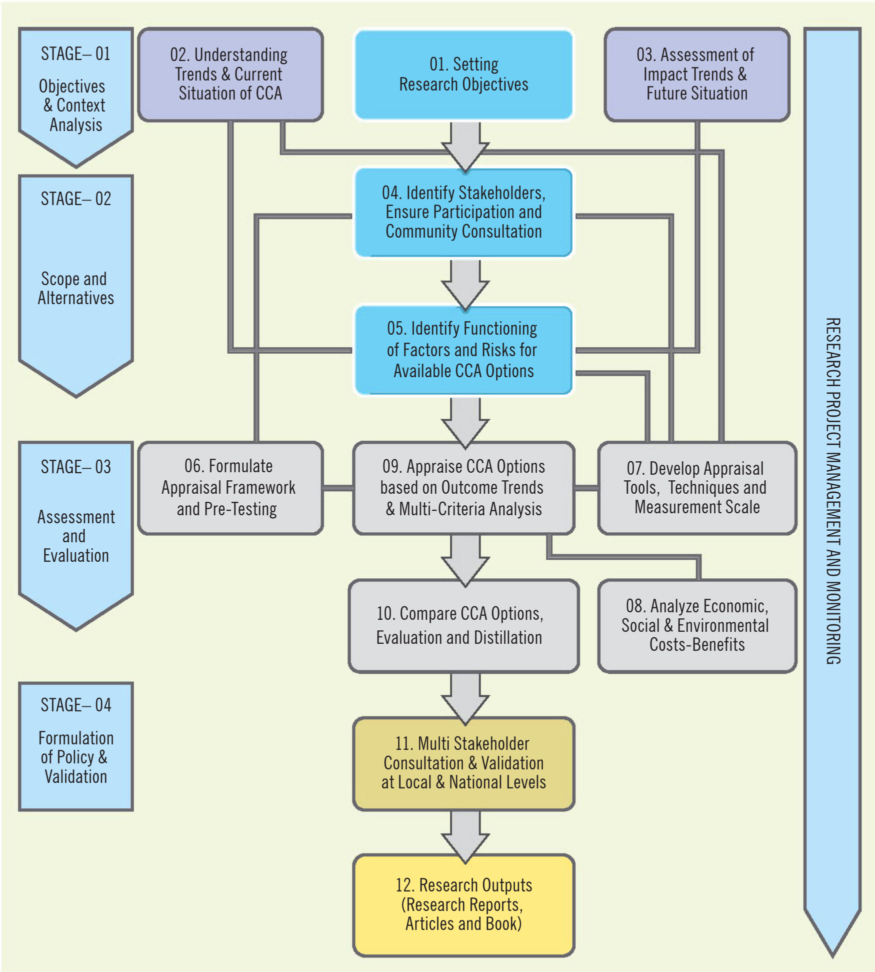
### Geographic Coverage

The research has been conducted in four upazilas, located in different ecological regions and representing major climate sensitivities, of Bangladesh. Assasuni upazila of Satkhira district, Chakaria upazila of Cox's Bazar district, Tarash upazila of Sirajgonj district and Porsha upazila of Naogaon district have been selected for this study for their geo–physical locations, relatively higher vulnerability to cyclone, salinity, flood, riverbank erosion, drought and other climatic variabilities.

### Collection of Data

The tools used for primary data collection is transect walk in the study areas, participant observation, key informant interviews and focused group discussion. Experts' opinion were also used for triangulation of data collected. The study has followed six steps: (1) developing inventory of adaptation

**Figure– 1.4: Methodological Scheme and Dependencies of Components of this Study**




options; (2) developing climate change–induced impact scenario based on updated scientific knowledge and prediction; (3) participant observation of the study area people and infrastructure. All the livelihood and social groups were included in the observation and focused group discussion; (4) developing a synthesis of overall findings from the field by adding expert judgments; (5) organize workshops to share the findings of the study, and (6) finalize and present the research findings.

**Literature Review:** A desktop study in the form of conducting a literature review was done as an additional method to achieve the aim of the research. Literature that is relevant to the study enables the researcher to understand the context of study problems. Searches were made through the university database system and Internet to locate and identify the most relevant texts, including online articles, journals, books, websites and other published reports relevant to the study problem and objectives. The process also helped in contextualize and compare the research issues with other regions. Furthermore, conducting a literature review allows a way for the findings made in the study to either be supported or opposed by alternative explanations. Concurrently done with the literature review was also identifying theory used in past studies as a means to understanding the basis for the study and accordingly, as a building block of creating a theoretical foundation for this book.

**Sampling and Survey:** A total number of 1440 households have been interviewed during the household survey. In the household survey household income, expenditure, food security, household assets and awareness of existence of disaster management committee were assessed in order to apprehend the capacity of the local people to withhold the effects of climate change induced disasters. In every upazila, 360 household interviews were conducted. Every upazila depending on the number of unions were divided in 12 clusters and from every cluster, 30 households were interviewed. The household survey was conducted using a structured questionnaire, which were pre–tested before the actual survey and data collection. Detailed distribution of samples is depicted in Appendix – 01 (please see for details).

**Ethnographic Observation:** Ethnographic fieldwork, based on extended periods of residence and research at a community level, has been anthropology's dominant approach to capture the elusive domains of cultural meaning and practice. Anthropology's emphasis on fieldwork and participant observation stems from the recognition that engaging in daily life and social relationships provides a contextual understanding of cultural realities that cannot be captured by structured survey methods alone (Atkinson and Hammersley 1994; DeWalt, et al. 2002; Guest, et al. 2012; Jorgensen 1989; Schensul, et al. 1999; Spradley 2016). Ethnographic interviews and participant observation provide important entry points into ways which reveal the phenomena that people use as evidence that the surrounding climate is changing.

Ethnographic interviews had been conducted for collecting research data. The ethnographic interviews allowed to the interviewees to carry on a flexible dialogue with the researcher while also offering strategic advantages for data gathering. Because interviews were conducted in Bangla with Bangla speaking person, employing this style of interview allowed data to be gathered in a more robust way. An interview guide was created to assist the researcher in organizing three main themes to be covered in the interview with suggested questions to ask during the actual event that correlate to the research goals. This proved useful during initial contact with sources and preparation leading up to the interview, as the themes were provided to the interviewees as context for the conservations. However, it is important to note that these themes did not lead the interviewee to any specific answer or bias the individual into providing a specific outcome that would compromise the quality of the data to be gathered. The researcher took both notes and audio recordings during the interview, with prior consent by the interviewees, to provide a means ensure accurately and validate findings in the interview (please see appendix for detail schedule of ethnographic interviews in different field locale).

**Key Informants Interview:** Key informants were brought together to uncover information on problems, hazards, perceptions, feelings, opinions and thoughts. Reflective, interpretative and decisional questions were structured and used depending on the research objectives and questions set. To avoid missing important information, exercises were supplemented with checklist questionnaires and semi–structured interviews. 16 KIIs were conducted in each of the study area. Key informants included government officials at upazila level, imam of local mosques; madrasa representatives; union parishad representatives; upazila parishad representatives, beneficiary group members, schoolteachers, staffs of the NGOs (local, national and international) operating at the local level.

**Case Study Method:** The research questions and objectives developed for the study indicates important first steps as to what is the most appropriate and effective research method to use. Classifying the type of research questions formulated, and in turn, giving the research itself substance and shape, allows the selection among various methods to be defined more specifically. It is important to note that the selected research methods for a study to answer the questions each provide advantages and disadvantages in their use. The types of research questions developed pursue specific study goals that inherently provide rationale for using specific research methods. In this instance, for this study, the chosen research method is case study to utilize an exploratory and explanatory function.

**Focus Group Discussions:** A Group Discussion involves a free exchange of thoughts and ideas among members of the small group. The group discussions, for this study, were quite informal and not conditioned by such procedural rules as in the case of a formal group discussion. This technique was used to identify and verify the socio–economic condition of vulnerable people, their feelings and condition during disaster, their present condition, the role of different stakeholder to reduce their vulnerability. The multicriterion assessment of different adaptation options, discussed at length in chapter eight, are also based on these group discussions. The present research involves several FGDs with different stakeholder including livelihoods groups, bazar committee, excluded social groups, women, and cross section groups of people.

**Participatory Learning Workshop:** Participatory learning workshop is a kind of technique where the participants learn lot about a particular thing through discussion. The present study involves four types of PLW in each study area consist of vulnerable group including their family members, disaster management personnel's, cross sectional group and the role of different stakeholder to reduce their vulnerability and probable future solutions about it.

**Social and Hazard Mappings:** Social mapping is a visual method of showing the relative location of households and the distribution of different people together with the social structure, groups and organizations of an area. Along with social maps, hazard calendar, livelihood calendar, adaptation matrix were also collected from the field to understand the social and hazard situation of regions. During the field nine different maps and matrix were prepared (please see appendix for details).

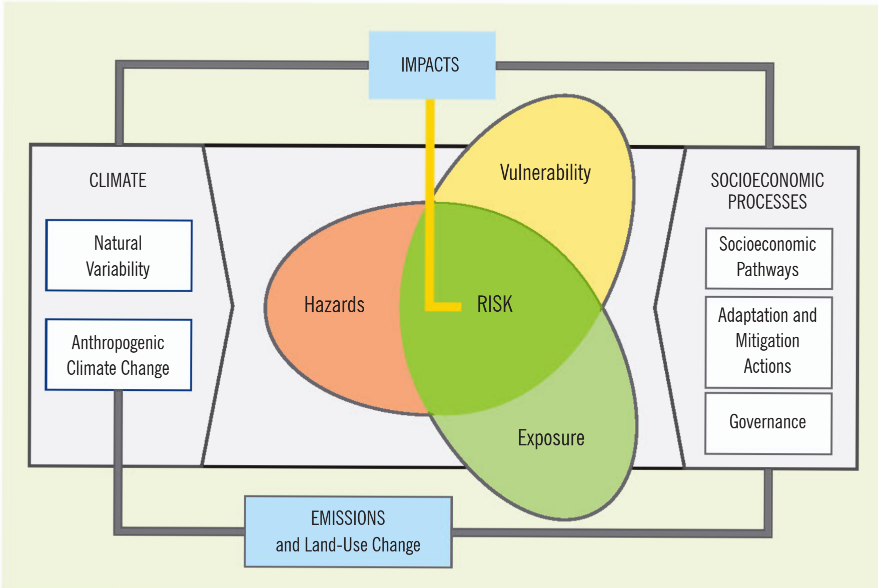
### Analysis of Data

**Climate Risk Assessment:** Climate Risk Assessment has established itself as an essential tool for the management of climate risk. An issue for climate risk assessment is the lack of an easily defined measure of what constitutes harm to the environment. In some cases, definitions of environmental damage are laid down in statute, but in others, appropriate criteria needs to be selected based on scientific and social judgments. A comprehensive treatment of the basic principles of climate risk assessment and management is represented in the Figure– 1.5 (see IPCC 2014).

**GIS Mapping:** For data collection and storing, an online platform was created. Enumerators in the field conducted interviews with digital tabs to transfer the data to the online server as soon as the interview was finished. The digital version of the survey questionnaire was programed for error and logical checking, thus, missing data was minimal. Uploaded data were crosschecked and stored in the online server. When data collection was completed, all the stored data were exported to SPSS for analysis and reporting. Besides, GPS was collected for all the household locations of the interviewees. Thus, created a provision for rechecking of data as well as ensured that the sampling procedures were maintained. Further, GPS was also used in identifying all the vulnerable locations of research areas. Thus, digital mapping of physical vulnerability of the areas was made possible.

**Vulnerability Analysis:** Assesses the impacts of a planned activity or different development scenarios on the vulnerability of an area. Vulnerability maps are produced showing degree of vulnerability for selected targets (e.g. people, landscape). These are overlaid and "weighted" (using GIS and multi–criteria analysis) to indicate areas of high vulnerability and then related to expected levels of impact associated with different development options–

**Figure– 1.5: Assessing Risks of Climate Change Impacts**




*Source: IPCC 2014*

revealing the locations of negative impacts regarding different targets, and the alternatives with the least impacts.

**Stakeholder Analysis:** Incorporates economics, game and decision theory, and environmental sciences. Current models apply a variety of tools on both qualitative and quantitative data to understand stakeholders, their positions, influence with other groups, and their interest in a particular adaptation option. In addition, it provides an idea of the impact of the PPP on political and social forces, illuminates the divergent viewpoints towards proposed PPPs and the potential power struggles among groups and individuals, and helps identify potential strategies for negotiating with opposing stakeholders.

## Validation and Reliability

The validation process for the data gathering was ensured through an iterative process that is implemented at multiple points in time during the study. Ethical considerations were made during the initial outreach that informed about the intention of the interview and how the data was to be used. Permission was granted prior to conducting the interview for it to be recorded with opportunities to have follow–up communication post–interview to clarify answers, if necessary. Validation of data occurred during the interview where any potential misunderstandings received by the researcher were expressed, and subsequently, requested clarification to ensure the answer was captured as it was intended. Repeating answers given by the interviewee and rephrasing questions that covers the same matter but from different perspectives were also ways to validate data during the interview. The researchers continuously reviewed the responses to ensure they were not interpreted, rather captured as they were exactly intended. These steps were followed and repeated for all interviews to ensure communication of intentions and consistency in the study. Finally, after the interview, the recording was reviewed along with notes taken to ensure the answers were reliable with minimal error and biases made.

The research involved a monitoring system to improve the quality and relevance of findings and review the impacts of activities, and on-site inspections were conducted based on performance indicators during the study. The research team emphasized the need of achieving and maintaining the highest level of quality possible throughout the study. All collected, accepted and analyzed data in this research undergone specific quality control assessment. At large, the data accepted for processing passed through extensive screening process for quality assurance based on interpretive and diagnostic analysis on the following criteria, e.g. (1) Precision, (2) Accuracy, (3) Representativeness, (4) Completeness and (5) Comparability. All data were critically assessed during and after the collection process to ensure the quality of the data. These assessments include independent performance audits, data processing audits as well as external review of the tools and templates to be used to collect the data.

*Image–04: Riverbank Erosion (Photograph by Hasan Shafie).*

*Image–05: Riverbank Erosion (Photograph by Khalil Ahmed Shamim).*

# Chapter Two

# Culture, Climate Change and Adaptation

## HISTORY OF ADAPTATION STUDIES

Adaptation to environmental conditions has been a focus of anthropology since the early 1900s. The use of the term adaptation in the context of human induced climate change has begun in the 1990s although scholars did not explicitly relating this back to the conceptual origins in anthropology. Adaptation is the core concept of any ecological studies in anthropology. It is not even a new idea and its scope is not limited to climate change studies. Human adaptation studies begun long ago when the earlier scholars wanted to understand the differences between various human populations and explain human variability. Herodotus (484– 425 B.C.), explains human variability as a result of adaptation to different environments and considers culture as a modifier (Bianchi 2016; Clay 1850 reprint). Similar explanatory ideas of adaptation came from Hippocrates (c. 460– 377 B.C.) while discussing the influence of the environment on health and temperament he suggests that human body can only be understood with its relationship to the environment and behavior (Alessi 2015; Karagiannis 2014). Aristotle (384– 322 B.C.) also argues for environmental causes of variation by explaining the woolly hair of Ethiopians (Africans) due to harsh and arid climate, and the straight hair of Thracians and Scythians due to moist air (Thompson 1910). Since then, Andreas Vesalius (1514–1564), Comte de Buffon (1707– 1788), Friedrich Blumenbach (1752– 1840), Chevalier de Lamarck (1744– 1829), Samuel Smith (1751– 1819), Carl Bergmann (1814–1865), Charles Darwin (1809– 1882) and many other scholars have made significant contribution to the study of man–environment interaction and human adaptation (Blumenbach, et al. 1865; Darwin 2009; Krieger 2005; Lamarck 1809; Smith 1810).

Scholars from a wide range of disciplines have been trying, for a long time, to understand the relationship between ecological and social systems. Glacken has extensively reviewed the Western conceptualization of the relationship between environment and society up to the 18th century (Glacken 1967). According to him, Western thought has oscillated between positions in which environment and society were treated separately as distinct entities (Davidson-Hunt and Berkes 2000). Karl Marx, in the 19th century, approached the relationship between environment and society as complementary processes and emphasized the opposition between both environment and society and between individual and society (Ingold 1980; Wolf 2010). During the 20th century, the relationship between environment and society has been explored in many disciplines, for instance, human ecology (Park 1936), cultural ecology (Steward 1972 [1955]), ecological anthropology (Bateson 1972; Bateson 1979; Netting 1974; Netting 1986; Vayda and McCay 1975; Vayda and Rappaport 1968a; White 1960), population ecology (Ehrlich 1968), human geography (Sauer Carl 1956), environmental history (Cronon 1983; Donald 1977; Worster 1988), ethnoecology (Conklin 1957; Nazarea 2006 [1998]; Toledo 1992), political ecology (Escobar 1996; Greenberg and Park 1994; Watts and Peet 1996), deep ecology (Naess 1973; Naess 1984) and so on. However, discussion on the environment and society relationship often cut across disciplinary boundaries and calls for much theoretical debates.

There is an emerging body of literature that recognizes that the ecological systems are characterized by multiliear–linear processes achieving multiple equilibria, instead of stability, (Berkes, et al. 2000; Davidson-Hunt and Berkes 2000; Keesing 1999; Scoones 1999; Vayda and McCay 1975; Zimmerer 1994; Zimmerer and Young 1998) and emphasizes the role of institutions in linking social systems and ecosystems (Berkes, et al. 2000). Exploitation of environmental resources advocate the relevance of understanding both economies and 'ecologies of scale' (Gardner 1997), both spatial and temporal, linking social and ecological systems is a cross–scale problem (Holling, et al. 1998). Reflecting on this broader area of scholarship, one point of departure is the idea of adaptation, which offers an important perspective to think about the interactions between environment and society.

## ANTHROPOLOGY, CULTURAL ECOLOGY AND ADAPTATION

The tension between 'anthropogeography' and 'historical possibilism', two contesting grand theoretical traditions, according to both Geertz and Moran (Geertz 1963; Moran 1979), has led to the emergence of cultural ecology and ecological anthropology. Anthropogeography, a variant of environmental determinism developed by Friedrich Ratzel in the late 1800s, proposes that the environment is the causal agent for the behavior of social systems. The propositions of this tradition, according to Moran (1979), consider habitat as primary in bringing about cultural diversity, while similarities between cultural groups are explained as occurring due to the diffusion of traits by migrating groups and the territorial competition between migrating groups results in human cultural evolution. It is further assumed that human beings are limited by their habitat in their range of response options, and human culture is shaped by environmental conditions.

Franz Boas, the American anthropologist during early 1900's, developed the historical possibilism as a perspective to explain the interactions between humans and the environment. Historical possibilism suggests the possibilities for humans are circumscribed by nature, while historical and cultural factors explain the actually chosen possibility among other alternatives (Moran 1979). According to Boas, cultural decisions are taken to decide which part of the nature to be exploited for human survival and these culturally made decisions are responsible for defining the trajectory of human societies and cultural change. Historical possibilism, thereby refuting environmental determinism, suggests that the culture is the foundation of human adaptation. In Boas's view, many different cultural traits can be nurtured within similar biophysical environments and therefore, differences between human groups can be explained in terms of cultural possibilities but not geographical limitations. Boas explained shared and similar cultural traits by diffusion from one culture area to another. This perspective, however, made the idea of culture as a 'superorganic' entity, which subordinated individual humans to its patterns. This line of reasoning have turned culture as the causal agent, rather than environment, while change emerged from historical and cultural forces, while the environment sets the screen where these forces are being played out (Davidson-Hunt and Berkes 2000).

Julian Steward's cultural ecology evolved out of the debate between these two opposing theoretical positions and explored the adaptive relationship between society and nature from an evolutionary perspective (Steward 1955). According to Frake, cultural ecology studies the role of culture as a dynamic component of any ecosystem of which man is a part (Frake 1962). Man carves his ecological niches primarily with cultural tools and he constantly devises new tools for carving out progressively effective places in the surrounding ecosystem. Therefore, the study of cultural ecology is the progressive cultural adaptation and specialization to environmental conditions. Instead of focusing only on the stages of cultural development, Steward primarily concentrated on the causes of cultural change by developing a methodology for determining the cross–cultural regularities of form, function and process. He framed cultural ecology largely as a methodology for building evolutionary theory (Steward 1955: 30–42). The idea of 'cultural core[1]' is also made relevant for cross–cultural comparisons by methodologically assuming that "certain basic types of culture may develop in similar ways under similar conditions but that few concrete aspects of culture will appear among all groups of mankind in regular sequence" (Steward 1955: 4). The basis of Steward's evolutionary theory is 'multilinear evolution' which he developed by focusing on empirical features, rather than deductive and universal theories. The understanding of the relationship between cultural change and the environment has been significantly reframed in Steward's cultural ecology. His emphasis on empirical cases is important for finding the similarities in cultural features across societies to theorize the processes. He also recognizes that human perception of the environment plays a role in the man–environment relationship and adaptation. Therefore, the application of the term adaptation to social systems can be traced back to the ideas of Julian Steward.

Apart from the theoretical positions of environmental determinism and historical possibilism and their respective emphasis on either nature or culture, Steward, in his seminar study, focused on causal connections between natural environmental conditions, subsistence and the social structures of a population or society (Steward 1955). Social, economic and political structures of different societies under similar environmental conditions exhibits comparable features and similar causal connections. Therefore, the ontological premise of Cultural Ecology always intends to explore regularities and common grounds in human behavior, social structure and belief systems, which would develop as responses to certain environmental conditions. The method of Cultural Ecology is culture–comparative in time and space and designed to search for generalizations in the function and emergence of human behavior. The patterns of food acquisition, under certain ecological conditions, constitute the immediate connections between environment and behavior.

The underlying mechanisms leading to the development of such behavior were believed to represent a human universal, whose impetus would arise from the necessity to use the naturally available resources, such as food. According to Cultural Ecology, social institutions possess an internal functional connection, e.g. as certain modes of production occur

1 *"Cultural core" is defined as the "recurrent constellations of basic features ... which have similar functional interrelationships resulting from local ecological adaptations and similar levels of sociocultural integration" (Steward 1955: 6).*

in combination with certain modes of social and political organization or the division of labor in a society. On this condition, the effect of one variable on a limited number of further variables can be examined within the system, rather than having to examine the much more complex system of social organization in its entirety. Cultural Ecology differs from classic functionalism (e.g. Malinowski 1960), emphasizing diachronic comparison, in that it puts an emphasis on the investigation of change and its causes and less so on the question of mechanisms by which equilibrium states can be maintained or basic and derived needs be met.

Central aspects of the culture–ecological approach refer to the question whether specific behavioral responses are necessary for the adaptation of human populations to their environmental conditions, or whether a broad behavioral repertoire would suffice, i.e. whether adaptation occurred through specialization or generalization of abilities. In this context, adaptation would be understood as the ability to find ever better solutions for the alternative possibilities of habitat use. The method chosen to examine these questions primarily aims at investigating the relationship between the environment and the subsistence system practiced. Subsequently, those behavioral patterns were analyzed which were connected with a certain subsistence technology, in order to eventually be able to study the effects of the respective behavior patterns on other aspects of culture in the population. Thus Cultural Ecology attempted to support the basic assumption that there is a causal relationship between natural resources, subsistence technology and those behaviors in a population that facilitate the use of resources at a given level of technological development (Moran 2000): 48). Yet the environment would only affect certain elements of culture, the so-called culture core, while other elements would develop in the course of an autonomous culture history (Orlove 1980). Steward's (1955) term of the culture core comprises all those social, political and religious behavior patterns, which can be empirically determined and associated with subsistence activities and economic operational sequences. The aim of Cultural Ecology is the investigation of adaptive processes, which, under comparable environmental conditions, bring about cross–cultural regularities. Hence, principles of cause and effect between culture, technology and environment were implied which consequently led to the formulation of a deterministic model of intrinsic cultural development (Steward 1949). It was based on the idea that certain regular transitional culture stages would appear in the process of the evolution of human social structures, the sequence of which could be regarded as a universal model.

The principles of Stewardian Cultural Ecology has been applied to deal with the functional connections of subsistence and characteristics of social organization as well as to confirm evidence of such intercultural commonalities. Apart from investigating into the behavioral connections with human subsistence, Cultural Ecology also explores the effect of resource change, population dynamics or the influences of other cultures on the cultural evolution of a certain population (Baker 1988b). Cultural ecology have developed an approach that would enable an explanation of origins of cultural characteristics and that the occurrence of certain types of resources, typical subsistence modes and behavior traits are covariant, i.e. functionally interconnected, and furthermore that the same correlations occur in different regions and historical times. Yet this does not necessarily mean that characteristic culture traits are always caused by certain environmental conditions (Hardesty 1977).

Leslie White, another proponent of Cultural Ecology developed a different approach than that of Steward, emphasizes on the use of energy as the determinant of cultural evolution (White 1943). White aimed at a linear and mono-causal explanation for cultural evolution where both the efficiency of energy utilization and the application of certain technological achievements was seen as the prime driver of cultural evolution. This is in contrast to the classic Stewardian view, which would permit different causes to bring about different lines of cultural development (Orlove 1980).

## ECOSYSTEM ANTHROPOLOGY AND HUMAN ADAPTABILITY

Ecological Anthropology adopted the principles of general ecology following from the work of Leslie White. Critiques of Steward's cultural ecology paradigm, focused on environment–culture–behavior nexus, led anthropologists towards a more biologically oriented ecological anthropology that regards humans as parts of the ecosystem, and examines human adaptability in terms of physiological, biological and behavioral reactions arising from interactions with environmental conditions. This perspective analyses culture characteristics by applying the principles of biological ecology (Geertz 1963; Vayda 1976; Vayda and McCay 1975; Vayda and Rappaport 1968b). Geertz (1963) first argued for the usefulness of the ecosystem as a unit of analysis by stating that systems theory provided a broad framework, essentially qualitative and descriptive, that emphasized the internal dynamics of such systems and how they develop and change (Geertz 1963). Barth, even before that in 1956, applied the concept of the "niche" to explain the ecologic relationships of adjacent groups and the maintenance of ethnic boundaries (Barth 1956). The methods of ecological anthropology incorporated core biological issues such as population or ecosystem and explored the functional role of different organisms in shaping environmental conditions and, in particular, the interaction with other human groups. According to Orlove ecological anthropology is the "study of the relations among population dynamics, social organization, and culture of human populations and the environments in which they live. It includes comparative research as well as analyses of specific populations from both synchronic and diachronic perspectives." (Orlove 1980: 235). He goes on to suggest that ecological anthropology provides a materialist examination of the range of human activity and thus bears an affinity to other materialistic approaches in the social, natural and biological sciences (Orlove 1980).

Humans like other organisms interact with their environment in different intensities and at different levels. The idea of ecosystem explains the relations between groups of organisms, and organisms and the environment acting at these different levels of integration. According to Odum, ecosystem is a self–contained entity which, in a given area, encompasses all organisms interacting with the physical and chemical environment, so that there is diversity of biological relations and material cycles, and energy flow that create clearly defined food chains (Begon, et al. 1986; Odum 1983 cf. Schutkowski 2006). An ecosystem is composed of a set of components, biotic and abiotic, which are connected through structuring principles within the system. Accordingly, ecosystems are characterized by the spatial and temporal distribution patterns of their components, by the transport of material (flow of matter) and utilization of energy (energy flow), by the exchanging and passing–on of information (information flow) and by the properties of change and evolution (Schutkowski 2006). The key ecological categories are units of space, time, matter, information and energy.

Holism is the ontology of systemic approach in ecological anthropology and assumes that the components and elements of the ecosystem are intimately interconnected and that they represent certain conditions and degrees of organization whose development can be adjusted by feedback mechanisms. Explaining and understanding the variability of human reactions to given environmental conditions would thus have to consider the interrelation between the realms of cultural, biotic and abiotic factors within the system or habitat. The idea of homeostasis is also applied to understand to self–regulating properties of the ecosystem, which fostered the much–celebrated work on the Tsembaga of highland New Guinea by Rappaport in 1968. Rappaport (1968) explored the Tsembaga society that had established a culture trait of self–adjusting homeostatic mechanism through the cyclical nature of certain feast ceremonies (Rappaport 1968). The Tsembaga people, during these celebrations, slaughter the growing pig population as part of their ritual and thus maintain a balance within the ecosystem by reducing the overexploitation of natural resources. According to this perspective, systemic correlates of homoeostasis refers to the maintenance of general ecosystem properties, which corresponds to the idea of resilience.

The human ecosystems are considered open and characterized by positive feedback, non–linear oscillating processes and intentional intervention. Homoeostasis and dynamic equilibrium are not equivalent to the absence or the impossibility of change. Homoeostasis or dynamic equilibrium requires the constant adjustment of parts within the system or complete structures. Systems therefore possess low–level mechanisms, which aim at the maintenance of stability, and other mechanisms which have an effect at a higher general level and which maintain the system as a whole. In order to be able to follow and analyze such processes, ecological anthropology is thus explicitly oriented towards a diachronic method with an emphasis on the study of change, in order to identify adaptation as a process (Orlove 1980). Although the application of an ecosystem perspective to human populations provides relevant insights into the complex situations of local populations at the micro level, but many scholars have argued its validity in explaining the overall context of human behavior and human adaptability (Schutkowski 2006). However, individual decisions and strategies are being increasingly included in ecological studies as, when aggregated, having effects on the population at the macro level (Barth 1981; Moran 2000; Moran 2016).

Human adaptability approach is concerned with the macro level influence of the natural and cultural environments on the biological characteristics of human populations based on the ontological assumption that humans are a product of natural evolution and in their genetic make–up would reflect the outcome of adaptations to their respective environments. According to this approach, adaptation is understood as any kind of biological reaction which reduces environmental stress and/ or increases resilience against the stressor, which might take the form of population–specific genetic characteristics, physiological acclimatization and learned behaviors (Baker 1988a; Schutkowski 2006). However, in this approach, the concept of environment is not limited to the natural conditions only rather the meaning of environment also embraces the cultural, social, political and economic reality of humans (Schutkowski 2006). Human adaptation, therefore from an anthropological perspective, means man–environment relations including all human requirements encompassing all of the environmental conditions, together with social milieu that are necessary for the viable maintenance and the amount of different resources that it requires. Adaptation is a process through which, “human population with all its collective and statistical social features, and a set of cultural ideas in terms of which these people try to understand and cope with themselves and their habitat” (Barth 1987).

## ANTHROPOLOGY AND ADAPTATION TO CLIMATE CHANGE

Anthropology has long been studying humans in the face of an uncertain future when they are attempting to cope with and adapt to climate. Human societies have always tried to predict the climate based on their previous experiences. However, recent studies of climate change suggest that the past performance of the climate is becoming a less reliable predictor of future performance. The frequency, variability, seasonal patterns and characteristics of climate events and phenomena will change in future. Phenomena once unknown to a particular region could become regular features of its future climate (IPCC 2014). An important consequence of climate change for adaptation is that the future climate will be less familiar and in key respects more uncertain. However, some climate parameters will follow the predictable trends, with a very high degree of confidence, while some climate parameters, e.g. average precipitation, will vary from decreases to increases depending on location and season, and the confidence in predictions of precipitation trends is less than for temperature trends. The projected trends in temperature, precipitation and extremes will push future climate variations and extremes beyond the bounds of what people and places have been exposed to and had to cope with in the past (Leary 2013; Leary, et al. 2008). Therefore, uncertainty in detecting and predicting climate change trends is an important barrier to climate change adaptation policy and actions.

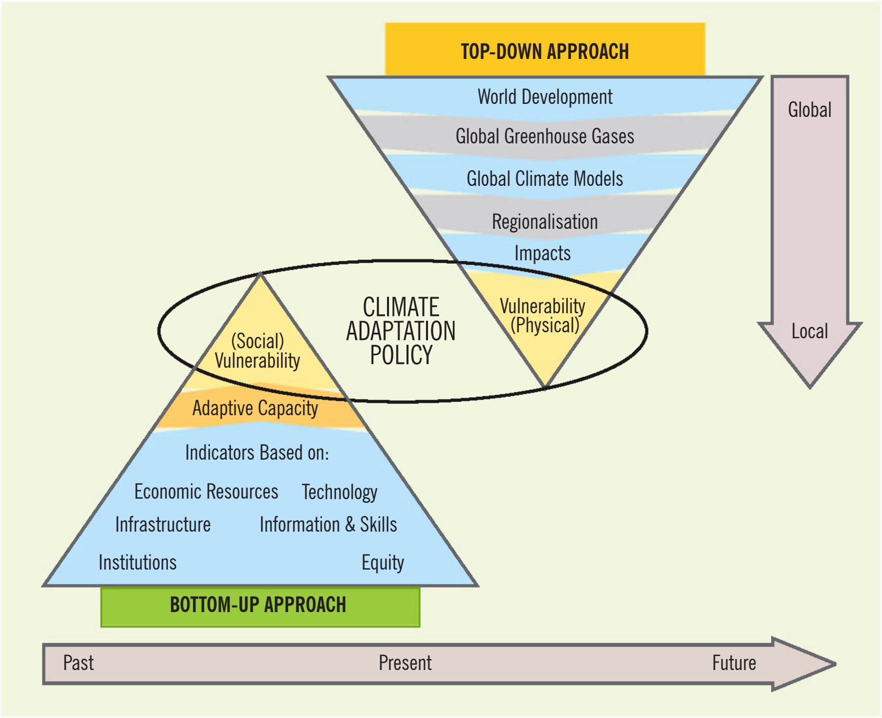
Exposure and uncertainty, the two essential components of climate risk, decisively play role in determining our adaptive response to climatic variability. The ways people understand risk has important theoretical and social implications in understanding how risk based decisions are made. People's understanding of risk-based decision-making is underpinned by human behavioral and social psychological aspects. Perception of climate risk has a cognitive dimension (Sjöberg 1996). According to this cognitive approach, risk is understood as a function of general properties of the risk object (Sjöberg 1996). Studies of risk perception have identified two important dimensions for the subjective risk judgment (Fischhoff, et al. 1984a; Fischhoff, et al. 1984b; Slovic 1987; Slovic, et al. 1985; Vlek and Stallen 1981). These dimensions summarize a large number of individual determinants of perceived risk. However, in the context of climate risk, they may be described as: (a) the degree to which the climate risk is unknown and (b) the degree to which the climate risk evokes a feeling of dread or fear. The former represents cognitive aspects of concern and expresses aversion to uncertainty, whereas the latter captures a risk's ability to evoke an instinctive response. Adaptive response to climate risk can be understood from both individualist and contextualist perspectives. The individualist paradigm suggests that people's adaptive response to climate risk depends on the knowledge and information they have as well as by personality type because personality defines whether a person is risk averse or a risk taker (Wildavsky and Dake 1990). The contextualist perspective, however, begins with the social structure, institutional form, or cultural elements (Douglas 1992; Kasperson and Kasperson 1996; Otway and Wynne 1989; Palmlund 1992; Rayner 1992; Tansey and O'Riordan 1999).

The recent literature on climate change defines adaptation as adjustments in ecological, social or economic systems in response to actual or expected climatic stimuli and their effects (IPCC 2001b; Smit and Pilifosova 2003). The IPCC defines climate change adaptation as "adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm or exploit beneficial opportunities" (IPCC 2001a). However, there are other definitions as well and are often used, for examples: adaptation (Smit, et al. 2000) (1) 'is a process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed and implemented'; (2) 'is the process through which people reduce the adverse effects of climate on their health and well-being, and take advantage of the opportunities that their climatic environment provides' (Burton 1992); (3) 'involves adjustments to enhance the viability of social and economic activities and to reduce their vulnerability to climate, including its current variability and extreme events as well as longer–term climate change' (Smit 1993); (4) 'means any adjustment, whether passive, reactive or anticipatory, that is proposed as a means for ameliorating the anticipated adverse consequences associated with climate change' (Stakhiv 1993; Stakhiv 1996). Slight differences exist among these definitions but they understand adaptation to climate change as a process that includes learning about risks, evaluating response options, creating the conditions that enable adaptation, mobilizing resources, implementing adaptations and revising choices with new learning.

Adaptation is adjusting to address ongoing and future climate changes. There is a substantial difference in adaptation approaches, depending on whether adjustments are made to actual, or expected, stimuli (Raiser 2014). According to the top–down approach, adaptation depends on the "projections of future emission trends, moving on to the development of climate scenarios, and thence to biophysical impact studies and the identification of adaptive options" (Kelly and Adger 2000: 326). On the other hand, the bottom–up approach to adaptation is focused primarily on the notion of vulnerability. The vulnerability approach assumes that if one can address actual vulnerability today, one inevitably reduces future (expected) vulnerability (Burton, et al. 2002). Vulnerability is generated by multiple factors (e.g. wealth, health and educational status, social equity, food reliability etc.) and processes in the social and ecological systems (Brooks, et al. 2005; O'Brien, et al. 2007: 75). The bottom-up is an integrative perspective, where the approach is centered on the human systems' coping capacity through promoting vulnerability reduction by enhancing resilience to future change (Uzielli 2006). Again, there are differences in the understanding of vulnerability as either 'outcome–vulnerability' or 'contextual–vulnerability', relating to either scientific predictions or actual human–security framing respectively (O'Brien, et al. 2007). However, according to Brooks vulnerability can be either 'actual' or 'expected' (Brooks 2003). 'The interpretation of vulnerability affects the type of adaptation that is promoted' (O'Brien, et al. 2007: 84; Raiser 2014). The Figure 2.1 provides a visual representation of the two approaches of dealing with uncertainty can inform climate adaptation policy: one is (epistemic) uncertainty 'reducer' while the other is uncertainty 'accepting' (Ciurean, et al. 2013; Dessai and Hulme 2004).

Both the approaches have their relative advantages and disadvantages. A combination of top–down and bottom–up approaches is valuable for policy makers as it provides relevant assessment of adaptation options in the face of uncertain future climactic conditions whilst maintaining much needed legitimacy through stakeholder involvement' (Bhave, et al. 2013; Bhave, et al. 2014a; Bhave, et al. 2014b; Bhave, et al. 2016). Another study on the applicability of three varying approaches to adaptation reveals that there is a considerable amount of co–evolution between the various strategies (Dessai and Hulme 2007; Dessai, et al. 2009; Dessai 2005). The suitability of approaches depend on a range of factors including 'spatial and temporal scales at which adaptation is taking place, availability of technical and

**Figure– 2.1: Approaches for Addressing Climate Adaptation Policy**




*Source: adapted from Dessai and Hulme, 2004.*

financial capacity to handle scenario information and the type of adaptation being considered' (Dessai 2005). However, these adaptation approaches, when utilized effectively together, enable a much more thorough assessment of adaptation possibilities, considering a wider array of vulnerabilities, and the solution to these (Raiser 2014).

## HUMAN DIMENSIONS OF ADAPTATION AND CLIMATE CHANGE

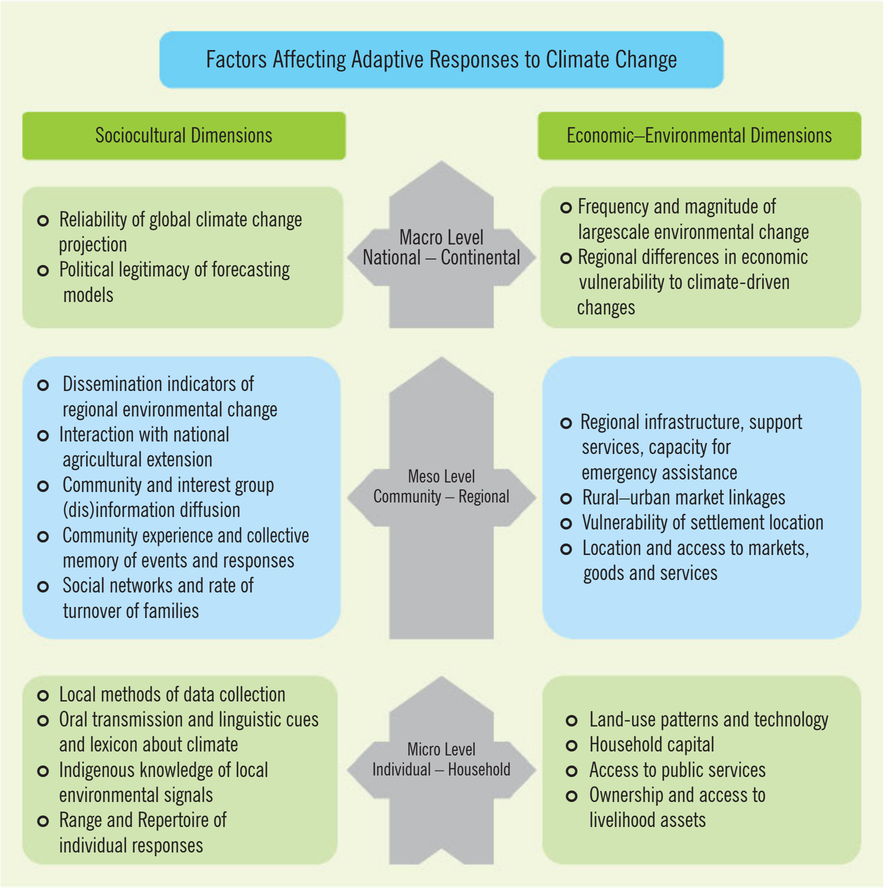
Trends in recent research studies have focused on the mitigation of greenhouse gas emissions from forests, and adaptations to climate change in agriculture (Locatelli, et al. 2017). However, studies on adaptation to climate change have underrated, or even perhaps ignored, the context in which people perceive and evaluate the risks of changing their livelihood strategies and make risk decisions. The cultural aspects and perceived realism of risks have remained discounted in the technical models of risk analysis and assessment. Risk perception assumes that the perceiver, within a social setting, selects certain risks for addressing, while suppresses some others from attention. An individual's own estimates of risk may be very different from that of the others as well as from apparently 'objective' estimates of risk calculated in terms of statistics and probability distributions. Actor's response to climate risks depends on how they experience the risk environment, which take them to compare the present situation with that of the past– anything they have experienced or culturally known and classified in the past. The actor first take resort to their previous experiences of similar situation and depending on the similarity, they choose a particular course of actions to be taken. In case of new experience, people employ a more complex assessment to see whether the new experience can be fitted to the existing cultural categories and behavior or requires more contextual assessment (Brondizio and Moran 2008; Shafie 2017). These risks are assessed in terms of the constraints of the individual as a member of a household and a community, and the external constraints he/ she faces. Therefore, people may respond to risk and uncertainties in a wide variety of ways because risk is more about thought, beliefs and constructions rather than about reality.

Adaptation policies need to account the decision factors influencing the protective response motivation of people living under risk and uncertainties induced by extreme climatic events. To understand human dimensions of climate change, we need to begin by examining the adaptive mechanisms of human populations to environmental change, the differential responses to the magnitude and the frequency of perceived and actual changes, and the differences between adaptive responses at the individual level and those visible at the population level (Brondizio and Moran 2008). Actor's adaptive responses to global environmental change are mediated by multiple factors including perception of change in terms of cultural and linguistic dimensions– such as whether people have experienced that type of change and whether it is easily understood and interpreted by existing cues and an appropriate lexicon and so on. In Bangladesh, flooding is a regular occurrence and therefore, established residents of this region are more likely to have a specific terminology and the ways to cope with flood compared to new residents who have never experienced a flood before. If flooding would have occurred infrequently in Bangladesh, the memory of past events may not be part of inter–generational cultural knowledge (Brondizio and Moran 2008; Moran 2009).

Studies on risk have raised the challenges of incorporating cultural and technical considerations into the risk management framework (Fischhoff, et al. 1984a; Fischhoff, et al. 1984b; Rayner 1992; Rowe 1977; Sitkin and Pablo 1992; Sitkin and Weingart 1995; Slovic 1987; Starr 1969). Factors altering the perceptions of people may lead the community people to underrate or even not perceive risks even though the actual risk might be out there. Risk perception assumes that the perceiver, within a social setting, selects certain risks for addressing, while suppresses some others from attention (Douglas 1985). Therefore, understanding the factors that contribute to form and change risk perception has significant bearing upon policy outcomes and program implementations for risk management.

Research on risk perception may vary, to a large extent, in terms of micro-macro levels of abstractions. Drawing on the analysis of individuals, the social psychological theory of risks is concerned with how individuals reacts to uncertainties, the formation of risk perception and judgment of risks at the individual level (Brehmer 1987; Loewenstein, et al. 2001; Tversky and Kahneman 1975). While, focusing on the macro level processes, the cultural theory of risk (Douglas 1985) looks at the relationships amongst individuals and argues that "risks are defined, perceived, and managed according to principles that inhere in particular forms of social organization" (Rayner 1992). Individual-level responses to environmental changes are time dependent and heterogeneous, with some individuals coping quickly and others taking one or more generations to adapt. While a few individuals may adapt quickly to an environmental shift, but a population might take at least one generation to become fully adjusted (Moran 2009). However, according to the cultural theory of risk perception, the perceiver of risk is not an isolated individual, rather he works, lives and has social relationships within a social context. Therefore, the cultural theory argues that "what societies choose to call risky are largely determined by social and cultural factors, not nature" (Johnson and Covello 1987). Within the wider social factors and processes, the individuals are motivated to make choices and decisions for risk response, and these choices become aggregated as patterns. The social and institutional arrangements set conditions for individual's behavior, provide broad frameworks for the shaping of their attitudes and

**Figure– 2.2: Mediating Factors of Adaptive Responses to Climate Change**

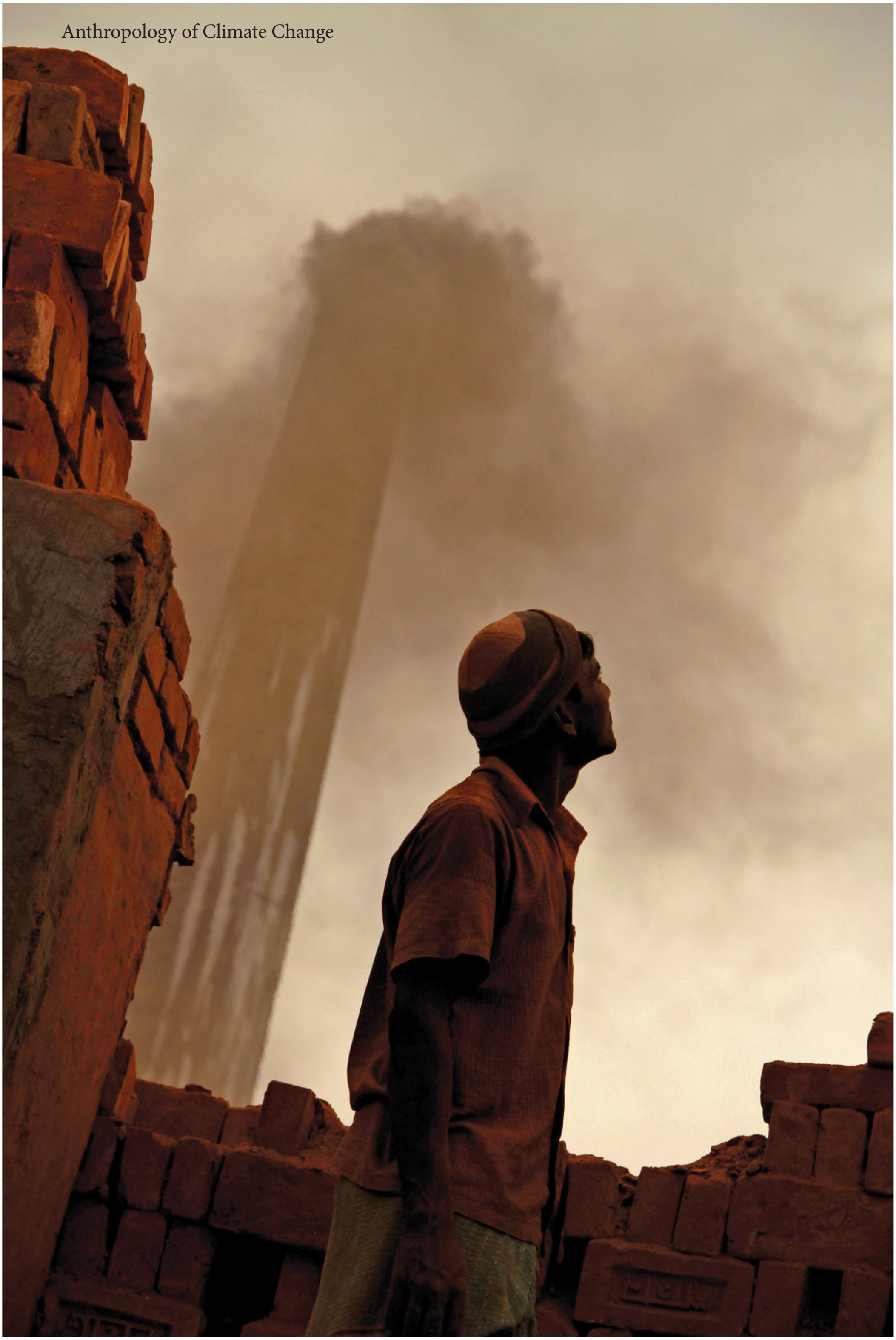



*(Source: Modified and adopted from Brondizio and Moran 2008)*

beliefs, and are also closely tied to questions of what is to be valued and what is not (Douglas 1985). Since risk perception is affected by both individual and cultural factors, we need to have appropriate frameworks to explain the diversity in perceptions, making of choices and decisions of response or action (see Figure– 2.2). In addition, In addition, differences in households' economic capital allow them to take risks by different capacities.

Challenges to human adaptation to climate change depend on understanding the scale of the problem: most environmental perception is local rather than global, and is manifested in experience with changes in precipitation and temperature and observation of crop responses to current conditions (Magistro and Roncoli 2001 cf. Brondizio and Moran 2008). The existing literature on human–environment interaction has had a tendency to treat human responses to change at a local, self-contained level, but limited in capturing the linkages and vertical interplay created by a growing functional interdependency of resource use systems and ecosystems (Berkes 2006; Brondizio and Moran 2008; Young 2006). The linkages between local and global understanding of climate change sometimes become conflicting when the national and global forecasts contradict local experience, which raise the question of authenticity leading people to resist believing either of them because they do not match personal understanding and experiences of climate patterns. People's interpretation and trust of such information depend on the spatial and temporal scopes with which it is presented, its significance to local–level decision making, and clarity of language and terminology. The roles of institutions, culture, social class and perception are significant variable for determining how people respond to forecasts (Lemos, et al. 2002; Moran, et al. 2006; Nelson and Finan 2000; Shafie 2017; Shafie, et al. 2009). Adaptation is likely to be quicker if there exist effective connections between climate factors and cultural practices (Magistro and Roncoli 2001). However, this line of reasoning suggests that we should pay due attention to processes those mediate the perception of change in climate and differ at individual, household, community and regional scales. Approaches to understand adaptation in Bangladesh, therefore, must account various social conditions differentiating adaptability of individuals and communities as well as consider understanding of individual environmental cognition and behavior into larger social, cultural and environmental contexts.

*Image–06: House on the Verge of Collapse during Cyclone Aila on 27 May 2009 (Photograph by Hasan Shafie)*



*Image–07: Emission from Brickfield (Photograph by Shuvashish Sarker).*

Chapter Three

# Profiling the Study Areas

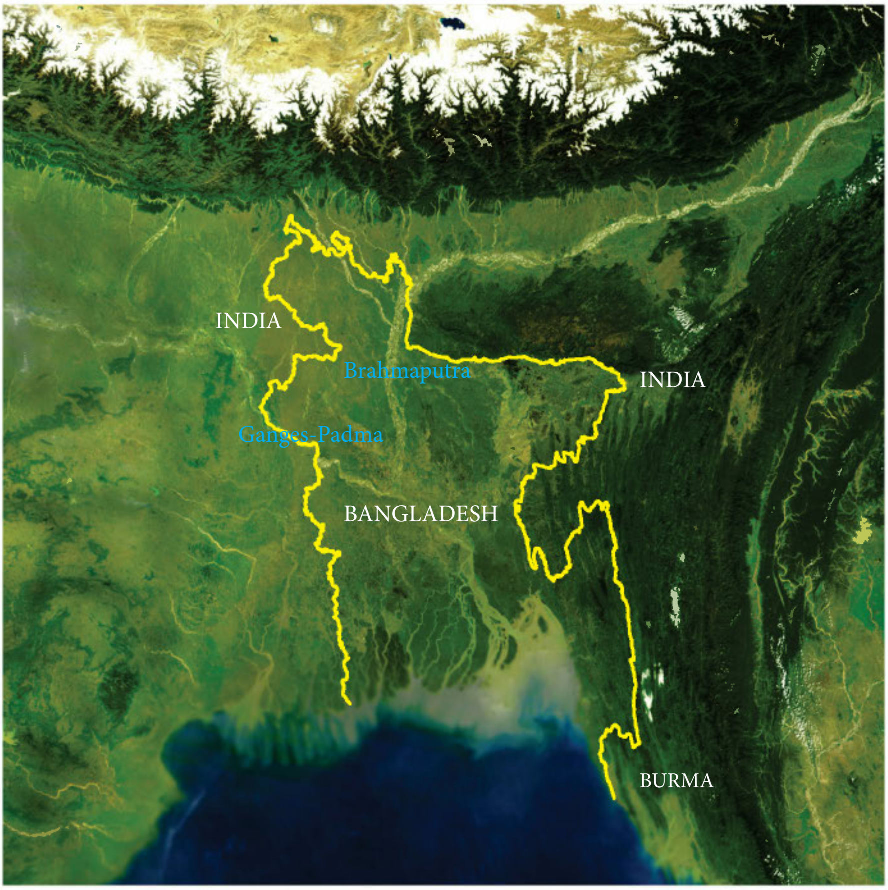
## GEO–PHYSICAL LOCATION OF BANGLADESH

### Quaternary Bangladesh and Paleoclimate

Bangladesh, a part of Bengal Basin, geologically located at the intersection of the Indian, Burma and Tibetan (Eurasian) Plates, the three interacting geo–tectonic plates (Alam, et al. 2003), while geographically, as a corridor, the West and South Asia to the Southeast and East Asia due to its strategic location between the Himalayan Mountain Range and the Bay–of–Bengal. The Quaternary history of the Bengal Basin reveals the interplay of several co–occurring factors, for instance, the uplift of the Himalayas, subsidence in the Bengal Basin and suppressed monsoon, have contributed in the making of alluvial sedimentation in the Bengal Basin (McArthur, et al. 2004; Ravenscroft, et al. 2005; Umitsu 1987; Umitsu 1993). The Himalayan glaciation, during the Ice Age, suppressed monsoonal circulation reducing rainfall and river flows (Dawson 1992; Gibling, et al. 2005). Oceanographic evidence, from the Bay of Bengal, indicates that river discharge was greatly reduced under the dominance of the dry northeast monsoon (Goodbred, et al. 2003; Sinha, et al. 2005; Wiedicke, et al. 1999), but at the low–stand of sea level during last glaciations, most river sediment would have passed over the Bengal Basin onto the submarine fan of the Bay of Bengal (Weber, et al. 2003). Therefore, the fluvial sedimentation on the Ganges–Brahmaputra River delta began around 11 kya, during post LGM, when the rising sea level intercepted the coastal plain about 50 meters below the present surface, causing floods in the Bengal basin and thereby, trapping most of the river's discharge on the inner margin (Goodbred and Kuehl 2000).

Significant variation in climatic regimes, during the Last Glacial Maximum (LGM) and late glacial phase across Indian plate and Bengal Basin, has been characterized by substantial aridity, reduced river flow and much lower summer monsoon compared to those of the present (Goodbred and Kuehl 2000; Kudrass, et al. 2001; Kumar, et al. 2008). During the post-glacial transgression, the rise of the sea level by more than 110 meters has altered the coastline considerably by shifting it in some places hundreds of

**Map– 3.1: Bangladesh Seen from the Sky on November 9, 2011**




*Source: MODIS on Terra Satellite, Earth Obs, NASA.*

kilometers inland. The formation of ice caps in the northern hemisphere, during the last glacial period[2] of Pleistocene epoch, had caused the lowering of world sea level by 120 meters below the present sea level (Beyin 2011; Chappell 2002; Clark and Mix 2002; Fairbanks 1989; Lambeck and Chappell 2001; Mellars 2006; Oppenheimer 2009; Siddall, et al. 2003; Van Andel 1989; Westley and Dix 2006; Yokoyama, et al. 2000), and thereby exposing the swathes of land presently submerged under sea water. Besides sea level changes, the last Ice Age during quaternary is characterized by fluctuations in climatic conditions and changes in geologic processes of weathering, erosion, sediment supply from the Himalayan mountain range and deposition of sedimentation changes in the Bengal Basin. Rainforest was replaced by dry grasslands due to cold and arid climatic conditions during this period in most of the regions of Indian subcontinent (Morrill, et al. 2006). Hunting gathering based subsistence would find difficulty in adapting to such ecological conditions (Williams and Clarke 1984). These conditions are expected to lead early human population to move towards eastern part of India through the Bengal Basin and to southern India, since some monsoon forests and woodlands had existed in those regions (Kumar, et al. 2008; Williams and Clarke 1984). Late Pleistocene and early Holocene periods, after the retreat of glaciations phase, are marked by rapid population growth, as the climatic conditions began to improve.

## The Ganges–Brahmaputra–Meghna (GBM) River Systems

Bangladesh, as one of the largest, youngest, and most active deltas in the world, has been formed by the alluvial deposits of the Ganges–Brahmaputra–Meghna (GBM) river systems. Numerous rivers and tributaries of the GBM systems drain through the country of which there are 57 trans-boundary rivers. The GBM river basin comprises a catchment area of 1.72 million square km distributed over 64.02 percent in India, 17.69 percent in China, 8.57 percent in Nepal, 7 percent in Bangladesh and 2.73 percent in Bhutan (MoWR 2017). The GBM river systems has an average annual flow of 1,009,000 million cubic meter and transports 1.8 billion tons of sediments each year into the Bay of Bengal. This the largest sediment supply in the world that leads to accretion of the land area in the coastal zone (5–10 square km per year, mainly in the Meghna Estuary), and to constantly changing and highly unstable network of rivers, estuaries, tidal inlets, and tidal creeks.

2 *The last glacial cycle was characterized by substantial millennial-scale climate fluctuations, but the extent of any associated changes in global sea level (or, equivalently, ice volume) remains elusive. Highstands of sea level is reconstructed from dated fossil coral reef terraces, which is complemented by a compilation of global sea-level estimates based on deep-sea oxygen isotope ratios at millennial-scale resolution or higher. Records based on oxygen isotopes, however, contain uncertainties in the range of ±30 m, or ±1 degrees C in deep sea temperature. The analysis of oxygen isotope records reconstruct the history of water residence times is, however, accurate to within ±12 meters (Siddall, et al. 2003).*

### Features of Coastal Zone of Bangladesh

Bangladesh has 710 km long coastline. The coastal zone includes 19 coastal districts, 153 upazilas and Exclusive Economic Zone (EEZ) in the Bay of Bengal[3]. Of these 19 districts, 51 upazilas of 12 districts are 'exposed coast' and subject to natural disasters. The landward distance of the demarcated coastal zone from the shore is between 30 and 195 km and the exposed coast is between 37 and 57 km (Ahmad 2005; Mohal, et al. 2006). The coastal zone is low–lying with 62 % of the land have an elevation of up to 3 m and 86 % up to 5 m above mean sea level (Nishat and Mukherjee 2013). The Coastal zone constitutes a 47,201 square kilometer and hosts nearly 42 million population, which is 32 percent of the land area and 28 percent of the population of Bangladesh respectively (Islam 2004). The coastal population is projected to grow to 61 million by 2050 (Ahmad 2005). Land of coastal area is used mainly for agriculture, shrimp and fish farming, forestry, salt production, ship–breaking yards, ports & industries. Land use in the coastal zone is diverse, competitive and often conflicting. In the north of Bay of Bengal, 'Swatch of No Ground', a submarine canyon present at 25 km south of the western coastline of Bangladesh (Mohal, et al. 2006). The coastal zone also includes the world's largest single track of mangrove forest, the Sundarbans, bordering the Bay of Bengal.

## LOCATING THE STUDY AREAS

### Selected Study Areas

Assasuni upazila of Satkhira district, Chakaria upazila of Cox's Bazar district, Tarash upazila of Sirajgonj district and Porsha upazila of Naogaon district have been selected for this study for their geo–physical locations, relatively higher vulnerability to cyclone, salinity, flood, riverbank erosion, drought and other climatic variabilities.

**Table– 3.1: Location and Demographic Profiles of the Study Areas**

| Key Indicators | Assasuni | Chakaria | Porsha | Tarash |
|---|---|---|---|---|
| Land Area | 374.81 sq km | 503.83 sq km | 3435.65 sq km | 300.07 sq km |
| Latitudes | 21°58' & 22°14' N | 21°34' & 21°55' N | 24°54' & 25°05' N | 24°20' & 24°34' N |
| Longitudes | 89°53' & 90°05 E | 91°54' & 92°54' E | 88°24' & 88°39' E | 89°15' & 89°26' E |
| Administrative Units | 11 unions, 143 mauzas, and 241 villages | 18 unions, 54 mouzas, and 221 villages | 6 unions, 155 mouzas and 246 villages | 8 unions, 176 mouzas and 254 villages |

3 *The delineation of the Coastal Zone, approved by the Ministry of Water Resources in 2003, comprises 19 districts, 147 upazilas and the exclusive economic zone.*

| Key Indicators | Assasuni | Chakaria | Porsha | Tarash |
|---|---|---|---|---|
| Population | 2,68,754 (male 1,33,990 and female 1,34,764) | 474,465 (male 239,198 and female 235,267) | 1,32,095 (male 66,299 and female 65,796) | 1,97,214 (male 97,447 and female 99,767) |
| Number of Households | 62,037 | 88,391 | 30,773 | 48,941 |
| Household Size | 4.33 | 5.35 | 4.24 | 4.02 |
| Density per sq km | 717 | 942 | 522 | 657 |
| Literacy Rate (7 years and above) | 49.8% (male 54.9% and female 44.8%) | 47.6% (male 47.9% and female 47.4%). | 42.5% (male 43.2% and female 41.9%). | 39% (male 43.0% and female 35.1%). |
| Ethnic Communities | Bengali, Munda | Bengali, Marma, Murong and Chakma | Bengali, Santal, Oraon | Bengali |
| *Sources:* | *BBS 2014a* | *BBS 2012* | *BBS 2014c* | *BBS 2014b* |

## Locations and Demography

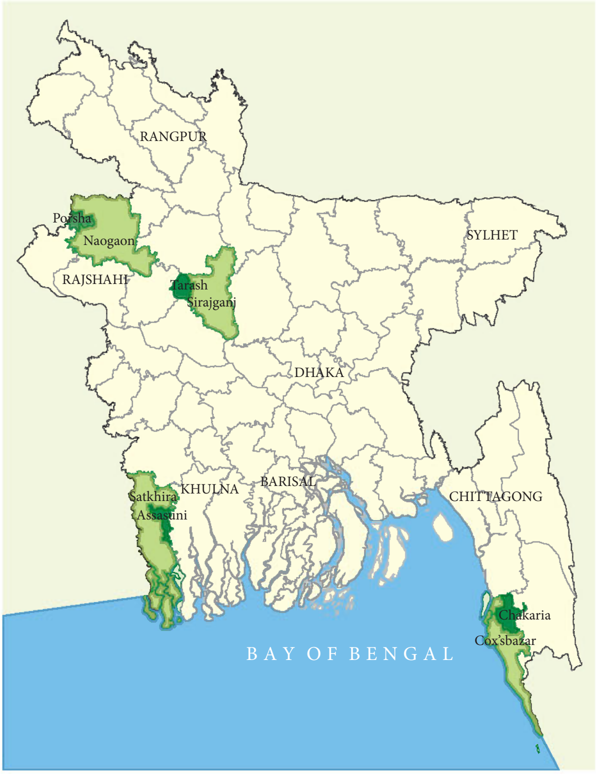
**Assasuni Upazila:** Assasuni is the second largest upazila of Satkhira District in respect of area. The upazila is bounded on the north by Satkhira Sadar and Tala upazilas, on the east by Paikgachha and Koyra upazilas of Khulna District, on the south by Shyamnagar upazila and on the west by Debhata and Kaliganj upazilas. The upazila consists of 11 unions, 143 mauzas and 241 villages. The Baradal union comprises the highest number of population 26,921 (male: 13,623, female: 13,297 and total number of households: 5,797) and Kadakati union has the lowest number of population 12,772 (Male 6,605 Female 6,167 and total no of households: 2,698). Both of Sobhnali and Kadakati union have the highest literacy rate (45%). In the Assasuni upazila, the population density is highest (772 per sq. km) in Anulia union and lowest (457 per sq. km) in Kadakati union (please see Table 3.1. for related information and sources).

**Chakaria Upazila:** Chakaria is the biggest upazila of Cox's Bazar District in respect of area and population. This upazila is consisted of 1 Paurashava, 18 unions, 54 mauzas, and 221 villages. This upazila is bounded by Lohagara, Banshkhali and Lama upazila on the north, Cox's Bazar Sadar, and Ramu upazilas on the south, Lama and Naikhongchhari upazilas on the east, Maheshkhali and Pekua upazila on the west. In Chakaria upazila, the Paurashava has the highest number of population (Total population: 50,993, Male: 27,007, Female: 23,986) followed by the Dulhazra union. The Paschim Bara Bheola Union has the lowest number of population (Total population: 7,775, Male: 4,102, Female: 3,673). Among the unions of this upazila the Lakhyarchar Union has the highest literacy rate (41%) where as the Demusha Union has the lowest literacy rate (22%). In the Chakaria upazila, the Paurashava has the highest (11,914 per sq km) population density, followed by the Lakhyarchar Union (2,679 per sq. km) and lowest (260 per sq. km.) in the Chiringa Union (please see Table 3.1. for related information and sources).

**Porsha Upazila:** The upazila is agriculture intensive with the area of 27,205.26 hectare consisting 06 unions, 155 mouzas and 246 villages. The upazila is bounded on the north by Sapahar upazila, on the east by Patnitala and Mahadebpur upazilas, on the south by Nimatpur upazila and Gomastapur upazila of Nawabganj District and on the west by India. As per population census, total population of this upazila is 1,32,095 in which 66,299 are male and 65,796 are female. Population density of this upazila is 522 per sq.km. Total literacy rate of this upazila is 42.5% of which 43.2% are male and 41.9% are female (please see Table 3.2. for related information and sources).

**Tarash Upazila:** The land area of the upazila is 30020.25 hectares consisting of 08 unions, 176 mouzas and 254 villages. The upazila is bounded on the

**Map– 3.2: The Selected Study Areas**



north by Sherpur upazila, on the south by Chatmohar upazila, on the east by Royganj and Ullapara upazila and on the west by Singra and Gurudashpur upazila of Natore Zila. According to the recent census, the total population of this upazila 1,97,214 out of which 97,447 are male and 99,767 are female. The population density of this upazila is 657 per sq.km. The literacy rate of this upazila is 39.0% of which 43.0% are male and 35.1% are female (please see Table 3.1. for related information and sources).

## Ecology and Climate

**Assasuni Upazila:** Assasuni upazila is located in the Kobadak, Kholpetua, Morischap, Guliakhali, Habra and Malancha River Floodplain, which is the Immature Delta, based on physical features, having direct interaction with the natural phenomena of the river and that of the Bay of Bengal. The region is barely above sea level. The soil of this area is mostly gray floodplain soils, with strong saline phase (Rashid 2005). The increasing trend of salinity and river siltation in Southwest region of Bangladesh has developed limiting conditions for the farmers to cultivate crops round the year. The salinity intrusion is highest in the months of March to June and lowest in the month August to October. The increasing salinity intrusion has restricted cultivation of necessary crops and affecting environment adversely as well as infusing social conflicts is this region. Moreover, severe siltation of rivers, khals, beels has created serious water logging in the area. However, the farming system of this area is generally shrimp (major *bagda*) culture with white fish. The major field crop in the area is T. aman, Boro (HYV) and farmers do not cultivate Aus crop due to salinity problem in this cropping season. Other minor crops like jute, sesame, ground nut, potato (mainly table potato followed by seed potato), mustered, vegetables are also grown in limited areas on small scale basis.

The average temperature at the area ranges from 21.4°C to 31.6°C. The annual average rainfall is 1742 mm. Average maximum rainfall recorded 377 mm in July and average minimum rainfall is 12 mm in the month of January. The dry season is November to February and Rainy season is March to October (BMD 2009).

**Chakaria Upazila:** Chakaria is located in the Matamuhuri Estuarine Floodplain. The upazila is surrounded by the Matamuhuri, Bara Matamuhuri, Maheshkhali and Kutubdia Channel. Chakaria upazila is influenced by wave and tidal energy originated from the Bay of Bengal along its open–ocean coast with some remnant mangroves in the river estuaries. Some plain–lands of Chakaria upazila are situated in the underneath area of hill tracts. The devastating cyclone and the tidal bore of 29 April 1971 caused serious damages to the upazila with a death of 16705 persons. The annual average temperature at the area ranges from 16.1°C to 32.8 °C. The climate remains hot and humid with some seasons of temperate weather. The average amount of rainfall is 4,285 mm. Average highest temperature from 2008 to 2011 was 34°C and average lowest was 14.1°C (BBS 2011).

**Porsha Upazila:** Porsha upazila is situated in the Barind Tracts in the northwestern Bangladesh. A stiff soil of reddish clayey loam characterize the region which lie within the flood plains of the little Jamuna, Atrai, Shiba and Purnabhaba rivers where soils are mainly silty in redges and clays in basin centers in some areas and heavy clays in some other areas. A large part of this Sal forest area has been cleared and now intensively used for agricultural purposes. About 81.44% people of this upazila is engaged in agriculture sector. Indigenous peoples like Santal, Munda especially their women play a great role in crop production systems. Wide range of rabi and *kharif* crops such as paddy, wheat, mustard, maize, potato, chili, vegetables etc grow here. Fruits grow well here are mango, litchi, jack-fruit, banana, papaya etc.

The average temperature of the area ranges from 8.6°C to 22.6°C. The annual average rainfall is 1160 mm and humidity is 79% (BMD 2009). The driest month is December, with 3 mm of rainfall. Most of the precipitation here falls in July, averaging 307 mm. The warmest month of the year is June, with an average temperature of 29.0°C. January is the coldest month, with temperatures averaging 18.2°C.

**Table– 3.2: Geo-physical Characteristics of the Study Areas**

| Key Indicators | Assasuni | Chakaria | Porsha | Tarash |
|---|---|---|---|---|
| Physiographic Features | Immature delta | Hill tracts and coastal tidal floodplain | Barind track | Ganges floodplain and chalan bill |
| Soil Texture | Clay Loam, Clay, Silt Loam to Silty Clay Loam, Clay Loam to Clay | Loam, Silt Loam to Silty Clay Loam, Silty Clay Loam, Silty Clay, Sandy Loam to Silty Clay Loam | Clay Loam to Clay, Loam to Clay Loam | Clay Loam to Clay, Loam to Clay, Silt Loam to Clay, Loam to Clay Loam |
| Major Rivers | Kobadak, Kholpetua, Morischap, Guliakhali, Habra and Malancha | Matamuhuri, Bara Matamuhuri, Maheshkhali and Kutubdia Channel | Atrai, Shiba and Purnabhaba | Atrai, Ghumani, Korotoya, and Vodraboti |
| Zone | Ganges Delta/ Tidal Floodplain/ Brackish Ecosystem | Coastal tidal Floodplain | Barind Tracts | Floodplain |
| Average Temperature | Ranges from 21.4°C to 31.6°C | Ranges from 16.1°C to 32.8 °C | Ranges from 8.6°C to 22.6°C | Ranges from 9.4°C to 35.2°C |

| Key Indicators | Assasuni | Chakaria | Porsha | Tarash |
|---|---|---|---|---|
| Annual Average Rainfall | 1742 mm | 4,285 mm | 1160 mm | 1371 mm |
| Major Hazard | Salinity Intrusion | Cyclone | Drought and Aridity | Flood and Riverbank Erosion |
| Other Hazards | Cyclone, Waterlogging and Flood. | Flood, Flash Flood, Salinity Intrusion | Cold wave, Hail-storm | Waterlogging |

**Tarash Upazila:** The upazila lies within the floodplain of the Karatoya, Atrai, Gumani and Vodraboti river basins and forms part of the Chalan Beel. Chalan Beel is an extensive lowland area in the lower Atrai basin. It is a neighboring upazila of Barind Tract (Borendra Bhumi). It is blessed by fertile plain land, vegetation, rivers sand, canals, ponds and beel etc. The rivers and beels play vital roles in the ecology, economy and the livelihood of the people of the upazila. This region consists of a series of beels connected to one another by various channels to form a continuous water body during the rainy season. Although the beel area expands into a vast water body with dense aquatic vegetation as long as the Jamuna, remains flooded during the monsoon months, it dries out in the winter months, leaving only patches of water in the central parts of this zone.

Average temperature of this upazila ranges from 9.4 to 35.2 with average rainfall 1371 mm and humidity 78% (BMD 2009). Historical Climatic data analysis shows that this upazila is mainly drought prone region with dry weather. Many people were victims of the famines of 1897, 1943 and 1974. Besides, the earthquakes of 1885 and 1897 caused heavy damages to settlements and other properties of the upazila.

## Livelihood Conditions and Economic Profile

**Assasuni Upazila:** In the upazila, 63.11% of the dwelling households depend on agriculture as the main source of household income with 30.44% on cropping, livestock, forestry and fishery and 32.67% on selling agricultural labor. Other dwelling households reported earning main incomes are from nonagricultural labor 5.12%, business 16.98%, employment 3.56%, construction 0.62%, religious service 0.24%, rent and remittance 0.14%, Industry 0.96%, transport and communication 1.74%, and others 7.53%. In urban area dwelling households having main incomes are from employment 14.17%, business 27.02%, construction 1.32%, rent and remittance 0.35%, religious service 0.41%, agriculture 30.62%, industry 0.46%, transport and communication 7.57%, non–agricultural labor 8.43% and others 9.65%

(MoL 2011a). The rural dwelling households observed getting main incomes are from agriculture 64.38%, non–agricultural labor 4.99%, business 16.58%, employment 3.14%, industry 0.97%, transport and communication 1.51%, construction 0.60%, religious services 0.23% and others 7.60% (BBS 2014a).

**Chakaria Upazila:** Agriculture, in Chakaria upazila, comprises highest (53.09%) level of income source whereas non–agricultural laborers are 7.80%. Industry provides 0.75% income source, commerce 15.01%, transport and communication 2.94%, service 6.7%, construction 1.1%, religious service 0.24%, rent and remittance 1.13% and others 11.24%. Among the population 34.30% is landowner and 65.70% is landless. Major crops are paddy, potato, mustard, sweet potato, chili, corn, sugarcane, wheat, peanut, betel leaf, tobacco, cauliflower, tomato, cabbage, brinjal, lady's finger, *barbati*, and felon (MoL 2011b). The other occupations are rearing of livestock, poultry and duck, boat building, fishing net making, mat making and few people are engaged in nursery business and tree plantation etc. Local people are also earning from homestead gardening and cultivation vegetables (BBS 2012).

**Porsha Upazila:** In Porsha upazila, Agriculture is the maiden source of income of 81.44% residents of this upazila. 3.16% people are non–agricultural laborer, 0.22% depend on industrial sector, 5.43% on commerce, 0.93% on transport and communication, 3.34% on service, 0.25% on construction, 0.13% on religious service, 0.03% on remittance, and 5.06% on other sources of subsistence activities (BBS 2014c). Major crops are, paddy, wheat and mustard. Major fruits are mango, jack-fruit, litchi and watermelon. Agriculture shapes a substantial part of Porsha's landscapes by providing large seasonal, functional and structural variations that impact on key components of the biosphere. Various Rabi and Kharif crops such as paddy, wheat and mustard are the notable crops, but paddy is the main crop of the upazila. Besides those crops, fruits like mango, jack-fruit, litchi and watermelon are also grown in the upazila (MoL 2015).

**Tarash Upazila:** Lives and Livelihoods in Tarash upazila are closely connected to agricultural production. Ownership of land plays a key role in determining social positions of people. There are indigenous groups and excluded communities in Tarash upazila, although a significant number of them are landless. However, in Tarash, agricultural landowners are 64.11% (urban 58.29% and rural 64.32%.), and landless people 35.89%. Major crops are paddy, wheat, mustard, maize, pulse, onion, garlic and kalai. Main source of income is Agriculture 84.75%. Other sources include non–agricultural laborer 1.62%, industry 0.26%, commerce 4.90%, transport and communication 0.99%, service 2.74%, construction 0.41%, religious service 0.14%, rent and remittance 0.07% and others 4.12% (BBS 2014b). Paddy, wheat, mustard, maize, pulse, onion, garlic, kalai are the notable crops, but paddy is the main crop of the upazila. Besides those crops, fruits like mango, jackfruit, guava, watermelon, papaya, banana also grown in the upazila. Extinct or nearly extinct crops are sesame and jute (MoL 2016).

## Land Use Patterns

**Assasuni Upazila:** The land of Assasuni upazila of Satkhira district is dominant in agriculture and also intensively used for shrimp (*bagda*) culture, mixed shrimp (bagda & white fish) culture with paddy, settlements with homestead forest, close water body, river/ canal and for other infrastructural developments (MoL 2011a). The upazila in one hand is rich in both aquatic and terrestrial resources and on the other hand is vulnerable to natural and man–made hazards like cyclone, storm surges, drainage congestion, salinity increase, land erosion, deforestation and unplanned uses for housing and industries etc. which are the main causes of land degradation, loss of biodiversity, human lives and properties. The diversified uses of land are always creating problems in respect of its criteria based uses and creating conflicting situation among the land users.

**Table– 3.3: Present Land Use Patterns in the Study Areas**

| Land Use Indicators | Assasuni | Chakaria | Porsha | Tarash |
|---|---|---|---|---|
| Total Area (ha) | 37660 | 47833 | 25858.60 | 29985.76 |
| Land Type (%) | | | | |
| High Land (HL) | 18.64 | 19.26 | 81 | 16 |
| Medium High Land (MHL) | 55.45 | 50.37 | 03 | 31 |
| Medium Low Land (MLL) | 25.00 | 27.42 | 13 | 34 |
| Low Land (LL) | 0.91 | 2.95 | 03 | 19 |
| Present Land Use (%) | | | | |
| Rural Settlement & HV* | 14.55 | 15.26 | 8.25 | 12.15 |
| Urban Area | 0.18 | 1.74 | 0.72 | 0 |
| Water Body/ Wet Land | 10.45 | 5.00 | 6.48 | 4.75 |
| Fallow land | 0 | 6.56 | 0 | 0 |
| Forest | 0 | 24.42 | 0.02 | 0 |
| Agriculture | 29.91 | 36.89 | 71.42 | 83.03 |
| Shrimp Area | 44.64 | 2.53 | 0 | 0 |
| Salt & Shrimp | 0 | 5.63 | 0 | 0 |
| Mango/ Litchi Garden | 0 | 0 | 13.05 | 0 |
| Others | 0 | 2.26 | 0.06 | 0.07 |
| *Sources:* | *MoL 2011a* | *MoL 2011b* | *MoL 2015* | *MoL 2016* |

*Notes: *HV = Homestead Vegetation. The percentage of agriculture area is considered as percentage of Net Cultivable Area (NCA) on total area of the Union.*

**Chakaria Upazila:** The land of Chakaria upazila of Cox's Bazar district is dominant in agriculture and also intensively used for hill forest, settlements with homestead forest, salt & shrimp, fish culture (homestead pond and commercial) and for other infrastructural developments. The newly accreted Chars and Islands have different uses also. The upazila is influenced by wave and tidal energy originated from the Bay of Bengal along its open–ocean coast with some remnant mangroves in the river estuaries. Chakaria upazila in one hand is rich in both aquatic and terrestrial resources and on the other hand is vulnerable to natural and man–made hazards like tidal movement, storm surges, cyclone, drainage congestion, salinity increase, erosion and deforestation, which are the main causes of land degradation and loss of biodiversity and human lives. The diversified uses of land are always creating problems in respect of its criteria based uses and creating conflicting situation among the land users. It is predicted that the upazila may face extreme impacts of climatic change in future. The major climate risks are, flash flood, salinity intrusion and cyclone, while the risks profile are significantly high in Chakaria upazila .

The land of the coastal area is intensively used for agriculture, housing and settlements, forests, shrimp *ghers*, water bodies and fisheries, salt production, industrial and infrastructural developments, tourism, preservation and management of environmentally important and special areas. These diversified uses of land have resulted into several aftermaths (MoL 2011b): (1) conflicting land uses and demands; (2) degradation of coastal ecosystem; (3) growing demand for expansion in all land uses (urban area, settlement, shrimp etc.); (4) increasing demands for new uses (tourism, export processing zones and others) and (5) encroachment and conversion of land from one use to the other.

**Porsha Upazila:** Broad land use types of the upazila are agricultural land, mango and litchi gardens, rural settlement and homestead vegetation, water bodies, urban built–up area, and forest. The Porsha upazila, under Naogaon district is situated in the northwestern part of Bangladesh. The region has been designated as drought prone area and eventually it is affecting the cultivation of crops and creates unfavorable environment. The upazila lies in the Barind Tract (AEZ–25). The climate of the area is hot in summer and relatively cold in winter and less rainfall during monsoon, which differs to the climatic conditions of rest of the country. The Barind Multipurpose Development Authority (BMDA) had installed deep tube wells in the area, which facilitated dry season irrigation for cultivation. As a result, agricultural production has increased to a large extent. Major crops grown in the area are: rice, potato, mustard, wheat, pulses etc. Mango and lichi productions, on commercial basis, are increasingly becoming popular among local people. The ponds and beels in the upazila are the source of local fish supplies.

Agriculture is the major land use of the upazila, which occupies about 71% of total land of the upazila. Land types vary from high land (81%) followed by medium low land (13%), medium high land (03%) and low land (03%). Land, which is above normal flood level, can provide wide range of opportunities for growing crops. Soil is moderately fertile and the cropping intensity is 169 %. About 51% of agriculture land is double cropped, 9% is triple cropped, and 40% is single cropped (MoL 2015). Mango, litchi, banana, maize, rice and wheat are principal crops. Boro and transplanted aman are the two major rice cultivated. Mango is one of the most important fruit and cash crop grown for commercial purpose in orchard and homestead area. About 65 % land is cultivated by the power tiller. Land resources are gradually degrading due to climate change impacts and many man-made interventions. To ensure food supply to an increased population of the country, cultivable land should be protected from being converted to other land uses. Protection of double and triple cropped land is a priority issue in Porsha upazila.

**Tarash Upazila:** The upazila lies in Chalan Beel area, which is the largest wetland of Bangladesh covering three Districts. Chalan Beel is a famous beel, which is the home of abundant natural fish and other resources. Huge natural fishes are grown in this wetland and the livelihood of many people depends on fishing. Although, geo–morphology of Chalan beel has been changed over the years and water bodies have been reduced drastically, the land use of the area is gradually changing. However, the Agro–ecological zones of the upazila are: Lower Atrai Basin (AEZ–5) and Level Barind Tract (AEZ–25). The Atrai basin region comprises the low–lying area between the Barind Tract and the Ganges river floodplain. It includes the Chalan Beel area. Dark gray, heavy, acidic clays are predominating in this smooth low–lying basin land. Level Barind Tract region is developed over Madhupur clay. The landscape is almost level. Shallow gray terrace soil and deep gray terrace soils are the major components of general soil types of the area. The soils have low moisture holding capacity and are slightly acidic to acidic in reaction. Major cropping Pattern are: Boro (HYV)– Fallow, Boro– Fallow– T.aman/ B.aman, Rabi crops– T.aus– T. Aman, Sesame/ Rabi crops– Fallow– T.Aman, Mustard– Fallow– T.aman, Fallow– Vegetables– T.aman (MoL 2016). Farmers also grow different crops and vegetables in the winter season. The area faces monsoon flooding which causes crop damage in almost every year in the low–lying areas.

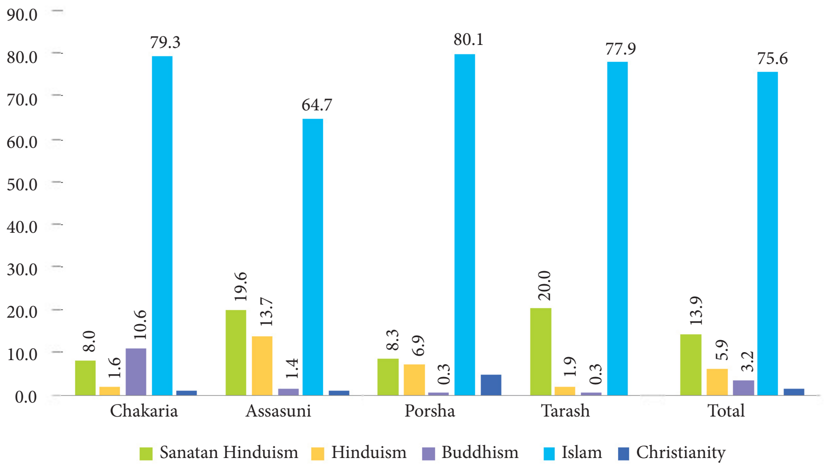
## PROFILING THE RESPONDENTS

### Religious Beliefs

The following diagram shows the religious status of the people under study in Chakaria, Assasuni, Tarash and Porsha upazilas. According to religious affiliation, Islam is practiced by majority of the respondents. Hinduism and Buddhism comprise second and third largest religious groups respectively, while Christianity is being followed by relatively small group of people in the study areas. Among all the study people, 13.9% believe in *Sanatan* or Folk Hinduism, 5.9% in Hinduism, 3.2% in Buddhism, 75.6% in Islam, and 1.4% in Christianity.

The following diagram shows the area wise religious status of the people in Chakaria, Assasuni, Tarash and Porsha upazilas. In Chakaria 8.0% people believe in *Sanatan* or Folk Hinduism, 1.6% in Hinduism, 10.6% in Buddhism, 79.3% in Islam, and 0.5%in Christianity. In Assasuni 19.6% people believe in *Sanatan* or Folk Hinduism, 13.7% in Hinduism, 1.4% in Buddhism, 64.7% in Islam, and 0.6%in Christianity. In Porsha 8.3% people

**Graph– 3.1: Religious Status of the People under Study**




believe in *Sanatan* or Folk Hinduism, 6.9% in Hinduism, 0.3% in Buddhism, 80.1% in Islam, and 4.4%in Christianity. In Tarash 20.0% people believe in *Sanatan* or Folk Hinduism, 1.9% in Hinduism, 0.3% in Buddhism, 77.9% in Islam, and 0.0% in Christianity. Overall 13.9% people believe in *Sanatan* or Folk Hinduism, 5.9% in Hinduism, 3.2% in Buddhism, 75.6% in Islam, and 1.4% in Christianity.

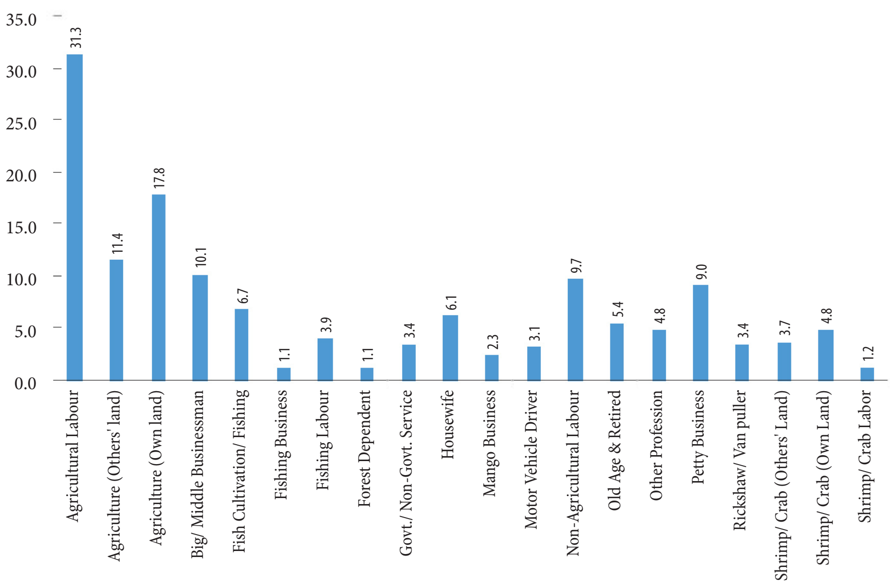
## OCCUPATIONAL DISTRIBUTION

There are various occupational groups found in Chakaria, Assasuni, Tarash and Porsha upazilas, which determines the socio–economic condition of their households. It has been found that agriculture (i.e. agricultural laborer (20.1%), agricultural works on own land (13.6%) or on other's land (7.6%) through sharecropping or mortgaging) is the major occupation for most of the households of these upazilas. Sometimes one can combine all these modes together. The other occupations include non–agricultural labor (8.3%), petty business (6.7%), old aged and retired household members (5.0%) and housewives (4.0%). 3.7% HH members are engaged in fishing labor, fish cultivation/ fishing, and shrimp/ crab cultivation on other's land. A small number of HH members (on an average 2.36%) are engaged in the occupations such as shrimp/ crab cultivation on own land, rickshaw/ van pulling and cart pushing, big/ middle business, government/ non–government service, motor vehicle drivers, mango business, fishing business, shrimp/ crab labor and forest dependent.

## Occupation of the Household Heads

The household heads of various households in Chakaria, Assasuni, Tarash and Porsha upazilas are engaged in multiple occupations. They do this for their survival strategy and resistance against the natural disasters and different conditions of climate change. Agriculture (i.e. agricultural labor (31.29%), agricultural works on own land (17.76%) or on other's land (11.43%) through sharecropping or mortgaging) is the major occupation for most of the household heads (see graph- 3.2). The other occupations include big/ middle business (10.14%), fish cultivation/ fishing (6.73%), fishing

**Graph– 3.2: Occupation of the Household Heads (Multiple Response)**

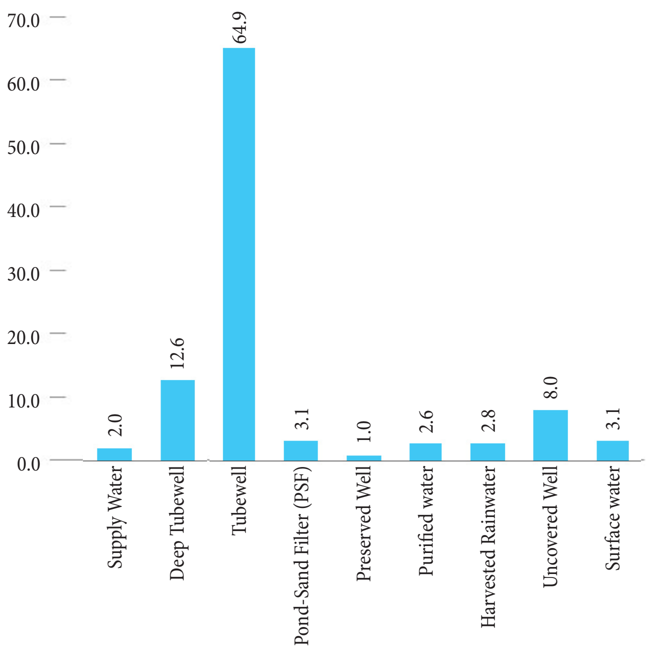


laborers (3.95%), government/ non–government service holders (3.40%), non–agricultural laborers (9.66%), housewives (6.12%), old aged/ retired (5.44%), petty business (9.05%), rickshaw/ van pulling and cart pushing (3.40%), shrimp/ crab cultivators on other's land (3.67%), and shrimp/ crab cultivators on own land (4.83%).

## SOURCES OF DRINKING WATER

The study findings show that the households of Chakaria, Assasuni, Tarash and Porsha upazilas have multiple sources of water (see Graph- 3.3). The average source of water with tube well is 64.9% (90.7% for Chakaria, 18.8% for Assasuni, 51.0% for Porsha, and 96.3% for Tarash). Water source with tube well is greater in Tarash (96.3%) than in other areas. These households have limited options to other sources of water. People have very low access to supply/taped water and in case of deep tube well it is the most for the people of Assasuni (32.5%). The other sources of water such as Pond–Sand Filter (PSF), preserved/protected well, reserved and purified water, harvested rainwater, and surface water (river, lake, pond, etc.) are very limited in these upazilas. However, people have a tendency to collect water from uncovered well and it is mostly found in Porsha (31.6%).

**Graph– 3.3: Sources of Drinking water**



The study findings show that the households of Chakaria, Assasuni, Tarash and Porsha upazilas have different sources of water for everyday use. It has been identified that tube well is the major source of water for most of the households in Chakaria (90.7%), Porsha (51.0%), and Tarash (96.3%). It is somewhat different for Assasuni where the major source of water is deep tube well (32.5%) while 18.8% households use tube well. In Porsha 31.6% households use uncovered well. However, considering all the upazilas the major sources of water are tube well (64.9%), deep tube well (12.6%), and uncovered well (8.0%). So, it has been observed that tube well (64.9%) is the highest source of water in all the upazilas.

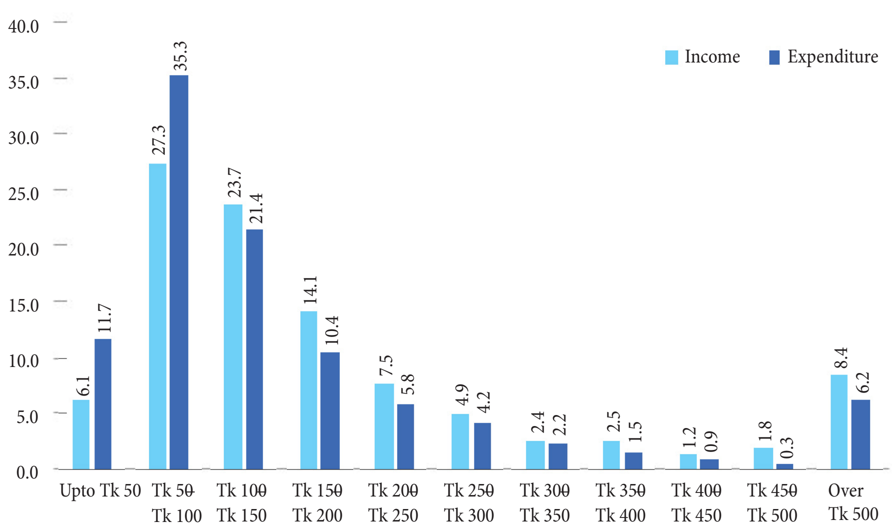
## ECONOMIC CONDITIONS

The study findings show that different households of these upazilas have different income and expenditures. The maximum income–expenditure ratio belongs to the income group of Tk 50,000–100,000 (14:18) and the lowest ratio belongs to Tk 400,000–450,000 (0.5:0.5). The second highest ratio belongs to Tk 100,000–150,000 (12:11). The ratio goes relatively high for the income group of Tk 500,000 and more (4:3.5).

### Household Income and Expenditure

The study findings show that different households of all the upazilas have different income and expenditures depending on their socio–economic

**Graph– 3.4: Income and Expenditure**



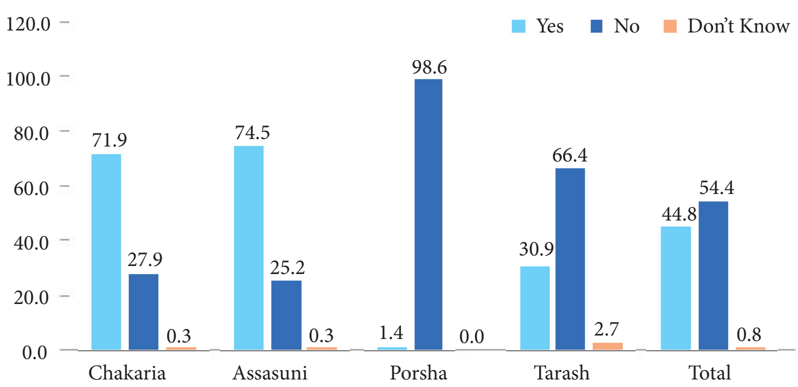
status. Majority i.e. 35.27% households (income group tk 50,000–100,000 or 27.33%) have the highest level of expenditure while 6.20% households (income group Tk 450,000–500,000 or 1.24%) have the lowest level of expenditure among all the income groups. The findings also show that households with low income (i.e. upto Tk 50,000 or 6.14%) have the high level of expenditure while households with high income (i.e. over Tk 500,000 or 8.40%) have relatively low level of expenditure.

## EXPERIENCE OF CLIMATIC EVENTS

**Vulnerability of Housing Structures:** The following diagram shows the condition of houses during last flood, flash flood or storm surge. Most of the houses (44.8%) were submerged during last flood, flash flood or storm surge. This shows the picture that natural disasters like flood, flash flood or storm surge cause damage to the houses of the local people (see Graph- 3.5).

The following diagram shows the condition of houses during last flood, flash flood or storm surge in the upazilas. The percentages for houses submerged during last flood, flash flood or storm surge for the upazilas are 71.88% for Chakaria, 74.51% for Assasuni, 1.39% for Porsha, and 30.93% for Tarash. Overall, in these upazilas, 44.76% houses were submerged during last flood, flash flood or storm surge and 54.42% houses were unaffected. This shows the picture that natural disasters like flood, flash flood or storm surge cause damage to the houses of the local people.

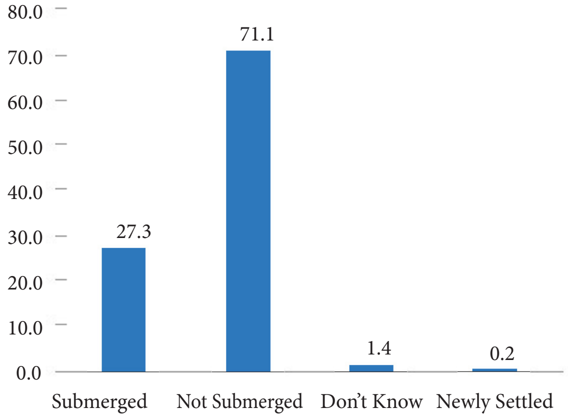
**Graph– 3.5: House Submerged during Previous Climatic Events**




**Vulnerability of Drinking Water Sources:** The following diagram shows the condition of water source during last flash flood, flood or storm surge. 27.3% water sources of Chakaria, Assasuni, Porsha and Tarash upazilas were submerged during last flash flood, flood or storm surge and 71.1%

water sources were not (see Graph- 3.6). This shows the picture that natural disasters like flood, flash flood or storm surge cause damage to the water sources of the local people.

**Graph– 3.6: Water Source Submerged during Previous Climatic Events**



*Image–08: Going to Bazaar during Flash Flood (Photograph by Mohosin Kabir).*

*Image–09: Overview of Damage Caused by Cyclone Sidr on 15 Nov 2007 (Photograph by US Navy).*

*Image–10: Riverbank Erosion (Photograph by S M Mahfuzul Islam Rahat).*

Chapter Four

# The Days After Tomorrow: Trends, Projections and Risks

## CHANGES IN GLOBAL CLIMATE SYSTEM

The IPCC's Fifth Assessment Report (AR5) unequivocally validates the warming of the climate system since the 1950s, while many of the observed changes are unprecedented over decades to millennia (IPCC 2014). The report goes on to say that 'the atmosphere and ocean have been warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased'. The AR5 also warns by projecting that "continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions" (IPCC 2013: 19). Built upon the AR4, the AR5 has been updated with subsequent new research findings on many independent scientific analyses from observations of the climate system, paleoclimate archives, theoretical studies of climate processes and simulations using climate models. The following Table– 4.1 presents a series of overarching highlighted findings of the assessment. The AR5 provides a comprehensive view of the variability and long-term changes in the atmosphere, the ocean, the cryosphere, and the land surface. IPCC's projections of changes in the climate system are made using a hierarchy of climate models ranging from simple climate models, to models of intermediate complexity, to comprehensive climate models, and Earth System Models. A new set of scenarios, the Representative Concentration Pathways (RCPs), was used for the AR5 climate model simulations. However, the projections in the table below are for the end of the 21st century (2081–2100) given relative to 1986–2005, unless otherwise stated.

**Table– 4.1: Projected Changes in the Global Climate System**

| Physical Change | Trends in Projected Change |
|---|---|
| **Atmosphere: Temperature** | **Global surface temperature is likely to exceed 1.5°C (RCP scenarios) and 2°C (RCP6.0 and RCP8.5) relative to 1850 to 1900 by the end of the 21st century. Warming will continue beyond 2100 under all RCP scenarios.** |
| | o Increase of mean surface temperatures for 2016–2035 relative to 1986–2005 will be 0.3°C to 0.7°C. |
| | o Seasonal and annual mean will be larger in tropics/ subtropics than in mid-latitudes. |
| | o Increase of mean surface temperatures for 2081–2100 relative to 1986–2005 will be 0.3°C to 1.7°C (RCP2.6), 1.1°C to 2.6°C (RCP4.5), 1.4°C to 3.1°C (RCP6.0), 2.6°C to 4.8°C (RCP8.5). |
| | o Warming over Arctic region and land surface will be rapid and more than the global mean. |
| | o Frequent hot and fewer cold temperature extremes over most land areas. |
| | o Heat waves with higher frequency and duration. |
| | o Occasional cold winter extremes will continue to occur. |
| | o Increases in intense tropical cyclone activity. |
| **Atmosphere: Water Cycle** | **Changes in the global water cycle over the 21st century will not be uniform. The contrast in precipitation between wet and dry regions and between wet and dry seasons will increase with some regional variations.** |
| | o Projected changes in the water cycle at the regional scale will be strongly influenced by natural internal variability and may be affected by anthropogenic aerosol emissions. |
| | o Increase in annual mean precipitation in high latitudes, mid-latitude wet regions and equatorial Pacific Ocean (RCP8.5 scenario). |
| | o Decrease in mean precipitation in many mid-latitude and subtropical dry regions. |
| | o Intense and more frequent extreme precipitation events over most of the mid-latitude landmasses and over wet tropical. |
| | o Area encompassed by monsoon systems will increase on global scale over the 21st century. |
| | o Weaken monsoon winds and intense monsoon precipitation due to increase in atmospheric moisture. |
| | o Lengthening of the monsoon season in many regions due to earlier onset and delayed retreat dates. |

| Physical Change | Trends in Projected Change |
|---|---|
| **Atmosphere: Air Quality** | ○ Increases in intensity and/or duration of drought<br>○ The El Niño-Southern Oscillation (ENSO) will be dominant mode of inter-annual variability in the tropical Pacific, and increase in moisture availability will intensify ENSO-related precipitation variability on regional scales.<br>○ Globally, warming will decrease background surface ozone but with high CH4 levels (as in RCP8.5) can offset this decrease.<br>○ Higher surface temperatures in polluted regions will increase local emissions and peak levels of ozone and PM2.5. |
| **Sea Level** | **Global mean sea level will continue to rise and under all RCP scenarios, the rate of sea level rise will exceed that observed during 1971 to 2010 due to increased ocean warming and increased loss of mass from glaciers and ice sheets.**<br>○ Global mean sea level rise for 2081–2100 relative to 1986–2005 will be in the ranges of 0.26 to 0.55 m (RCP2.6), 0.32 to 0.63 m (RCP4.5), 0.33 to 0.63 m (RCP6.0), and 0.45 to 0.82 m (RCP8.5).<br>○ In the RCP projections, thermal expansion accounts for 30 to 55% of 21st century global mean sea level rise, and glaciers for 15 to 35%.<br>○ Sea level rise will not be uniform.<br>○ Sea level will rise in more than 95% of the ocean area, and after 20% change in mean level, 70% of the coastlines worldwide will experience sea level change by the end of 21st century. |
| **Ocean** | **The global ocean will continue to warm during the 21st century. Heat will penetrate from the surface to the deep ocean and affect ocean circulation.**<br>○ The strongest ocean warming is projected for the surface in tropical and Northern Hemisphere subtropical regions but at greater depth, the warming will be most pronounced in the Southern Ocean.<br>○ Ocean warming in the top one hundred meters are about 0.6°C (RCP2.6) to 2.0°C (RCP8.5), and about 0.3°C (RCP2.6) to 0.6°C (RCP8.5) at a depth of about 1000 m by the end of the 21st century.<br>○ The Atlantic Meridional Overturning Circulation (AMOC) will be weak and reduced by 11% (1 to 24%) in RCP2.6 and 34% (12 to 54%) in RCP8.5. |
| **Cryosphere** | **The Arctic sea ice cover will continue to shrink and Northern Hemisphere spring snow cover will decrease as global mean surface temperature rises. Global glacier volume will further decrease.**<br>○ Year-round reductions in Arctic sea ice extent range from 43% (RCP2.6) to 94% (RCP8.5) in September and from 8% (RCP2.6) to 34% (RCP8.5) in February.<br>○ The climatological mean state and 1979 to 2012 trend of the Arctic sea ice extent suggest a nearly ice-free Arctic Ocean in September before mid-century (RCP8.5).<br>○ By the end of the 21st century, the global glacier volume, excluding glaciers on the periphery of Antarctica, is projected to decrease by 15 to 55% (RCP2.6), and by 35 to 85% (RCP8.5).<br>○ The area of Northern Hemisphere spring snow cover is projected to decrease by 7% (RCP2.6) and by 25% (RCP8.5) by the end of the 21st century.<br>○ By the end of the 21st century, the area of permafrost near the surface (upper 3.5 m) is projected to decrease by 37% (RCP2.6) to 81% (RCP8.5). |

| Physical Change | Trends in Projected Change |
|---|---|
| Carbon and Bio-geochemical Cycles | **Climate change will affect carbon cycle processes in a way that will exacerbate the increase of $CO_2$ in the atmosphere. Further uptake of carbon by the ocean will increase ocean acidification.** |
| | ○ Ocean uptake of anthropogenic $CO_2$ will continue under all four RCPs through to 2100, with higher uptake for higher concentration pathways. |
| | ○ Based on Earth System Models, climate change will partially offset increases in land and ocean carbon sinks meaning that more of the emitted anthropogenic $CO_2$ will remain in the atmosphere. |
| | ○ Earth System Models project a global increase in ocean acidification for all RCP scenarios. The corresponding decrease in surface ocean pH by the end of 21st century is in the range of 0.06 to 0.07 (RCP2.6), 0.14 to 0.15 (RCP4.5), 0.20 to 0.21 (RCP6.0), and 0.30 to 0.32 (RCP8.5). |
| | ○ Cumulative $CO_2$ emissions for the 2012 to 2100 period compatible with the RCP atmospheric $CO_2$ concentrations range from 140 to 410 GtC (RCP2.6), 595 to 1005 GtC (RCP4.5), 840 to 1250 GtC (RCP6.0), and 1415 to 1910 GtC (RCP8.5) |
| Climate Stabilization and Irreversibility | **Cumulative emissions of $CO_2$ largely determine global mean surface warming by the late 21st century. Most aspects of climate change will persist for many centuries even if emissions of $CO_2$ are stopped. This represents a substantial multi-century climate change commitment created by past, present and future emissions of $CO_2$.** |
| | ○ A lower warming target, or a higher likelihood of remaining below a specific warming target, will require lower cumulative $CO_2$ emissions. |
| | ○ A large fraction of anthropogenic climate change resulting from $CO_2$ emissions is irreversible on a multi-century to millennial time scale, except in the case of a large net removal of $CO_2$ from the atmosphere over a sustained period. Surface temperatures will remain approximately constant at elevated levels for many centuries after a complete cessation of net anthropogenic $CO_2$ emissions. |
| | ○ Due to the long time scales of heat transfer from the ocean surface to depth, ocean warming will continue for centuries. Depending on the scenario, about 15 to 40% of emitted $CO_2$ will remain in the atmosphere longer than 1,000 years. |
| | ○ It is virtually certain that global mean sea level rise will continue beyond 2100, with sea level rise due to thermal expansion to continue for many centuries. |
| | ○ Sustained mass loss by ice sheets would cause larger sea level rise, and some part of the mass loss might be irreversible. Sustained warming would lead to the near-complete loss of the Greenland ice sheet over a millennium or more, causing a global mean sea level rise of up to 7 m. |
| | ○ Geoengineering methods aim to alter the climate system to counter climate change have assessed the prospect of both Solar Radiation Management (SRM) and Carbon Dioxide Removal (CDR) and their impact on the climate system. CDR methods have biogeochemical and technological limitations to their potential on a global scale. Modeling indicates that SRM methods, if realizable, have the potential to substantially offset a global temperature rise, but they would also modify the global water cycle, and would not reduce ocean acidification. CDR and SRM methods carry side effects and long-term consequences on a global scale. |

*Note: RCP- Representative Concentration Pathway scenarios.*
*Source: Fifth Assessment Report (IPCC 2014)*

## BANGLADESH SCENARIO: TRENDS AND PROJECTIONS

It is a widely known fact that Bangladesh is at a very risk due to its exposure to climate change impacts and natural hazards. It seems likely that the country will experience the widest range of effects and the severity of climate change, which will include: erratic rise in average weather temperature; more extreme and prolonged hot and cold spells; less rainfall in times of dire need for agriculture, again prolonged monsoon causing excessive flood and in-turn damaging agriculture; unexpected changes in the hydrological cycle due to increased melting of glaciers and snow in the source areas of Bangladesh's rivers; more devastating tornadoes and cyclones; and sea level rise causing displacement of people and settlements, intrusion of salinity into freshwater regions and robust storm surges taking huge toll on life and livelihoods (Pender 2008).

With a population density of 1045 people per sq. km (Ahmed 2012), which is thought to be one the highest in the world, the adverse impacts of climate change will trigger many unforeseen risks and vulnerabilities to millions of people. Bangladesh, one of the largest deltaic countries of the world, is considered highly susceptible to climate change induced disasters due to its unique geographical location, flat and low-lying topography, vast area of floodplains, low mean elevation relative to sea level, geological formation etc. As a result, the country encounters many different kinds of recurring natural hazards like droughts, floods, river and coastal erosion, cyclones and tidal surge, thunderstorm, water logging, arsenic contamination, salinity intrusion, tornadoes, cold waves, earthquakes, landslides, hailstorm etc. These wide ranges of devastating natural disasters are said to be intensified and adversely impacted by climate change. The simultaneity of these natural events are often mixed with the high severity vulnerabilities of the individuals, households and communities produces greater environmental degradation, hunger, poverty, social deprivation and political conflicts, and thereby obstructing the socio-economic development of the country (Shafie and Rahman 2009: 25). In Bangladesh, we are yet to have comprehensive national level analysis of vulnerability within a broader socio-economic, cultural, political and policy contexts, and capturing shifts over spatio-temporal scales.

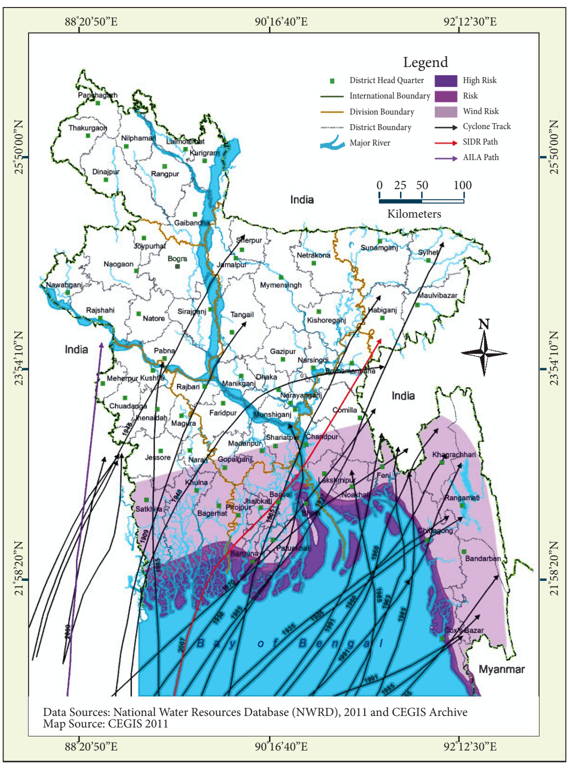
The development in Bangladesh is not only impeded by the co-occurance of these natural disasters, but also implies the severity of indirect and secondary impacts, such as on the demand for goods and services and livelihood opportunities. This has triggered growing concerns for the potential human, structural and economic threats that natural hazards and climate change impacts pose. Over the last few decades, both national and international communities have been engaged in reducing the impacts of climate change through climate change adaptation and through disaster risk reduction measures. However, we need to unfold the predicted effects of climate change and disasters those are predicted to increase in number and severity.

## Increase of Surface Temperature

Global surface temperature is likely to exceed 1.5°C (RCP scenarios) and 2°C (RCP6.0 and RCP8.5) relative to 1850 to 1900 by the end of the 21st century. Warming will continue beyond 2100 under all RCP scenarios (IPCC 2013). Increase of mean surface temperatures for 2016–2035 relative to 1986–2005 will be 0.3°C to 0.7°C. The AR5 (IPCC 2013) suggests significant increase of mean surface temperatures for 2081–2100 relative to 1986– 2005 will be 0.3°C to 1.7°C (RCP2.6), 1.1°C to 2.6°C (RCP4.5), 1.4°C to 3.1°C (RCP6.0), 2.6°C to 4.8°C (RCP8.5). People over most land areas would experience frequent hot and fewer cold temperature extremes with heat waves of higher frequency and duration. Tropical cyclone activity will be increased (IPCC 2013).

The coastal regions of Bangladesh, which are situated along the 700 km coastline of the country, are prone to destructive cyclones along with huge

**Map– 4.1: Tracks of Major Cyclones Affected Bangladesh Coastline between 1960 – 2009**

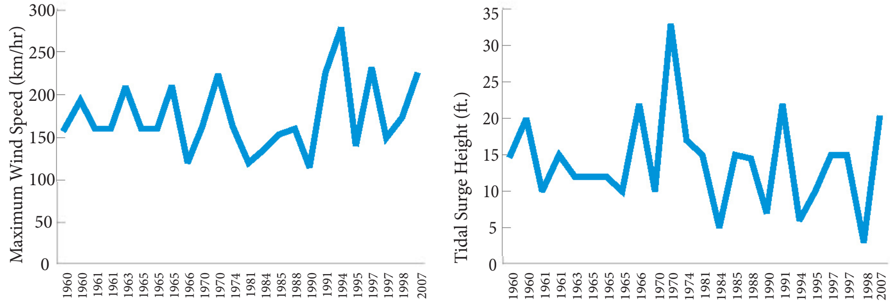


tidal surge. Choudhury (1992) informs that South-Asian subcontinent very often faces many dreadful cyclones which can be classified in respect to their intensity as: (a) depression i.e. winds upto 62km/h; (b) cyclonic storm i.e. winds from 63-87 km/h; (c) severe cyclonic storm i.e. winds from 88-118 km/h; and (d) severe cyclonic storm of hurricane intensity i.e. winds above 118 km/h (Choudhury 1992). The severity and frequency of cyclonic storms in Bangladesh can be easily understood with the fact that the rate of occurring cyclonic storms in Bangladesh is 1.3 per year having maximum speed of 275 km/h (Chowdhury 2002). Different nomenclature is found to be used in Bangladesh to denote these cyclonic storms such as tornado, hurricane or only cyclone.

Even though Bangladesh faces only one percent of total cyclones taking place in the world, due to high population density mentioned above fifty percent of the world's death from cyclones happens in Bangladesh (Pender 2008; Tanner, et al. 2007). The horrifying memory of the cyclones that hit the coastal regions of Bangladesh in 1970 and 1991 still haunt the people of the country. On 12 November 1970, a devastating cyclone hit the country with an outrageous wind velocity of 224 km/h, which killed more than half million people causing damage to more than 400,000 houses and 3,500 educational institutions. Again, on 29 April 1991 another ruinous cyclone hit the country causing death to more than 150,000 lives and homelessness to more than 10 million people (DS 2017). In Bangladesh cyclones generally hit in early summer (usually April-late May) and during October-November locally known as late rainy season. Among the recent cyclones, SIDR is considered as most damaging as The Red Crescent Society estimated causality of upto 10,000 deaths (DS 2017). This one occurred on 15 November 2007 with a wind speed of 223 km/h.

But, because of climate change it is projected that due to the increase in global temperature frequency of tropical cyclones will be decreased by 6-34%. However, the intensity of these cyclones will increase by 2-11% by 2100 which will undoubtedly be more damaging (Knutson, et al. 2010;

**Graph– 4.1: Major Cyclonic Storms from 1960 to 2007 (>100 km/ hr)**



Walsh, et al. 2016). It is said that in future tropical cyclones will be more powerful accompanied by larger peak wind speeds and more heavy rainfall coupled with ongoing increases of tropical sea surface temperatures (IPCC 2013). The graph 1.1 shows that the peak wind speed of major cyclones made landfall in Bangladesh coastlines between 1960 and 2007, while the forecast trend line (red color line) suggests a gradual increase in the wind speed over this period.

It is also projected that sea level rise due to climate change will lead towards retreating landward coastline and a steady decrease in the supply of sediment to the shore. As a result, the drainage basin and river system will lose their capability of delivering large amount of sediment to the shore.

Tidal surge becomes more threatening when it is added with powerful cyclonic storm. This particular wind is considered more dangerous than general cyclonic winds. Due to this wind, the abnormal rise in water level results into severe flooding in coastal regions, damage of property and wealth, shoreline erosion and most dangerously, loss of lives. It means, the rise of the tide causes more catastrophic damages than the power of the cyclonic storm. The aforementioned two ruinous cyclones of 1970 and 1991 can be cited here as proof of the claim. Both had exceptionally high tidal surges of 33 and 22 feets respectively (BMD 2009; Pender 2008)

As there are some well-identified connections between wind speed, sea surface temperature and the height of the storm surge, it is estimated that climate change will intensify sea surface temperature which will increase wind speeds and thus storm surge heights will increase from 15% to 25% in the 2020s and 32% in the 2050s (IPCC 2013; Tanner, et al. 2007). A cyclonic storm today with same magnitude of 1991 will produce a surge around 3 foots higher (Mohal and Hossain 2007) and will travel more towards the inland than it did in 1991. The same rise will take place when it comes to considering the number of people at risk. While it is 7.4 million people who are at risk of storm surge, a cyclone similar to that of 1991 will put nearly 15 million people at risk by 2050 (Pender 2008).

**Effects on Agriculture:** The climate change will alter regional agricultural systems, with consequences for food production. The specifics of the impact will depend on how the effects of climate change are translated into factors that determine the viability and utility of ecosystems. The effect of rising temperature on agriculture in Bangladesh depends on a complex combination of variables. These factors include higher Carbon–dioxide levels, heat stress, higher evapo–transpiration, shorter growing seasons, soil moisture levels, soil salinity and so on. However, it is expected that climate change will result in overall lower production of most foodstuffs such as most varieties of rice, wheat and potato (Challinor, et al. 2007; Howden, et al. 2007; Smit and Skinner 2002). In Bangladesh, yield would be reduced up to 17–28% for rice and 31–68% in wheat production (Fischer, et al. 2002; Karim, et al. 1996; Karim, et al. 1999). Evapotranspiration and loss of soil moisture content because of warmer weather will be most severe during the post–monsoon and pre–monsoon seasons especially considering already diminishing rainfall in winter and erratic rainfall patterns, particularly in the northwest of Bangladesh (Ahmed 2006). *Pre–Karif or Rabi* crops, growing season from December–March, will be mostly affected.

**Likely Impacts on Fisheries:** Increased temperatures in water bodies will affect fisheries sector in Bangladesh (Adger, et al. 2003; Ali 1999; Allison, et al. 2009; Huq, et al. 2004). The rise in surface water temperatures would adversely affect Bangladesh's coastal shrimp farming industry. With a temperature rise over 320 C, the death rates of small shrimp will become higher. Moreover, shrimp growth will be reduced due to increased algal bloom in warmer water (Ahmed 2006). The availability of important fish foods such as plankton and snails will be decreased, and marine fish habitat and growth of fish species will be impeded because of factors including increased ocean temperature, changing ocean currents, and increased water acidity due to more dissolved carbon dioxide (Board and Council 1999; Jennings, et al. 2009; Pender 2008). As a result, marine fishing industry of Bangladesh will sustain significant loss by reducing catch size (Botsford, et al. 1997; Jennings, et al. 2009; Naylor, et al. 2000; Peters, et al. 2006; Pinkerton 2009; Turner, et al. 1999).

**Rise of Temperature and Human Health**: Warmer weather will have direct correlation with child- and old-age mortality due to overheating and dehydration (Patz, et al. 2005). Extreme weather events have already increased in frequency. This has exacerbated mortality across South Asian countries (McMichael, et al. 2006). Bangladesh has also experienced increased cold waves over the last decade (Roach 2005; Simms and Johnson 2007). Warmer weather and changing rainfall patterns will result in the outbreak of water borne diseases (Githeko, et al. 2000; Hales, et al. 2003; Haq 2005; Kovats and Alam 2007; Patz, et al. 1996). Death cases of malaria will be significantly increased due to temperature rise (Rahman, et al. 2007). Climate change will accelerate the spread of Dengue Fever in Bangladesh (Guha-Sapir and Schimmer 2005; Hales, et al. 2002; Patz, et al. 1998). Increasing sea surface temperatures with favorable growth of phytoplankton along coast of Bangladesh, which will facilitate the survival and spread of infectious bacterial diseases such as cholera (Colwell 1996; Cruz, et al. 2007; Hales, et al. 2003; Patz, et al. 2005).

**Table– 4.2: Projected Effects of Weather and Climate on Human Health**

| Health Outcome | Known Effects of Weather |
|---|---|
| Heat Stress | : Deaths from cardio-respiratory disease increase with high and low temperatures. |
| | : Heat-related illness and death due to heat waves. |

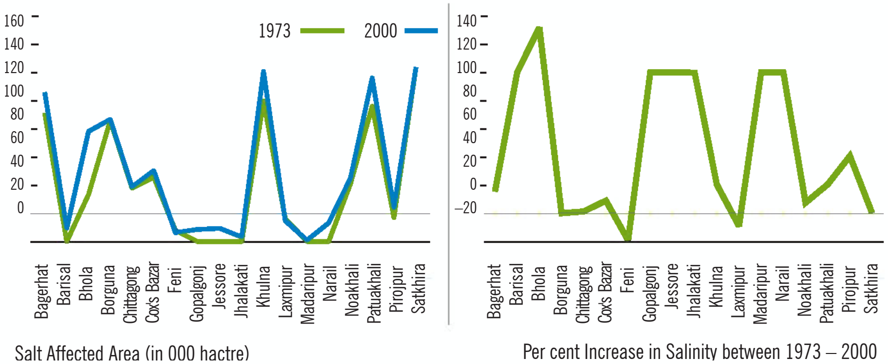
| Health Outcome | | Known Effects of Weather |
|---|---|---|
| Air Pollution-related Mortality and Morbidity | : | Weather affects air pollutant concentrations. |
| | : | Weather affects distribution seasonality and production of aeroallergens. |
| Health Impacts of Weather Disasters | : | Floods landslides and windstorms cause direct effects (deaths and injuries) and indirect effects (infectious disease, loss of food supplies, long-term psychological morbidity). |
| Mosquito-Borne Diseases, Tick-Borne Diseases (e.g. Malaria, Dengue) | : | Higher temperatures reduce the development time of pathogens in vectors and increase potential transmission to humans. |
| | : | Vector species require specific climatic conditions (temperature humidity) to be sufficiently abundant to maintain transmission. |
| Water-/ Food-Borne Diseases | : | Survival of important bacterial pathogens is related to temperature. |
| | : | Extreme rainfall can affect the transport of disease organisms into the water supply. Outbreaks of water-borne disease have been associated with contamination caused by heavy rainfall and flooding, associated with inadequate sanitation. |
| | : | Increases in drought conditions may affect water availability and water quality (chemical and microbiological load) due to extreme low flows. |

*Source: Kovats and Akhtar 2008: 167.*

## Changes in Water Cycle

Changes in the global water cycle over the 21st century will not be uniform, according to the AR5 (IPCC 2013). The contrast in precipitation between wet and dry regions and between wet and dry seasons will increase with some regional variations. The IPCC assessment projects changes in the water cycle at the regional scale, which will be strongly influenced by natural internal variability and may be affected by anthropogenic aerosol emissions. RCP8.5 scenario predicts decrease in mean precipitation in many mid-latitude and

**Graph– 4.2: Comparison of Soil Salinity Status in the Coastal Districts of Bangladesh (1973 and 2000)**



subtropical dry regions unlike the annual mean precipitation increase in high latitudes, mid-latitude wet regions and equatorial Pacific Ocean. Area encompassed by monsoon systems will increase on global scale over the 21st century. Monsoon winds will be weaken and monsoon precipitation will be intense due to increase in atmospheric moisture. Monsoon season will be lengthened in many regions due to earlier onset and delayed retreat dates. There will be significant increase in the intensity and/ or duration of drought (IPCC 2013).

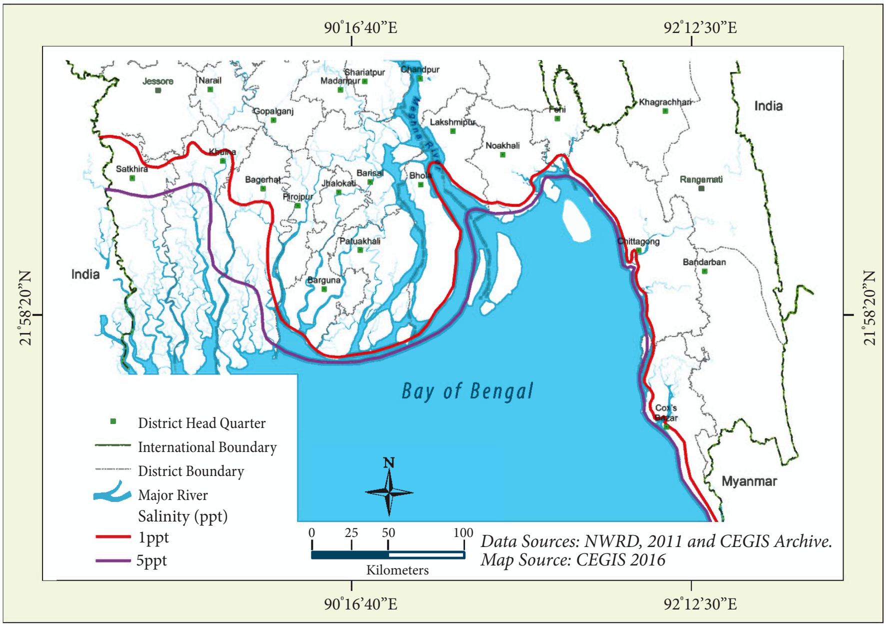
**Salinity Intrusion in Coastal Bangladesh:** Intrusion of saltwater from the sea and contamination of local groundwater source and freshwater aquifers has become an emerging problem in the low-lying coastal regions of Southern Bangladesh. Salinity in this region has already increased and is likely to be increased in future due to many various reasons of which sea level rise, reduction in freshwater inflows from upstream especially from the trans-boundary Ganges River, siltation occurring to the tributaries of the Ganges that flow through Bangladesh, siltation of other rivers due to empoldering effect are few of the main reasons (Dasgupta, et al. 2014a: 4). For example, Pussur River at Mongla has already witnessed a robust increase of salinity from 2ppt in 1962 to 20ppt in 2008 (Dasgupta, et al. 2014a). The dry seasons come with more concentration of salinity due to decrease in freshwater flow from upstream sources.

While the number of people exposed to high salinity (>5 ppt) is about 6.0 million people now, this number is expected to increase to 13.6 million by the year 2050 and 14.8 million by the year 2080 (Mohal and Hossain 2007; Pender 2008). Salinity has already cast enormous negative impacts on health, agriculture, aquaculture, coastal ecosystem, fresh and drinkable water supply. It was found in a study Khulna, Bagerhat and Satkhira districts of Southwest Bangladesh that due to increased salinity Aman rice cultivation will reduce from 88% to 60% with 32 cm rise in sea level and 12% with an 88 cm rise in sea level (CEGIS 2005 cf. Pender 2008: 35). At this juncture it must be noted that critical salinity level for agriculture is 2 ppt and projection says that in Bangladesh "area with salinity less than 2ppt is expected to decrease by 11.1 percent in the best case future scenario and by 29.7 percent in the worst case future scenario" (Dasgupta et.al 2014:25). If that happens, we can easily assume the devastating effect that we will face in future regarding agricultural yield.

Networks of rivers and canals characterize the coastal areas. These are fed by seawater during every tide and are left behind with saline water in the canals, water bodies and on the soil of these areas. Saline water, which enters seasonally, begins to penetrate inland during winter season, and the affected areas rise sharply from 10 percent in the monsoon to over 40 percent in the dry season (GoB 2007). Agricultural production, agricultural land, agraic practice, fisheries, livestock, mangrove forests and livelihood pattern are largely affected by salinity intrusion. It is observed that the trend of dryness owing to the short river flow has been resulted in the spreading of the salinity inside the country leaching with both surface and ground water. Additionally, barrages and embankments constructed to control hydraulic monopoly at the upper streams have reduced water flow from the catchment areas to wash away the salinity that enters into the land areas and hence, the increase of salinity goes on unabated. Again, during the rainy season, the inflated water from the rivers and canals let the saline water spread over the surrounding areas.

Bangladesh has been experiencing higher rate of salinity intrusion in recent years, causing serious damage to the normal agraic activities and livelihood resources. It has devastated the sources of livelihoods primarily of the farming communities. The general occupation of the inhabitants of this region had been farming, mostly based on rain fed paddy cultivation. Due to salinity intrusion, normal agricultural products cannot be grown well now-a-days. According to Shafie et al (2009), before the region went through the intrusion of higher salinity, most of the people of the Southwest Bangladesh were engaged in cultivating normal agricultural products, especially *Aman* and *Boro* paddy (Shafie, et al. 2009). However, due to increase in salinity intrusion, normal agricultural products cannot be grown any more. This

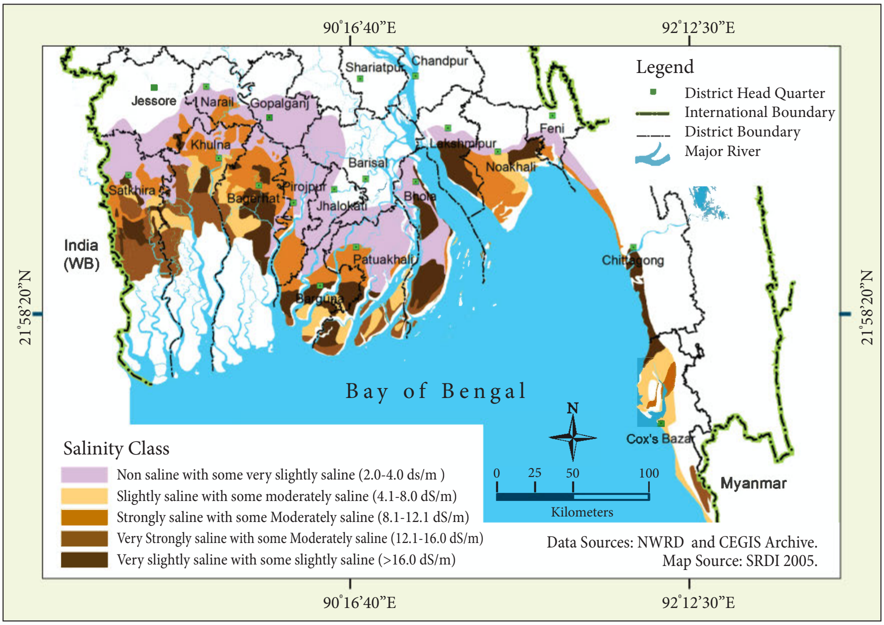
**Map– 4.2: Surface Water Salinity in Southern Bangladesh**



altered circumstance in the ecology has compelled the farmers to change their livelihood pattern. Seeing no other option at their disposal, farmers have adopted measure to use salinity by cultivating products like shrimp, prawn, crab etc. "The Daily Star (28 February 2005) reported that in Shyamnagar upazila of Satkhira district, salinity has affected 88 percent of the cultivable lands. The survey also shows that the lands under shrimp cultivation have been increased to 115 lakh hectares now from 1300 hectares in 1975 in Bagerhat and Khulna region. Again, the survey showed that Satkhira was the worst affected area where about 1.47 lakh hectares out of total 2.28 lakh hectares of cultivable lands were contaminated with salinity. It also showed that waters of 56 percent of rivers and canals in the south-west region are highly affected by salinity" (Shafie, et al. 2009: 146). The poor farmers of these areas, being unable to maintain their livelihood, migrated to urban or semi-urban areas outside.

Scarcity of fresh drinking water is another imminent problem that the people of Southwest Bangladesh have been suffering caused by salinity. Shafie et al (2009) reports that a team of researchers from Water Aid Bangladesh carried out a study in Assasuni and Shyamnagar upazilas of Satkhira for finding out the degree of scarcity of drinking water induced by salinity. It was found in that study that women and adolescent girls have to collect drinking water from a nearby deep tube well at a distance of 3-4 km. Due to the distance of

**Map– 4.3: Soil Salinity in Southern Bangladesh**



tubewell and the long queue there they do not get enough time and energy to give adequate time to other household duties like cooking, bathing, washing clothes etc. The situation thus very often results into domestic disagreement and quarrel. This burden for fetching fresh drinking water from a far away tube-well has become a double burden for women with advanced pregnancy and having breastfeeding babies. These additional burdens bring various diseases for the womenfolk which has a chain effect. For example due to recurrent sickness sometimes, a poor family cannot collect water. In those situations they have depend on water vendors, which cost them Taka 10 for per pitcher. In order to avoid the extra financial burden they instead prefer to drink saline water. And since women enjoy lack of mobility in the society and hence remain in the household most of the time they are the prime consumers of saline water within their family leading them to be the worst victims of diseases indicated above (Shafie, et al. 2009: 146-147).

Salinity intrusion is also causing stagnancy in industrial sector investment since freshwater supply is necessary to start industrial activities. Many of the industries have already been shifted to elsewhere. This overall stagnation has again affected the buying capacity of the local people since there remains a huge absence of non-farm activities in the entire saline prone region. Salinity is also creating harmful impacts on the biodiversity of the area. Shafie et al (2009:146) inform us that the forest department officials have reported 'top dying' disease suffered by about 75 lakh trees of Khulna and Satkhira (Shafie, et al. 2009). Due to the decline in biodiversity local people', especially the poor, wellbeing in respect to nutrition is highly threatened now. It has been observed that in rural areas of Bangladesh "low-value, wild, small freshwater fish are the most common fish consumed in rural areas and the most important source of dietary protein" (Belton, et al. 2011; Dasgupta, et al. 2014a; Dasgupta, et al. 2014b; Dasgupta, et al. 2017; Thilsted 2012; Thilsted, et al. 2010). Another study has observed that rural poor people now can't even afford to buy small fishes in adequate quantities so as to ensure equitable share among the household members (Roos, et al. 2007). Moreover, it is easy to assume that the womenfolk are the first one to get deprived of fish intake causing them the easy target for malnutrition. Due to salinity intrusion, freshwater fishes are also in great decline and as a result, fishermen depending on freshwater catch are under pressure to give up their profession. The data provided by the forest department indicates decline in fruit bearing trees and hence suggests us to assume that children cannot take vitamins and essential minerals they used to obtain from fruit previously. The overall scenario thus takes us to the conclusion that the public health in this region has been facing a great threat. Again, decreasing grazing lands are producing an adverse impact on cattle heads which are also are declining fast in the areas. It is also affecting the economy and livelihood of the poor people.

**Erratic Rainfall:** The southwest monsoon dominates the summer over South Asia during June to September and influences the seasonal cycles. The Fifth Assessment Report predicts that area encompassed by monsoon systems will increase on global scale over the 21st century. Monsoon winds will be weaken and monsoon precipitation will be intense due to increase in atmospheric moisture (IPCC 2013). Monsoon season has already been observed to be lengthened in Bangladesh due to earlier onset and delayed retreat dates. Furthermore, a warmer, moister atmosphere is also likely to lead to heavier rainfall during the monsoon (IPCC 2007). Bangladesh is likely to observe mean increase in rainfall during the summer monsoon and being wetter by 1–11% by 2030, 3–17% by 2050 and 4–29% by 2100 (Tanner, et al. 2007).

Bangladesh is geo-morphologically formed at the confluence of the world's largest trans-boundary river systems including Ganges, Brahmaputra and Meghna rivers and their tributaries. In the wider context of the Ganges–Brahmaputra–Meghna basin, rainfall in the monsoon will be increased from 4–8% by the 2020s and 9–10% by the 2030s, while winter rainfall is expected to reduce by 4–5% by 2050 (Tanner, et al. 2007). Located at the receiving end of this river system, the land territory is being intersected by more than 300 rivers, having a total length of 24,140 kilometers (BBS 2006), flowing towards the Bay of Bengal. The catchment area of the GBM river system comprises 1.74 million $km^2$ and Bangladesh is the gateway of draining approximately 5000 cubic meters per second during the driest period (March–April), to 80,000–140,000 $m^3/s$ in late August to early September (Tanner, et al. 2007). As a result, higher rainfall in the upstreams of this river system outside Bangladesh causes frequent and severe floods.

The trans-boundary rivers in Bangladesh account for 80 per cent of the total fresh water availability (Gain and Giupponi 2014; Islam 1992; Mirza 2006). These rivers serve as the main source of water for irrigation and sweet-water fishes, as well as they are the principal arteries for commercial transportation. This is the reason why cooperation for the management of the trans-boundary Rivers is crucial for Bangladesh. It has been found that the diversion of water of river Ganges by building Farakka barrage in India has caused reduction of surface water availability and also contributed to the desertification process in western districts in Bangladesh (Gain and Giupponi 2014; Mirza 2006; Rahaman 2009). River Garai, which is the only source of fresh water supply to southwestern region, has reduced significantly because river Ganges no longer carries enough water to flush the tributaries (Adel 2001; Khan 1996). A treaty was sign between India and Bangladesh regarding the Ganges water sharing 1996 (Faisal 2002; Nishat and Faisal 2000). However, the construction of the polders and embankments resulted into another the massive anthropogenic impact to the natural water ecosystem in Bangladesh in the southwestern region. The building of polders in 1960s caused drainage problems and water logging in the area. These polder systems delinked the wetlands from the rivers and caused enormous drainage problems and water logging, which led to significant change in the ecosystem of the wetlands (Haque, et al. 2015; Islam 2006; Nowreen, et al. 2014; Rahman and Rahman 2015; van Staveren, et al. 2017). Besides, evidences suggest, with the agricultural intensification there has been rapid increase in water use for irrigation resulting in to significant fall in the ground water table in south-western coastal region (Khatun 2004). Salinity problem is also increasing, as shown in Figure– 4.2, in the coastal districts of Bangladesh, because of sea level rise and fall in the flow of the upstream rivers, which make it possible for the saline water to penetrate up to 240 kilometers inside the country (Shamsuddoha and Chowdhury 2007). Expansion of shrimp culture also led to significant increase in soil and water salinity in southwestern districts (Guimaraes 2002: 271; Mirza 1998).

**Loss of Biodiversity:** The species diversity in Bangladesh will be at risk due to climate change. The wetlands of Bangladesh are the habitat of rich diversity of 400 species biodiversity, which will be at risk due to changes in the water cycle induced by climate change (Pender 2008). The Modhupur and Barind tract region will loose flora and fauna diversity due to increased evapotranspiration, drought and moisture stress. Flash floods and erosion due to heavier rainfall will damage hill forests in Chittagong Division. The Sundarbans will sustain the highest damage severely affected (Ahmed, et al. 1999; Donato, et al. 2011; Duke, et al. 2007; Giri, et al. 2011). The Sundarbans is the largest mangrove forest in the world covering an area of about 1 million hectares of which about 60% lies within Bangladesh (Ahmed, et al. 1999; Islam 1994). The Sundarbans is already tidal and saline but with increasing sea level allowing saline water to penetrate further with tidal and storm surges; higher evapotranspiration due to hotter weather; and a reduction of freshwater in the dry season flowing into its rivers due to changing rainfall patterns; it is expected to get more saline (Ahmed, et al. 1999; Pender 2008). The Sundarbans will be reduce from 60% to 30% in the year 2100 with 88 cm SLR (Hassan and Shah 2006; Hossain, et al. 2016; Mohal and Hossain 2007; Pethick and Orford 2013). In a worst case scenario 32 cm of sea level rise may flood 84% of the Sundarbans possibly by 2050 and with an 88 cm sea level rise possible by 2100 the whole of Sundarbans will be lost (Mohal and Hossain 2007; Pender 2008).

## Sea Level

Because of the changes in natural processes such as terrestrial water shortage, over extraction of ground water, building of reservoirs, changes in runoff, and seepage into aquifers, changes in the circulation of surface and deep ocean, storm surges, subsidence in river delta region, tectonic displacement, thermal expansion, exchange of the water stored on land by glaciers and ice sheets with ocean water are the significant reasons that result into the rise of sea level (IPCC 2013).

Sea level rise varies geographically. Apart from global reasons, each geographic location has its own dynamics, which can also act as additional factors. For example, displacement of tectonic plate can be treated as an imminent threat to coastal Bangladesh since the region "is very gradually sinking due to the weight of the silt being deposited by its rivers and the continued rise of the Himalayas that is slightly tipping Bangladesh seawards; 'compaction of peat layers' which are soft layers of organic dead plant and animal material that are gradually being squeezed tightly together by the weight of the land above; and 'human activities' such as removal of water from the ground for irrigation which speeds up compaction and the building of dams, dyke, embankments and other measures to prevent floods, for these prevent new layers of silt raising the land level as older layers compact and sink" (Mohal and Hossain 2007; Pender 2008).

It has already been reported that movements in tectonic has caused the ground level in Bangladesh to fall down slightly along with a subsequent impact on sea level which is rising by 4.8 millimeters per year. Moreover, if this continues, within 20 years the country will see a rise by 8.16 centimeters (Butzengeiger and Horstmann 2004: 6). According to Butzengeiger and Horstmann, if the sea level rise by 45 centimeters then the country may lose 15,600 square kilometers and if it is by one meter without any dyke enforcement measure being taken then one fifth of Bangladesh i.e. 14,000 to 30,000 square kilometer will go under water (Butzengeiger and Horstmann 2004). This permanent loss of land will be followed by increased and prolonged flood covering more new areas that have never experienced flood before, threat of epidemics during and after flood as the country has inadequacy in sanitation, increase in malaria infections and many other water born diseases due to the expansion of wetlands.

Scientists and researchers have many opinions regarding the impacts of sea level rise on Bangladesh. Apart from decrease in agricultural production, livestock, and aqua-cultural species the entire ecosystem of the country will be jeopardized largely. One worrisome example is the Sundarbans, which has been recognized as part of World Natural Heritage by UNESCO. It is anticipated that if climate change and sea level rise keep continuing at this unabated rate then Sundarbans ecosystem will be highly damaged followed by the extinction of Bengal Tiger, mangrove swamps and many hundreds of water species like marine turtles, crocodiles, fresh water dolphins (locally known as *Irabati* Dolphin) etc. The disappearance of Sundarbans ecosystem will lead to loss of livelihood of over 2 million forests dependent people who live on forests products like honey, shells, crabs, fish, wood and many so on (Butzengeiger and Horstmann 2004).

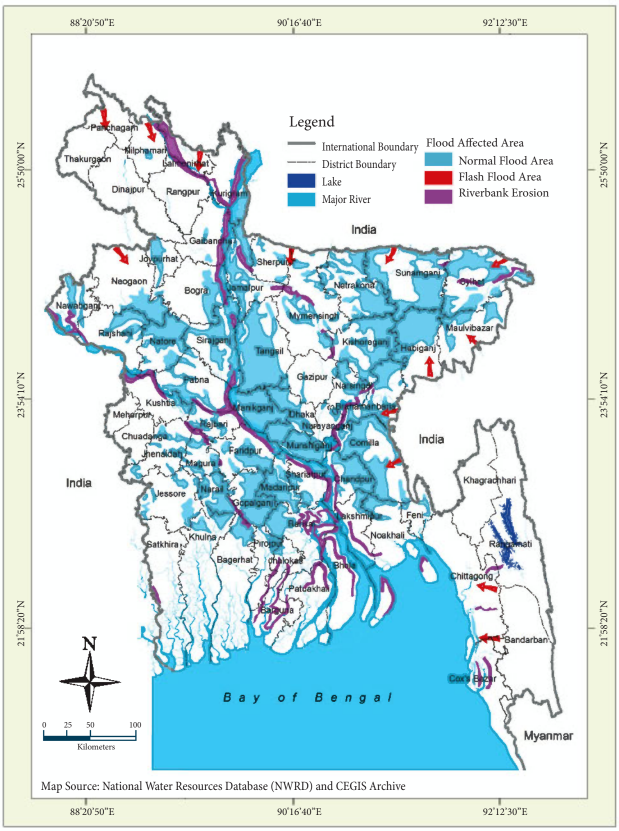
Bangladesh has been ranked as the 3rd most vulnerable in the world to sea level rise in terms of the number of people and in the top ten in terms of percentage of population living in the low elevation coastal zone. Therefore, the threat of the communities being forced away due to the effects of climate change is one of the most severe on earth (McGranahan, et al. 2006; McGranahan and Satterthwaite 2006). Currently almost 40 million live in the coastal areas of Bangladesh but depending on the rate of population growth, by 2080 when the situation begins to get more serious it could be between 51-97 million in this vulnerable area. In year 2050 assuming a sea level rise of 27 cm, around 26 million people will be at a low risk and almost 7 million will be at medium risk of flooding, of which 58% of these people will be from Khulna, Jhalokati, Barisal and Bagerhat districts. In year 2080 assuming a sea level rise of 62 cm, 17 million, 12 million and 14 million people are expected to be at low, medium and high risk respectively, of being permanently flooded by the sea (Mohal and Hossain 2007).

The total length of the Bangladesh coastline is 710 km long (Mohal and Hossain 2007) and historically, the coastline has been undergoing erosion and deposition (Best, et al. 2003; Islam, et al. 1999). However, the balance between erosion and deposition is being affected by climate change. With the rise of 2 cm in sea level, the coast may go back to 80–120 meters by the year 2030 implying that the Cox's Bazar beach will be completely submerged (Hossain and Sakai 2008; Hossain, et al. 2008; Islam 1994). Approximately, 5,800 hectares of land could be lost due to sea erosion by 2030 and 11,200 hectares by 2075 (Hossain, et al. 2008; Islam, et al. 1999). Grain production will be reduced significantly and a large number of people will be displaced.

Natural drainage system will be obstructed resulting congestions due to climate change (Tanner, et al. 2007). Drainage congestion will be resulted from a number of factors: rivers gradients will be reduced due to backwater effect of sea level rise; subsidence of earlier deposits of sediment will reduce river flows; siltation of estuary branches will obstruct channels and thereby river flows; riverbed siltation will reduce water discharge; and reduced sedimentation in flood–protected areas will result in uneven land elevation (Pender 2008). All these causal factors with generate drainage congestion and increase waterlogging. Disease outbreak, crop failure, population displacement and similar associated problem will become more frequent and intensified (Mohal and Hossain 2007; Pender 2008). It is estimated that sea level rise would force around 33 million of their land by 2050 and up to 43 million of their land by 2080 due to sea level flooding (Mohal and Hossain 2007). Accounting the compound effects of salinity, river gradient reduction, drainage congestion, erosion and other indirect effects of sea level rise, the entire coastal population constituting 51–97 million will be effected by 2080.

**Flooding Scenario:** Bangladesh is known to be a "Land of water or better still water in land" (Novak 1993). However, there is a paradox in terms of availability of water in the country. Water problems fall between the extremes of flood during monsoon and scarcity during the dry season (Rahman 2005). Apart from seasonality, trans-boundary river issue is a major factor causing water problem. In addition to these two factors, in the southwestern region intrusion of saline water is linked to water scarcity. As a matter of fact, the level of the problem regarding water scarcity varies across regions and in different region it is compounded or intensified by multiple different factors. Nevertheless, in some regions water crisis has become a vital concern for livelihood and food security in Bangladesh. The National Water Policy (1998) of Bangladesh identifies the flood mitigation and seasonal water scarcity as the most critical problems. Besides, massive river sedimentation, bank erosion, water quality management including arsenic contamination and salinity are considered major problems in the Water Policy. For sustainable water management coordinated effort concerning

**Map– 4.4: Different Types of Flood Affected Areas**



Map Source: National Water Resources Database (NWRD) and CEGIS Archive international river basins like the Ganges basin, the Brahmaputra basin and the Meghna basin is given much importance in the policy document.

The effects of increased flooding, both coastal and riverine, flooding resulting from climate change will be the greatest problem faced by Bangladesh. Bangladesh experiences frequent flooding. The monsoon floods are a consequence of the country's low topography and its location at the end of the world's most concentrated river and draining network system. As about 60% of the country is lower than 6 meters above sea level with an average river gradient of only 6cm/km in the delta (Pender 2008). Upstream rainwater beyond the national border often results in reduced channel flow and consequent overland runoff water. Factors in catchment areas beyond the national borders lead to reduced channel flows and consequent flooding of land. These factors include heavy rainwater, river siltation, while human intervention (such as construction of barrages and protective works along the banks of the river and deforestation in the upper reaches of the rivers) are not only brining accelerated water flow downstream, but are also causing deposition in river beds.

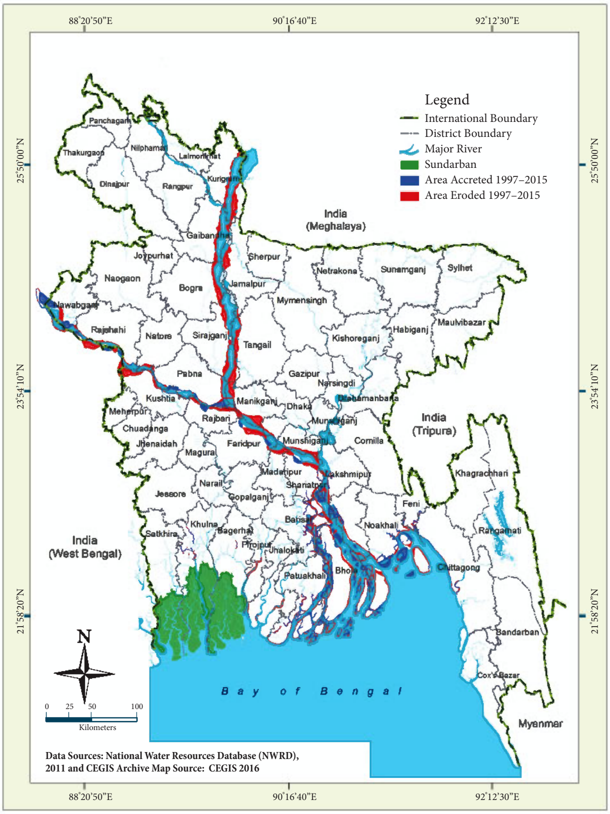
In recent years, the frequency of floods has increased substantially, causing serious damage to lives and property. The 1988 flood affected about two-thirds of the country's total area. The 1998 flood, which remained for 65 days from July 12 to September 14, affected about 67% of the area. It caused 1,100 deaths, made 30 million people homeless, damaged 500,000 homes and caused heavy loss to infrastructure. This devastating flood had an enormous impact on the national economy, in addition to causing hardships for people and disrupting livelihood systems in both urban and rural areas. In 2000, Bangladesh faced an unusual flood over its usually flood-free south western plain, which also caused loss of life and massive damage to property. In 2004, floods inundated about 38% of the country (WARPO, 2005) and some 747 people lost their lives. Around 2,500 kilometers of embankment were damaged and 74 primary school buildings were washed away.

Flooding is the most severe hazard in Bangladesh in respect of frequency and the magnitude of damage caused. Flooding affects every aspect of livelihoods, including natural resources, physical resources, social resources, economic or financial resources and human resources. Flooding is seen by Bangladeshi people as the most important disaster event, ahead of drought and cyclones. The history of floods goes hand in hand with the history of land formation in Bangladesh. Floods are annual phenomena with the most severe occurring during July and August. Regular river-floods affect 20% of the country – increasing to 68% in extreme years. About 68% of the country is susceptible to flooding, while 25% to 30% of the area is inundated during times of normal flooding (GoB 2007). Annually, around 20% of the country is temporarily flooded but in extreme cases this may rise to as high as 70%

of the country (Mirza 2002). Climate change will increase about 18% of current lowly flooded areas will be susceptible to higher levels of flooding, and about 12–16% of new areas will be at risk of flooding of various levels, while in an average year flood prone areas will increase from 25% to 39% (Ahmed, 2006).

Other types of floods include flash floods, caused by the onrush of hilly rivers in Eastern and Northern Bangladesh, and storm surges induced by coastal floods. Flash floods occur in the eastern and northern rivers, along the borders of Bangladesh and they are caused by exceptionally heavy rainfall occurring over neighboring hills and mountains in India (Mirza 2002), and tend to occur between April–May and between September–November (NAPA, 2005). Climate change is likely increase flash flooding in the Sylhet and Chittagong Divisions as heavy rainfall leads to a rapid rise and fall in river levels as it flows quickly down from the hills (BCAS 1994).

**Map– 4.5: Major River Erosion and Accretion between 1997 – 2015**



**River Bank Erosion and Accretion:** Morphologically, Bangladesh's rivers are highly dynamic. The main rivers are braided and form islands or chars, where many people live. The rivers erode every year– often several times a year– and that has dramatic consequences for the lives and livelihoods of people living in those areas. River bank erosion is a form of hydraulic action, whereby the force of the water wears away the riverbank from below. Erosion may also be increased by factors such as redirection and acceleration of flow, removal of protective vegetation from banks, intense rainfall events, and inundation of bank soils. As most of the country is made up of soft silt soils**,** riverbanks are very washed away by river currents and wave action. River bank erosion includes channel shifting, the creation of new channels during floods, bank slumping due to undercutting and local scour from turbulence caused by obstruction (Ahmed, 2006).

A 1991 study concluded that 100 of the country's 462 administrative units were subject to some form of riverbank erosion; and of those 35 were serious, affecting about 1 million people every year. Around 10,000 hectares of land are eroded annually by rivers (NWMP, 2001). A CEGIS study in 2005 showed that bank erosion along Padma River between 1973 and 2004 claimed 29,390 hectares, while 87,790 hectares were lost along the Jamuna River from 1973 to 2004. Erosion accelerates acute poverty by producing a significant number of environmental refugees.

River bank erosion is experienced every year. It causes massive loss of land, settlements, roads, embankments and other infrastructures. In 2004 it destroyed 702 hectares of land, 139 hectares of settlements, 160 miles of district roads, 571 miles of upazila roads, 248 miles of rural roads and 3,724 miles embankment in Sirajganj district alone (CEGIS, 2005). The BWDB estimated that 1,200 km of riverbank has been actively eroded and more than 500 km has been facing severe problems related to erosion, and every year despite some deposition of silt, a net area of 8,700 hectares of land was being lost (Ahmed, 2006). Another estimate suggests that a million people are pushed off their land by river erosion each year and many of these end up permanently displaced (Christian Aid, 2006).

**Drought and Aridity:** Droughts and aridity have caused considerable economic losses and human sufferings in Bangladesh. An analysis of the relative effects of flood and drought on rice production between 1969-70 and 1983-84 shows that drought is more devastating than floods to aggregate production (World Bank, 2000). The Northwest part of the country is generally considered as the drier region than other parts of Bangladesh. This research, however, capture indigenous knowledge and coping strategies related to drought and aridity in several research sites located in Barind Tracts (the districts within), arid char-lands of Gaibandha, Kurigram and Nilphamary districts.

Drought appears to be a creeping phenomenon in Bangladesh. The effects of drought accumulate slowly over a considerable period of time, and may linger for years after the termination of the event. The Northwest part is prone to drought mainly because of rainfall variability in the pre-monsoon and the post-monsoon periods. Inadequate pre-monsoon showers, a delay in the onset of the rainy season or an early departure of the monsoon may create drought conditions in Bangladesh, and adversely affect crop output. Again, drought episodes transpire when precipitation has been significantly below normal recorded levels, resulting serious hydrological imbalances that adversely affect land resources production systems.

Consequently, during the dry period, the ground aquifer level goes below 8.95m to 18.56m in some regions of Northwest Bangladesh (MoEF 2002). This indicates that most of the shallow tubewells go below the suction lift capacity having severe implications for terrestrial vegetative cover and aggregated agricultural yields. Drought acts as a catalyst of land degradation through reducing soil moisture and water retention capacity, and thereby increasing soil erosion, decline in soil organic contents and overexploitation of sparse vegetation. Human interventions may have exacerbated these actions during the spells of periodic droughts.

After 1971 Bangladesh has experienced droughts of major magnitude in 1973, 1978, 1979, 1981, 1982, 1989, 1992, 1994, and 1995 (MoEF 2002). Past droughts have typically affected about 47 percent area of the country and 53 percent of the population. However, Bangladesh does experience long spells of dry weather and moderate to severe droughts are spread over a region of 5.46 million ha and 33 percent of total land acreage in Bangladesh falls below the minimum threshold for sustainable cultivation. For instance, the droughts of 1994-95 in the Northwest districts of Bangladesh led to a shortfall of rice production of 3.5 million tons (Paul, 1995).

The *Rabi* and *pre-Kharif* (January – May) agricultural seasons are likely to be affected by drought (Karim et al., 1990) due to: (1) the cumulative effect of dry days; (2) higher temperatures during *pre-Kharif* (>40 degrees Celsius in March - May); and (3) low soil moisture availability. This drought affects all the Rabi crops, such as HYV Boro, Aus, wheat, pulses and potatoes, especially where irrigation possibilities are limited. It also affects sugarcane production. *Kharif* droughts during June to October, caused by sub-humid and dry conditions, affects the critical reproductive stages of transplanted Aman crops resulting significant yield reduction, particularly in those areas with low soil moisture holding capacity.

Water is the main limiting condition for human adaptation in the drought prone regions. The people had to depend mainly on rain water for cultivation that does only allow mono crop (single crop throughout the year). The crop production is rarely met the demand of increasing number of population, and again the expected production sometime affects mainly by the natural calamities. The context of climate change and geopolitical aftermath of Farakka Barrage have also exposed the region to increased and prolonged drought. The introduction of deep tube-well irrigation by the BMDA has yielded significant change in the production scenario, but still many areas located in upper Barind remain outside of having irrigation facilities due to the unavailability of the ground aquifer as well as for unfavorable geological conditions. Consequently, people are always being chased by famine or near famine like situations.

Besides these physical conditions, the socially generated pervasive processes of inequality in the distribution of goods and services, exclusion of the minority and indigenous communities, and other concomitant factors accelerate the sufferings of people intensifying wide-scale food insecurity in that region. Again, domestic agriculture itself depends upon a variety of imported inputs such as fertilizer, fuel and machinery. Small family firms suffer from crises, such as a harvest failure or animal disease, or natural disasters, especially drought, which significantly disrupts the domestic food supplies in an uncertain market.

Drought aftermaths multiplied by concomitant social pragmatics have cumulative bearing upon the socio-economic conditions and livelihood support systems of people living in those regions. It causes scarcity of fresh drinking water, reduces the prospects for irrigation and thereby diminishing of the food security base of human beings as well as livestock. Drought also reduces availability of biomass for fuel and significantly causes bio-diversity loss. It affects the state of health and nutrition of the population, and above of all, drought intensifies poverty.

## Cryosphere and Melting of Himalayan Glaciers

The AR5 predicts that the Arctic sea ice cover will continue to shrink and spring snow cover of northern hemisphere and global glacier volume will decrease as global mean surface temperature rises (IPCC 2013). The spring snow cover of northern hemisphere is projected to decrease by 7% (RCP2.6) and by 25% (RCP8.5) by the end of the 21st century. The AR5 also says that the climatological mean state and 1979 to 2012 trend of the Arctic sea ice extent suggest a nearly ice-free Arctic Ocean in maputra traces their origin in the Himalayan glacial snowfields, which store about 12,000 km$^3$ of freshwater, (Pender 2008). The Himalayan glaciers are at risk of being complete disappearance by the 2035, since these glaciers are melting at an accelerating pace than anytime before (Immerzeel, et al. 2012; IPCC 2014; Kehrwald, et al. 2008). In the Himalaya–Hindu Kush Mountains, melt-water from glaciers feeds seven of Asia's largest rivers, including 70% of the summer flow in the Ganges, which provides water to around 500 million people, including much of the population of Bangladesh (Stern 2006). Faster melting of Himalayan glaciers is likely to increase water flowing down rivers like the Ganges in the spring and monsoon months, which already contributes along with rainfall to causing devastating river floods in Bangladesh (Ahmed 2006).

*Image–11: Seedbed Preparation near Water Source (Photograph by Shuvashish Sarker).*

*Image–12: Children Playing on the Sandy Bank of Dying Stream (Photograph by Mohosin Kabir).*

*Image–13: Deposition of Silt and Formation of Charland (Photograph by Shuvashish Sarker).*

Chapter Five

# Assessing Climate Risks in Study Areas

## BACKGROUND AND CURRENT STATE OF CLIMATE

This chapter briefly reviews changes in climate indicators and assesses the likely risks portfolio of climate change impacts for the different unions of the study areas. Bangladesh has a humid, warm, tropical climate. Its climate is influenced primarily by monsoon and partly by pre–monsoon and post–monsoon circulations (Rashid and Shafie 2013; Rashid 1991). Bangladesh has four prominent seasons: Winter (December to February), Pre–monsoon (March to May), Monsoon (June to early–October), Post–monsoon (late–October to November). The dry season begins first in the west–central part of the country by December, where it lasts about four months. It advances towards the east and south, reaching the eastern and southern margins by January where its duration is about one and a half months. The monsoon has its onset during the beginning of June and ends at the first week of October, with some inter–annual variability in schedule. The southwest monsoon originates over the Indian Ocean and carries warm, moist, and unstable air. The mean annual rainfall is about 2300mm, but there exists a wide spatial and temporal distribution. The average annual rainfall varies from 1329 mm in the Northwest to 4338 mm in the Northeast (Rashid 1991).

Inundation level classifies land area into four types: highland areas– above the normal flood–level; medium highland– normally submerged under

90 cm water during the flood season; medium lowland– normally remains flooded between 90 cm and 180 cm during the flood season; lowland– usually remains flooded between 180 cm and 300 cm during the flood season; and very lowland– mostly remains flooded deeper than 300 cm during the flood season. There are also depression sites that remain wet throughout the year. This scaling of inundation level is somewhat flexible, because the depth varies between years and because the peak level may remain only for a few days. The average relative humidity for the whole year ranges from 70.5% to 78.1 % with a maximum in September and a minimum in March (Rashid 1991).

## ASSESSING CLIMATE RISKS IN ASSASUNI UPAZILA

### Climatic Hazards in Assasuni

The major climatic hazards in Assasuni upazila are river erosion, water logging/ flood, shrimp viruses, *kalboishakhi* (storm in the month of *Boishakh*), salinity, scorching heat (warming), excessive rainfall, thundering and arsenic. Local inhabitants think that these disasters cost huge damage to the soil, harvest, wealth and human lives every year. After collecting and analyzing information from the yard–meetings (FGD) with local inhabitants, members of the Union Council and Union Disaster Management Committees of the eleven Unions (Anulia, Borodal, Budh hata, Dargahpur, Kadakati, Khajra, Kulya, Protapnagar, Assasuni Sadar, Shovnali and Sreeula), the scenario of the disaster and jeopardy of this upazila is presented in the following table:

**Table– 5.1: Major Climatic Hazards in Assasuni**

| Union | Salinity | Norwester and Cyclone | River erosion | Heat Wave | Torrential Rain | Flood & Water Logging | Thunder Storm |
|---|---|---|---|---|---|---|---|
| Anulia | √ | √ | √ | √ | √ | √ | √ |
| Bordal | √ | √ | √ | √ | √ | √ | √ |
| Budhhata | √ | √ | — | √ | √ | √ | √ |
| Dargahpur | √ | √ | — | √ | √ | — | √ |
| Kadakati | √ | √ | √ | √ | √ | √ | √ |
| Khajra | √ | √ | √ | √ | √ | √ | √ |
| Kulya | √ | √ | √ | √ | √ | √ | √ |
| Protapnagar | √ | √ | √ | √ | √ | √ | √ |
| Assasuni Sadar | √ | √ | √ | √ | √ | √ | √ |
| Shovnali | √ | √ | √ | √ | √ | √ | √ |
| Sreeula | √ | √ | √ | √ | √ | √ | √ |

**Excessive Rainfall and Water Logging:** Most of the Unions of this upazila are almost surrounded by water. The excessive rainfall in the months of Ashar, Srabon and Vadro causes water logging. The three–kilometer long dam through the river at Manipur of Anulia Union has been collapsed. As the riverbed silts up every year, the navigability declines and tidal water gets higher. Ultimately, the water logging problem has been intensifying. Again, the declining navigability of the Kholletua River aggravates the water logging of Barodal area. Moreover, the absence of drainage system allows excessive rainfall to create water logging at Kenjatali and Keyarghat areas. The yard–meetings held in Dargahpur union has implied that the water logging crisis has deteriorated in Khariati and ward number 1, 2and 3 of this union.

The navigability of the river at Assasuni upazila is on decline. Main reasons for this are the over siltation and rising of tidal water every year. Heavy rainfall is causing more water logging than before due to leasing out canals, their miss management and turning those canals stagnant. Yard–meetings held in Assasuni Sadar Union show another noteworthy cause of water logging: undertaking unplanned development programs and their implementation.

This water logging causes a great harm to the resources of local inhabitants. For instance, superfluous rainfall put the harvest submerged under water that spoils both the harvest and the land. In some cases, the habitats are in a lower altitude than the river and thus it seems difficult to drain the extra water and ultimately the shrimp girdle goes under water. Usually the girdle should be in such an altitude where, during the tide, water can be brought easily through a pipe/aqueduct. Due to the lower altitude of the girdle's position, excessive rainfall results water logging. Fishes escape out of the ponds/ water reservoirs during a heavy rainfall. Excessive rainfall–induced water logging causes damages to mud houses and dirt roads. When the tube wells are submerged under water due to excessive rainfall, it causes scarcity of drinking water. During this time, diarrhea and mosquito–borne diseases spread forcing the day laborers jobless.

> *"Despite government efforts, sometimes, local people make impediment to the construction of the culverts to overcome water logging, because they do not allow building culverts on their own lands. Moreover, a few people build houses on the culverts that cease the culverts. The Kapotakkha River driven beside the Borordal Union is dying gradually. Twenty years ago, this river had a high tide, but now only monsoon brings the tide. There is now low current for almost 6-8 months in a year."*
>
> *- A Villager*

> *"A connecting road to the bridge was constructed at ward number 1 of this union. As a result, all the canals were closed causing damages to the drainage system of the area. Union Council sent letters to the Water Development Board (WDB) for solution, but did not get any reply. Before constructing the connecting road it was necessary to excavate the canals. Due to this missmanagement, the impact was on the drainage system to be ceased. Water logging from this has done a lot of damages to the resources of the local inhabitants."*
>
> *A Member of Assasuni Sadar UP*

**Riverbank and Embankment Erosion:** River erosion is one of the most recurrent curses to the people of Khajra, Protapnagar, Assasuni Sadar and Anulia Union of Assasuni upazila. Local inhabitants accounted that 20–30 years ago the river stream was much higher. Without any dam, there was no occurrence of shortages of water during high tide. However, this is not the same today and despite the existence of dam, water submerge has become a common phenomenon.

According to the local inhabitants, some of the major causes for riverbank and embankment erosions are over siltation of river bed, easily dispersible soil, delicate dam, declination of navigability of river, lack of river training and high/low tide. Fishes are escaping from the overflowed ponds/ water reservoirs and girdles because of riverbank/ embankment erosion. Shrimps of a girdle move to another one as the logged water removes the barriers among the girdles. Moreover, damages are done to arable lands and houses. Salt water gets into the arable lands and cultivation of crops is ruined. Children, old, physically challenged persons, PWD all fall prey to the water–breakout due to sudden erosion of river. The everyday *modus vivendi* is disrupted and the livelihood of day laborers face menace due to this water logging. Mud houses, dirt roads, and even cobbled roads are damaged as well. The river water gets into the tube wells and pollutes drinking water. Arable lands become salty because of being washed by river water. Trees die due to saline in soil and plantation becomes impossible. Cattle lose their shelters and fall prey to water borne diseases. In almost all the yard–meetings, local inhabitants pointed to the failure and procrastination of responsible authorities to maintain the river and the dam.

> *The duty of WDB (Water Development Board) is to upkeep dam. But we think that they do not play their role in time and perfectly. For any occurrence of riverbank or dam erosion they (WDB) take a long time to inspect the situation, prepare a report, seek allotment for its reconstruction, and get allotment approved to finish the task. That's why, after any erosion of the riverbank or dam, this long term process by WDB aggravates the situation and the chance of habitat.*
>
> *- A Villager*

**Salinity Intrusion:** Salinity is one of the major problems of almost all the Unions of this upazila. Salinity causes damage to agro–production, seedbeds and arable lands, grass, ceases reproduction of grass, and turns water salty. Thus, cattle and animals suffer from the scarcity of grass and drinking water. Besides, adaptation to salinity compels to introduce more shrimp girdle on arable lands and fallow pastures. Thus, less cultivation/ paddy cultivation and declining of fallow pastures make the scarcity of dry straw. Salinity is responsible for the imbalance of nutrition ingredients; that makes plants parched and fruit trees get withered and is responsible for the scarcity of firewood/ trees. The cement plaster of different buildings of houses, educational institutions and government–private infrastructures get decayed and may collapse due to salinity. Local inhabitants of Budh Hata area mentioned that tube well water cannot be found here. The presence of salinity, arsenic and iron in the drinking water aggravates the crisis for safe drinking water. People have to take their bath either in saline water, river water, or in the girdle or stagnant water. Saline water causes kidney diseases, stagnant polluted water causes allergy in human body and other water borne diseases. Human skin is burned and turns gray due to salinity in water. People suffer from different chronic diseases for the scarcity of drinkable water. As the number of trees declines, the temperature also rises.

> *Salinity has become an epidemic now. Earlier it was not such a big issue in this area. Nevertheless, gradually the situation is getting worse. Excessive shrimp farming is key to the salinity problem. If the current scenario prevails then in near future, we may have to quit farming and fall in ultimate uncertainty.*
>
> *- A shrimp farmer*

**Cyclone and Norwester:** *Kalboishakhi* and cyclone are other disasters that affect the people of some Unions of Assasuni upazila. Local people anticipate cyclone seeing thick black clouds in the sky. Radio and TV telecast the forecast for the cyclone. But local people monitor the wind speed and type of clouds to make their own forecast. According to them, *kalboishakhi* not only hits in the month of *Boishakh–Jyestha,* but also in *Falgun–Chaitra.*

> *Earlier kalboishakhi used to hit our area in the month of Boishakh-Jyestha, now it attacks in Falgun-Chaitra also. The paddy cultivation is hampered by Kalboishakhi and cyclone; and paddy plants are grounded. The isles of the girdle, mud houses, semi-concrete houses and educational institutions are damaged by Norwester and Cyclone. These disasters toll not only resources but also human lives.*
>
> *- A shrimp farmer*

The year 2016 experienced several storms in the area. The damages caused by storm are minimized in recent times because people are more vigilant now. Remarkably, in the aftermath of cyclone *Sidr* people have become more conscious. Getting the forecast of any disaster, people are made alert by the Union Council so that damages can be minimized. There are more mud houses than that of concrete houses in Budh Hata Union of this upazila. Local people are advised and guided to take a safe place in cyclone shelters, school/college buildings or in concrete houses. As there are not enough cyclone shelters and buildings, only nearby people can take shelter there. People living in distant places cannot reach there.

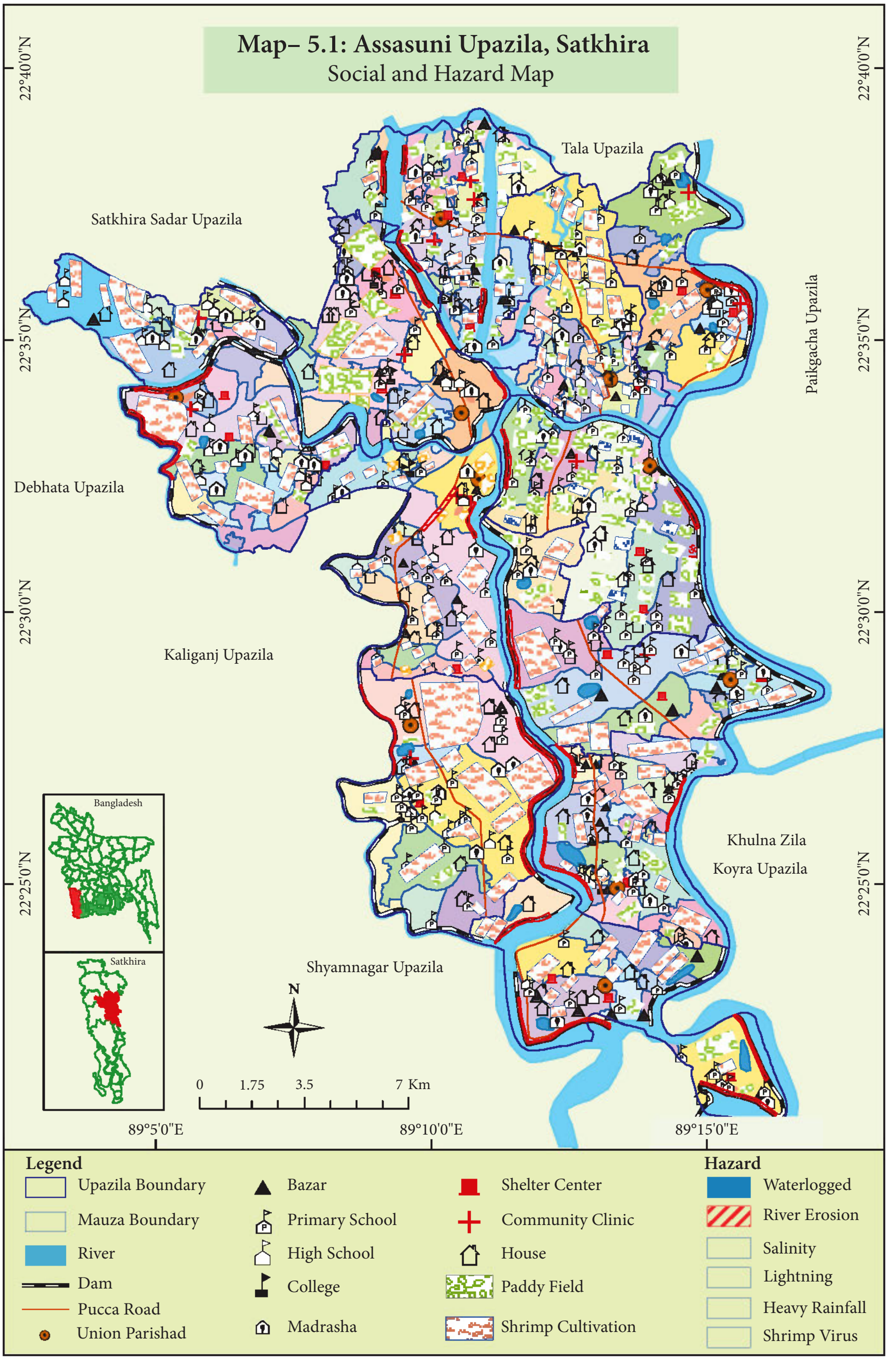
**Thunder Storm:** In recent times, thundering has become the new enrollment to the index of natural disasters. In their report of 2010, National Lightning Safety Institute of USA mentioned that one fourth of the global thundering was seen in Bangladesh. According to the Bangladesh Meteorological Department (BMD), 5,772 incidents of thundering were seen in last five years (2011–2015). 978 in 2011, 1,210 in 2012, 1,415 in 2013, 951 in 2014 and 1,218 incidents were seen in 2015.

According to a report by disaster forum, 36 persons were killed by thundering in 2016 (Till 4 April); 186 people were killed in 2015; 210 people were killed in 2014; 285 people fell victim to thundering in 2013; the death toll was 301 in 2012; and 179 in 2011. This organization prepared the report based on news reports published in mass media. The 2015 report implied that Chapainababganj, Kishorganj, Lalmonirhat, Sunamganj, Satkhira, Dinajpur and Brahminbaria experienced most incidents of thundering.

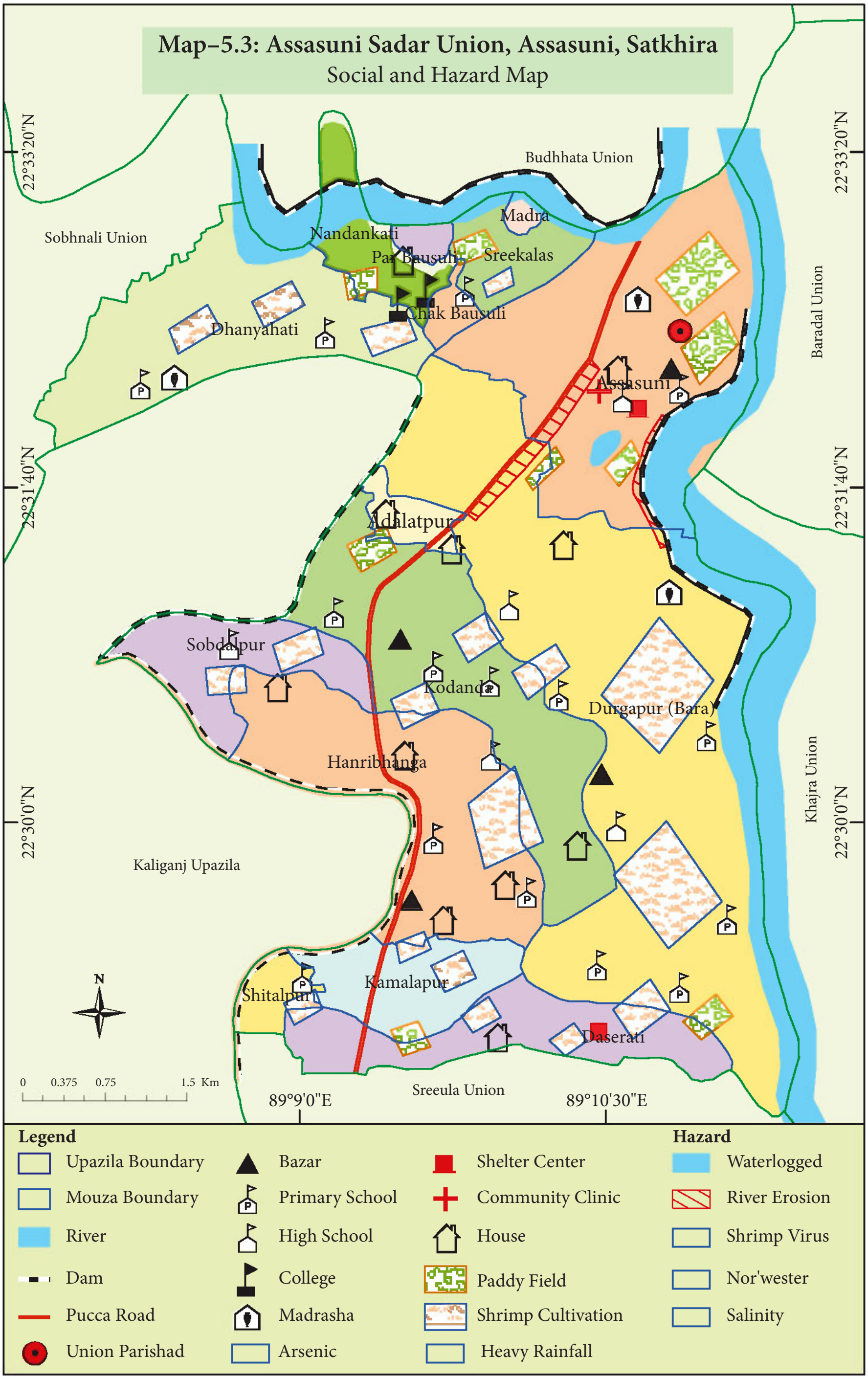
SMRC has been doing research on thundering since 2009 and their researchers proclaimed that among the SAARC countries, Bangladesh is at the highest risk of thundering and death toll of it. As per the observation made by the researchers of Dhaka office of this organization, 500 to 800 people fall victim to thundering every year in Bangladesh. SMRC report further mentioned that between the months of March and May 40 thundering incidents occur in every kilometer area of Bangladesh. Environmentalists denote severe muggy heat in the perpetual rapid thermal weather, regular temperature hike in sea and earth surface, caused by the adverse change of weather–climate, and continuous excessive pollution of environment and atmosphere as the main reasons for the excessive thundering. Climate change causes more force of encounter between server speedy cold and hot wind wreath in the air that causes excessive thundering. People of Assasuni upazila consider thundering as a disaster. They have their own belief regarding the causes of thundering. For instance, people believe that a type of magnet was grounded deep into the earth, which prevented thundering. As these magnets were stolen, the rate of thundering is rising. In the last few years, several mishaps were caused by thundering such as loss of human and animal lives, distortion of human limbs, numbness of head and feet, burning of the body, and damage to trees and plants.

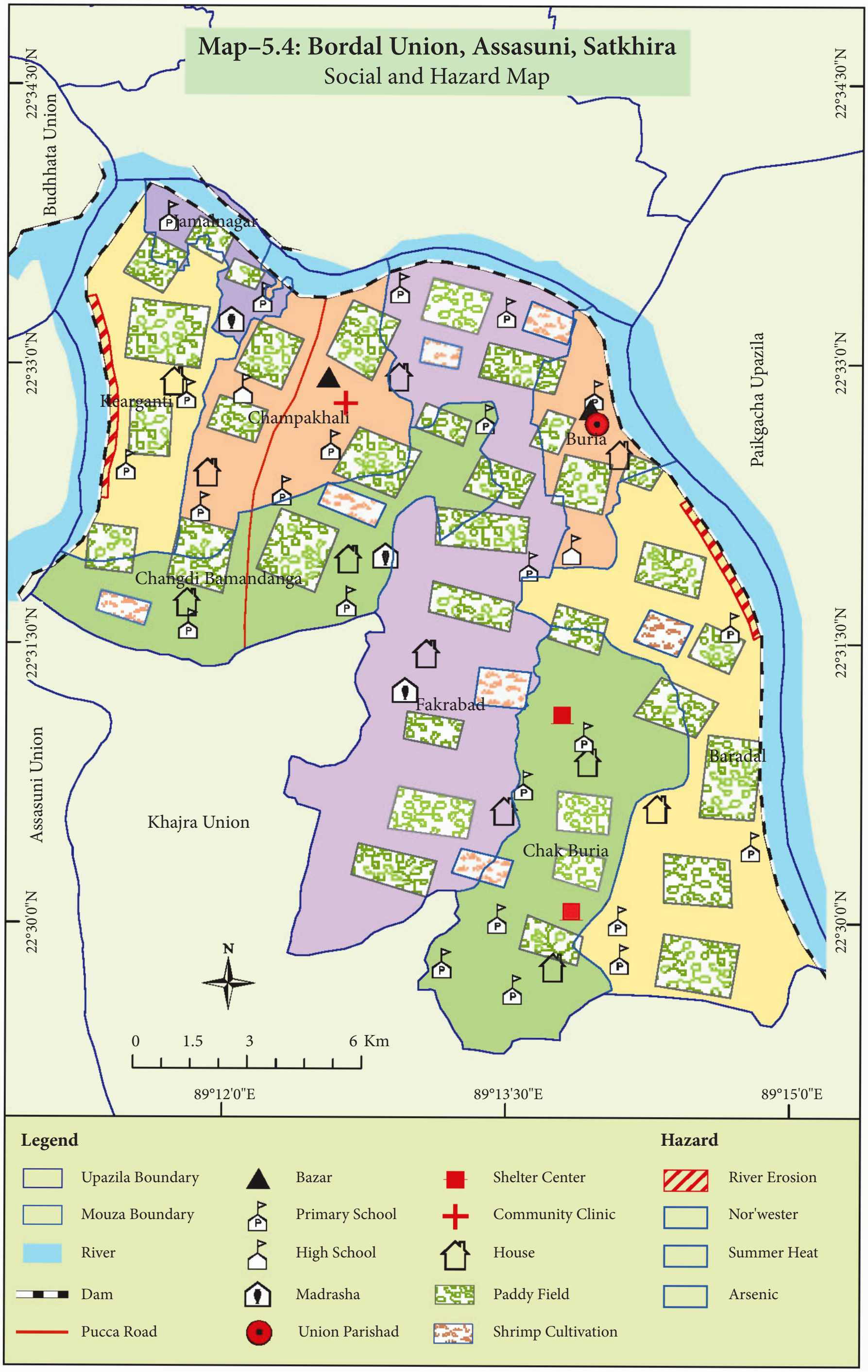
**Heat Wave:** Scorching heat resulted by drought is a major crisis of this upazila. For the last few years, the temperature has been very high even though there was much rainfall. But earlier lower temperature used to succeed more rainfall. That scorching heat and unavailability of water, induced by the drought in the month of Falgun, Chaitra, Boishakh, Jyestha and currently Ashar–Srabon, make it impossible for people to cultivate in due time. Often the seed bed/tender plants have to face damage, the crop of the field is withered, the water level goes down; and irrigation becomes impossible in the summer season. In addition, because of all these, the crop cannot get enough ripeness. Rise in temperature lets shrimps fall prey to the pestilence and their regular growth is interrupted. This is same for the fishes of ponds/ water reservoirs. Drought causes the scarcity of water in the pond/water reservoir and tube well. Thus, people suffer from the scarcity of water in doing daily chores such as bathing, washing dishes and clothes, and most importantly drinking pure water. During this time, staying outside the house is detrimental to the skin.

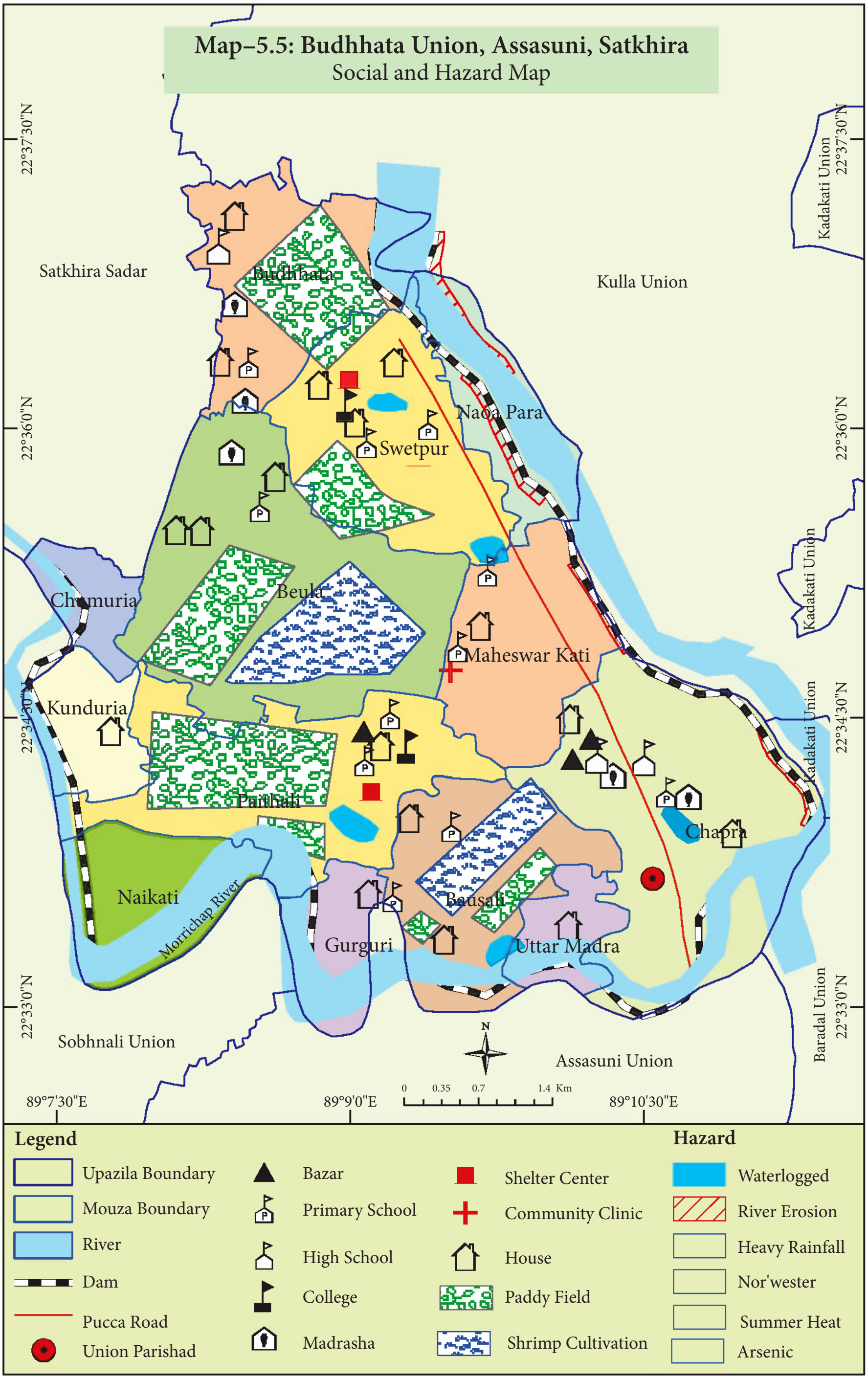
## Social and Hazard Map of Assasuni



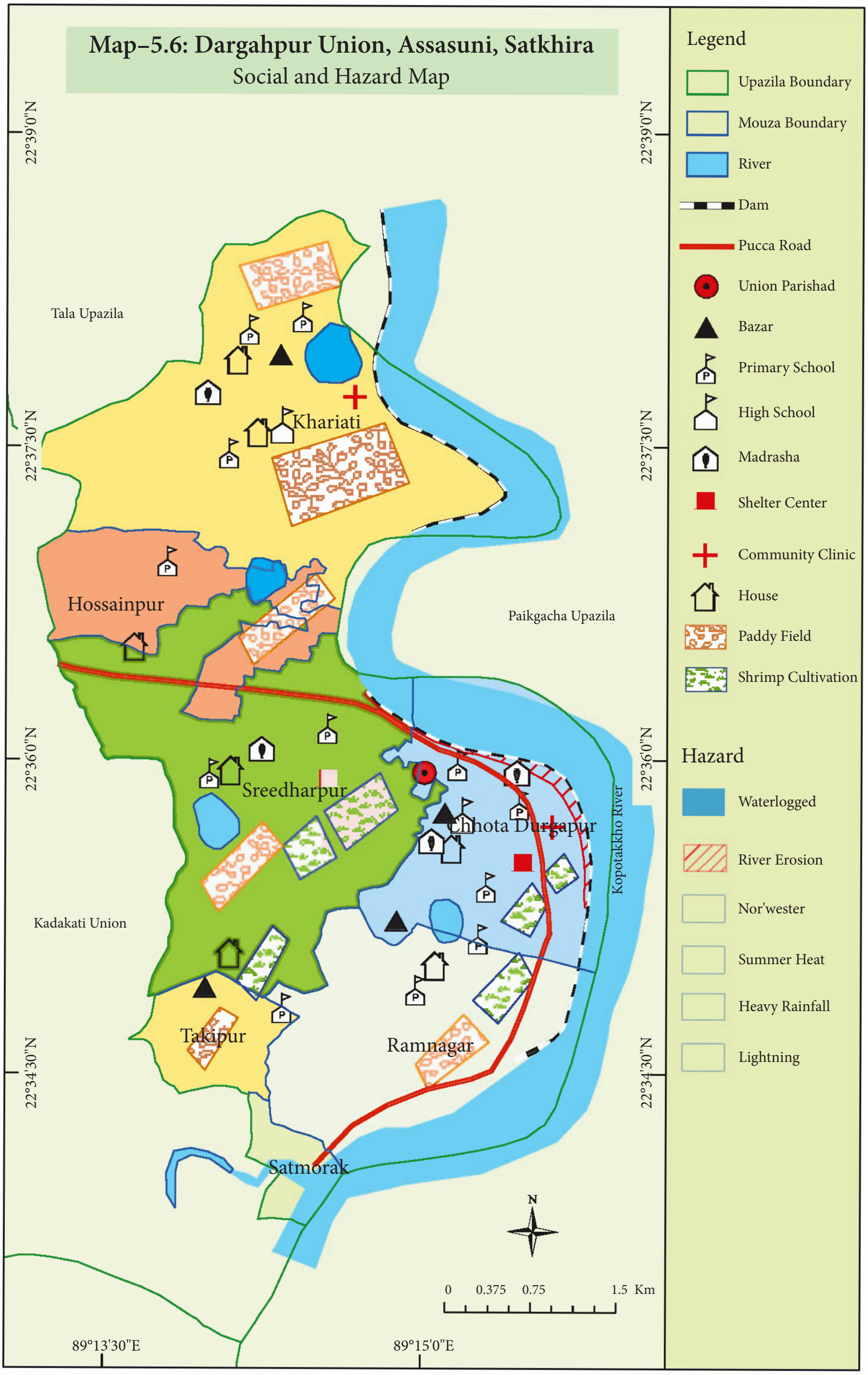

Map–5.2. Anulia Union, Assasuni, Satkhira
Social and Hazard Map
Khajra Union
Sreeula Union
Kakbasia
Bara Nasipur
Bholanathpur
Manipur
Swaranpur
Naka Gadarghat
Anulia
Mirzapur
Paikpara
Khulna District
Koyra Upazila
Ballabhpur
Basudebpur
Bichhat
Eksara
Rajapur
Dakshin Eksara
Nangla
Khul Patua River
Pratap Nagar Union
N
0 0.5 1 2Km
22°28'0"N
22°26'40"N
22°25'20"N
22°24'0"N
89°12'0"E
89°13'30"E
89°15'0"E
Legend
Upazila Boundary
River
Dam
Pucca Road
Union Parishad
High School
College
Madrasha
Shelter Center
Bazar
House
Primary School
Paddy Field
Shrimp Cultivation
Waterlogged
Hazard
River Erosion
Salinity
Lightning
Heavy Rainfall
Shrimp Virus


Map–5.3: Assasuni Sadar Union, Assasuni, Satkhira
Social and Hazard Map
Budhhata Union
Sobhnali Union
Baradal Union
Khajra Union
Kaliganj Upazila
Sreeula Union
Nandankati
Madra
Par Bausuli
Sreekalas
Chak Bausuli
Dhanyahati
Assasuni
Adalatpur
Sobdalpur
Kodanda
Durgapur (Bara)
Hanribhanga
Kamalapur
Shitalpur
Daserati
22°33'20"N
22°31'40"N
22°30'0"N
89°9'0"E
89°10'30"E
N
0 0.375 0.75 1.5 Km
Legend
Upazila Boundary
Mouza Boundary
River
Dam
Pucca Road
Union Parishad
Bazar
Primary School
High School
College
Madrasha
Arsenic
Shelter Center
Community Clinic
House
Paddy Field
Shrimp Cultivation
Heavy Rainfall
Hazard
Waterlogged
River Erosion
Shrimp Virus
Nor'wester
Salinity

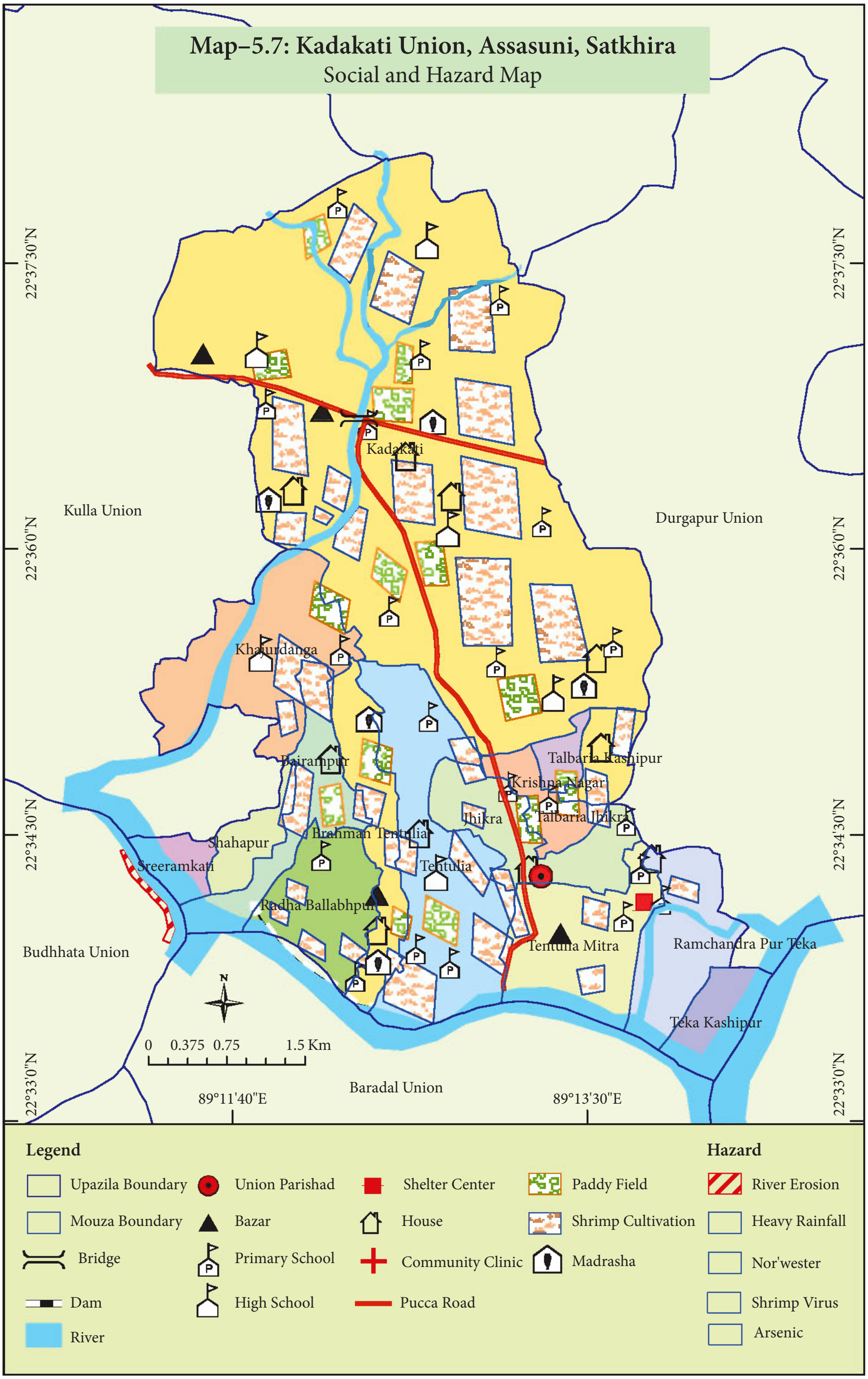

Map–5.4: Bordal Union, Assasuni, Satkhira
Social and Hazard Map
22°34'30"N
22°33'0"N
22°31'30"N
22°30'0"N
Budhhata Union
Paikgacha Upazila
Assasuni Union
Khajra Union
Jamalnagar
Kearganti
Champakhali
Buria
Changdi Bamandanga
Fakrabad
Baradal
Chak Buria
N
0
1.5
3
6 Km
89°12'0"E
89°13'30"E
89°15'0"E
Legend
Upazila Boundary
Mouza Boundary
River
Dam
Pucca Road
Bazar
Primary School
High School
Madrasha
Union Parishad
Shelter Center
Community Clinic
House
Paddy Field
Shrimp Cultivation
Hazard
River Erosion
Nor'wester
Summer Heat
Arsenic

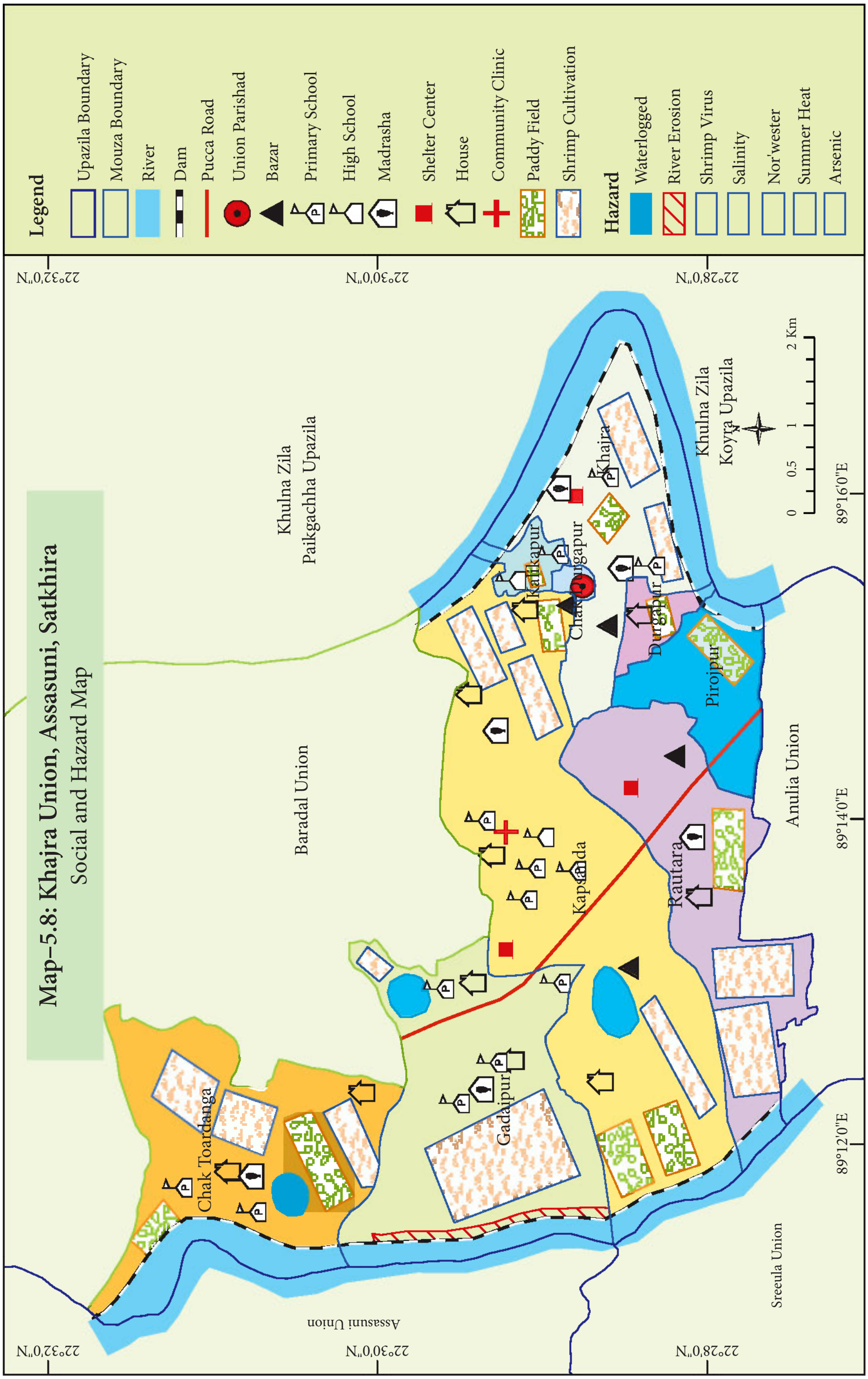


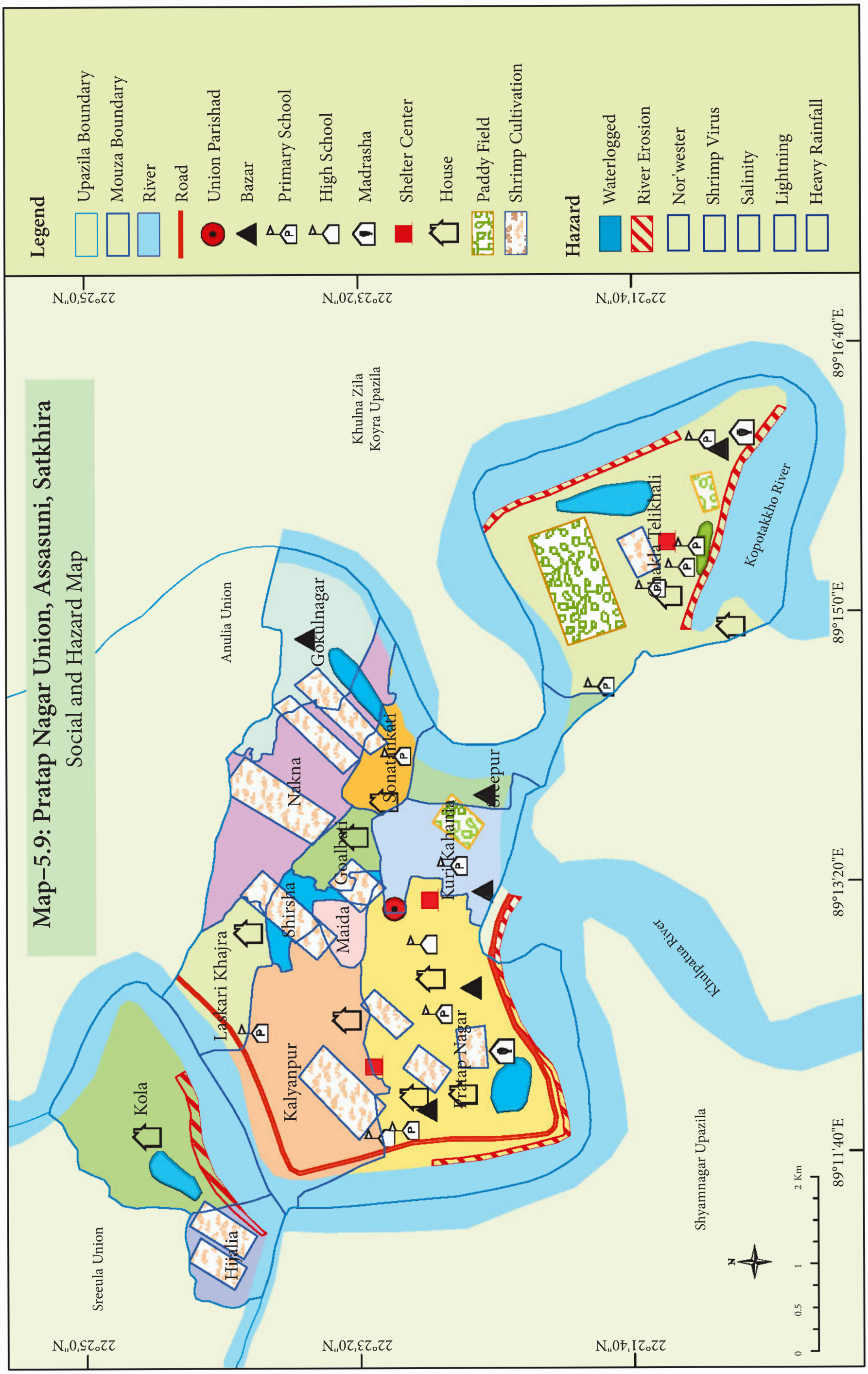

**Map–5.5: Budhhata Union, Assasuni, Satkhira**
Social and Hazard Map



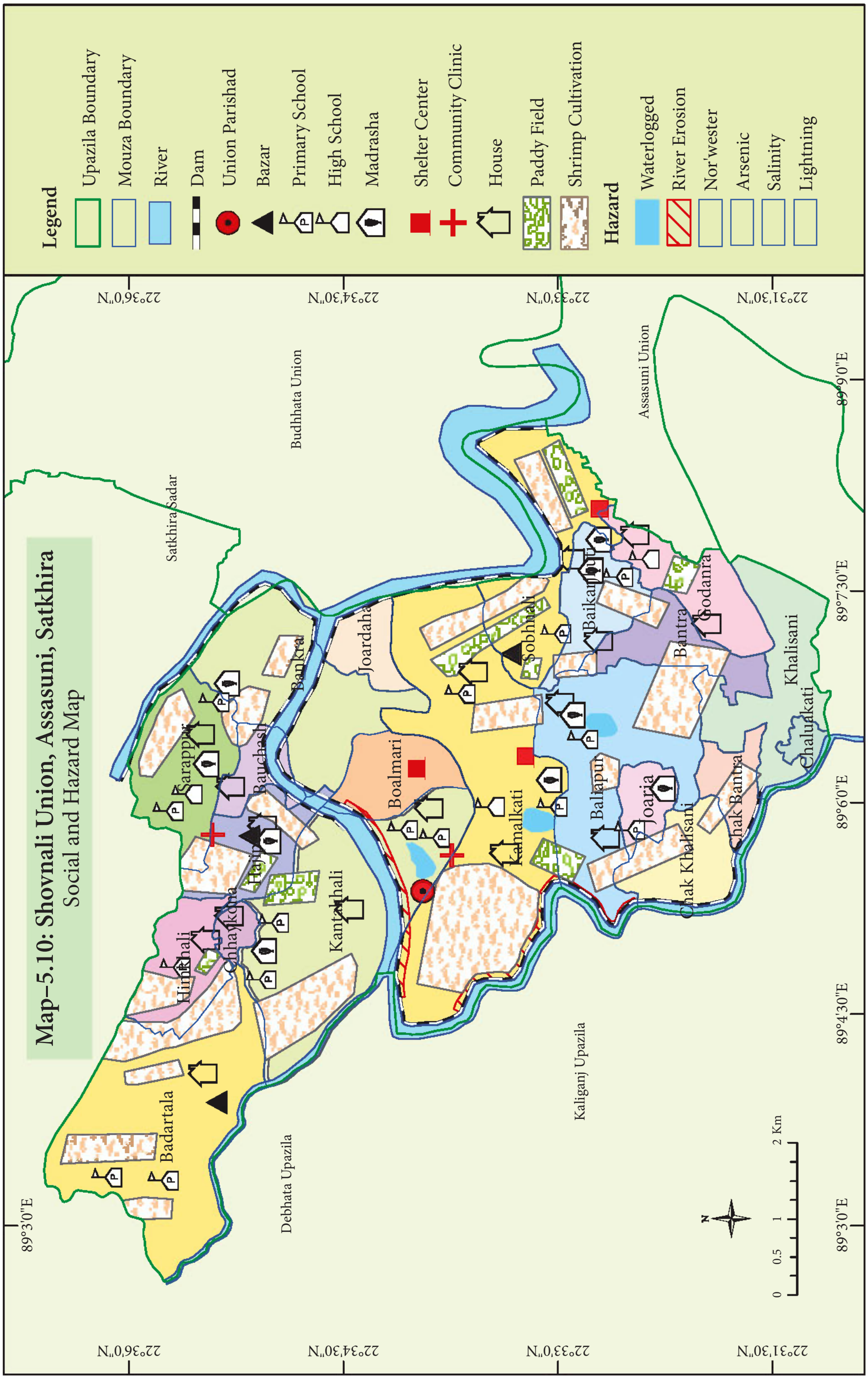
Map–5.6: Dargahpur Union, Assasuni, Satkhira
Social and Hazard Map
Tala Upazila
Khariati
Hossainpur
Paikgacha Upazila
Sreedharpur
Chhota Durgapur
Kopotakkho River
Kadakati Union
Takipur
Ramnagar
Satmorak
N
0 0.375 0.75 1.5 Km
22°39'0"N
22°37'30"N
22°36'0"N
22°34'30"N
89°13'30"E
89°15'0"E
Legend
Upazila Boundary
Mouza Boundary
River
Dam
Pucca Road
Union Parishad
Bazar
Primary School
High School
Madrasha
Shelter Center
Community Clinic
House
Paddy Field
Shrimp Cultivation
Hazard
Waterlogged
River Erosion
Nor'wester
Summer Heat
Heavy Rainfall
Lightning

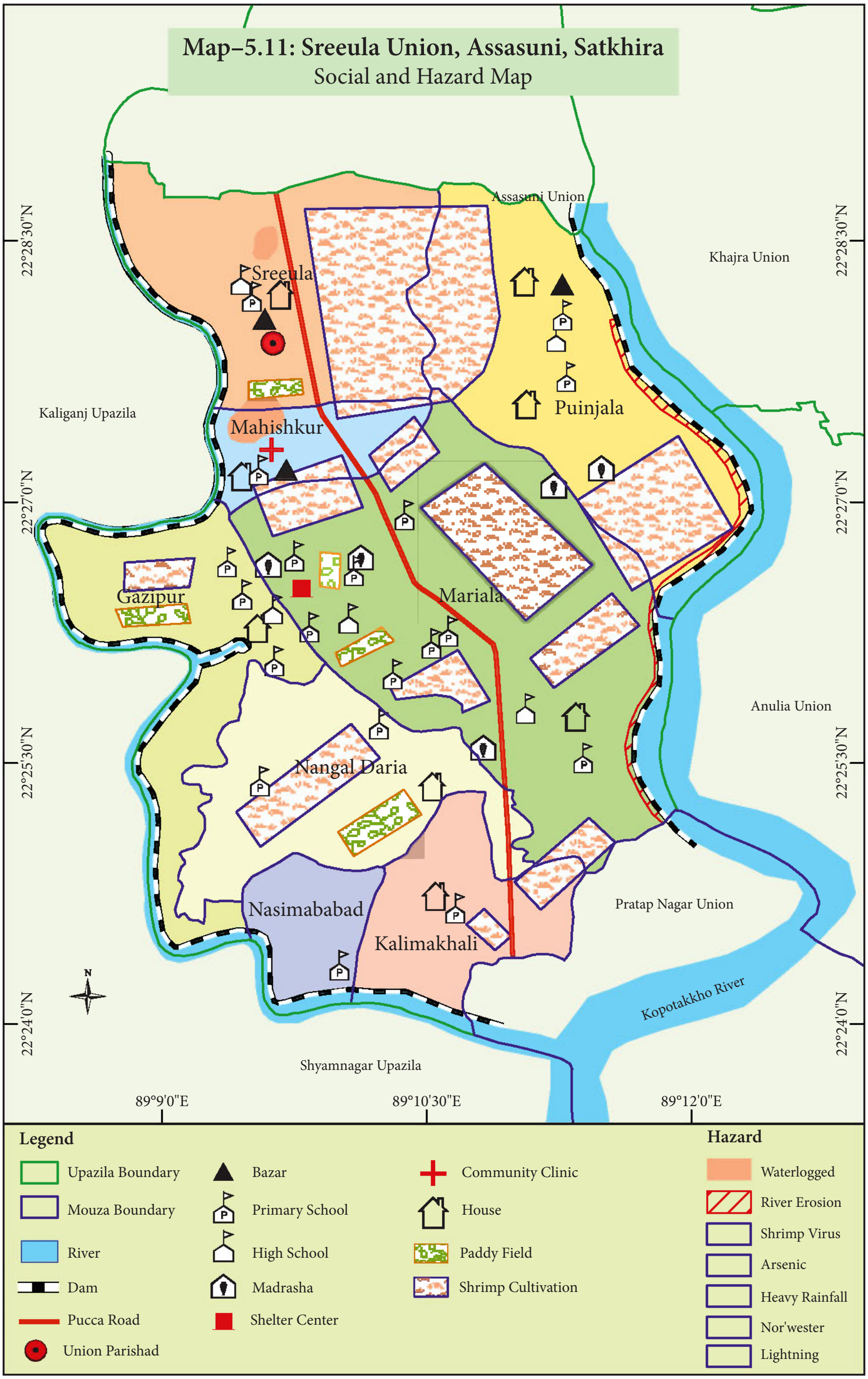

Map–5.7: Kadakati Union, Assasuni, Satkhira
Social and Hazard Map
Kadakati
Kulla Union
Durgapur Union
Khajurdanga
Bairampur
Talbaria Kashipur
Krishna Nagar
Jhikra
Talbaria Jhikra
Brahman Tentulia
Shahapur
Sreeramkati
Tentulia
Radha Ballabhpur
Tentulia Mitra
Ramchandra Pur Teka
Budhhata Union
Teka Kashipur
Baradal Union
N
0 0.375 0.75 1.5 Km
22°37'30"N
22°36'0"N
22°34'30"N
22°33'0"N
89°11'40"E
89°13'30"E
Legend
Upazila Boundary
Mouza Boundary
Bridge
Dam
River
Union Parishad
Bazar
Primary School
High School
Shelter Center
House
Community Clinic
Pucca Road
Paddy Field
Shrimp Cultivation
Madrasha
Hazard
River Erosion
Heavy Rainfall
Nor'wester
Shrimp Virus
Arsenic


Map–5.8: Khajra Union, Assasuni, Satkhira
Social and Hazard Map
Legend
Upazila Boundary
Mouza Boundary
River
Dam
Pucca Road
Union Parishad
Bazar
Primary School
High School
Madrasha
Shelter Center
House
Community Clinic
Paddy Field
Shrimp Cultivation
Hazard
Waterlogged
River Erosion
Shrimp Virus
Salinity
Nor'wester
Summer Heat
Arsenic
Khulna Zila
Paikgachha Upazila
Baradal Union
Khulna Zila
Koyra Upazila
Anulia Union
Sreeula Union
Assasuni Union
Chak Toardanga
Gadaipur
Kapsanda
Rautara
Pirojpur
Durgapur
Chandipur
Kathkapur
Khajra
0
0.5
1
2 Km
22°32'0"N
22°30'0"N
22°28'0"N
89°12'0"E
89°14'0"E
89°16'0"E




Map-5.9: Pratap Nagar Union, Assasuni, Satkhira
Social and Hazard Map


Map–5.10: Shovnali Union, Assasuni, Satkhira
Social and Hazard Map
Legend
Upazila Boundary
Mouza Boundary
River
Dam
Union Parishad
Bazar
Primary School
High School
Madrasha
Shelter Center
Community Clinic
House
Paddy Field
Shrimp Cultivation
Hazard
Waterlogged
River Erosion
Nor'wester
Arsenic
Salinity
Lightning
Satkhira Sadar
Budhhata Union
Assasuni Union
Debhata Upazila
Kaliganj Upazila
Badartala
Himkhali
Chhaykona
Kantakhali
Sarappur
Bauchasi
Bankra
Joardaha
Boalmari
Kamalkati
Sobhnali
Baikanpur
Bantra
Godanra
Ballapur
Joaria
Chak Khalisani
Chak Bantra
Khalisani
Chaludkati
22°36'0"N
22°34'30"N
22°33'0"N
22°31'30"N
89°3'0"E
89°4'30"E
89°6'0"E
89°7'30"E
89°9'0"E
0
0.5
1
2 Km
N


Map–5.11: Sreeula Union, Assasuni, Satkhira
Social and Hazard Map
Assasuni Union
Khajra Union
Kaliganj Upazila
Anulia Union
Pratap Nagar Union
Shyamnagar Upazila
Kopotakkho River
Sreeula
Mahishkur
Puinjala
Gazipur
Mariala
Nangal Daria
Nasimababad
Kalimakhali
22°28'30"N
22°27'0"N
22°25'30"N
22°24'0"N
89°9'0"E
89°10'30"E
89°12'0"E
N
Legend
Upazila Boundary
Mouza Boundary
River
Dam
Pucca Road
Union Parishad
Bazar
Primary School
High School
Madrasha
Shelter Center
Community Clinic
House
Paddy Field
Shrimp Cultivation
Hazard
Waterlogged
River Erosion
Shrimp Virus
Arsenic
Heavy Rainfall
Nor'wester
Lightning

Map–5.12: Kulya Union, Assasuni, Satkhira
Social and Hazard Map
Satkhira Sadar Upazila
Mahishadanga
Aitala
Madarbaria
Mahajanpur
Dadpur
Kulla (Benadanga)
Gunakarkati
Purohitpur
Agardari
Kadakati Union
Bahadurpur
Kachua
Khajorvhanga River
Gobindapur (Valuka)
Arar
Banbasat
Budhhata Union
Manoharpur
Bhagia
Gabtala
N
0 0.375 0.75 1.5Km
22°39'0"N
22°37'30"N
22°36'0"N
22°34'30"N
89°9'0"E
89°10'30"E
89°12'0"E
Legend
Upazila Boundary
Mouza Boundary
River
Dam
Pucca Road
Union Parishad
Bazar
Primary School
High School
College
Madrasha
Shelter Center
Community Clinic
House
Paddy Field
Shrimp Cultivation
Hazard
Waterlogged
River Erosion
Salinity
Nor'wester
Summer Heat
Arsenic

## Vulnerability of Livelihood Groups

The climate change impacts have made different occupations and livelihoods become more challenging and prone to disaster. The climate change impacts on different selected livelihood groups of Assasuni upazila are discussed below to have insights into the vulnerability portfolio of the people.

**Inland and Offshore Fishing:** Ramjan Ali, a key informant from the fisher community, said that during flood, their houses are submerged under water and they have to suffer a lot. During flood males take their bath in a distant place from the house but females cannot. Then they have to take bath in the floodwater or river water. To avoid the crisis they have nothing to do. As long as the flood prevails, the fishers must suffer and suffering for the female is the most.

Fishers do fishing in the lakes, rivers and sea. Drought makes the lakes and rivers dry and fishing becomes impossible. Thus if they cannot do fishing most of them go to Khulna or Jessore district to work as laborers in the hatchery or commercial ponds/ water reservoir of sweet water. The fishers work only six months in a year and for the rest six months they have to stay idle and ultimately search for loan. The principal informant argued that heavy rainfall is helpful for them, because with more rain, fishes come to the upstreams of lakes and rivers, while excessive rainfall is not a blessing for the poor huts of the fishers.

The worst disaster for the fishers is the cyclone. If there is a warning of a cyclone, they do not go fishing into the sea. If they fall prey to cyclone during fishing in the sea, their lives and boats may be destroyed. Losing any boat or net is a big loss to any fisher. To avoid cyclone, whenever fishers notice a deep black cloud in the sky or a wind from the east, they go to the safe zone. As soon as they receive any warning signal of cyclone on the radio, they take shelter in the coastal area or in the shelter center of the coast guard.

Salinity makes fishers suffer most from the scarcity of drinking water. When they sail in the sea, they have to bear a shortage of drinking water. The salty environment of the sea turns their skin scorched. Digging almost 2 feet deep into the ground of catkin forest in the coastal area, the fishers meet up their thirst for the sweet water and store it for the next time. The fishers think that the number of fish has declined. Moreover, now it takes more time to catch fish than before. This means that the number of fish is on a decline.

**Agriculture and Farming:** One of the farmers said that due to salinity, farming in the lowlands of Assasuni upazila is not possible. This has led people to turn their cultivable land into shrimp farming. Floodwater makes a hindrance to the timely marketing of vegetables. For instance, the local market went under water by tidal wave succeeding the cyclone Aila in 2009.

On the other hand, drought makes the soil dry making sowing of seeds in time almost impossible. Drought also demands for irrigation.

*During childhood, I have not seen drought for such a long time in this area, but now it lasts for long. It's becoming warm now. In addition lack of adequate number of trees has caused higher temperature here than ever before. Vegetables do not get matured in time due to the lack of adequate rainfall. The leaves of trees droop to lump shape by the noon. This condition favors the worms to attack on the leaves. For example, now spinach is not growing properly and getting a reddish outlook.*

*Spinach and water spinach both need water. Water spinach gets longer if it gets water. But for red spinach and some other spinach drought is favorable. As my field is just in front of my house, I can irrigate water from my pond. But those who have no source of sweet water beside their field, cannot irrigate. So, I cultivate red spinach and pumpkin at the time of drought. These require less water.*

*- A shrimp farmer*

In recent times, changes have been observed for rainfall in time. Lack of adequate rainfall is not favorable for the cultivation of spinach. If it rains excessively, particularly when the crop gets ripe, it can ruin the crop. Excessive rainfall makes the farmers undone leaving them with no other alternatives than to selling the immature vegetables. Harvest can be damaged if the trees collapse by cyclone in the months of Chaitra, Boishakh, and Jyestha. As the cyclone hits suddenly it is not possible to take any protective measure. But as a protective measure, big trees are kept out of the sideline of the crop fields. If there is any, the branches of these trees are trimmed. Water logging causes a great deal of harm to the agriculture of this area. Especially, the farming of vegetables and paddy are tough tasks in such an area. Nevertheless, jute cultivation is a good choice in waterlogged areas.

Salinity is harmful for the crops. If the level of salinity is not too high, production of spinach is possible. Usually river erosion allows salt to enter the land. One of the most devastating impacts is that it becomes impossible to cultivate on this land for at least five years.

*I have been pulling van for the last three years. Earlier I used to work in agriculture, but working in agriculture is less profitable than that of van-pulling. I can earn around taka 300-400 a day. After spending taka 100-150, I can save the rest of the money. I spend these savings in the rainy season or during any other disaster. Because during rainy season, flood or cyclone we cannot earn much.*

*- A Farmer*

**Off–Farm Laborers and Seasonal Employment:** The brick-field workers do their work during the months of Kartik and Agrahayan. After this period, workers become jobless and some of them join agriculture. During its high time, workers from other sectors come to work in the brick-field. The alternative livelihoods for the brick-field workers are small businesses, car driving, etc. Wages of a brick-field worker ranges from tk 400–600. Hot weather and salty mud are good for the brick making. According to the workers, salinity is good for their work but not for drinking pure water. Drought is beneficial for a brick-field and its workers because they get more jobs during that time. But cyclone, thundering and river erosion damage the brick-field and turn its workers jobless. Thundering does not allow the workers to work outside and river erosion pours water into the brick-field.

The van–pullers represent another occupation in Assasuni upazila. Natural disasters bring a curse to this group as well. Flood makes it impossible for them to pull the van on the road. They lose their livelihood. Similarly, excessive heat also makes it difficult to go outside to run the van and earn money. A van–puller informs that there is sever heat in Assasuni upazila nowadays. Thus, it sweats more and pulling a van seems more arduous. When the temperature gets high, passengers avoid riding on the van. Because a van has no hood over and heat comes down directly on the body of the passengers. Some pullers set polythene–shed over the van, but it causes more heat. During this warm weather, van–pullers go out early in the morning. They pull the van less at noon but more in the afternoon. In heavy rainfall passengers are not likely to ride on a van rather a Bhatvati (a local vehicle run with a shallow machine), because van has no hood over. Van–pullers can earn a very little in this period of the year.

> *It was not a huge flood in 2016, but the paddy of the most farmers' lands got rotten because of that flood. Those farmers had to recultivate with new rice plants. For this reason, farmers had to bear huge loss. When the flood occurs or the water of Chalan Beel increases, many farmers (whose lands get submerged under water) get involved in fishing. Many leave the area in search of day laborer's job in other areas. The farmers try to prepare their seedbeds on a higher place as though the flood can do no harm. For the same reason, we build our houses on a higher homestead, make an entresol inside the house for cooking, and to resist the erosion of the road, construct guide walls with bamboo/stone along the two sides.*
>
> *- A Farmer*

When the cyclone hits, they do not go to pull the van. To avoid any casualty they remain cautious about the possibility of the cyclone. Whenever black clouds appear in the sky or the wind starts blowing then they take safe shelters. In a waterlogged situation, the road gets submerged under water and they face trouble to pull the van.

**Shrimp Farming and Cultivators:** Shrimp farming has become a major occupation and business in Assasuni upazila. Except some professional groups, majority people of this upazila are, directly or indirectly, depend on shrimp farming for daily subsistence. This shrimp farming related livelihood has also employed a significant groups of women as daily wage labors. But the trends of changing climatic conditions have been adversely affecting shrimp production and associated livelihoods therein. One of the shrimp farmers, in a yard meeting, told that he had been involved in this occupation since 1990. At first, he did not do farming commercially. Then he used to do shrimp farming on the other side of dam (at the inner part of the river). Then they did not use to release the minnows artificially. They used to cultivate the minnows that entered with the high tide. Thus, shrimps did not need any food and grew up normally. Now, there is a high demand for shrimp minnows, and that is why, the farmers import minnows from other districts. After preparing girdles in December, the farmers release shrimp minnows into there. Earlier, the farmers used to release minnows at the end of January. Now winter comes delayed and the farmers have to face financial loss. According to the shrimp farmers, if it were possible to release the minnows at the end of January, shrimps would grow up to the size of selling in March–April. However, they have to face the financial crisis because of the change in the arrival of winter. They are now using their agricultural land for shrimp farming. The reasons behind the low rate of agro–production were lack of rain in time and drought.

They added that earlier shrimp farming was more profitable, but now it is declining. The reason for this is the frequent attack of virus. The virus appears at the time of catching shrimp. Moreover, the virus prevails until the months of Kartik–Agrahayan when the work of girdle ends. They sometimes use aqua Z powder, alum, bleaching powder and lime to check virus. They often blame Bangladesh Government of not taking any step to prevent the shrimp virus. Shrimps get afflicted with the virus as the temperature rises. The usual growth is hampered as well. When the water temperature rises, shrimps take shelters deep into the clay and gets spots on their shells. These spots lower the price of shrimp. At high temperature, the rate of salt in the water declines and thus production declines as well. Pouring lime in the water increases the rate of salt. Nevertheless, those who have girdles on the bank of the river can allow water into the girdle during the tide. In addition, those who do not have their girdle beside the river take help from the owners of adjacent girdles to bring saline water and expel that.

## ASSESSING CLIMATE RISKS IN CHAKARIA UPAZILA

### Climatic Hazards in Chakaria

Through analyzing the overall natural disasters of the selected ten Unions of Chakaria upazila in Cox's bazar district it has been identified that the major natural disasters of this upazila are waterfall from hill and flood, water logging, water from tide, cyclone, tidal surge, salinity, river erosion, kal boishakhi, less rainfall, and hill land slide. According to the local people, every year their land, agricultural production, natural resources and human life are damaged due to these natural disasters. For this research separate focus group discussions and interviews have been conducted with the local people, members of union parishad and union disaster management committee (UDMC) of Badarkhali, Bamubilchari, Boroitali, Fashiakhali, Khutakhali, Konakhali, Lakkharchar, Paschim Boro Veola, Surajpur–Manikpur and Veola Manikchar unions of Chakaria upazila. Following chart shows the major natural disasters of Chakaria upazila based on the data and information collected from the field.

**Table– 5.2: Major Climatic Hazards in Chakaria**

| Union | Flood/ Flash Flood | Cyclone & Norwester | Land Slide | Riverbank erosion | Tidal Surge | Salinity | Water logging |
|---|---|---|---|---|---|---|---|
| Badarkhali | √ | √ | × | × | √ | √ | √ |
| Bamubilchari | √ | √ | √ | × | × | × | × |
| Boroitali | √ | √ | × | × | √ | √ | √ |
| Fashiakhali | √ | √ | × | × | √ | √ | √ |
| Khutakhali | √ | √ | × | × | √ | √ | √ |
| Konakhali | √ | √ | × | √ | √ | √ | × |
| Lakkharchar | √ | √ | × | √ | × | × | × |
| Boro Bheola | √ | √ | × | × | √ | √ | × |
| Surajpur–Manikpur | √ | × | × | √ | × | × | × |
| Bheola Manikchar | √ | × | × | × | × | × | × |

**Flash Flood and Flood:** In Chakaria upazila due to heavy rainfall during the first few weeks of the months of Ashar, Shrabon and Bhadra water fall from the hill and flood increases. It causes damages to the people of various occupational groups. For example shrimp cultivators face lots of troubles and damages such as the banks of their shrimp enclosures breaks down, whole land becomes flooded, and due to over siltation it becomes useless for future shrimp cultivation. At the same time, for the salt cultivators their land becomes flooded and damages done to existing salt. For the farmers their seedbed and cultivated crops remains under water and their crops and vegetables are damaged and rotten due to over siltation. Pond fish cultivators and fishermen also face a lot of troubles during this time. For the pond fish cultivators their ponds become over flooded, all the fishes float away and over siltation keeps their ponds unfit for further fish cultivation. And the fishermen cannot collect sufficient fish which ultimately affects their livelihood. Day laborers cannot find enough work to manage everyday needs of their family. It has been recorded from the focus group discussions conducted at Badarkhali union of Chakaria upazila that because of the activities of some local influentials, water logging from flash flood increases and the rate of damages also remains high.

Alongside occupational groups, damages are also done to the animal and infrastructural resources. People become engaged with ensuring security of their own life and assets during flood and it is not possible for all to bring their animals to safe places. As a result, a lot of domesticated animals get drowned and float away in the river. Though they are able to save few of their animals, these animals suffer from various diseases after the flood. For infrastructure, most of their houses remain under water, roofs of these houses are washed away, houses made with mud fall down and the roads and dams are damaged.

**Cyclone and Norwester:** In Chakaria upazila, cyclone occurs during the months from Chaitra to Ashar. The occurrence is frequent during the end of Chaitra and throughout the Baishak months. According to the local people, the number of cyclone has increased during these days. People of various occupations have to suffer a lot and these causes sever damages to their life and assets. For instance, shrimp cultivators face the problem of damages with over flood to their shrimp plot, salt cultivators lose their cultivated salt with serious damages to their salt plot, fishermen lose their lives while fishing in the sea and damages are caused to the crops of the field. However, most of the damages are caused to the agricultural sector as this is the season for harvesting Boro crop. Therefore, with the increase in intensity of cyclone more damages are done to the ripe paddy. According to the local farmers, it becomes difficult for them to overcome the losses caused by cyclone. All of their investments face a great loss at the time when they have to harvest the product from the field.

*Many influential persons of several unions of this upazila have built their shrimp and salt cultivation lands. They have done this through using their power and influence and to fulfill their needs at their own wills. Their activities have been unplanned and as a result they have not maintained proper drainage systems. This has created and increased water logging in this area more than ever before. Due to this people of various occupational groups have faced loss. To solve this problem local people have talked to the elite people of this upazila and the UNO has given words to take necessary actions.*

*- A Farmer*

*Due to tidal surge saline water enters the paddy field and as a result it becomes difficult to further cultivate in that field. This is one of the major reasons for many people to start shrimp and salt cultivations in their paddy fields. Cultivating shrimp and salt also brings them lots of profit. But this practice has a negative side as well. Too much engagement with shrimp and salt cultivation has made them dependent on market for agricultural products.*

*- A Farmer and Salt Cultivator*

**Tidal Surge:** In Chakaria, tidal surge occurs during the months from Chaitra to Ashar of Bangla. People of various occupations have to suffer a lot and these cause severe damages to their lives and assets. For instance, shrimp and salt enclosures become over flooded, fishes of ponds wash away, and serious damages done to houses, schools, colleges and roads.

**Salinity Intrusion:** From a discussion conducted in Chakaria upazila Parishad it has been identified that the salinity of water usually increases during the months of Ashin and Kartik. Almost all of the local people from all the unions have made the point that natural intrusion of saline water through tide is not harmful for their land, but when it is illegally done by the local influential (they cut the channels to enter the tidal water/ saline water in the field) people for shrimp and salt cultivations, it causes a lot of troubles for them. According to them this was not so problematic at least 30 years ago. But today many of their lands are losing productivity. Moreover, people of various occupations have to suffer significantly by sustaining severe damages to their health, livestocks and productive assets. Agricultural lands, for instance, are reducing and crops are getting damaged due to salinity and also causing different diseases to shrimps.

*Due to the increase in salinity of the land it has become impossible to do any agricultural activities in the same land. As a result local farmers have no other way but to engage themselves in the cultivation of shrimp and salt cultivations. This has led them to convert their land from agriculture to saline water based cultivation processes. To me this is the reason for the increase of shrimp and salt cultivations in Chaakaria Upazila today than ever before.*

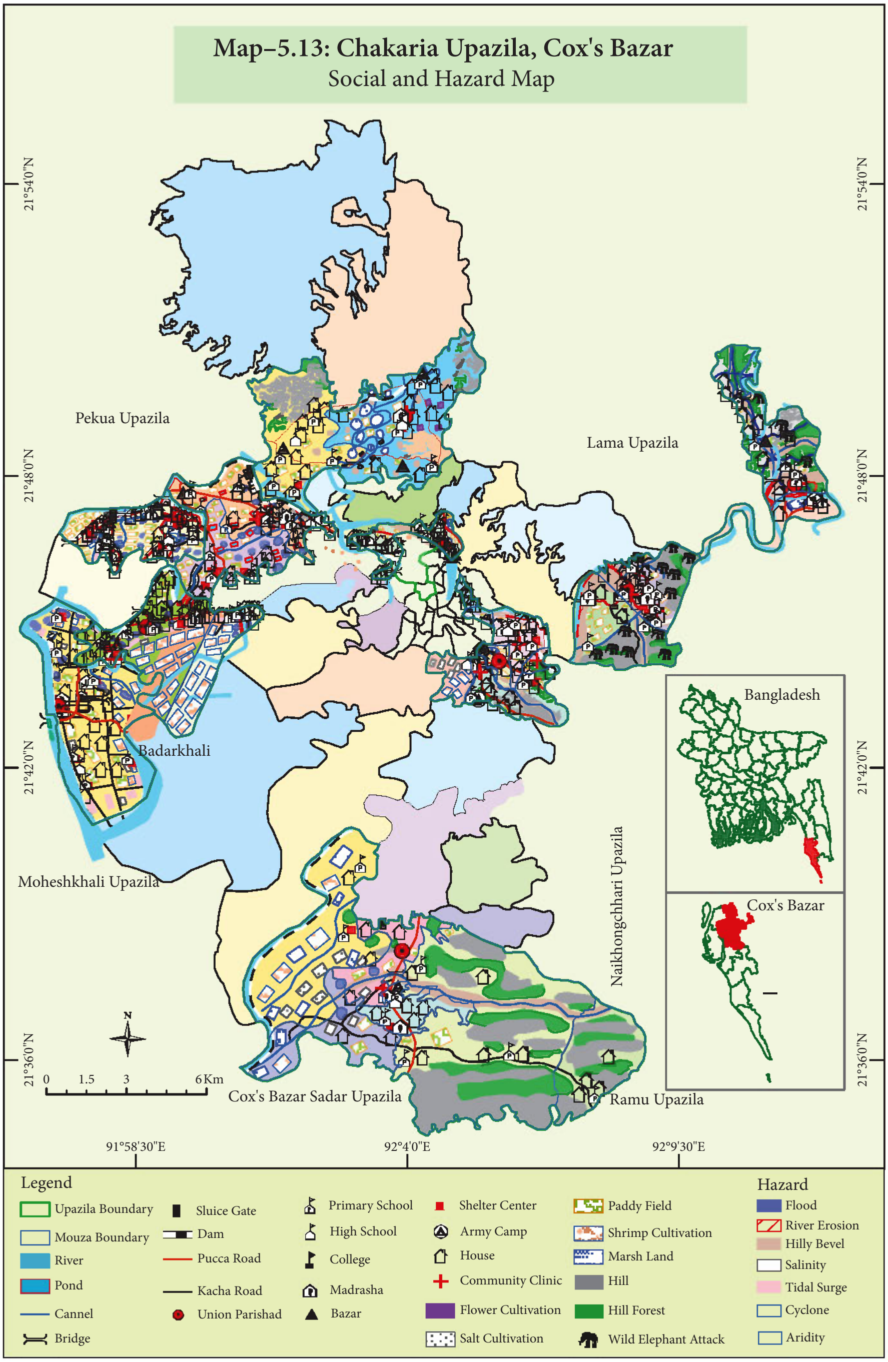
*- A Farmer*

**Riverbank Erosion:** In Chakaria upazila, river erosion occurs during the months of June, July and August. But river erosion can also take place during any time of the year due to the changes of direction of the rivers. According to the local people, river erosion is increasing day by day due to felling of trees. For example, because of felling of trees, river erosion has increased in the ward numbers 1, 2, 3 and 4 of Fashiakhali union. They further informed that the rate, intensity and loss of river erosion have increased after the year 2010. But this was less during the period of 2000–2010. The major causes of river erosion are – over siltation, decrease in depth, unplanned and weak construction of dam and tidal wave among others. Some of the damages done by riverbank erosion include shrimp enclosures and ponds overflow with water, shrimps and fishes wash away, water logging, damages of agricultural lands and houses, intrusion of saline water in the agricultural lands hindrances the agricultural production, livelihood of local people and day laborers is hampered, loss and damage to infrastructures such as kacha roads, pitch of pucca roads, Masjid–Temple and tube wells in the locality. However, another major problem of riverbank erosion is the increase of saline water in the field. As a result, trees die and it becomes impossible to plant new trees. Riverbank erosion damages the living places of domesticated animals and increases different water borne diseases.

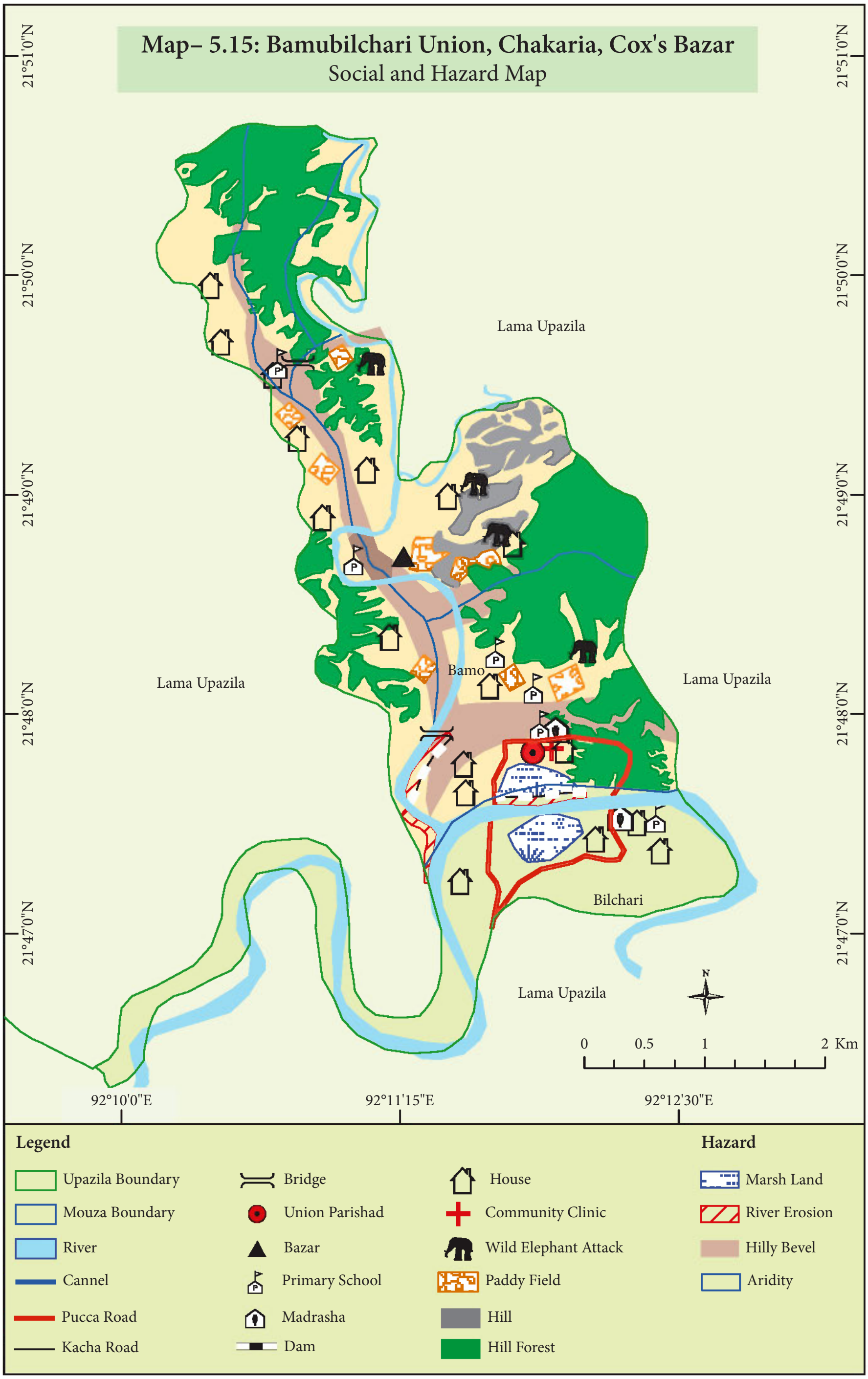
*I have been engaged in fish farming for a long time. I do not bother in any natural disaster or by any other adversities. Drought is the main problem of this area and I take all the necessary precautions at the beforehand of this disaster. I rent a car to sell the fish at the entrepot of Sirajganj road. In a trip, the car carries 7/8 Mon (280/320 kgs) of fish. I collect the minnows from the hatcheries of Sreekrishnapur and Nimgachi at a price of taka 6,000 per Kg. The hatcheries provide oxygen in the polyethylene that is used to carry the minnows. I release that minnows to my pond. Besides fish farming, I do stock business and agro-farming. I cultivate Irri paddy in my 10 bighas of land. But the ultimate income comes from the fish farming. I got training on fish farming from the Upazila Fishery office.*

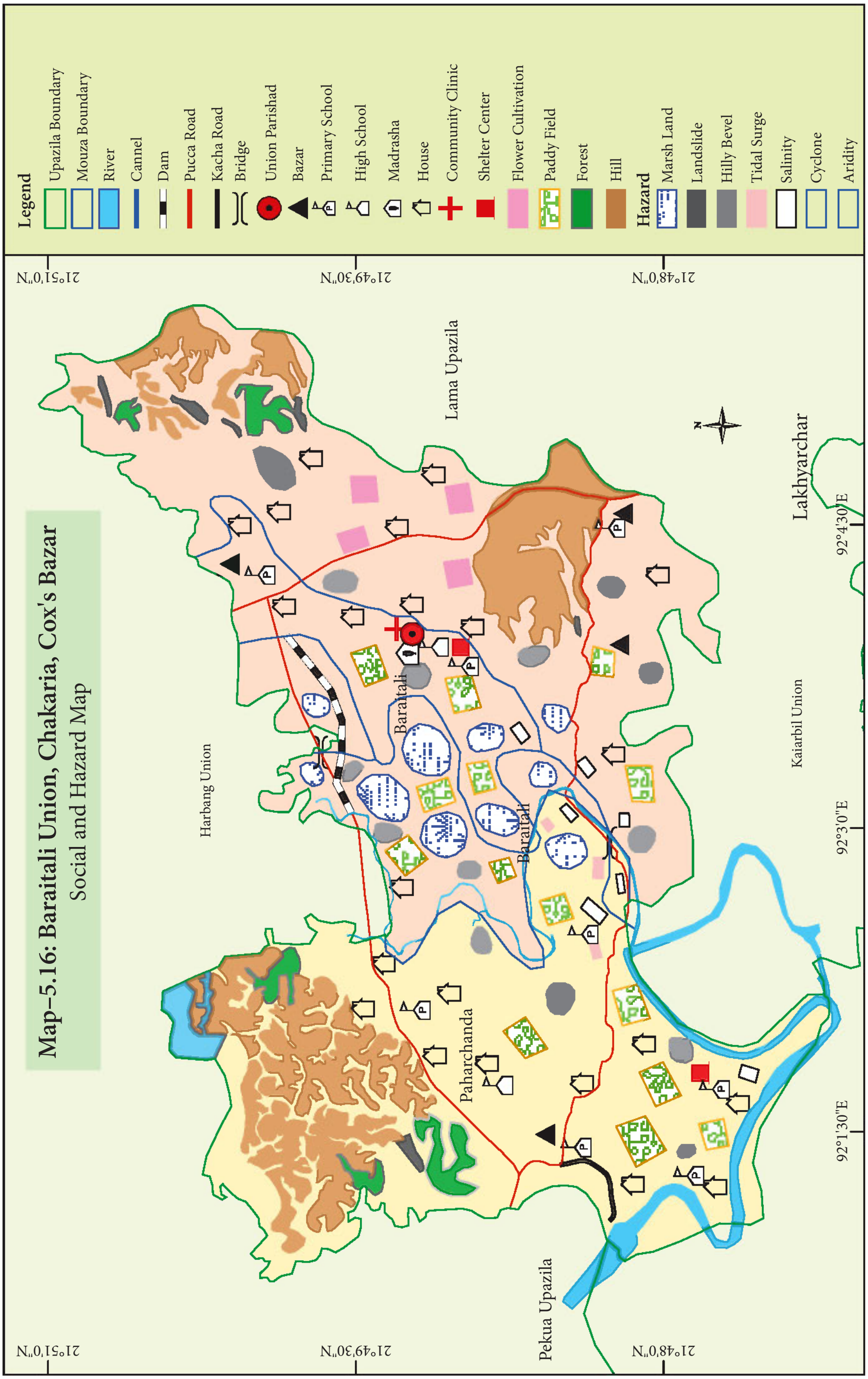
*- A Fish Farmer*

## Social and Hazard Map of Chakaria

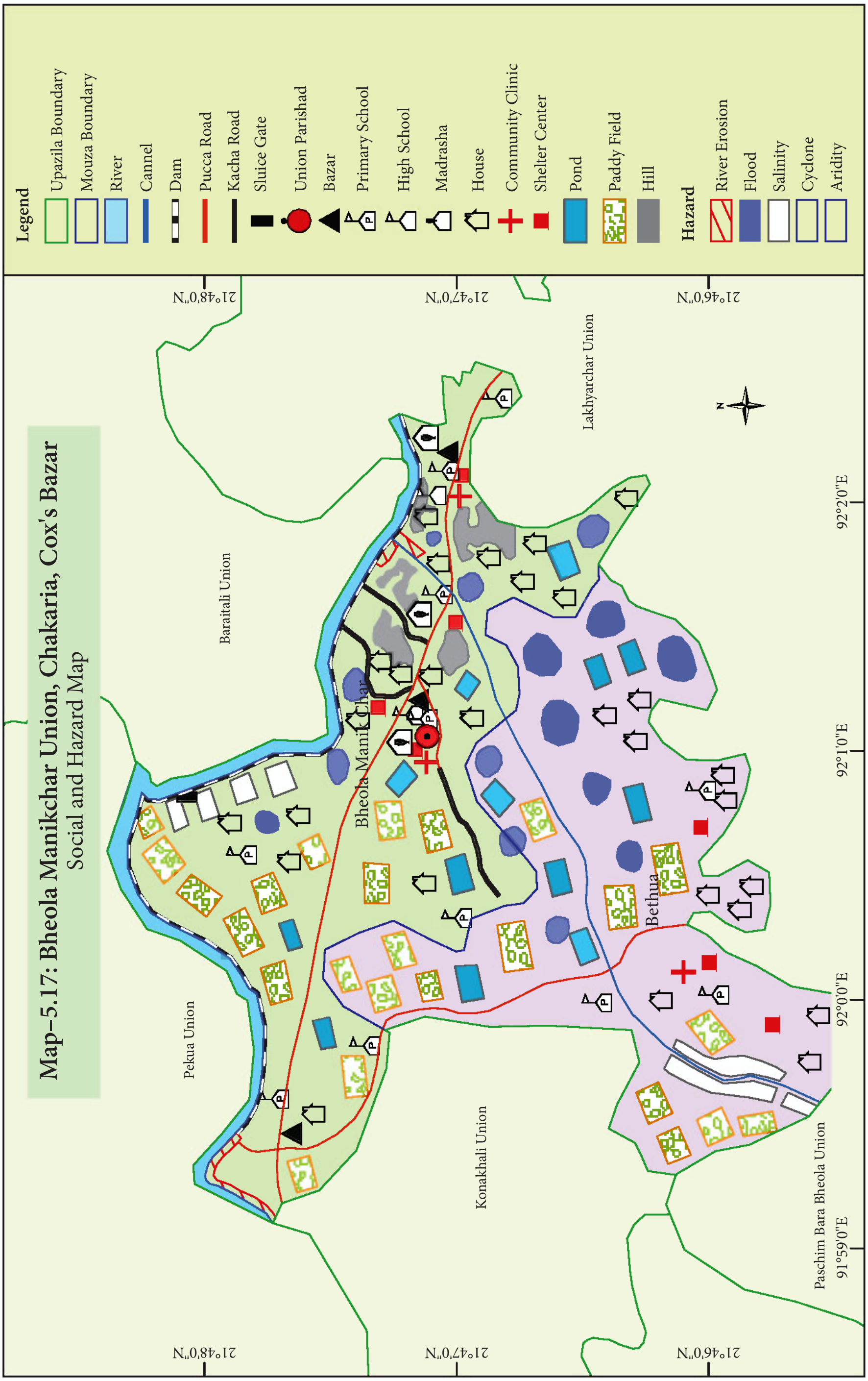



Map–5.14: Badarkhali Union, Chakaria, Cox's Bazar
Social and Hazard Map
Paschim Bara Bheola Union
Pekua Upazila
Badarkhali
Saharbil Union
Moheshkhali Upazila
21°45'0"N
21°43'20"N
21°41'40"N
91°56'40"E
91°58'20"E
N
0
0.475
0.95
1.9 Kilometers
Legend
Upazila Boundary
Mouza Boundary
River
Cannel
Dam
Pucca Road
Kacha Road
Bridge
Sluice Gate
Union Parishad
Bazar
Primary School
High School
Madrasha
House
Community Clinic
Shelter Center
Shrimp Cultivation
Paddy Field
Mangrove Forest
Hazard
Flood
River Erosion
Hilly Bevel
Salinity
Tidal Surge
Cyclone
Aridity


Map– 5.15: Bamubilchari Union, Chakaria, Cox's Bazar
Social and Hazard Map
21°51'0"N
21°50'0"N
21°49'0"N
21°48'0"N
21°47'0"N
Lama Upazila
Lama Upazila
Lama Upazila
Lama Upazila
Bamo
Bilchari
N
0
0.5
1
2 Km
92°10'0"E
92°11'15"E
92°12'30"E
Legend
Upazila Boundary
Mouza Boundary
River
Cannel
Pucca Road
Kacha Road
Bridge
Union Parishad
Bazar
Primary School
Madrasha
Dam
House
Community Clinic
Wild Elephant Attack
Paddy Field
Hill
Hill Forest
Hazard
Marsh Land
River Erosion
Hilly Bevel
Aridity

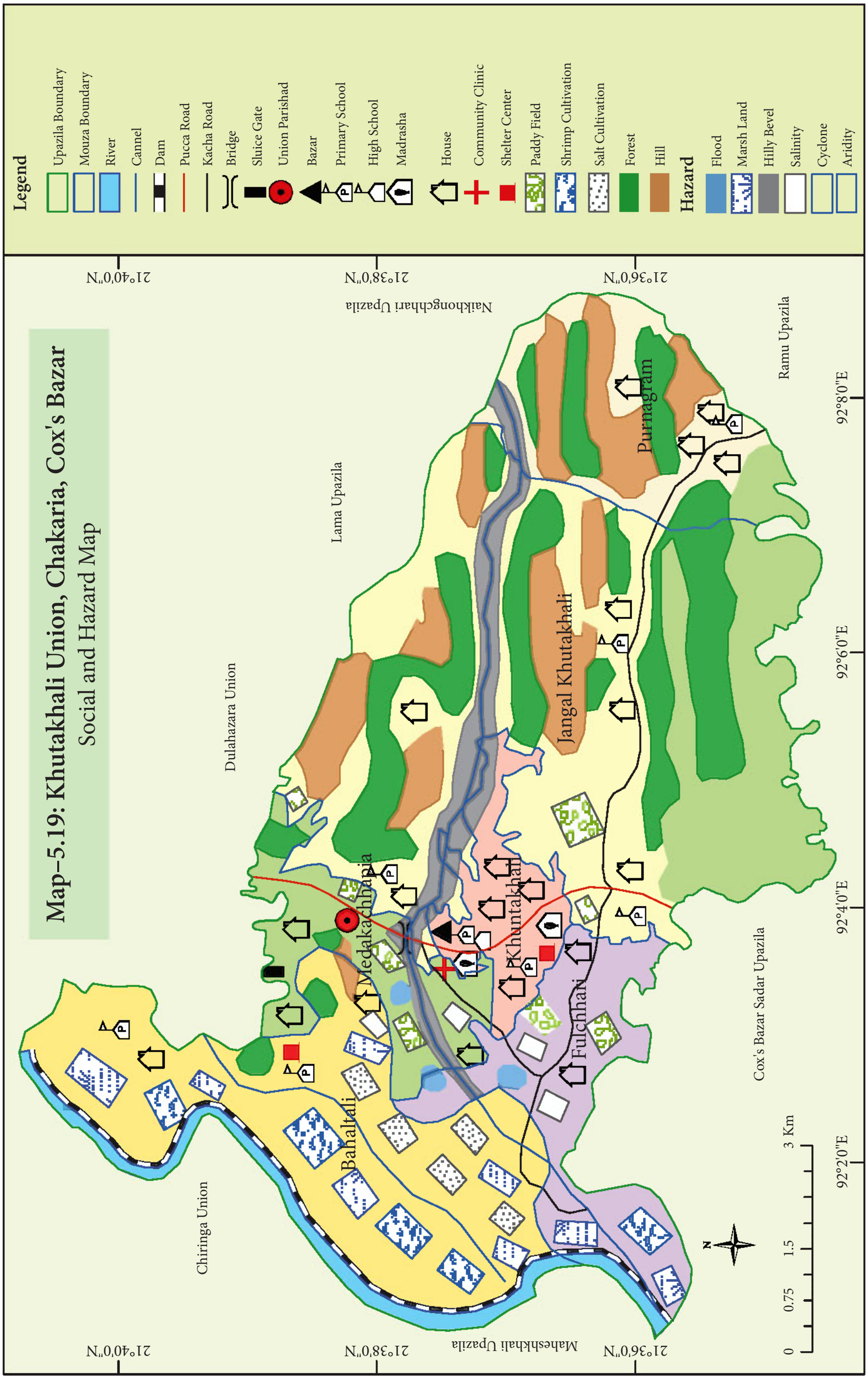


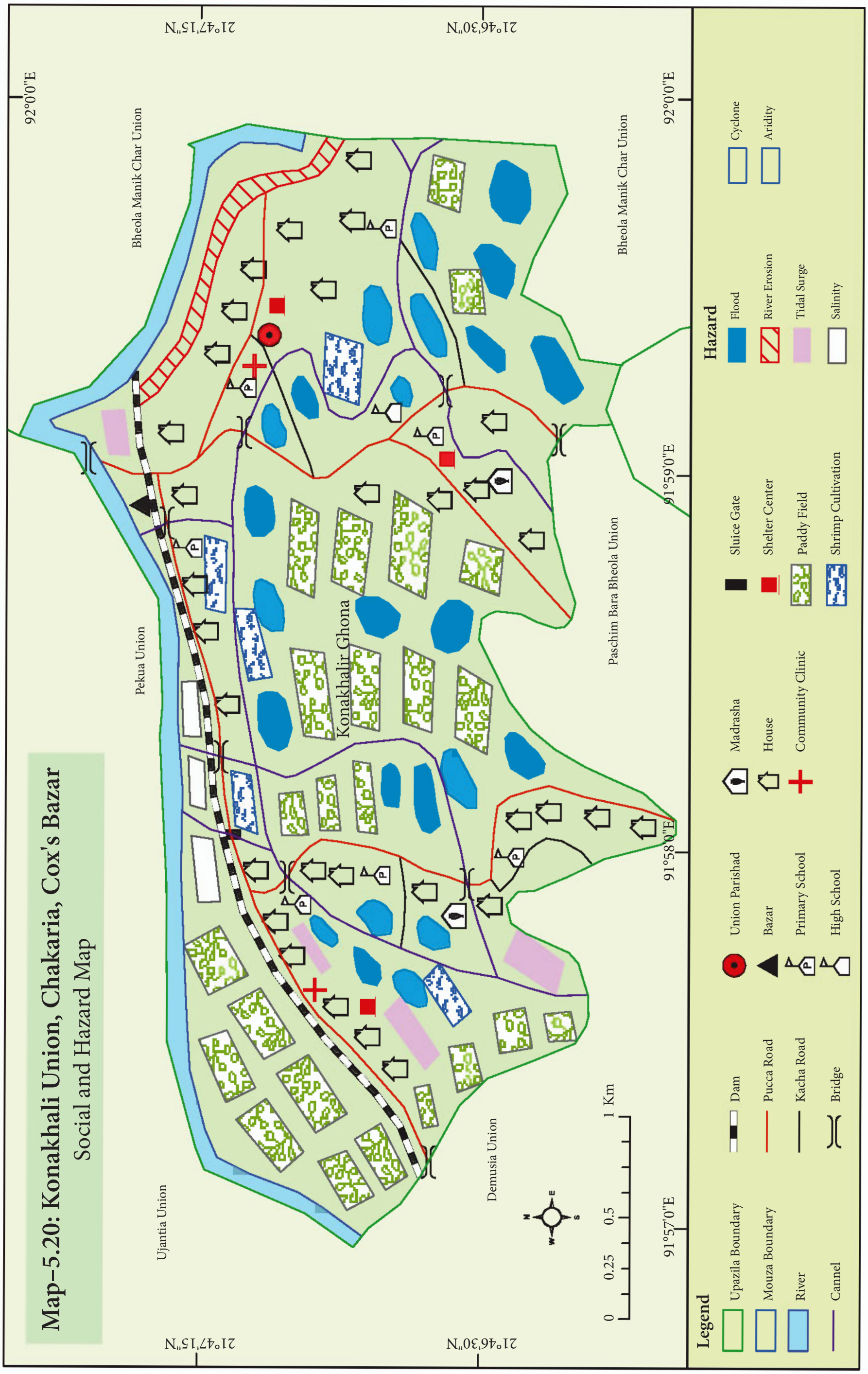

Map-5.16: Baraitali Union, Chakaria, Cox's Bazar
Social and Hazard Map

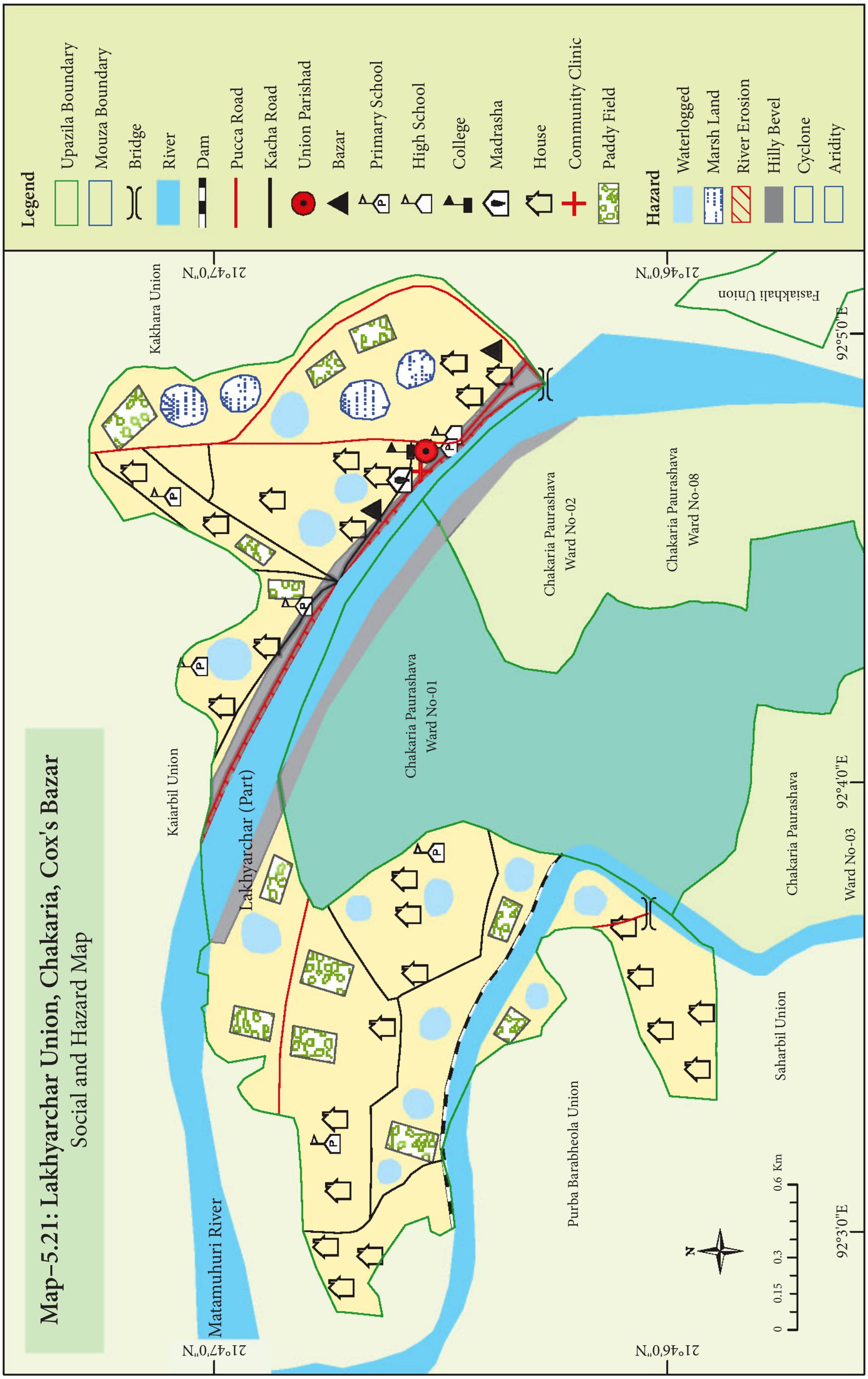



Map–5.17: Bheola Manikchar Union, Chakaria, Cox's Bazar
Social and Hazard Map

Map–5.18: Fasiakhali Union, Chakaria, Cox's Bazar
Social and Hazard Map
Ward No-3
Hajian
Ward No-8
Pokpokharia (Pankhali) (Part)
Kakhara Union
Digar Pankhali(Part)
Ward No-9
Rajarbil
Ghunia
Fasiakhali
Chiringa Union
Lama Upazila
Uchitarbil
Dulahazara Union
N
0 0.25 0.5 1 Km
21°46'0"N
21°45'0"N
21°44'0"N
21°43'0"N
92°5'0"E
92°6'0"E
92°7'0"E
Legend
Upazila Boundary
Mouza Boundary
River
Cannel
Dam
Kacha Road
Union Parishad
Bazar
Primary School
High School
House
Community Clinic
Army Camp
Shelter Center
Pucca Road
Shrimp Cultivation
Salt Cultivation
Forest
Paddy Field
Hazard
River Erosion
Marsh Land
Hilly Bevel
Cyclone
Aridity


Map–5.19: Khutakhali Union, Chakaria, Cox's Bazar
Social and Hazard Map
Legend
Upazila Boundary
Mouza Boundary
River
Cannel
Dam
Pucca Road
Kacha Road
Bridge
Sluice Gate
Union Parishad
Bazar
Primary School
High School
Madrasha
House
Community Clinic
Shelter Center
Paddy Field
Shrimp Cultivation
Salt Cultivation
Forest
Hill
Hazard
Flood
Marsh Land
Hilly Bevel
Salinity
Cyclone
Aridity
21°40'0"N
21°38'0"N
21°36'0"N
92°2'0"E
92°4'0"E
92°6'0"E
92°8'0"E
Naikhongchhari Upazila
Lama Upazila
Dulahazara Union
Chiringa Union
Maheshkhali Upazila
Cox's Bazar Sadar Upazila
Ramu Upazila
Purnagram
Jangal Khutakhali
Medakachhapia
Khuntakhali
Fulchhari
Bahaltali
0
0.75
1.5
3 Km
N


Map-5.20: Konakhali Union, Chakaria, Cox's Bazar
Social and Hazard Map
Bheola Manik Char Union
Pekua Union
Ujantia Union
Demusia Union
Paschim Bara Bheola Union
Konakhalir Ghona
92°0'0"E
91°59'0"E
91°58'0"E
91°57'0"E
21°47'15"N
21°46'30"N
0
0.25
0.5
1 Km
Legend
Upazila Boundary
Mouza Boundary
River
Cannel
Dam
Pucca Road
Kacha Road
Bridge
Union Parishad
Bazar
Primary School
High School
Madrasha
House
Community Clinic
Sluice Gate
Shelter Center
Paddy Field
Shrimp Cultivation
Hazard
Flood
River Erosion
Tidal Surge
Salinity
Cyclone
Aridity


Map-5.21: Lakhyarchar Union, Chakaria, Cox's Bazar
Social and Hazard Map
Legend
Upazila Boundary
Mouza Boundary
Bridge
River
Dam
Pucca Road
Kacha Road
Union Parishad
Bazar
Primary School
High School
College
Madrasha
House
Community Clinic
Paddy Field
Hazard
Waterlogged
Marsh Land
River Erosion
Hilly Bevel
Cyclone
Aridity
Kakhara Union
Kaiarbil Union
Lakhyarchar (Part)
Matamuhuri River
Chakaria Paurashava Ward No-01
Chakaria Paurashava Ward No-02
Chakaria Paurashava Ward No-08
Chakaria Paurashava Ward No-03
Fasiakhali Union
Saharbil Union
Purba Barabheola Union
21°47'0"N
21°46'0"N
92°3'0"E
92°4'0"E
92°5'0"E
0 0.15 0.3 0.6 Km
N


Map–5.22: Paschim Boro Bheola Union, Chakaria, Cox's Bazar
Social and Hazard Map
Konakhali Union
Demusia Union
Bheola Manik Char Union
Paschim Bara Bheola(Part)
Paschim Bara Bheola
Saharbil Union
Badarkhali Union
21°46'30"N
21°45'0"N
21°43'30"N
91°58'30"E
92°0'0"E
N
0 0.325 0.65 1.3 Km
Legend
Upazila Boundary
Mouza Boundary
River
Dam
Pucca Road
Kacha Road
Bridge
Union Parishad
Bazar
Primary School
High School
Madrasha
House
Community Clinic
Shelter Center
Shrimp Cultivation
Paddy Field
Hazard
Flood
River Erosion
Salinity
Tidal Surge
Cyclone
Aridity


Map–5.23: Surajpur Manikpur Union, Chakaria, Cox's Bazar
Social and Hazard Map
21°47'0"N
21°46'0"N
21°45'0"N
21°44'0"N
92°7'30"E
92°9'0"E
Gajalia Union
Kakhara Union
Manikpur
Surajpur
Fasyakhali Union
Fasyakhali Union
N
0
0.25
0.5
1 Km
Legend
Upazila Boundary
Mouza Boundary
River
Cannel
Dam
Kacha Road
Bridge
Union Parishad
Bazar
Primary School
Madrasha
House
Community Clinic
High School
Pucca Road
Shelter Center
Paddy Field
Wild Elephant Attack
Forest
Hill
Hazard
River Erosion
Hilly Bevel
Nor'wester
Aridity

## Vulnerability of Livelihood Groups

Due to climate change, different types of occupation and livelihood groups of people suffer from various natural hazards. To understand the pattern of risks and vulnerability several key informant interviews have been conducted with a number of occupation and livelihood based groups of Chakaria upazila. The following is a discussion based on these interviews.

**Agriculture and Farming:** According to the key informant of this agriculturalist group, the harmful sides of climate change (high or low temperature, heavy or less rainfall and fog) and natural disaster of this upazila center around different sectors. Some of these are: with high temperature the number of brown grass hoppers increases, due to less rainfall crop fields dry up, seedbeds get damaged due to heavy fog during winter, increase of insects during summer season, seedbed and paddy field become over flooded due to water fall from the hills, all types of crop fields get damaged during cyclone, heavy rain submerges the seedbed and crop fields, betel leaf becomes red because of less rain fall, domesticated animals suffer from various diseases during winter, and overall there is less agricultural production in the locality. He also mentioned that agriculturalists like him use their local knowledge for adaptation to these losses. Such as usage of local insect killers to reduce the attack of insects to their crops, hanging *'kaktarua'* (scarecrow), keeping branches of trees in the crop field to save their crops from insects, collecting seeds from others, usage of locally made roofs on the seedbeds and betel leaves to keep them from heavy fog and excessive heat respectively, keeping channels besides the vegetable fields to remove excess water from the field, cultivating crops in advance, depending on supplying water from shallow machine for irrigation, keeping the domesticated animals in dry and safe places and using medicine for diseases, and to save their crops from the attacks of animals keeping locally made fences (usually made from bamboos) around their crop fields among others.

He produces different types of crops in different seasons. Such as, he produces Aman paddy (some of the variety of this paddy are Mukti–1, Shakti–2, Rupali–7, BR–11, BR–22 and Hori–33) from the months of Ashar to Agrahayan and Boro paddy (some of the variety of this paddy are BR–28, BR–33 and red paddy) from the months of Poush to Boishakh. For this he prepares the Aman seedbed during the month Jaistha in a land which is usually never flooded. And for the seedbeds of Boro he prepares the land in the lowest area in the month of Poush. He prepares the land before rainy season. In case of shortage of water he manages water from deep tube well and nearest river and canal for irrigation. It has been observed that many of the farmers still use plough and cow besides tractor for cultivating the land. But, according to him, due to climate change it rains less during the period of Aman cultivation and as a result they have to collect and supply water from deep tube well. After all preparation, he cultivates the Aman and Boro seeds during the last week of the month of Srabon and middle of the month of Magh respectively.

According to him, most of the farmers of this upazila usually cultivate different types of vegetables such as corolla, chichinga, jhinga, borboti, brinjal, potato and chili from the months of Kartik to Boishakh when the rainwater goes down. He produces vegetables in an amount of 60 decimals of land but does not get enough profit from this. One of the reasons for this he mentioned is that nowadays many farmers are producing vegetables in this upazila. For example, for vegetables he invested taka 15000 in 20 decimals of land and earned taka 22000, but in the same year he invested taka 35000 for betel leaf in five decimals of land and earned taka 60000. For him this has forced many of the farmers to cultivate those crops, which will give them a better return. Finally, he argued that it has become difficult for the farmers to live their lives due to various natural disasters and changes in weather variation.

**Salt Panning and Cultivators:** One of the salt cultivators said that cultivation of salt starts during the months of Agrahayan and Poush. They prepare their field during this time and use three different types of water for salt panning such as raw water, stale water and boiled water. After this, they set high dam all around the salt field. He mentioned that earlier they used to cultivate salt only on the soil through creating beds, but today they prepare modern beds using three to four layers of polithin. The size of each bed is 8 feet in width and 18 feet in length and it takes 15 to 30 days for the production of salt from one bed. They collect approximately 3 mounds (120 kgs) of salt from one bed after sixty days. Regarding price he said that the price of each mound of dry salt is taka 430 and salt mixed with soil is taka 500. The local dealers directly collect salt from their field.

According to him, the best condition for salt cultivation is dry weather (i.e. the months of Boishakh and Jaistha). Although he can cultivate salt even during the month of Ashar because today there is no long lasting rainfall. Therefore, he can cultivate salt very well until the start of rainy season. Heavy fog is harmful for salt because during this time their dried up salt turns into water. They try to cover their salt field during heavy fog. During cyclone, all of their salt fields become over flooded. In his own words,

> *During the cyclone 'Roanu' of 2016, the costing of the amount of salt washed away was taka two lac. Many others like me have lost their investment during that cyclone. I have noticed that during different climatic conditions we suffer from serious loss. The more warmth the weather is the better it would be for the cultivation of salt. Therefore, the months of Falgoon, Chaitra, Boishakh and Joistha are the best time for the cultivation of salt. However, I do cultivate salt from the months of Ashar to Kartik. I usually cultivate different varieties of*

*salinity prone fishes in the same field during this time such as Koral, Bata, etc. Similarly, we do not cultivate salt in the winter season. I have come to realize that there are some changes in our climate and these changes have major effects on our salt cultivation processes.*

> *I have two ponds. I am cultivating fish in this pond for a long period. When the water falls from the hills, the banks of my ponds break down and as a result, floodwater enters these ponds. Again, due to flood over siltation fills up these ponds and pond fish cultivation becomes difficult. To keep my fishes safe from these hazards I try to build the banks of the ponds higher and keep net fencing around the ponds. However, it is not always possible for me to take all these measures and hence face some loss.*
>
> *- A Fish Farmer*

Offshore Fishing and Inland Culture Fishing: Suruj Mia said that they could collect more fishes during the months of Shrabon, Vadro, Asshin, Poush and Magh because during these months the sea remains silent and contains less salinity. According to him, more fishes can be captured during rainy season (this is because of low salinity of water and the fishes come near the shore to lay eggs), but it is tough to catch fish during this season as it becomes billowy sea. He further mentioned that due to monsoon they could get some fishes even during the months of Poush and Magh. However, during winter season (particularly when the weather becomes very cold) most of the fishes go into the deep sea and as a result, less fish is available for them. He also mentioned that when government restricts them to catch fish in the sea during the months of April, May, June and October they receive some financial assistance from the upazila fisheries office. It becomes difficult for them to run their families during this off–peak season and sometimes they have to take loan from others to survive. One of the major aspects of their livelihood is that they never shift their occupation. Finally, he argued that they do not get enough fish as they used to get at least 20 years ago and the reason for this is climate change.

He and his family members are collecting fish from the sea for a long time and this is their family occupation. He mentioned that when the weather becomes very hot all the fishes go under the deep water of the sea and due to this, they have to collect fish from the deep sea. However, for him fishing in deep sea is very risky because of heavy wind. He mentioned that rainy season is the best time for fishing because during this time the salinity of water reduces. However, they do not go into the deep sea to catch fish especially during unfavorable weather. He argued that fishing was the occupation only for the fishermen, but in these days many Muslims and other community people are involved in fishing. Today they are not able to collect enough fish because of climate change and natural disasters. For example, he mentioned that with waterfall from the hills siltation is filling the sea, routs for fishing channel are changing and living areas for fish are being damaged.

He further mentioned that fishing in the pond has also become difficult for them. This is because with the increase in temperature all ponds dry up and damages are done to the living environment for the fish. In this situation, they supply water to the ponds with shallow machine for creating a favorable environment for the fishes.

He mentioned that at the time of heavy winter fishes grow slowly and die from various diseases. At these times, they put medicines and increase the supply of fish fodder. Also during hot weather, he plants various types of trees on the banks of the ponds and the shadow of these trees keep the water cool. Thus, according to him, these are the hazards and risks for the fishermen like him of this upazila and they try to face the problems using their different techniques.

*Boishakh, Joistha, Ashar and Shrabon months are the most suitable time for collecting the cultivated shrimps. Nevertheless, tidal wave and waterfall from the hills damages the shrimp enclosure. During 2016 cyclone 'Roanu' I have lost everything. After collecting whatever the shrimps remaining in the enclosure, I have opened the channels so that all varieties of fishes can enter. I have to live my life through collecting other species of fishes at these times. In the past, I have collected the food for shrimp from Chakaria Sundorbon, but now it is not possible and I have to buy food from shops. This has increased my costing for shrimp cultivation. I have observed that once the shrimps become habituated with these foods, they can no more take the natural food stuffs. However, I can say that because of climate change, nothing is like the past and I can see its impact on shrimp cultivation.*

*- A Shrimp Farmer*

**Shrimp Farming and Cultivators:** Md. Shiful said that shrimp cultivation is not the same, as it happened to be 20 years ago. According to him, the reasons are: (i) in the past they could get young shrimp naturally, but now they have to buy the young shrimp from the hatcheries; (ii) water from the sea cannot enter the shrimp enclosure naturally because of increasing construction of dams; and (iii) there is the lack of natural food for the shrimps in the coastal areas and due to this both young shrimp and mother shrimp remain in the deep sea. Thus, he has to invest more money and labor to collect both young shrimp and mother shrimp. Lack of natural food is causing damages to the shrimp cultivation and this is happening due to destruction of the forests. He also mentioned that because of siltation, the depth of their shrimp enclosure has been reduced and due to this, during summer its water becomes very hot and causes various diseases to the shrimps. To overcome this situation they keep coconut leaves to create shadows. He further mentioned that too much salinity in the water is harmful for the shrimps and causes various diseases. Therefore, the best option is the mixing of sweet and saline water for shrimp cultivation. At the same time cyclone not only damages their shrimp enclosures and dams but also washes away the cultivated shrimps. To adapt to this situation he tries to construct the dam of shrimp enclosure relatively higher. Nevertheless, this is not always the best solution to their problems, and during heavy tide or cyclone, they have nothing to do.

**Flower Cultivators:** Akbar mentioned about the harmful sides of climate change (high or low temperature, heavy or less rainfall and fog) and natural disaster of this upazila. Some of these are: with the increase in temperature black and white gunguni insect increases the disease of flowers, ledara insect eats all the leaves of flower trees and lay egg on the leaves which reduces the production of flower, flower gardens over flooded because of heavy rainfall and waterfall from the hills, cyclone destroys the flower plants, and excessive fog during winter reduces the production of flowers among others.

> *During the flood of 2015, I have had great financial loss from my garden. Moreover, during the flood of 2016 I have lost taka five lac due to damages done to my gardens. I have had to start from the beginning every time with cultivating new plants, preparing new channels around the gardens, made new fences and overall cultivated papaya and banana trees around the gardens to increase the income of my family. I think that all these happened because of climate change.*
>
> *- A Flower Cultivator*

In this regard, as he mentioned, flower cultivators like him use their local knowledge for adaptation strategies. Such as, usage of local insect killers to reduce the attack of insects, preparing gardens on relatively higher lands to keep the flower plants safe from heavy rainfall and waterfall from the hills, keeping the banks of the gardens relatively higher if the garden is in lower places, keeping channels besides the gardens to remove excess water, keeping strong fences around the gardens, and cultivating papaya and banana trees around the gardens to make good profit among others.

**Forest Dependent Livelihood:** Md. Shamsul lives in Uttarghunia village of Fashiskhali Union. He collects fuel wood from the forests and he has nothing but his homestead area. He has to suffer during different seasons and he mentioned that this suffering is related to his earnings and sustainable living. For example, he said that during winter, he cannot go to the forest early in the morning to collect fuel wood and this decreases his average collection for a day. In other words, he cannot collect more than one bundle of fuel wood during winter. This is also the same in case of rainy season. He has been collecting fuel wood from the forests for a long time and from his experience, he said that due to the changes in environment and occurrences in natural disasters they are facing various losses. Therefore, for him excessive cold, hot or rain– none of these is good for them to collect fuel wood from the forest.

**Seasonal Off–Farm Employment and Laborers:** According to the key informant of this non–agricultural laborer group, the harmful sides of climate change (high or low temperature, heavy or less rainfall and fog) and natural disasters of this upazila center around different sectors. Some of these include illness due to increase in temperature, damages of houses due to waterfall from the hills, and road accidents due to heavy fog among others.

He said that it becomes difficult to work out both during winter (during this time temperature falls) and summer (during this time there is the lack of pure drinking water). Both these situations make them suffer from various diseases such as diarrhea, flue, dysentery, etc. He also mentioned that non–agricultural laborer like him use their local knowledge for adaptation to these losses. Such as, keeping their houses in a relatively higher place to be safe from flood caused by waterfall from the hills, taking shelter in flood shelter or on the higher places in the hills, during high temperature starting their work very early in the morning, and taking liquid food as much as possible among others. He said that during heavy fog they do not go to the highways to avoid road accidents. Moreover, when they become ill they receive treatment from village doctor and upazila hospital.

## ASSESSING CLIMATE RISKS IN TARASH UPAZILA

### Climatic Hazards in Tarash

Tarash upazila endures different natural disasters like flood, water logging, drought, nor'westers, cold wave, hailstorm and lightning throughout the year. Nevertheless, the intensity levels of disasters are different in different upazilas. For instance, though flood used to occur in the low–lying areas of Baruhas union, now it becomes rare in that area. In 1988, 1998 and 2004 flood occurred in this area. As the water level of Chalan Beel has declined, flood has become a temporary issue here. Generally, in the rainy season, a sudden rise of the water of Chalan Beel perishes the croplands. The local people blame these natural disasters for the massive damage of the land, crop, resource and human resource in every year. Different FGDs (Focus Group Meeting/Yard Meeting) have been held with the local people, the UP members, the Union Disaster Management Committee of the eight Unions of this upazila. The unions are, Baruhas, Deshigram, Madhainagar, Magura Binod, Naogaon, Saguna, Talam and Tarash sadar union. After collecting and analyzing the data obtained through these FGDs the scenario of the most occured disasters and jeopardies of Tarash Upozila is as follows:

**Table– 5.3: Major Climatic Hazards in Tarash**

| Union | Flood | Water Logging | Drought | Norwester | Cold Wave | Hail Storm | Thunder Storm |
|---|---|---|---|---|---|---|---|
| Baruhas | √ | √ | √ | √ | √ | √ | √ |
| Deshigram | √ | √ | √ | √ | √ | √ | √ |
| Madhainagar | X | √ | √ | √ | √ | √ | √ |
| Magura Binod | X | X | √ | √ | √ | √ | √ |
| Naogaon | √ | √ | √ | √ | √ | √ | √ |

| Union | Flood | Water Logging | Drought | Norwester | Cold Wave | Hail Storm | Thunder Storm |
|---|---|---|---|---|---|---|---|
| Saguna | √ | √ | √ | √ | √ | √ | √ |
| Talam | √ | √ | √ | √ | √ | √ | √ |
| Tarash sadar | √ | √ | √ | √ | √ | √ | √ |

**Flood:** In the meetings of FGDs, the flood has been addressed as a major trouble for this area. The local people have to endure plenty of damages because of flood every year. Flood causes different crises: houses are flooded, the landslide is induced by, tube wells of low–lying areas are submerged under water that induces the crisis of drinking water, water–borne diseases—diarrhea, malaria, cholera, typhoid—break out, toilets get damaged and unhygienic condition emerges. Almost all the participants in the FGDs admitted that people take shelter at any school when a major flood occurs. At that time, schools are closed, and thus the academic activities are hampered. According to the participants, a big flood causes the ponds submerged under water, and the fish farmers suffer a huge loss. Those who rear poultry or cattle at home, have to face trouble in keeping their abode out of the water and in feeding them. The outbreak of poultry and livestock diseases is a common hazard during this time.

*It was not a huge flood in 2016, but the paddy of the most farmers' lands got rotten because of that flood. Those farmers had to recultivate with new rice plants. For this reason, farmers had to bear huge loss. When the flood occurs or the water of Chalan Beel increases, many farmers (whose lands get submerged under water) get involved in fishing. Many leave the area in search of day laborer's job in other areas. The farmers try to prepare their seedbeds on a higher place as though the flood can do no harm. For the same reason, we build our houses on a higher homestead, make an entresol inside the house for cooking, and to resist the erosion of the road, construct guide walls with bamboo/stone along the two sides.*

*- A Farmer*

Most of the participants said that this area had to endure flood in 1988, 1992, 1993, 1998 and 2004. Moreover, water floods the low–lying area every year. Farmers have to face trouble in farming because of water–logging. That's why the farmers cultivate the Bona Aman paddy in low–lying areas. This variety of paddy grows as the water level rises.

They mentioned that in this area the number of flood shelter centers is few. The local primary schools are used as the shelter centers during flood. In the floods of 1988 and 1992 people had to take shelters in the local primary schools.

The local people have to endure a variety of losses during the natural disasters. For example, some areas that are next to Chalan Beel go under water at the very first moment. But in the recent times, the fish farmers don't have to face major loss. The van–pullers or the people from other walks continue their own livelihoods. In the six months of water–logging, induced by flood or Chalan Beel overflow, the farmers cannot run any cultivation. All the crop lands go under water. As a result, only one crop can be cultivated in a year. The livestock cannot move anywhere during the flood. According to the people of Tarash upazila, they have to encounter the above–mentioned crises during flood.

**Waterlogging:** The affected sectors are like agriculture, infrastructure, fisheries, livestock, health, water, trees–plants, etc. The account of damages induced by water–logging are many. For example, filling in of the low–lying lands and the rivers induces water–logging, erosion of the pond's shore, escaping of the fishes because of the drowning of the pond's shore, falling down of tree, destruction of resident, culvert, road, educational institution, breakout of diarrhea, cholera, fever, malaria, typhoid because of contaminated water, etc. As the tube wells of the low–lying areas of this upazila get submerged under water, a major crisis occurs in the water sector.

**Drought:** Drought is another disaster that was mentioned by the people. Generally, at the end of the Falgun, temperature rise begins and in Chaitra, Baishakh and Jyestha, drought occurs. People admitted that now the temperature in drought is higher than that of earlier. The crop lands are affected by the drought of Chaitra. Then the farmers have to irrigate their lands because the lands get dry. Again, as the pond water gets evaporated in drought, the fishes suffer. Local inhabitants admitted that earlier in this time of Chalan Beel used to have water. But now the water of the beel is decreasing, and the drought is increasing. As a result, along with the damage to agriculture and *Rabi* crops, cattle's heat stroke and humans' ailments of different types are induced.

**Hail Storm:** According to the local people, hail storm occurs mostly in the mid of Chaitra and Baishakh–Jyestha and stops in the beginning of Asar. Paddy lands, crops, seed beds, fruit, trees, and plants are damaged because of the hail storm. Hail storm also causes damage to the roofs of the tin shed houses. Local people do not have any way to get rid of these losses. To them, any damage to crop is damage to the farmer. The farmers do not know how to keep safe paddy from the hailstorm. If hailstorm destroyed rice plants within 30 days of the plantation, then farmers plow the land again. After this re–plow, the rice plants get broken, and the new plant grows from the root. This process causes no irregularity to the crop but delayed harvest. Nevertheless, if the hailstorm hits at the flowering time of paddy then there is nothing to do. Hailstorm causes sudden ups and downs in the temperature of the pond that result in oxygen crisis in pond water. Eventually, this oxygen crisis is responsible for the increase of gas in the pond water, and thus kills fishes. In this crisis, many fish farmers try to increase oxygen level through striking the pond water with a bamboo or making artificial wave by boating.

**Cold Wave:** In the FGD meetings, the cold wave was admitted as another natural disaster. According to the people, cold wave occurs mostly from the mid of Agrahan to Poush–Magh. Again, at the beginning of Falgun, light cold wave persists. In this time local community suffers from various troubles such as different cold–borne diseases of the human being and animals break out, seed beds get damaged because of the lack of heat, the growth of the fish is hampered, and often the fishes die within 2/3 hours because of the gas created within the pond. As a result, fish farmers have to bear a great loss. To reduce the health risks, they wear warm clothes and caps. As part of the adaptation in saving the livestock, cows and goats are worn with the sack, hens are kept in a dry and warm place, a fireplace is placed near the animal abodes, and electric bulb is lit in the hens' abode to increase the temperature of that place.

*Drought induces damage to agriculture; excessive heat makes the poultry suffer from different diseases. We face trouble working in the field because of drought. Eventually, a lot of working hours are wasted.*

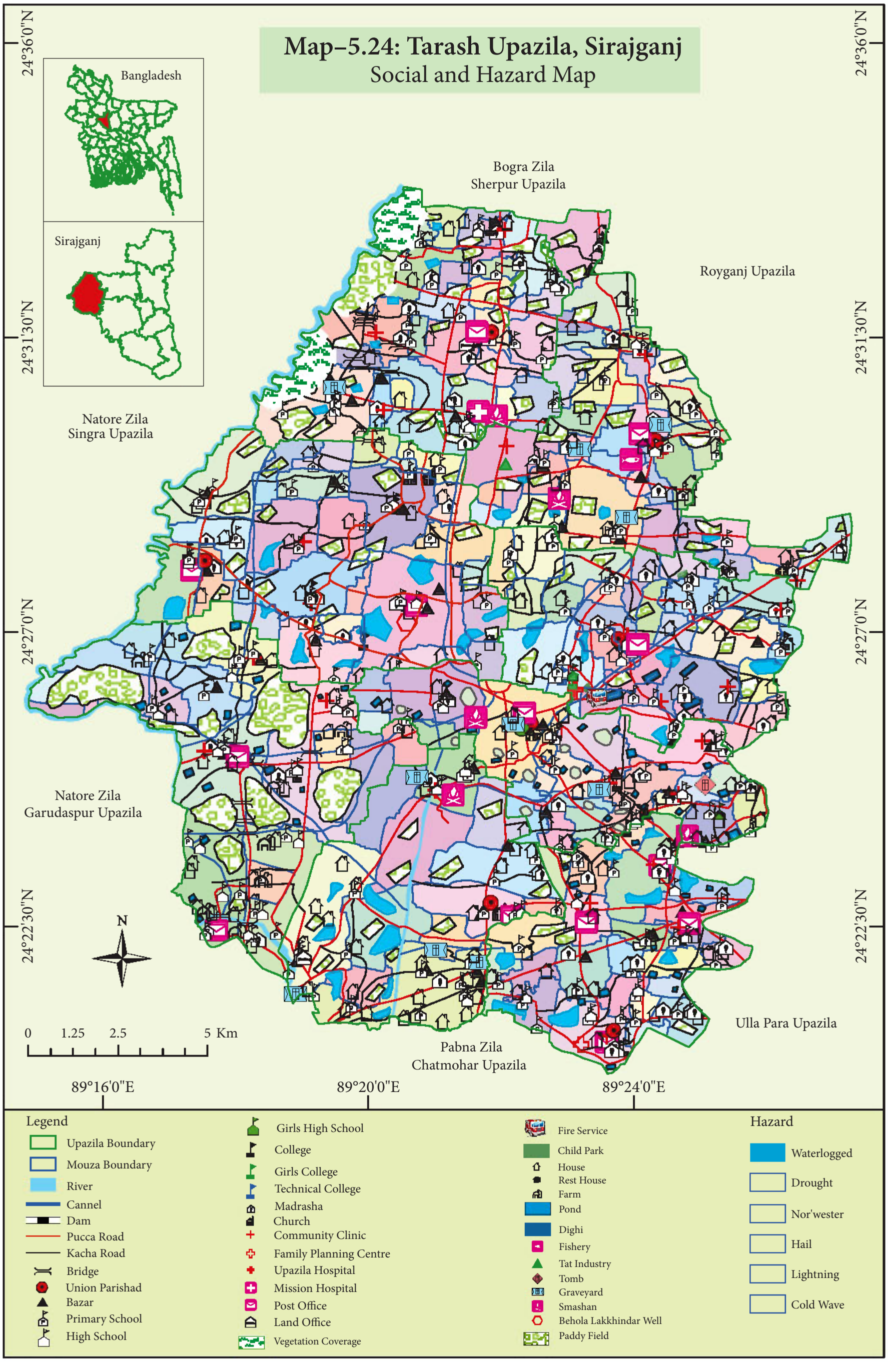
*During the 40 day soil digging in 2016, many working hours were wasted because of excessive heat. The rise in the temperature compelled our workers to take more rest, and that's why they couldn't do much work. As the water level was falling down, farmers faced trouble in cultivation. That's why we get used to irrigating with underground water. Now in every 5/7 bigha of land, there is a deep tube well for more irrigation. Because of more irrigation, our costs increase as well. That's why many of us are abandoning crop cultivation and digging a pond to start fish farming in that land.*

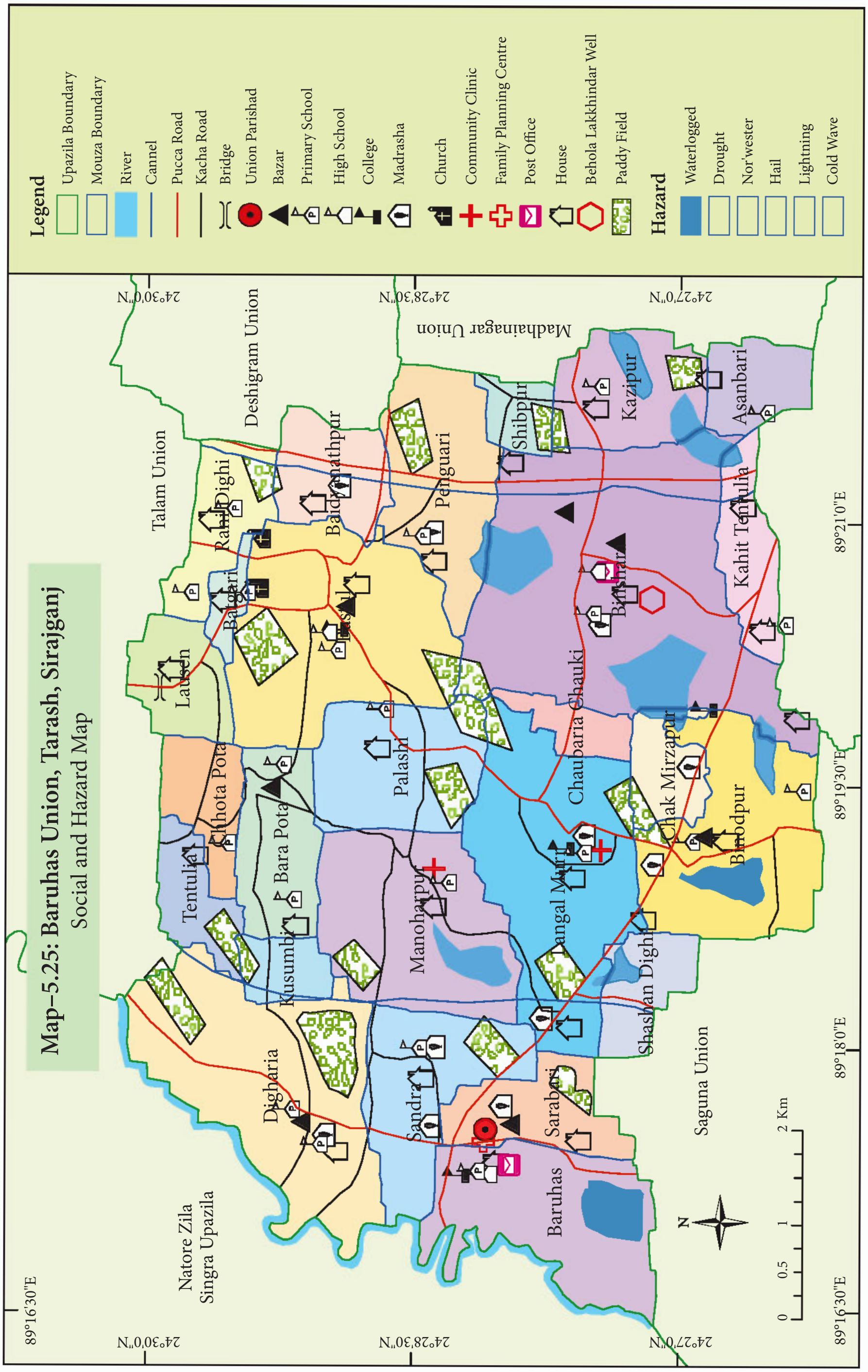
*- A Fish Farmer*

**Thunder Storm:** From the beginning of Chaitra to Jyestha, the lightning occurs in this area. Though it occurs in other months, from Chaitra to Jayestha it becomes more frequent. People said that human beings and cattle die by lightning and this risk is increasing now. There is no remedy for the loss of this disaster because it occurs all of a sudden. However, as during the storm and rain lightning is more possible, people take safe shelters because the possibility of getting thunderstruck becomes higher when anybody stays outside in the midst of lightning. That is why in the midst of lightning, people try to stay in the house or in a safe shelter.

**Norwester:** According to local people, norwester occurs in Baishakha–Jayestha. The ultimate sectors that fall prey to the norwester are like, agriculture, infrastructure, fishery, livestock, health, water, electricity, and trees. Local people mentioned that norwester causes the most harm to the houses. The tin of house is blown away, fences of houses are broken, electricity is disrupted, and paddy is spoiled in the land. Farmers loss their investment and profit if the crop is crushed just before harvest. During this crisis moment, they have to take loans for their living.

## Social and Hazard Map of Tarash





Map-5.25: Baruhas Union, Tarash, Sirajganj
Social and Hazard Map
Legend
Upazila Boundary
Mouza Boundary
River
Cannel
Pucca Road
Kacha Road
Bridge
Union Parishad
Bazar
Primary School
High School
College
Madrasha
Church
Community Clinic
Family Planning Centre
Post Office
House
Behola Lakkhindar Well
Paddy Field
Hazard
Waterlogged
Drought
Nor'wester
Hail
Lightning
Cold Wave
Talam Union
Deshigram Union
Madhainagar Union
Saguna Union
Natore Zila
Singra Upazila
Rahit Dighi
Baidyanathpur
Panguari
Shibpur
Kazipur
Asanbari
Kahit Tentulia
Biruhar
Chaubaria Chauki
Chak Mirzapur
Binodpur
Palashi
Lausen
Balgari
Chhota Pota
Bara Pota
Tentulia
Kusumbi
Manoharpur
Langal Murti
Shashan Dighi
Digharia
Sandra
Sarabari
Baruhas
24°30'0"N
24°28'30"N
24°27'0"N
89°16'30"E
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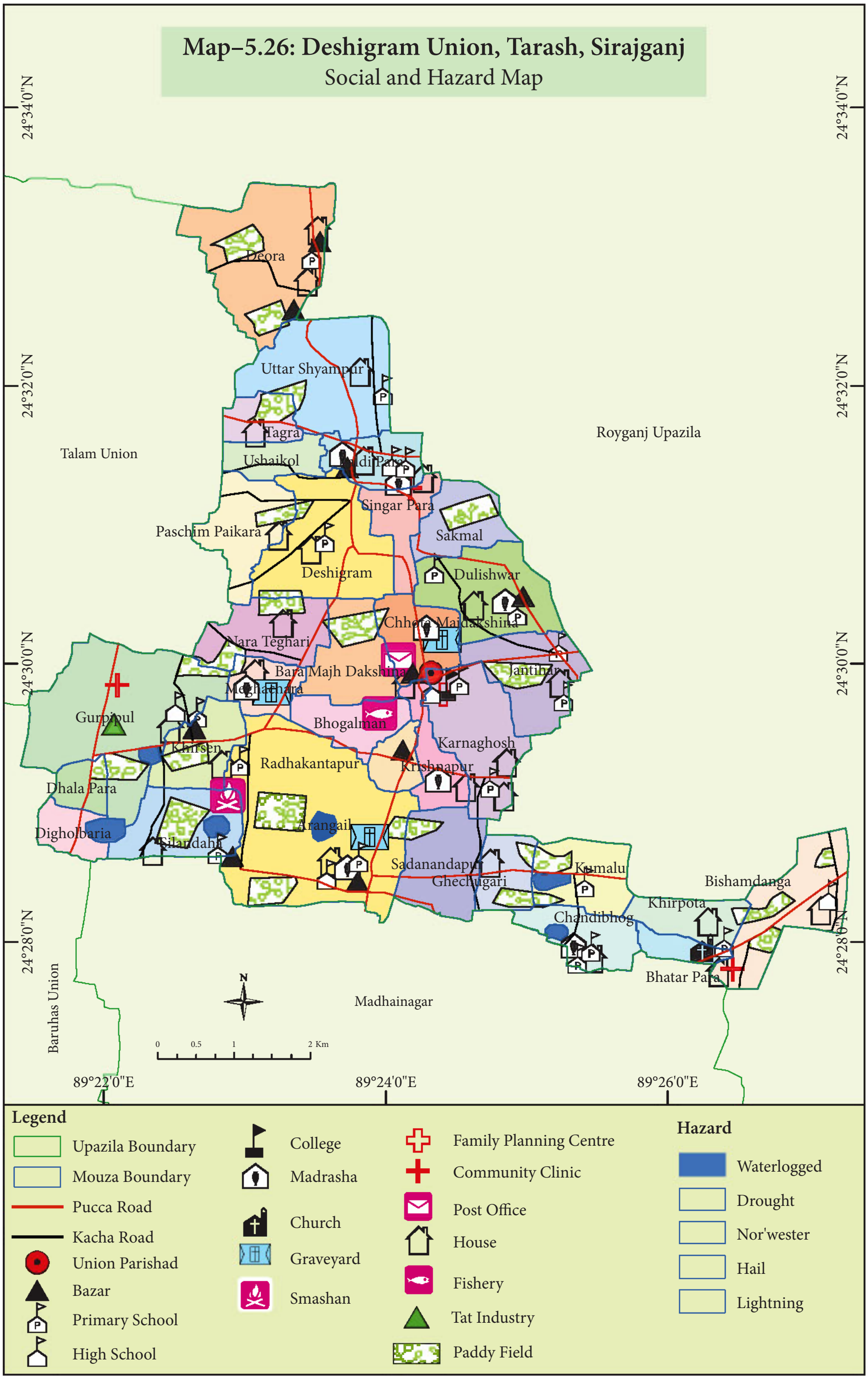
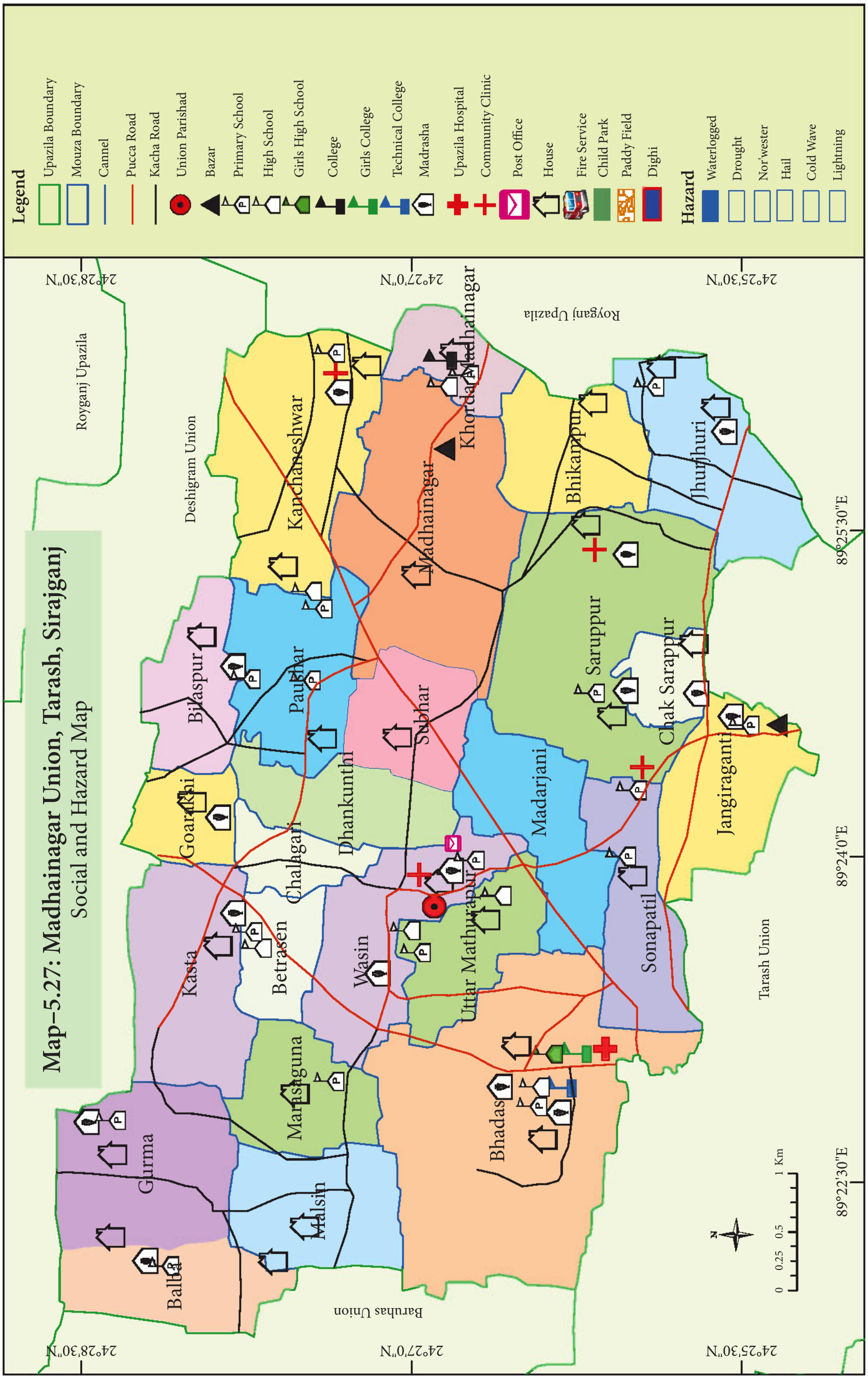
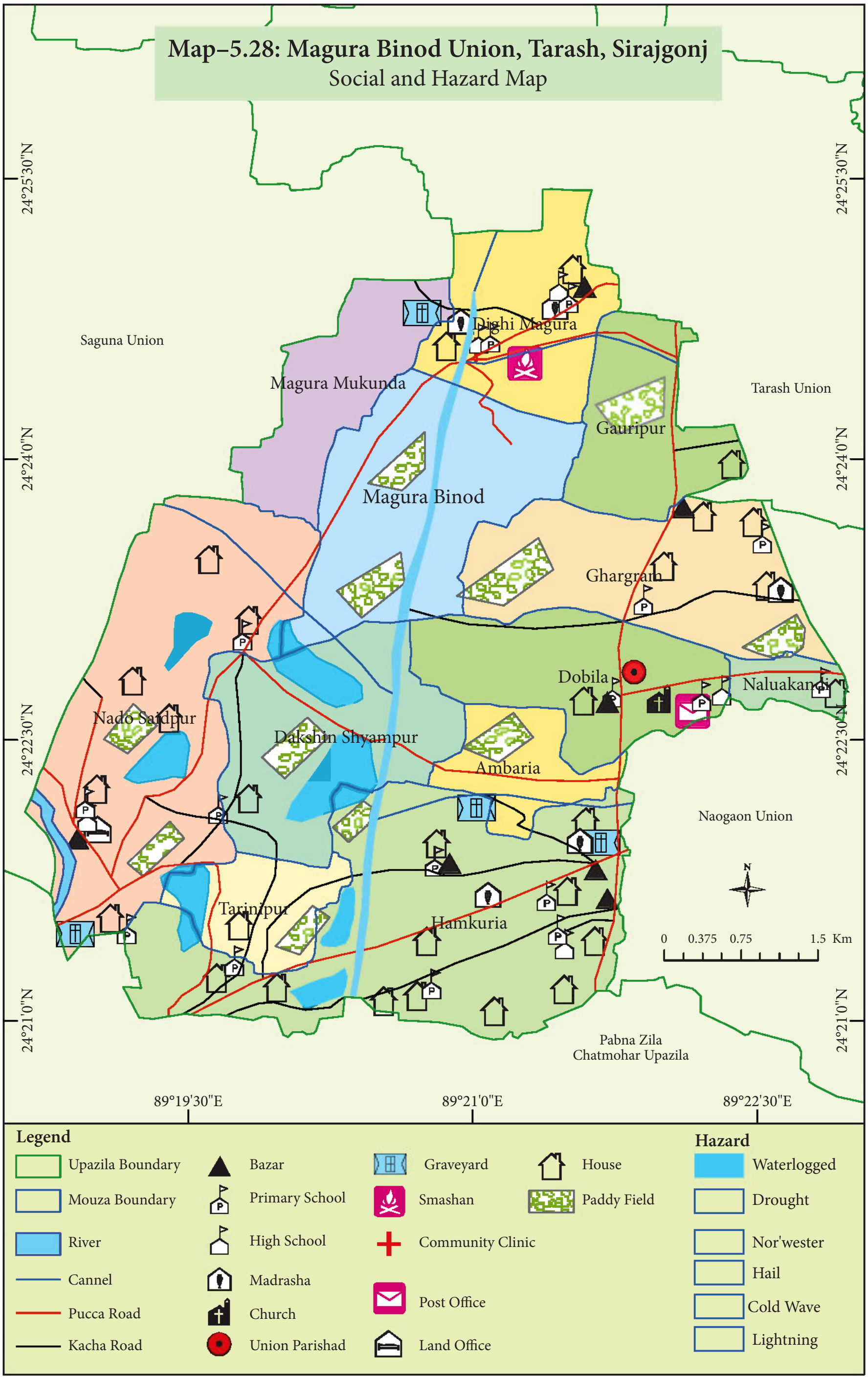
89°21'0"E
0
0.5
1
2 Km
N

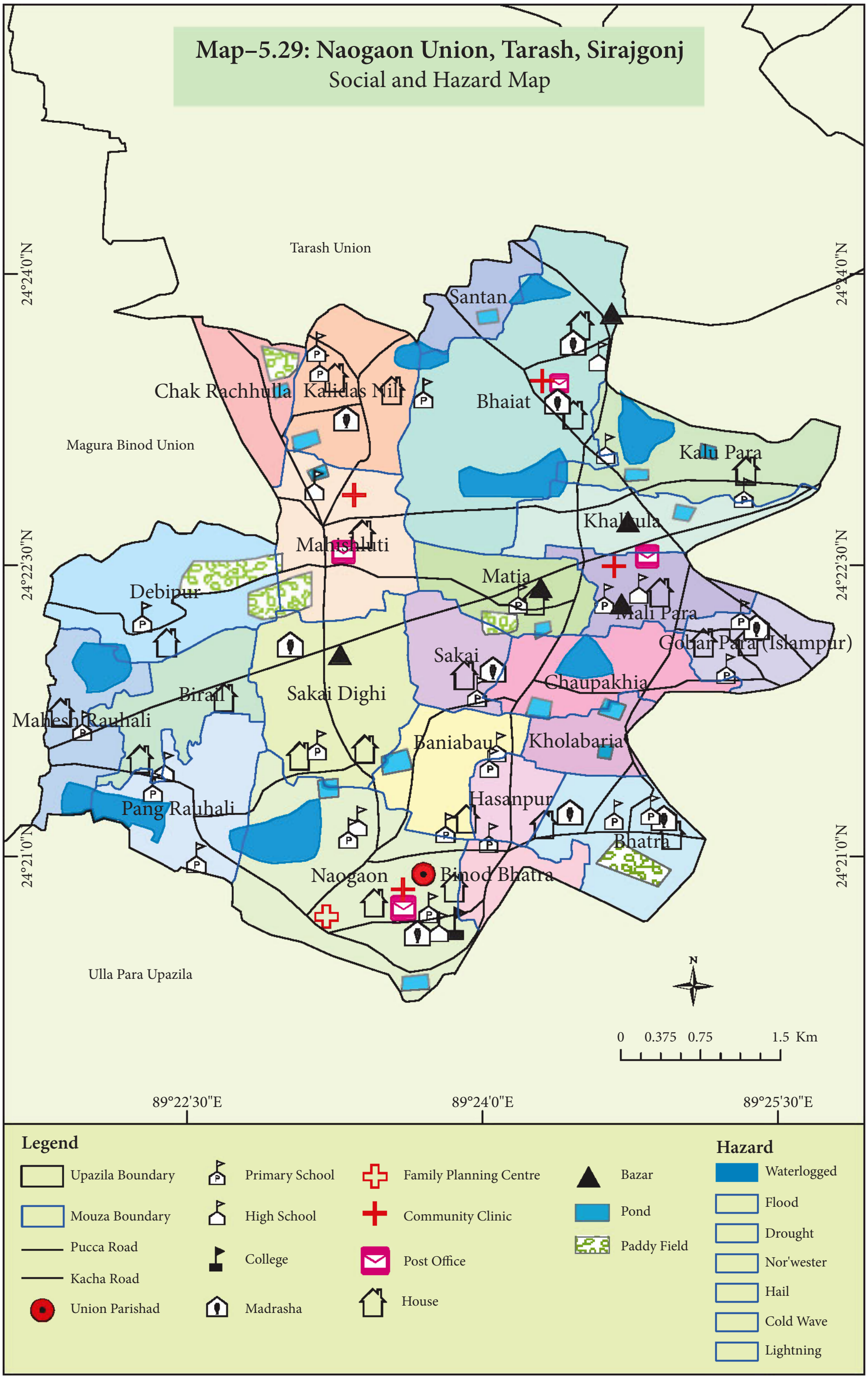


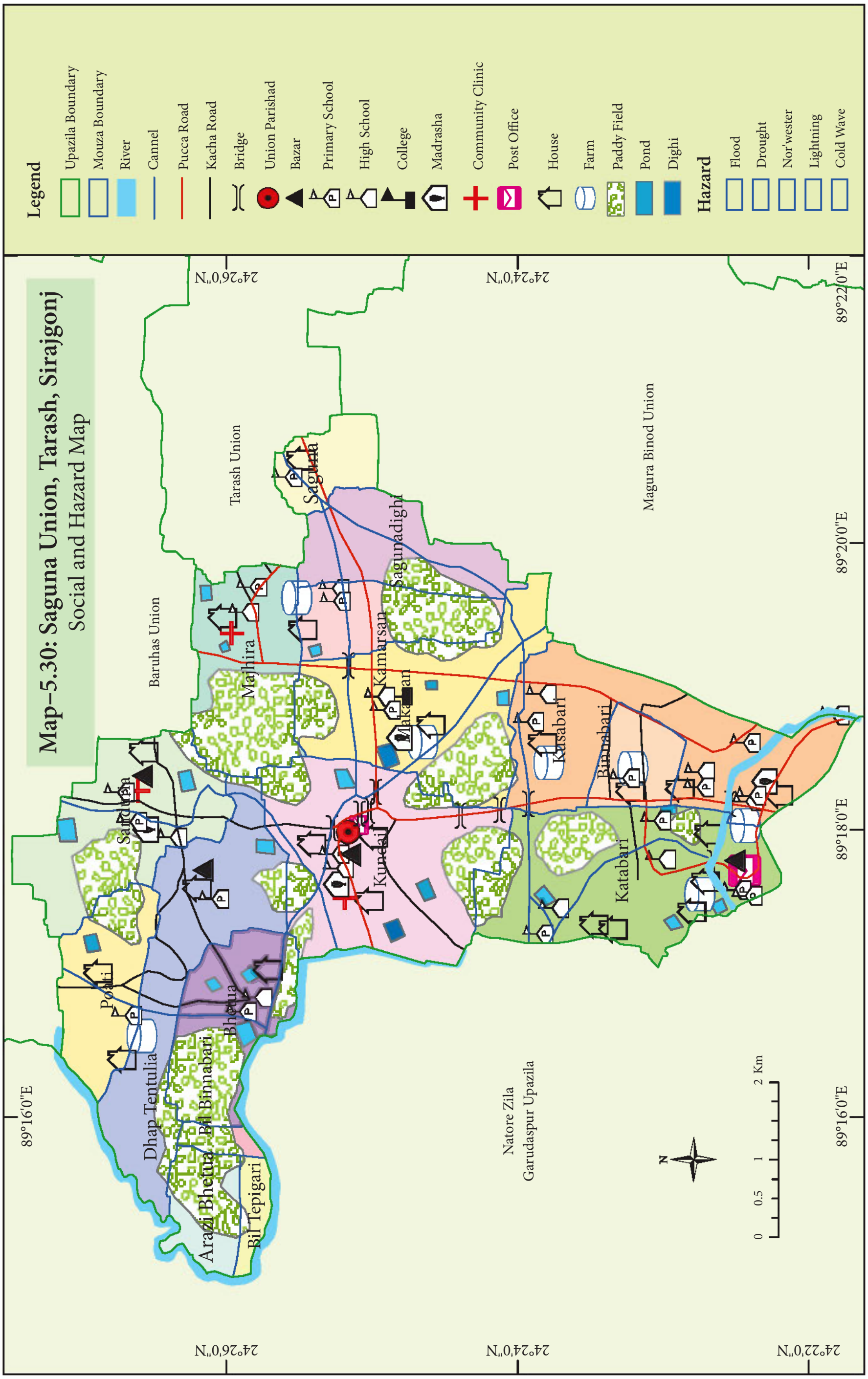

**Map–5.26: Deshigram Union, Tarash, Sirajganj**
Social and Hazard Map

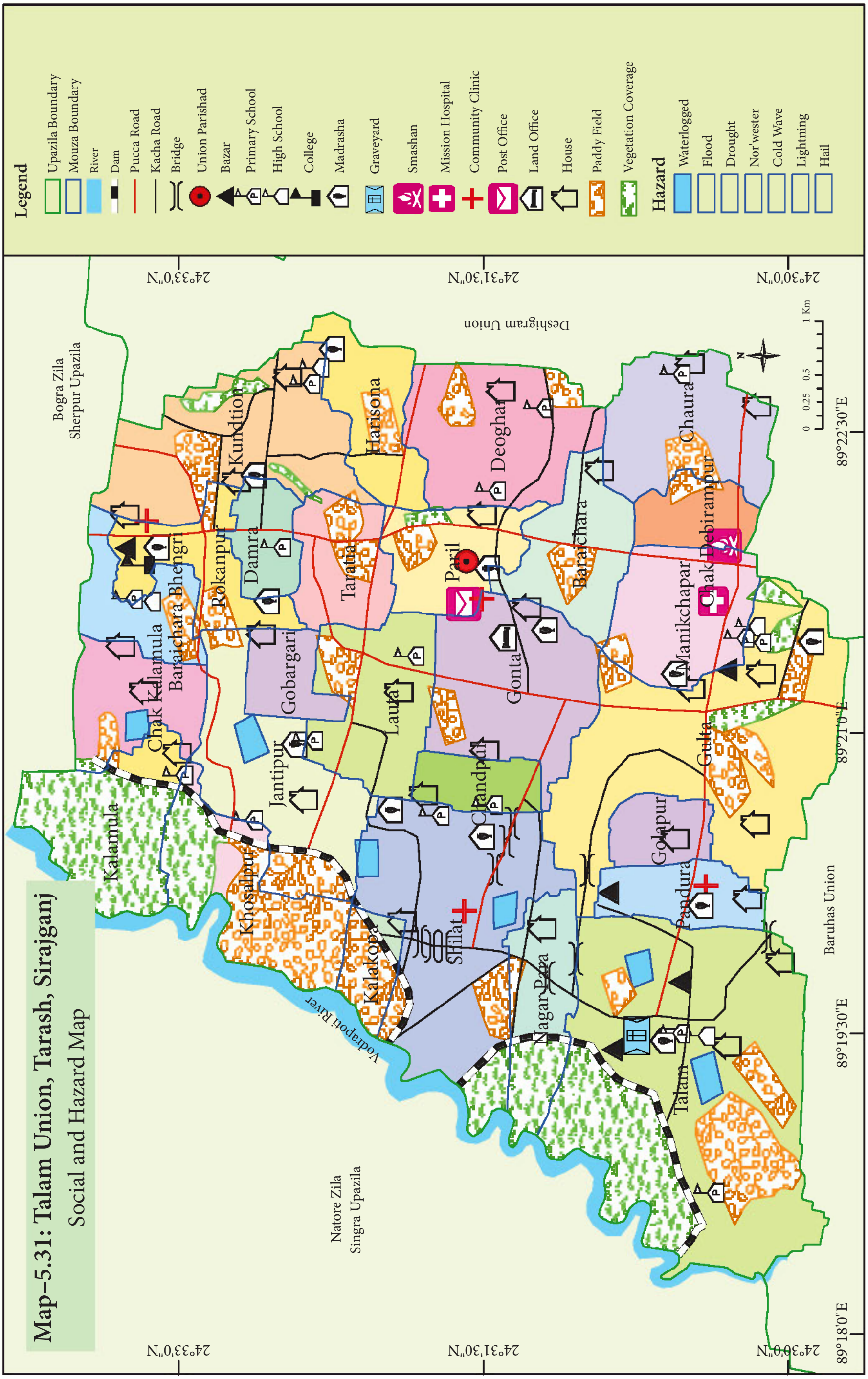



Map–5.27: Madhainagar Union, Tarash, Sirajganj
Social and Hazard Map

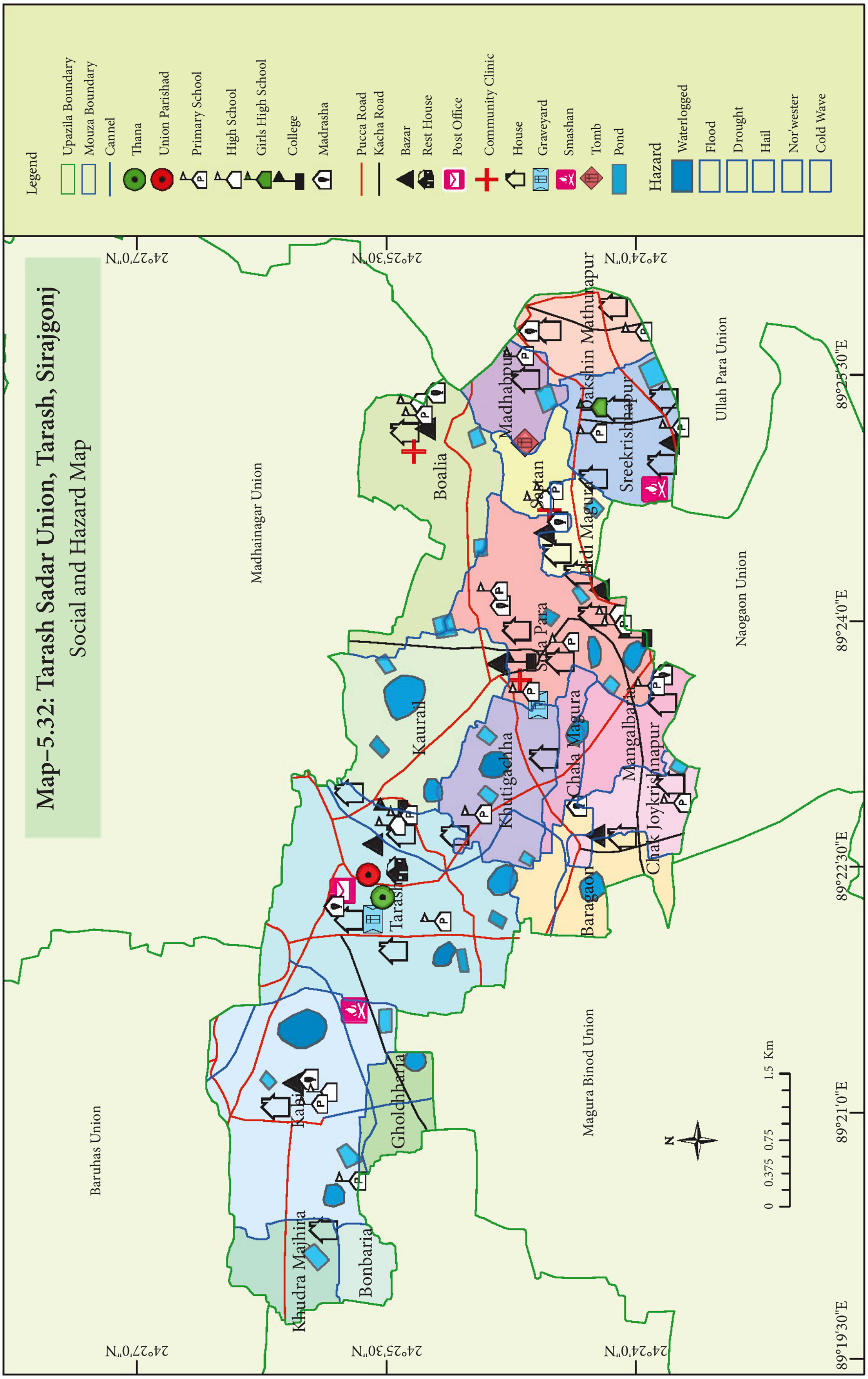

Map–5.28: Magura Binod Union, Tarash, Sirajgonj
Social and Hazard Map
Saguna Union
Tarash Union
Naogaon Union
Pabna Zila
Chatmohar Upazila
Dighi Magura
Magura Mukunda
Gauripur
Magura Binod
Ghargram
Nado Saidpur
Dobila
Naluakandi
Dakshin Shyampur
Ambaria
Tarinipur
Hamkuria
24°25'30"N
24°24'0"N
24°22'30"N
24°21'0"N
89°19'30"E
89°21'0"E
89°22'30"E
N
0 0.375 0.75 1.5 Km
Legend
Upazila Boundary
Mouza Boundary
River
Cannel
Pucca Road
Kacha Road
Bazar
Primary School
High School
Madrasha
Church
Union Parishad
Graveyard
Smashan
Community Clinic
Post Office
Land Office
House
Paddy Field
Hazard
Waterlogged
Drought
Nor'wester
Hail
Cold Wave
Lightning


Map–5.29: Naogaon Union, Tarash, Sirajgonj
Social and Hazard Map
Tarash Union
Magura Binod Union
Ulla Para Upazila
Santan
Chak Rachhulla
Kalidas Nilt
Bhaiat
Kalu Para
Khalkula
Mahishluti
Debipur
Matia
Mali Para
Gobar Para (Islampur)
Sakai
Chaupakhia
Sakai Dighi
Biral
Mahesh Rauhali
Baniabau
Kholabaria
Hasanpur
Pang Rauhali
Bhatra
Naogaon
Binod Bhatra
24°24'0"N
24°22'30"N
24°21'0"N
89°22'30"E
89°24'0"E
89°25'30"E
N
0 0.375 0.75 1.5 Km
Legend
Upazila Boundary
Mouza Boundary
Pucca Road
Kacha Road
Union Parishad
Primary School
High School
College
Madrasha
Family Planning Centre
Community Clinic
Post Office
House
Bazar
Pond
Paddy Field
Hazard
Waterlogged
Flood
Drought
Nor'wester
Hail
Cold Wave
Lightning


Map–5.30: Saguna Union, Tarash, Sirajgonj
Social and Hazard Map
Legend
Upazila Boundary
Mouza Boundary
River
Cannel
Pucca Road
Kacha Road
Bridge
Union Parishad
Bazar
Primary School
High School
College
Madrasha
Community Clinic
Post Office
House
Farm
Paddy Field
Pond
Dighi
Hazard
Flood
Drought
Nor'wester
Lightning
Cold Wave
Tarash Union
Baruhas Union
Magura Binod Union
Natore Zila
Garudaspur Upazila
Saguna
Sagunadighi
Majhira
Kamarsan
Kusabari
Binnabari
Katabari
Kundail
Dhap Tentulia
Bil Binnabari
Arazi Bhetua
Bil Tepigari
Bhetua
Poali
Saidpur
24°26'0"N
24°24'0"N
24°22'0"N
89°16'0"E
89°18'0"E
89°20'0"E
89°22'0"E
0
0.5
1
2 Km
N




Map–5.31: Talam Union, Tarash, Sirajganj
Social and Hazard Map


Map–5.32: Tarash Sadar Union, Tarash, Sirajgonj
Social and Hazard Map
Legend
Upazila Boundary
Mouza Boundary
Cannel
Thana
Union Parishad
Primary School
High School
Girls High School
College
Madrasha
Pucca Road
Kacha Road
Bazar
Rest House
Post Office
Community Clinic
House
Graveyard
Smashan
Tomb
Pond
Hazard
Waterlogged
Flood
Drought
Hail
Nor'wester
Cold Wave
Madhainagar Union
Baruhas Union
Magura Binod Union
Naogaon Union
Ullah Para Union
Boalia
Madhabpur
Dakshin Mathurapur
Sreekrishnapur
Kaurali
Khutigachha
Chala Magura
Mangalbaria
Chak Joykrishnapur
Baragaon
Tarash
Kabi
Gholdhbaria
Khudra Majhiria
Bonbaria
24°27'0"N
24°25'30"N
24°24'0"N
89°19'30"E
89°21'0"E
89°22'30"E
89°24'0"E
89°25'30"E
0 0.375 0.75 1.5 Km
N

## Vulnerability of Livelihood Groups

Different occupation and livelihood groups endure disasters because of the climate change. Here is a description of disaster and jeopardy of the people from different occupation and livelihood.

**Agriculture and Farming:** Mr. Kafil Uddin Ahmed said that he has no land except the home area (3.5 Decimal). He is a sharecropper. During flood, his land was submerged by water and he has lost his works. He had to migrate to Dhaka where he rode a rickshaw and did other jobs to earn money. Usually he has to do these works from Jyestha to Agrahayan. He cannot but do these jobs to run his family. He said that there is a mono cropping area. He takes the lease of a one bigha land for taka 6000 and cultivates cucumber and corn on that leased plot.

He said that agriculture is affected by the fog or cold induced by the severe cold wave. In response to that hazard, they take the following actions: pouring water in the agro lands, spraying pesticides to resist the attack of insects, spraying sand on the tree roots, covering up with the polythene to keep safe from the fog, etc. Excessive heat causes damage to agriculture. Trees and crops are affected. Farmers follow different strategies to counter this loss. In drought, they irrigate the agro lands with deep tube well and water the trees. If the current worm attacks during drought, they put sand on the root of the tree to get rid of the attack. He took loans from ASA and Ekti Bari Ekti Khamar (one farm for one house) during different disasters. He mentioned that the loan taken from Ekti Bari Ekti Khamar had to be paid within a year and that taken from ASA had to be paid in the weekly installments of taka 250. He took the loan to cultivate corn and cucumber. He has some poultry looked after by his wife. It is not a tough job to rear these poultry. However, if there is a chance of the flood, he sells out the hens and keeps the ducks.

To keep the house safe from flood, he builds his house in a higher place. For further safety, he has made an entresol inside the house. During the floods of 1988 and 2004, his house sank under water and his family had to take shelter in the shelter center for 20–25 days. He kept dry foods like chira and biscuit at home as the preparation for flood. Upazila parishad distributed rice as relief.

**Capture Fish and Fish Farming:** Zaman has been involved in fish farming since 1998 and this is his main occupation. Now he has two ponds: one is of 3.5 bighas and another of 2.5 bighas. The second one has been taken for a 3–years lease (taka 50,000 have to be paid per year). In addition, he owes the first one. Earlier he used to cultivate Bighead and Mirror carp, but now he cultivates the mixed variety of fishes such as Mrigal, Katla, silver, and Ruhi. He appoints day laborers for Tk 250–300 per day to work in his ponds.

Their duties are to irrigate the pond with a pump, and clean the ponds and its surroundings. To clean a pond, it requires almost taka 800. He uses dust, rubbish of chaff, fertilizer, saline, and feed as foods of the fish.

*I have been engaged in fish farming for a long time. I do not bother in any natural disaster or by any other adversities. Drought is the main problem of this area and I take all the necessary precautions at the beforehand of this disaster. I rent a car to sell the fish at the entrepot of Sirajganj road. In a trip, the car carries 7/8 Mon (280/320 kgs) of fish. I collect the minnows from the hatcheries of Sreekrishnapur and Nimgachi at a price of taka 6,000 per Kg. The hatcheries provide oxygen in the polyethylene that is used to carry the minnows. I release that minnows to my pond. Besides fish farming, I do stock business and agro-farming. I cultivate Irri paddy in my 10 bighas of land. But the ultimate income comes from the fish farming. I got training on fish farming from the Upazila Fishery office.*

*- A Fish Farmer*

As a protection against natural disasters, he has elevated the surroundings of the pond to the height that exceeds the highest mark that the pond water reaches every year. Now his ponds and fishes remain safe. However, if there is any hint of an excessive rising of the water level, he puts net and bamboo fence around the pond so that fishes cannot go out. In the cold wave, fishes grow slow. That is why they provide less amount of feed to the fish because even more feed cannot ensure the growth of the fish. In an excessive heat, gas increases in the water and the application of fertilizer in the pond boosts the gas level. Therefore, he does not use fertilizer in the warm condition. The increase in the gas can kill the pond fish. To increase oxygen level during the warm, he uses oxy flow, drinking saline, oxygen liquid, and lime in the pond. If the water dries up in an excessive heat, he irrigates the pond with a shallow machine. He thinks that the fish suffers no damage because of the hail storm.

**Petty Business and Trading:** Samad Miah trades rice, rice flecks, oil cake, and chaff. He said that the business runs well from the months of Poush to Baishakh. Nevertheless, in the time of harvesting, the business degrades because of the ample supply of paddy and rice. From Jyestha to Agrahayan, the land goes under water and thus cultivation is hampered. People need to buy food from the market because their stocked food is consumed already. That is why the demand for rice rises during that time and he can trade a very good deal of rice. However, during flood his business goes dull as the transportation is hindered and people cannot reach the market to buy food. During flood, he keeps the goods in a safe stock and makes the shop firmly. He mentioned that his business is not hampered much by the disasters such as cold wave, excessive cold, and drought or excessive heat. He further added that kalboishakkhi damages shops and compels them to sell goods at a low price.

He admitted that there was flood in the area during 2004 and 2007. Though some nearby houses were affected, his house was safe because of its higher elevation, but the crops were damaged.

**Farm based Wage Employment and Daily Laborer:** One of the day laborers admitted that there is no employment in the firm lands during flood or rainy season. He does fishing at that time. From the months of Asar to Kartik, he does fishing in the beel. He has fishing rod to catch fish. He has a boat to use for this purpose.

Severe cold is not hazardous rather favorable to his occupation of a day laborer. However, in excessive heat, it seems very difficult to work in the field. He has to work from 7 am, but at 12 pm it seems very difficult to work in the excessive warm condition. Nevertheless, has no other option than work to run his family. He said that if he gets ill because of an excessively high or low temperature, he must take a loan. He has to pay that loan with his next earnings. Every year, from BRAC, he takes taka 20,000 as a loan for buying cattle, but with that money he buys the total rice needed for the whole year. He does this because the price of rice may rise in the course of the year and his income may fall as well. He takes some help from the relatives and takes a new loan as soon as pays the previous one.

> *I do farming besides the business. If I have to face any loss in business, I can recover that loss with farming. My wife looks after my cattle and poultry farming. Farming these is not a big challenge. But during flood, these animals get affected. Then I sell out the hens. In the winter cows suffer from foot and mouth disease (FMD). In the rainy season, my business runs very well. Because at that time, people who do cattle farming cannot bring those out of the shed and have to feed those with oil cake and chaff and I can sell those items a lot.*
>
> *- A Fish Farmer*

He has 20–22 poultry. His wife looks after the poultry. Rearing these is not a tough job. If there is any chance of flood, he sells the hens keeping the ducks. He said that when there is a scarcity of work, he leaves the area for 'Keyar Desh' (a distant area) in search for work. He works there for 15–20 days. There he has to pluck onion and garlic from the field and earns taka 250 a day along with free food and housing. Most of the time he goes to Tangail alone. During the flood of 1988, his house went under water and he had to take shelter in Sandra Primary school for almost a month. His family got rice as the relief from the UP office. However, other food stuff had to be managed by them. During the time of flood, he can earn very little.

## ASSESSING CLIMATE RISKS IN PORSHA UPAZILA

### Climatic Hazards in Porsha

The analysis regarding natural disasters of Porsha upazila of Naogaon district reveals that the main disasters of this area are drought/heat wave, hailstorm, thunderstorms, northwester and cold waves. According to the local populace, these disasters bring about great losses for their land, harvest, natural resources and human lives every year. Separate FGDs were conducted with the local people, members of the UP and the Union Disaster Management Committee from six unions of Porsha upazila: Chaor, Ganguriya, Ghatnagar, Tetulia, Nitpur and Moshidpur. After collecting and analyzing information obtained through FGDs the scenario of the mostly occurred disasters and jeopardies of Porsha is as follows.

**Table– 5.4: Major Climatic Hazards in Porsha**

| Union | Drought | Hailstorm | Thunderstorm | Northwester | Cold Wave |
|---|---|---|---|---|---|
| Chaor | √ | √ | √ | √ | √ |
| Ganguriya | √ | √ | √ | √ | √ |
| Ghatnagar | √ | √ | √ | √ | √ |
| Tetuliya | √ | √ | √ | √ | √ |
| Nitpur | √ | √ | √ | √ | √ |
| Moshidpur | √ | √ | √ | √ | √ |

**Drought:** Drought hits when there is inadequate rainfall for a long time. Drought occurs when the evaporation and transpiration rate of an area is higher than that of local rainfall, drought occurs. During drought it becomes very hot and humid, water reserves such as streams, wells etc. get dried up and usable water gets very scarce. Along with these river flow gets hampered, corps start dying, underground water level decreases, and cattle suffer from the shortages of food. Drought is a big problem for the people who are dependent on farming and cattle husbandry for their livelihood. Sandstorms and arsons caused by the droughts often bring about great destructions in the locale.

In Bangladesh, if the moisture of the farmlands is lower during the crop season, it is called a drought. The Barind Tract areas of Bangladesh are often afflicted by this disaster. Many times, famines follow as a direct consequence of drought. The infallible indicator of drought is the burning out of the joints of Bamboo shoots and Betel Nut trees. They also start losing their green leaves. As the land loses its moisture, the new leaves turn pingle. If rainfall does not occur for a long time and the trees are not hydrated enough, more often than not, the trees die out.

In the recent decades, frequent occurrences of droughts have become a characteristic of the Barind Tracts (Barendra vumi) of Bangladesh. The Barendra area consists of Dinajpur, Rangpur, Pabna, Natore, Rajshahi, Bagura, Joypurhaat and Naogan districts. The general rate of rainfall is lower in this area compared to other areas of Bangladesh. The average rainfall in this area is 1,971 mm, which usually occurs during the rainy season. The rate of rainfall varies based on locale and year. During summer, the temperature of this area remains between 35° and 25° centigrade and during winter it hovers between 12° and 15° centigrade. This older sediment area has retained an extreme weather pattern in comparison with other areas of the country.

From the aspect of Meteorologists, droughts can be separated into three categories: permanent Drought; which is a property of a dry weather; Seasonal Drought, which happens due to the discrepancies in the general pattern during the rainy and winter seasons; and Hazardous Drought, which happens due to irregular rainfall. For Bangladesh, the latter two are the more common occurrences.

In Porsha upazila drought or heat waves hit from the months of Chaitra to Vadro. The biggest disaster of this area is drought. Problems such as fire due to overheating, drying up of water reserves, food shortages for both humans and animals, water scarcity, drying up of tube wells, and lack of preparing seedbeds become prevalent during drought. Poor people are mostly affected by drought. Besides these diseases such as viral fever, heat stroke, diarrhea, jaundice, and skin diseases become very prevalent. Thus, daily life of people gets arduous.

**Hailstorm:** Usually during the months of Boishakh and Joishtho, this upazila faces a lot of hailstorm. Because of such storms, seedbed, watermelons, potato, paddy, and mango are heavily damaged and perished. The hailstorms also damage the husk and tin roofs of houses. The poor people endure the most of the damage caused by hailstorms. The hailstorms turn poor people into even poorer by causing devastation across the land. They are mostly harmed when their harvest is damaged by the hailstorms.

**Thunder Storms:** Thunderstorms are the newest addition in the list of natural disasters of Bangladesh. According to specialists, Bangladesh has been recognized as a thunderstorm risk country due the increased rate of thunder strikes. The disaster Forum works regarding the Thunderbolts. According to their latest report, 36 people died by thunderbolts (until 4th April). In 2015, 186 people lost their lives, including 40 children, 28 women and 123 men. In 2014 the numbers were 39 children, 28 women and 148 men; totaling up to 210 people. In 2013, 285 people lost their lives, amongst them 55 were children, 53 women and 177 men. In 2012, 301 people were killed; 61 of them were children, 50 women and 180 men. The organization prepared this report using information from various news–media. According to the information of 2015, Chapainobabgonj, Kishorgonj, Lalmoninrhat, Sunamgonj, Satkhira, Dinajpur and Brahmanbariya had experienced the most thunderstorms. The climate experts have attributed this increased number of thunderstorms to continuous hot weather with heavy humidity, the boundless increase of the temperature of the land mass and sea–level and extreme levels of environmental pollution. Because of climate change, the clash of momentous cold and hot winds has increased their strengths.

As a result, the thunderbolts are increasing. The environmental scientists opine that a little rain or gusts of strong winds are creating thunderstorms. They are citing the abundance of black clouds as the reasons for this. The increase of Nitrogen and sulfur in the air has resulted in the increase of the black clouds. The sulfur is increasing because of the climate change.

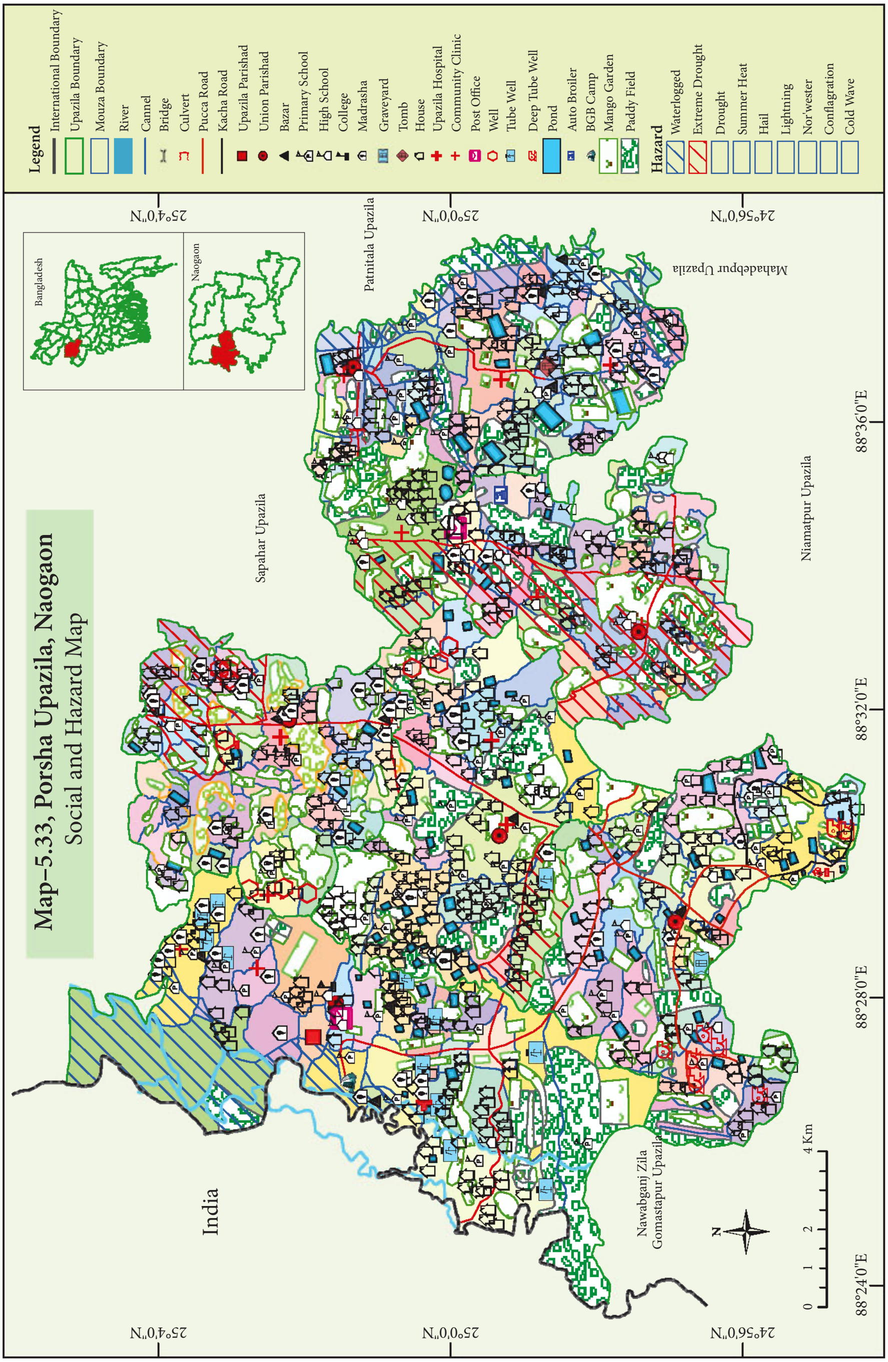
During the Joishtho and Ahsar, this upazila is afflicted with thunderstorms. Because of the Thunderbolts, trees, cattle and people lose their lives. The tin roofs, palm trees and electrical pillars are damaged. The people of the locality build their houses with cheap materials. They are very much affected in the thunderstorms.

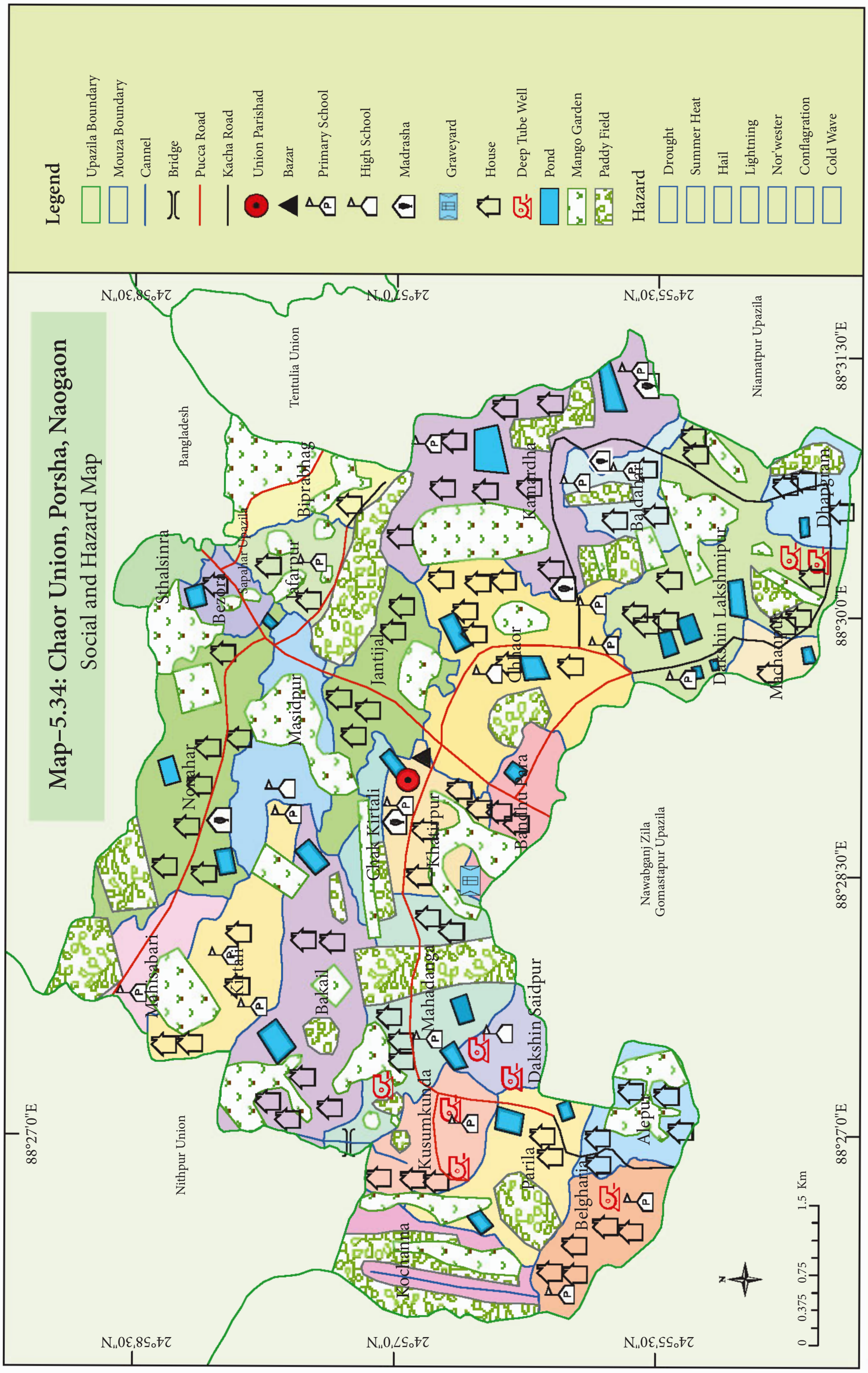
**Norwester:** The usual season for the northwester is during the months of Boishakh and Joishtho. According to the local people, northwester destroys households, electric supply pillars and trees. They uproot trees and as a result, streets are damaged, electric supply is hampered. Local people consider the gathering of black clouds in the sky as the warning signs of the impending northwester.

**Cold Wave:** According to the Bengali Calendar, the winter season is supposed to be during the months of Poush and Maagh. Nevertheless, in reality, the cold wind starts blowing from November and carries on until February. Around this time, the sun shines from the Southern hemisphere so the rays of the sun falls crookedly on the earth, resulting in lower temperature. In the month of January, the average temperature of the northwestern region of the country begins from 11°Celsius and it goes up to 20°–21° Celsius in the Bay areas. The Cold is more intense in the Northern areas compared to the southern areas of the country. During intense cold waves, people lose their lives in the northern regions of the country.

During the months of Poush and Magh, this upazila faces intense cold waves. Because of this, the saplings in the seedbeds die, the aviary faces death streaks, and the cattle become sicker. Local people are at the most risk during the cold waves. Specially children and older people suffer most during those times and sometimes meet their demises even.

## Social and Hazard Map of Porsha




Map-5.34: Chaor Union, Porsha, Naogaon
Social and Hazard Map
Legend
Upazila Boundary
Mouza Boundary
Cannel
Bridge
Pucca Road
Kacha Road
Union Parishad
Bazar
Primary School
High School
Madrasha
Graveyard
House
Deep Tube Well
Pond
Mango Garden
Paddy Field
Hazard
Drought
Summer Heat
Hail
Lightning
Nor'wester
Conflagration
Cold Wave
Bangladesh
Tentulia Union
Niamatpur Upazila
Nawabganj Zila
Gomastapur Upazila
Nithpur Union
Sthalsinra
Bezora
Jafarpur
Biprabhag
Kamardha
Baldahar
Dhanpram
Dakshin Lakshmipur
Machaipur
Chhaor
Jantijal
Masidpur
Nowahar
Chak Kirtali
Khatirpur
Bandhu Para
Mahisabari
Kirtali
Bakail
Mahadanga
Dakshin Saidpur
Kusumkunda
Parila
Alepur
Belghari
Kochanna
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24°57'0"N
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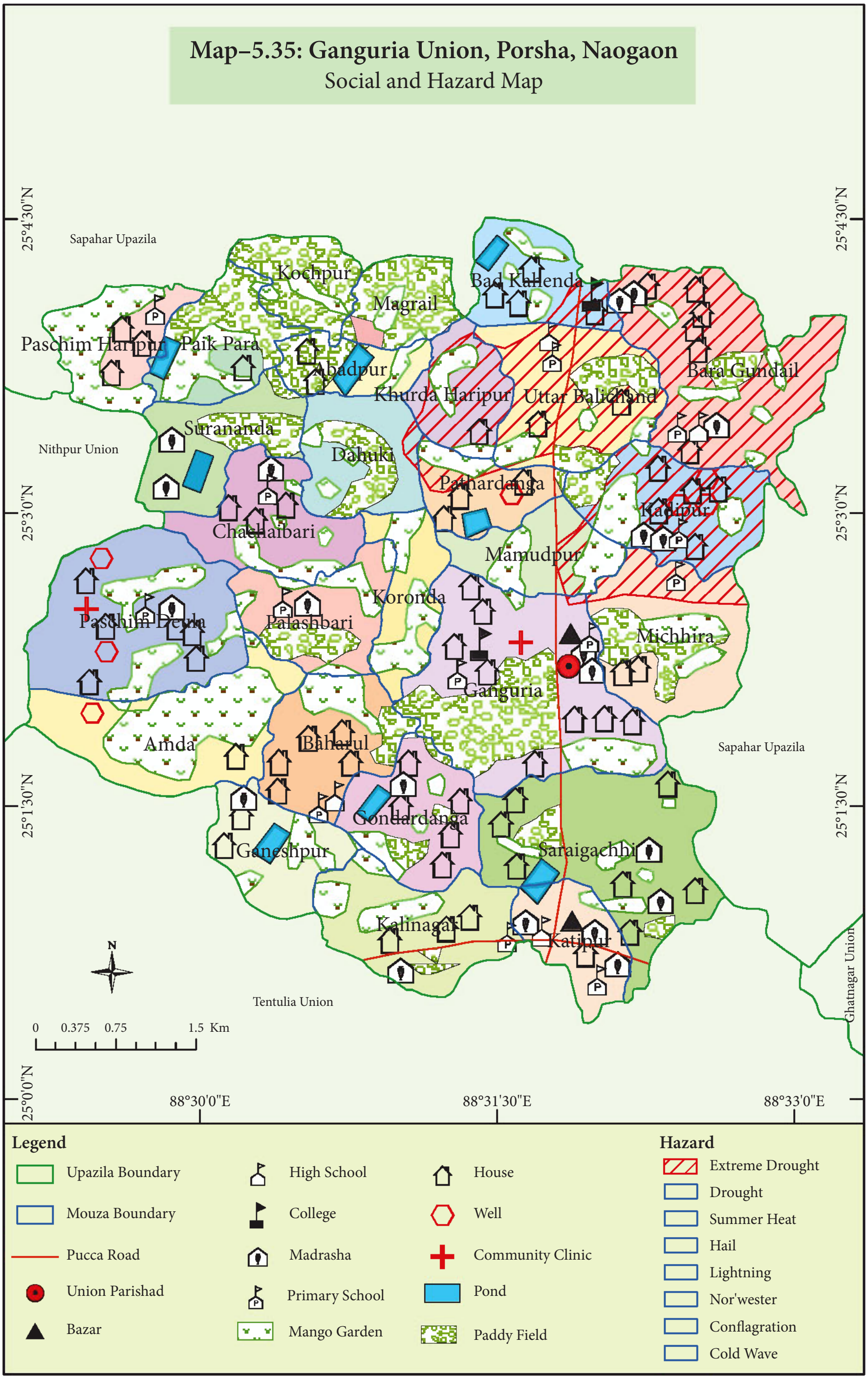
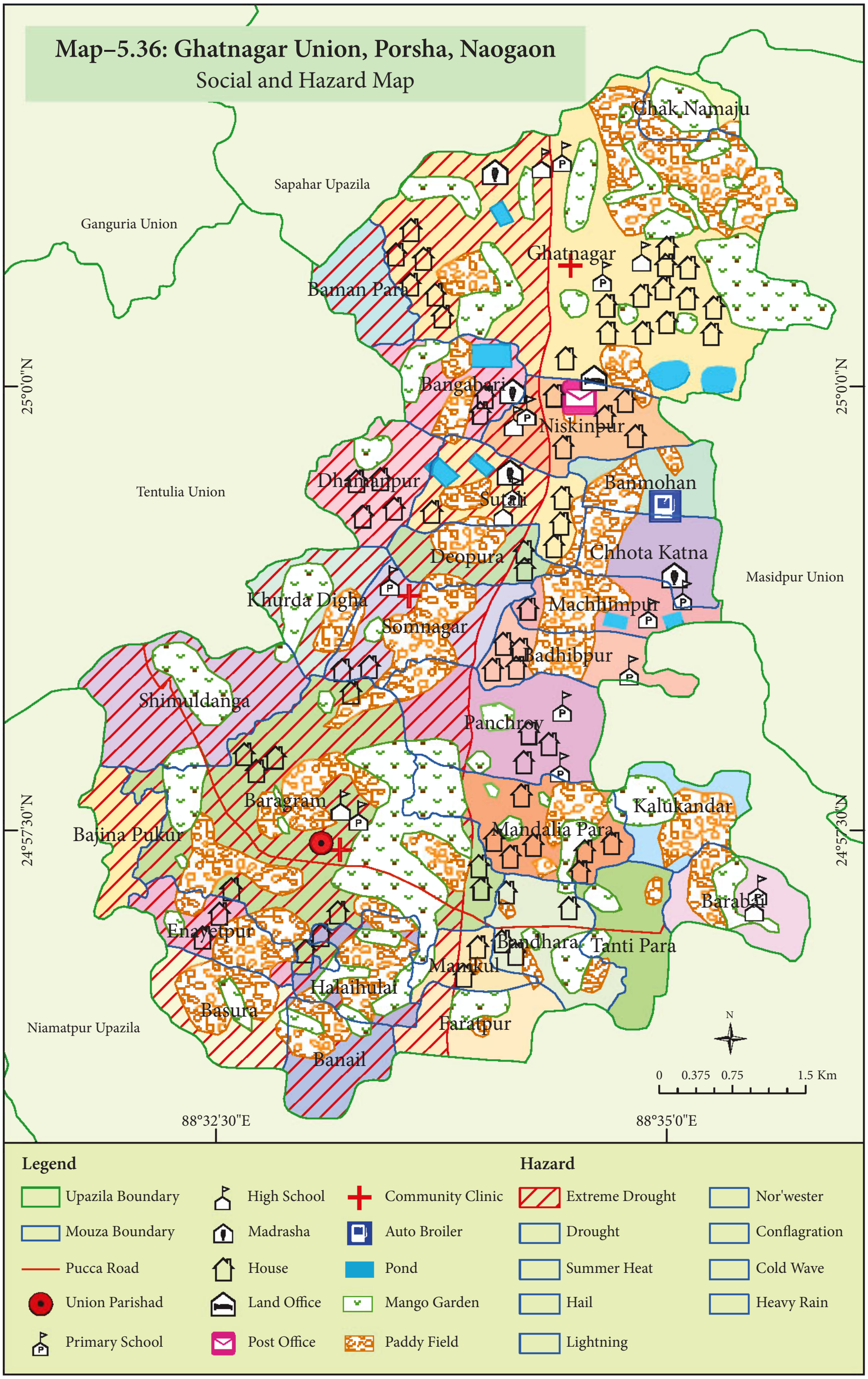
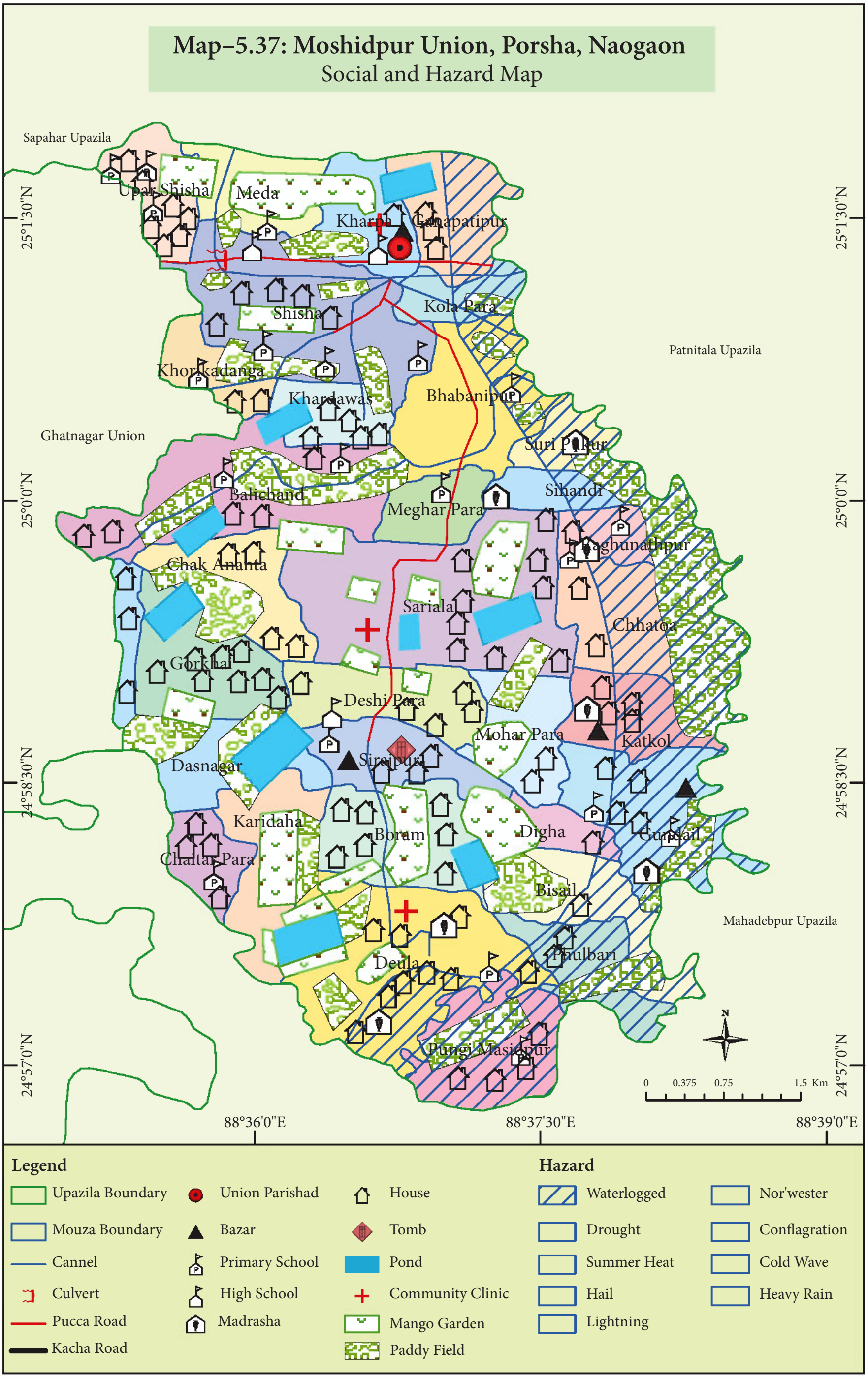
88°28'30"E
88°30'0"E
88°31'30"E
0 0.375 0.75 1.5 Km
N

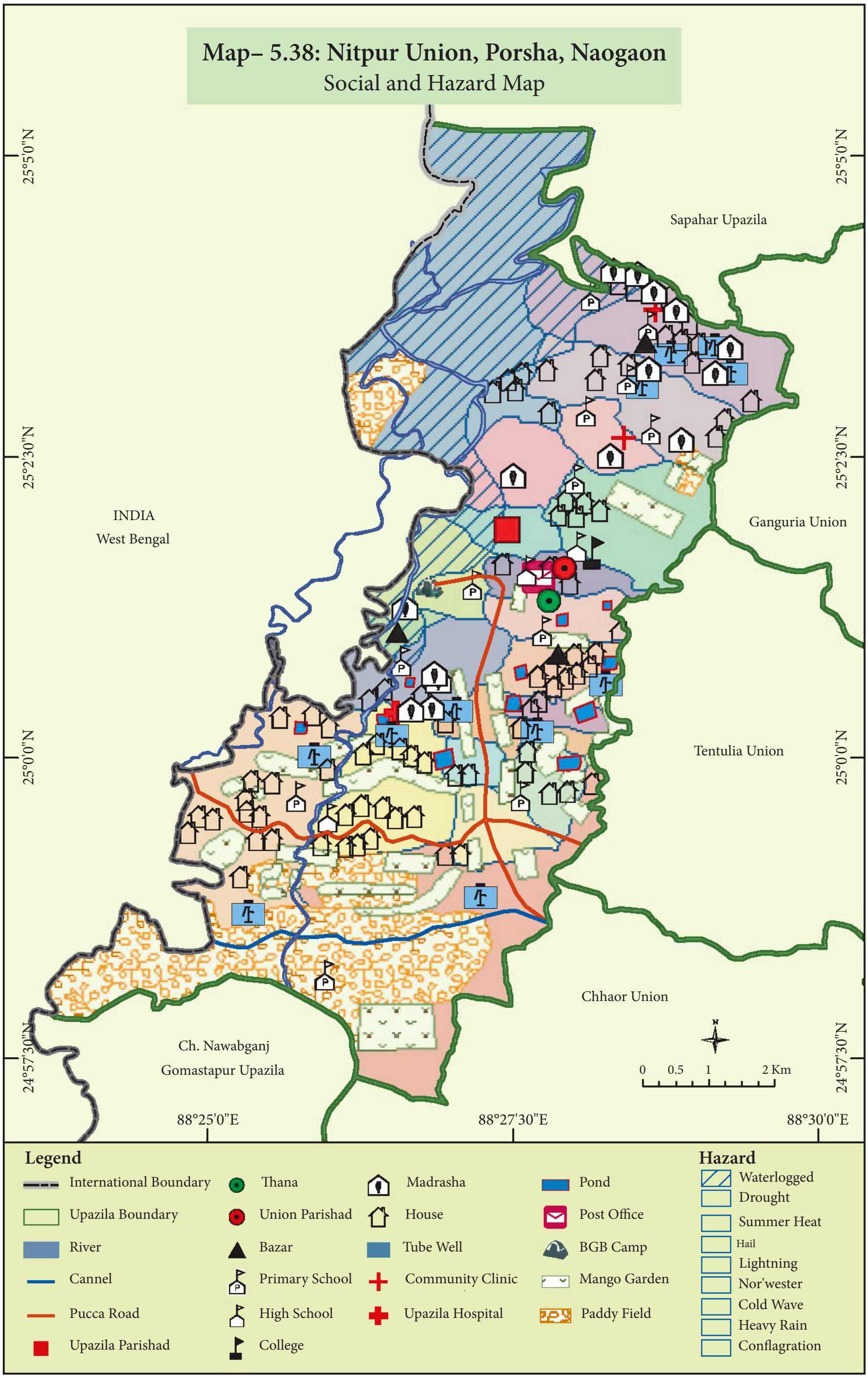


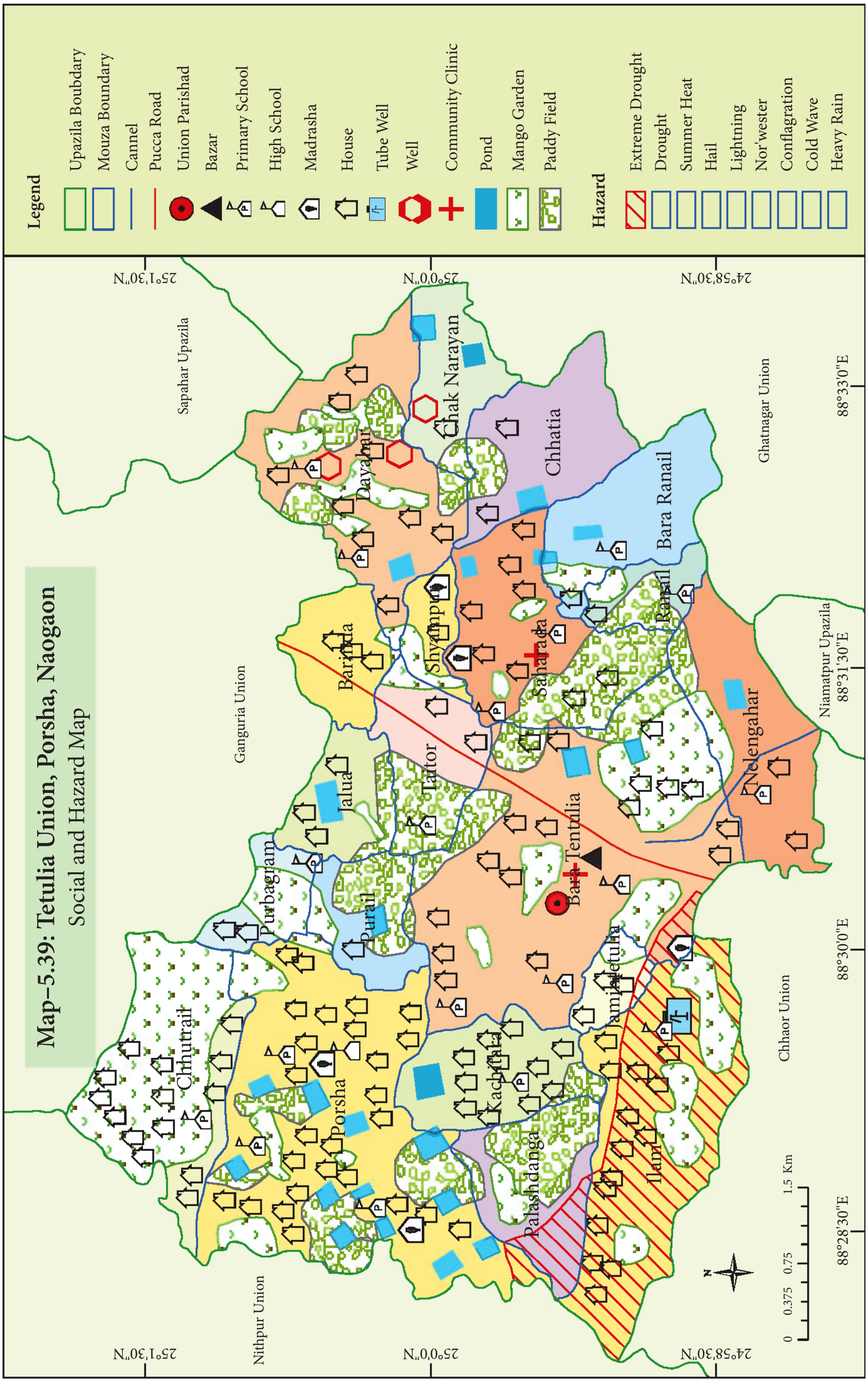

**Map–5.35: Ganguria Union, Porsha, Naogaon**
Social and Hazard Map



Map–5.36: Ghatnagar Union, Porsha, Naogaon
Social and Hazard Map
Sapahar Upazila
Ganguria Union
Tentulia Union
Masidpur Union
Niamatpur Upazila
Chak Namaju
Ghatnagar
Baman Para
Bangabari
Niskinpur
Dhamarpur
Sutali
Banmohan
Deopura
Chhota Katna
Khurda Digha
Machhimpur
Somnagar
Badhibpur
Shimuldanga
Panchroy
Baragram
Kalukandar
Bajina Pukur
Mandalia Para
Barabil
Enayetpur
Bandhara
Tanti Para
Mankul
Halaihulai
Basura
Faratpur
Banail
25°0'0"N
24°57'30"N
88°32'30"E
88°35'0"E
N
0 0.375 0.75 1.5 Km
Legend
Upazila Boundary
Mouza Boundary
Pucca Road
Union Parishad
Primary School
High School
Madrasha
House
Land Office
Post Office
Community Clinic
Auto Broiler
Pond
Mango Garden
Paddy Field
Hazard
Extreme Drought
Drought
Summer Heat
Hail
Lightning
Nor'wester
Conflagration
Cold Wave
Heavy Rain


Map–5.37: Moshidpur Union, Porsha, Naogaon
Social and Hazard Map
Sapahar Upazila
Upar Shisha
Meda
Kharpa
Ganapatipur
Shisha
Kola Para
Khorkadanga
Khardawas
Bhabanipur
Patnitala Upazila
Ghatnagar Union
Suri Pukur
Balichand
Sihandi
Meghar Para
Raghunathpur
Chak Ananta
Sariala
Chhatoa
Gorkha
Deshi Para
Mohar Para
Katkol
Dasnagar
Sirajpur
Karidaha
Boram
Digha
Gundail
Chaitar Para
Bisail
Mahadebpur Upazila
Deula
Phulbari
Pungi Masidpur
25°1'30"N
25°0'0"N
24°58'30"N
24°57'0"N
88°36'0"E
88°37'30"E
88°39'0"E
N
0 0.375 0.75 1.5 Km
Legend
Upazila Boundary
Mouza Boundary
Cannel
Culvert
Pucca Road
Kacha Road
Union Parishad
Bazar
Primary School
High School
Madrasha
House
Tomb
Pond
Community Clinic
Mango Garden
Paddy Field
Hazard
Waterlogged
Drought
Summer Heat
Hail
Lightning
Nor'wester
Conflagration
Cold Wave
Heavy Rain


Map– 5.38: Nitpur Union, Porsha, Naogaon
Social and Hazard Map
25°5'0"N
25°2'30"N
25°0'0"N
24°57'30"N
88°25'0"E
88°27'30"E
88°30'0"E
Sapahar Upazila
INDIA
West Bengal
Ganguria Union
Tentulia Union
Chhaor Union
Ch. Nawabganj
Gomastapur Upazila
N
0 0.5 1 2 Km
Legend
International Boundary
Upazila Boundary
River
Cannel
Pucca Road
Upazila Parishad
Thana
Union Parishad
Bazar
Primary School
High School
College
Madrasha
House
Tube Well
Community Clinic
Upazila Hospital
Pond
Post Office
BGB Camp
Mango Garden
Paddy Field
Hazard
Waterlogged
Drought
Summer Heat
Hail
Lightning
Nor'wester
Cold Wave
Heavy Rain
Conflagration


Map-5.39: Tetulia Union, Porsha, Naogaon
Social and Hazard Map
Legend
Upazila Boubdary
Mouza Boundary
Cannel
Pucca Road
Union Parishad
Bazar
Primary School
High School
Madrasha
House
Tube Well
Well
Community Clinic
Pond
Mango Garden
Paddy Field
Hazard
Extreme Drought
Drought
Summer Heat
Hail
Lightning
Nor'wester
Conflagration
Cold Wave
Heavy Rain
Sapahar Upazila
Ganguria Union
Nithpur Union
Ghatnagar Union
Niamatpur Upazila
Chhaor Union
Chhutrail
Purbagram
Porsha
Purail
Jalua
Barinda
Tator
Shyampur
Dayamir
Chak Narayan
Chhatia
Bara Ranail
Ranail
Saharada
Bara Tentulia
Nelengahar
Jamjetulia
Kachhitala
Palashdanga
Ilam
25°1'30"N
25°0'0"N
24°58'30"N
88°28'30"E
88°30'0"E
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0 0.375 0.75 1.5 Km
N

## Vulnerabilities of Livelihood Groups

Due to climate change, different types of occupation and livelihood groups of people suffer from various natural hazards. To understand the pattern of risks and vulnerability several key informant interviews have been conducted with a number of occupation and livelihood based groups of Porsha upazila. The following is a discussion based on these interviews.

**Agriculture and Farming:** Abul Hossain said that he faces various risks during natural disasters such as not finding enough water to irrigate the farms during drought. This causes him less production and less profit. There are other problems connected to this. Some of these include difficulty to sell his produce, high transportation cost, scarcity of labors, difficulty to store the products in government storages, no access to government subsidies, and impurities in the fertilizers. Abul Hossain mentioned that natural disasters bring about far more destruction than anything else does. He said that during drought, the farms are irrigated with water from deep tube wells, using the pond water through power engines, and the laborers have to be paid more. To cope up with extra costing, he has to choose a cheaper ox–drawn cart to transport his produces. He said that more people are dying due to thunderbolts, and during droughts, it is difficult to grow crops without any moisture in lands. On the other hand, excessive rainfall damages the crops. These extreme situations also damage the production of fruits such as mangoes and jack-fruits.

He also mentioned that hailstorms destroy paddy, mango and watermelons. The northwester damages the paddy crops and mangoes are nipped. During winter, the seedbeds are damaged and the mango flowers are nipped. Several protective measures are taken by him such as covering the roots of mango trees with hay and leaves, using cow urine as insecticide, covering the plants with ashes in extremely cold weathers, and irrigating the paddy fields. He said that farming techniques have been changed over the years. He used to utilize cows to farm, now he uses tractors to dig the lands. He also uses TSP, urea, Potash etc. as fertilizers. He thinks that science has increased the yield of productions. He cannot store his produces in the government storages. If he could do so, he would have received a fair price for his harvest. He also thinks that one cannot change the natural disasters. These disasters cause damage to the harvest and decrease the yield. By losing almost everything, people like him have to take loan from NGOs and other people with a high interest. Due to the lack of irrigation, there is a lack of natural resources such as grazing fields for cattle. This leads to a lack of bio–fertilizer. He mentioned that local administration provides them only suggestions and token plots.

**Fish Farming and Fishermen:** One of the fishermen from Moshidpur said that both excessive rainfall and lack of rainfall are troublesome. Excessive rainfall washes the fishes away and drought causes the water bodies to dry up. In both cases, fishes have to be sold in a lower price as the collection of fishes and price goes down. There are other problems such as gases in the pond, death streak in the fishes, scarcity of fish larvae and lack of resources. There are problems of leasing the ponds as well. If they lease the pond, they will have to pay for it, even if the fishes die out and that causes a lot of loss. They have to face these problems and some of the solutions include fencing the ponds with nets during flood, applying gas tablets in the ponds, mixing salt and saline in the ponds, and leasing the ponds based on its history of drying up. He understands climate change as the drying up of ponds, inability to farm fishes, death of fishes, and losing oxygen. He said that when the ponds dry up, fishes have to be sold out at a very lower price. Sometimes the fishes have to be sold even long before they reach the desired size. In such situations, he opts to farm the breeds that can survive in shallow water. Fish breeds such as African Catfish and telapia are ideal for situations like this. He also takes various initiatives to run the fish farming smoothly. He hits pond water with bamboo to increase its oxygen level, release excessive water from pond, fencing the pond, dropping banana trees in the ponds to get rid of gases, applying calcium caliphate in the water, and filling the pond with water from the deep tube well when the water level goes down.

He also said that today they know techniques for their work. Nevertheless, they have limited support from different government officials. According to him, there are problems with the government ponds allocated politically. He mentioned that they do not receive government or non–government trainings on the cultivation and trade of fish. They gather advice from experienced fishermen and people who run the drug store. He thinks that there is no way to save this business, so, after the ponds dry out, they go for sharecrop and farms on his own land. He said that fishes do not get much natural food.

*I have seen it before, if you do not feed the fishes they do not grow up. It means that there is a lack of natural food in the pond. If it does not rain in time, if the water is low, then the fish has less food in the water. Getting help from the government office is both time-consuming and costly. I have no pond of my own. Only rich people own them. Because of that, we have to depend on the mercy of others to survive.*

*- A Fish Farmer*

**Farm based Wage Employment and Daily Laborer:** Shabbir, a day laborer from the Chaora union, said that drought forces him to work less. It is the cause of his less income and poverty. In addition, he cannot buy necessary things from the market due to his extreme low wage. He does not get work throughout the year. The months of Ashwin Kartik lack opportunities for work. Therefore, he has to borrow money for his family. He also has to seek help, borrow money from his relatives, and go to other places in search for work. During excessive rainfall, heat and cold he has to suffer a lot. During the months of Ashwin and Karthik, he has to go to Dhaka to look for labor works. He had been working the fields since his childhood and he had learnt this work from his father. He said that he has no way of coping with the natural disasters and as a result, he has to go to other areas.

**Mango Cultivation and Trading:** Tota Mia, a mango trader, said that natural disasters cause damage to the mangoes and reduce its yield. Excessive attack of insects destroys the harvest. The full lease of the mango orchard has to be paid to the owner. Besides, the high cost of transportation, less price and illegal racketeering take away their profits. Therefore, they have no other alternatives than taking out loans at an exorbitant interest. He had to apply poisons to the orchards so that his fruits are not eaten by bats and insects. Due to hailstorms, the mangoes are ruined and the northwester destroyed the trees, branches and the fruits. Most of the times the trees do not survive the damages. Moreover, there is nothing left to do when the mango flowers are nipped because of the extreme cold wave.

He mentioned that the mango farming is new here. Very little care produces good crops. The mangoes are tended with medicines such as Gain, Super Mastan, and Syngenta, etc. both during and after the mangoes are picked. Older forms of tending such as trimming the branches and protecting the roots are also utilized. Although hay is used to package, the bamboo baskets have been replaced with modern day plastic. He noted that the general traders do not have any traction in the bidding of the government orchards, and people of political influence are the only ones who can take part in the government bidding.

Other mango traders like him take counsel from experienced traders. The traders arrange meetings to decide the selling price of mangoes and the buying price of the orchard. A political identity will lead to lesser payment in the transportation racket. He said that one cannot protect the mangoes if there are natural disasters such as drought, northwester, hailstorm and cold wave.

**Off–Farm Employment:** Date sap collection is the livelihood for several informants. The key informant said that he stops collecting the saps from the trees when the natural disaster hits. It is a common practice among other collectors. He only gathers the sap during winter. To collect it one shears, bucket and ropes. He said that no political problems has to be faced while collecting saps as it has demand among people from all the walks of life as well as the demand is going up. He mentioned that if rainfall comes after clearing the roots of the trees in winter, the likelihood of the trees dying increases. He thinks that frequent disasters will put this profession in danger and look for other works.

The informants, involved in masonry and brickwork, say that during drought there is a great lack of water. The excessive heat makes working miserable. He also pointed out some of the troubles they face are lack of works due to the aftermath of the disasters, low pay, high costs, carrying water from distant places, and migrating to Dhaka in search for work. He employs both new and old techniques of trade. He uses machines to cut rods, breaking bricks and cementing the floors. He thinks that the masonry works opportunities are significantly reduced after the disasters because people are economically in danger.

**Rickshaw and Van Puller:** Ronju said that he had been operating the vans for a long time. He used to operate a paddle van, but now, he uses the machine driven auto rickshaw. It is not suitable to ride on the narrow and muddy roads of the village areas and is susceptible to damage. The auto rickshaw has of course decreased his workload, but has increased his expanse on the vehicle. Because during heavy rain the charge of its battery goes down for riding on slippery roads and costs him extra money to recharge. He had to borrow money to buy the auto van and the interest rate is very high. Therefore, he has to work in all sorts of hazardous weather. He has to take out extra loans to pay off the loan for the van. He stated that during the disasters, roads are blocked due to uprooted poles and trees, which stop him from taking fares. They do not get any help from the government.

*Image–14: Riverbank Erosion (Photograph by S M Mahfuzul Islam Rahat).*

*Image–15: Dry Season (Photograph by S M Mahfuzul Islam Rahat).*

*Image–16: Drinking Water Collection from Inside the Sandy Bank (Photograph by Mohosin Kabir).*

Chapter Six

# Policies, Institutions and Finance

## PRELUDE TO CLIMATE POLICY

Government adopts a range of policy instruments to achieve their mandates and objectives. These policy instruments are of three categories: economic instruments, legislative and regulatory instruments and information instruments (Bemelmans-Videc 1998; Bemelmans-Videc, et al. 2011). According to Howlett, these three sets of instruments underplay the importance of a fourth category: the government provision of goods and services (Howlett 2011). Government make use of a mix of all four types of instrument while addressing climate change mitigation and adaptation (Miller 2013). All these components of public policy on climate change have respective vital roles to play in effectively limiting the negative impacts of climate change and building resilience to climate risks. Moreover, apart from the policy interventions to address the primary objective of mitigation or adaptation to climate change, the relevant and supportive sectoral policies may have important benefits or costs on climate change outcomes.

MoEF has taken the lead in setting policy agenda for climate change in Bangladesh, although climate change impinges on the responsibilities of a wide range of other Ministries and agencies. In response to international treaties, protocols and programs Bangladesh has been a significant participant in the following:

- Signed the UNFCCC on June 9, 1992 and ratified it on April 15, 1994
- Accessed the Kyoto Protocol on August 21,2001
- Participated in the US Climate Change Country Study Program and prepared its emission inventory and vulnerability assessment in 1994
- Participated in the Asia Least Cost Green House Gas Abatement Strategy (ALGAS) Study in 1995-98
- Submitted the first National Communication to the UNFCCC in 2002
- As being an early mover (Heger 2011), Bangladesh has completed submitted the NAPA to the UNFCCC in November 2005. The NAPA was prepared by the MOEF as a response to the decision of the COP7 of the UNFCCC.
- The NAPA was updated in 2009 that prioritized nine short-term and nine long-term adaptation programs. A priority program– Community Based Coastal Afforestation– was funded by UNFCCC's Least Development Countries Fund (LDCF).
- Bangladesh as one of the 18 priority countries has been included under the United States Government (USG)'s Low Emissions Development Strategies (LEDS) program and received support under the Enhanced Capacities for Low Emissions Development Strategies (EC-LEDS) program.
- Bangladesh holds alternate memberships of the GCF Board and Adaptation Fund Board.
- Established a two tier Designated National Authority (DNA) including the National Clean Development Mechanism (CDM) Board and Committee under the CDM change and development.
- Bangladesh was elected as the Vice Chair of the Rio+20 Conference. Bangladesh is also an Alternate Member of the CDM Executive Board. In addition, Bangladesh is a member of the UNFCC's GCF, Adaptation Fund Board, Adaptation Committee, Compliance Committee, and Consultative Group of Experts.

Bangladesh has been a participant in the UNFCCC process from signature in June 1992, ratification in 1994 and in the Kyoto Protocol since 2001. The GoB submitted the Initial National Communication (INC) to UNFCCC in October 2002. The country has increasingly become a significant player in the UNFCCC negotiations, as the largest Least Developed Country (LDC) with special status and with a strong voice. The country has developed national positions across the range of international negotiation issues through the Climate Change Unit in the MoEF and with the support of several policy institutes. Its position is aligned closely with other LDCs. Bangladesh gave a statement on behalf of the LDCs to the United Nations General Assembly (UNGA) in February 2008 arguing for immediate support to LDCs for climate change. Bangladesh operates within the SAARC group with aims for South Asia to be a world leader in climate resilience. The third Climate Vulnerable Forum, immediately before the UNFCC Durban Conference of the Parties (CoP) was held in Dhaka in November 2011 with many country leaders attending. In addition to MoEF, other Ministries, Members of Parliament, policy institutes, NGOs and journalists from Bangladesh are increasingly participating in the main CoPs with key messages and clear negotiation positions. These international events on climate change governance had an influence over climate change planning in Bangladesh.

## NATIONAL CLIMATE CHANGE POLICY AND LEGAL FRAMEWORK

There are more than 200 laws and by-laws exist to address environmental related issues in Bangladesh. Strategies and policies are in place. The Government of Bangladesh (GoB) realizes that good public policy needs to be complemented by investments to ensure implementation. The 7th Five Year Plan (FYs 2016-2020) will be the vehicle for implementing the Perspective Plan (2010-2021) of the Government of Bangladesh (GoB 2012b; GoB 2016). The Perspective Plan envisages that, by 2021, the poverty will largely be eradicated and the country will have crossed the middle-income threshold on a sustainable basis without damaging the environment. Yet, investments in the Environment, Forestry and Climate Change (EFCC) sectors have suffered from a lack of coherence and articulation owing to ineffective finance architecture. However, in 2016, the country has developed a Country Investment Plan (CIP), a formal framework, to link environmental, forest, and climate change policies to the investments needed to achieve the desired time-bound results. The CIP provides a strategic framework for national and international investments for the EFCC sectors in Bangladesh and coordinate implementation in alignment with key legal and policy documents. Four investment areas have been identified: (1) sustainable development and management of natural resources; (2) environmental Pollution Prevention and Ecosystem Restoration; (3) adaptation, mitigation and resilience to climate change; and (4) environmental Governance, Gender & Human and Institutional Capacity Development.

The government strategy is to integrate climate change challenges and opportunities into the overall development plan and programs involving all sectors and processes for economic and social development. In the midst of global debate on climate forecasts and long-term global climate change predictions, Bangladesh is focusing on addressing the issue on short-, medium- and long-term bases. The country is showing global leadership in planning global climate change strategy, programs and activities. Led by the MoEF, the GOB not only recognized that climate change is both an environmental and a developmental issue, it has also made tangible commitments. The GOB under the leadership of the MoEF in 2005 prepared a National Adaptation Program of Action (NAPA), and updated this in 2009. Spurred on by Cyclone Sidr and with the stimulus of the Bali Action Plan, the GoB prepared the Bangladesh Climate Change Strategy and Action Plan (BCCSAP) in 2008/9 to provide strategic direction on climate change. The BCCSAP highlighted Bangladesh as a pioneer in adopting a comprehensive strategy. Since the development of the BCCSAP, the government strategy is to integrate climate change challenges and opportunities into the overall development plan and programs involving all sectors and processes for economic and social development. There is now growing awareness about the interrelationship between climate change and development. The GoB has also formulated country framework to mainstream climate risk management and adaptation. However, the key significant policy developments include:

- National Adaptation Program of Action (NAPA 2005 and revised 2009);
- Bangladesh Climate Change Strategy and Action Plan (BCCSAP 2009);
- Climate Change Unit in Ministry of Environment & Forests; and
- Climate Change focal points established in relevant ministries;
- Completed the CPEIR study;
- Prepared the Climate Protection and Development Budget Report, 2017-18;
- Introduced the Climate Change Trust Fund Act 2010 (CCTFA)
- Prepared the 7th Five Year Plan (2016-2020)
- Developed the Country Investment Plan for Climate Change (CIPCC) in 2016
- Among South Asian nations, Bangladesh was the first to develop the Nationally Determined Contributions (NDC) of Bangladesh and submit its INDCs (intended nationally determined contributions) to UNFCCC.
- Developed the Climate Fiscal Framework (CFF) to ensure that external and internal finances are used most effectively in addressing climate change.

The government strategy is to integrate climate change challenges and opportunities into the overall development plan and programs involving all sectors and processes for economic and social development. The GOB has also started implementing the strategy with the integration of climate change constraints and opportunities into the Seventh Five Year Development Plan (GoB 2016) and the GoB's Vision 2021 (GoB 2010; GoB 2012b). The 7FYP intends to mainstream climate change and the NDC is closely aligned with the 7FYP, which is designed to facilitate climate change mitigation and adaptation by promoting a whole-government approach to climate readiness, improving capacity, improving coordination and communication amongst key institutions and encouraging research (MoEF 2017b). The Government is developing sectoral action plans for the thirteen sectors set out in the 7FYP as part of its implementation. The MoEF will coordinate action on NDC implementation (see section 3) in close collaboration with the Planning Commission to ensure that climate considerations are integrated throughout the relevant 7FYP action plans.

**Table– 6.1: Cross-referencing between Climate Policy and the 7FYP**

| 7FYP sector | Link with NOC implementation | Nature of link |
|---|---|---|
| Industrial and Economic Services | NDC Industry Sector Action Plan | Ensuring that the expanding manufacturing sector is low carbon and energy efficient. |
| Agriculture | NAP | Encouraging low carbon practices in the sector and strengthening the sectors resilience to climate change |
| Power and Energy | NDC Power Sector Action Plan | Renewable energy and state of the art coal generation technology that minimizes the impact on the environment |
| Transport and Communication | NDC Transport Sector Action Plan | Modernizing the transport system, reducing congestion and encouraging lower carbon transport modes |
| Local Government and Rural Development | NDC Implementation Roadmap | Building the capacity of local governments can help support climate action at the local level |
| Environment and Climate Change | BCCSAP | The need to take into account environment, climate change adaptation and mitigation in a broader development context |
| Housing and Community Amenities | BCCSAP | Encouraging energy efficiency of residential sector |
| Health | NAP | Climate change affects the social and environmental determinants of health - clean air, safe drinking water, sufficient food and secure shelter' |
| Education and Technology | BCCSAP | Raising awareness of climate change and building capacity, technological capability etc |
| Social Protection | NAP | Disaster management and food security |

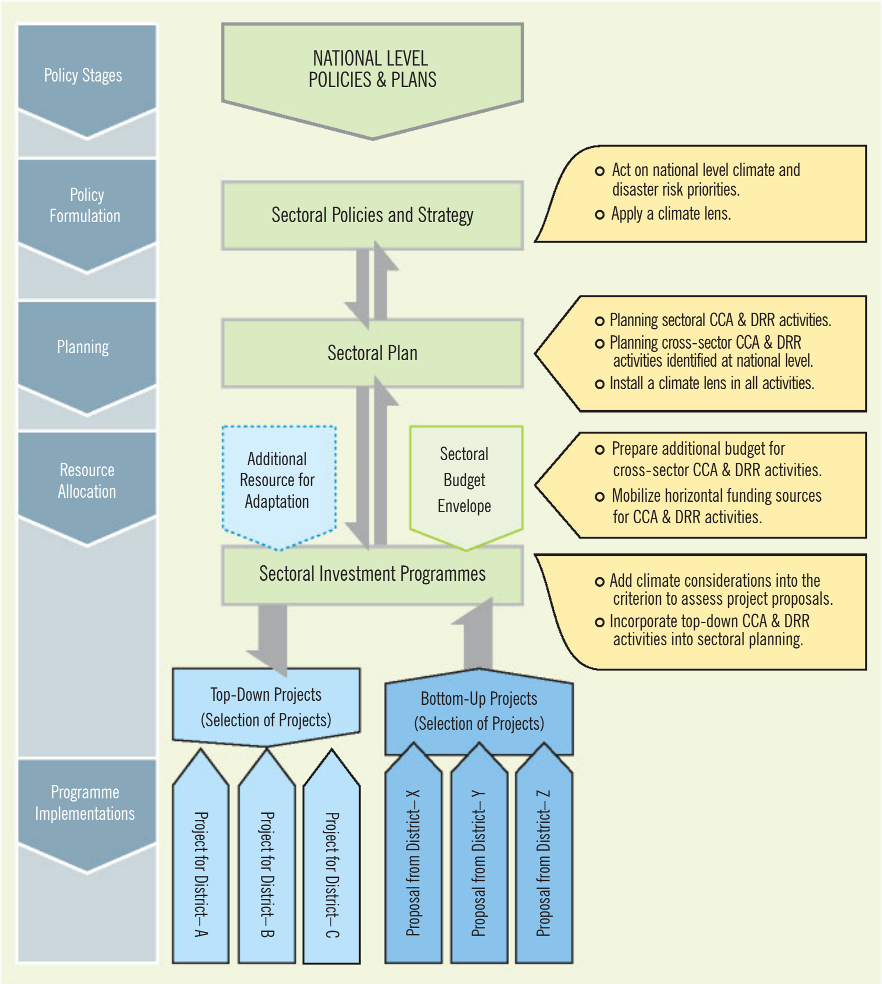
*Sources: MoEF 2017b*

## CLIMATE POLICY AND NATIONAL DEVELOPMENT PLANNING

Bangladesh's commitment to increase aid effectiveness, following from Paris Declaration (PD) and Accra Agenda for Action (AAA), has intensified country efforts to strengthen governance and improve development performance. Making aid effectiveness a high priority, in recent years, the GoB has increased leadership in aid coordination to enhance the impact of aid in reducing poverty and inequality, increasing growth, building capacity and accelerating achievement of the MDGs. Along this line, Bangladesh has prepared a series of national policy documents including the National Development Strategy in the form of Poverty Reduction Strategy (PRS), entitled as the National Strategy for Accelerated Poverty Reduction (NSAPR) since 2003. The current NSAPR-II (Revised) was launched in 2009 for three years, FY 2009-11. The Seventh Five year Plan and the Perspective Plan (2010-2021) has been developed (GoB 2012b; GoB 2016).

As part of the development planning process, the Ministries, agencies and departments use DPPs (Development Plan Pro-Forma) formats in outlining project components and implementation strategies. Conventionally, these projects are rarely developed based on public consultations. The Planning Commission, based on inputs (initial proposals/ budgets) received from line Ministries, prepare the Annual Development Plan (ADP) for respective Ministries in line with guidelines and prioritization criteria. The respective

**Figure– 6.1: CCA and DRR Inclusive Planning and Implementation at Sectoral Level**



Ministries then submit detailed proposal to the Planning Commission using the DPP. After that, the Finance Division (FD) provides the total available resources for the ADP, and Planning Commission finally prepares the sectoral allocations. Balancing the allocation of resources in terms of the priorities set forth by different sectoral and cross-sectoral policies is of vital significance, so that the Annual Development Plans are adequately synchronized with the objectives of different policies. An effective coordination mechanism in the allocation of resources is essential to optimize resource allocation through ensuring a balance between climate policy and other policy priorities.

There exists an inadequate cross-referencing between development planning and policies in Bangladesh. A lack of clarity and gap exist in providing guidelines to incorporate climate change policies into national development framework and particularly sectoral development planning at institutional level. The overlaps between broad policy areas and inadequate cross-referencing between policies can be said to be impeding the implementation of climate change policies. The present research reveals a gap in practices due to lack of cross-referencing between climate change policies and other national development policy documents. The government ministries, departments and agencies tend to develop their respective ADPs based on sectoral mandates, policies and strategies. National climate change strategies receive less attention and priorities, while each institution focuses on respective sector policies in the ADP preparation processes.

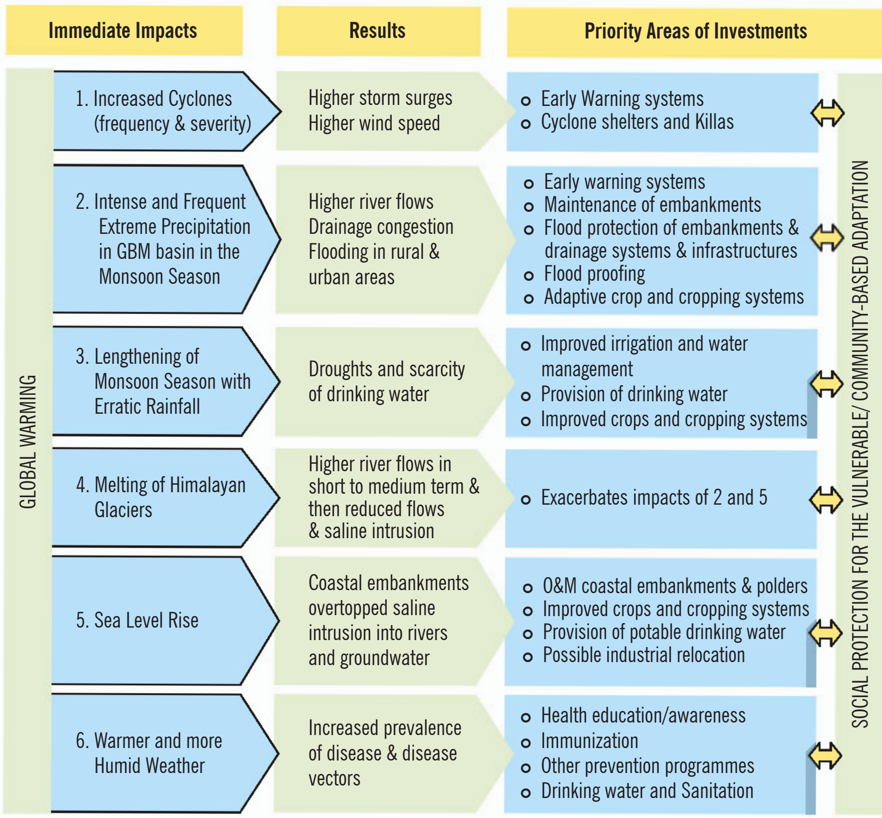
## WINDOW OF CLIMATE CHANGE POLICY-MAKING

### Situation and Context of BCCSAP

The BCCSAP provides an overall framework for action recognizing the need for adaptation and simultaneously highlighting the GoB's willingness to follow a low carbon pathway towards achieving development (Islam, et al. 2013; MoEF 2009; O'Donnell, et al. 2013). BCSSAP is widely recognized to be a major achievement and is a basic reference for aligning investments. The programs are categorized under four time-lines, from immediate to long–term, focusing on medium and long–term actions through pillars which drew on the areas set out in basically drawn from those set out in UNFCCC negotiations under the Bali Road-map i.e. adaptation, mitigation, technology transfer and financing. The BCCSAP identifies 145 actions under 44 program thematic areas and develops an umbrella policy covering all the concerned sectors and ministries. Emphasis is placed on adaptation and the use of knowledge base towards planned adaptation. The BCCSAP has six themes and these are (GoB 2012a):

- **Theme 1– Food Security, Social Protection and Health:** Addresses issues of food and livelihood security, especially for the poorest and most vulnerable

**Figure– 6.2: Impact of Global Warming on Bangladesh and Required Investments**




in society, including women and children. This also includes safe housing, employment and access to basic services, and health matters.

- **Theme 2– Comprehensive Disaster Management:** Reinforcement of country's already proven disaster management systems to deal with increasingly frequent and severe natural calamities.
- **Theme 3– Infrastructure:** Ensure that existing assets (e.g. coastal and river embankments) are well maintained and fit-for-purpose and that urgently needed infrastructures (e.g. cyclone shelters and urban drainage) are put in place.
- **Theme 4– Research and Knowledge Management:** This is to predict the likely scale and timing of climate change impacts on different sectors of the economy and socioeconomic groups; to underpin future investment strategies; and to ensure that Bangladesh is updated with global thinking and innovations.
- **Theme 5– Mitigation and Low Carbon Development:** This is to evolve low carbon development options and implement these as the country's economy grows over the coming decades and the demand for energy increases.

- **Theme 6– Capacity Building and Institutional Strengthening:** This is to enhance the capacity of government ministries and agencies, civil society and the private sector to meet the challenge of climate change and mainstream them as part of development actions.

The BCCSAP was first developed during a state of emergency in Bangladesh in 2007 and 2008. The first version of the document, which is referred to as BCCSAP 2008, was launched at the "UK Bangladesh Climate Conference" in London in September 2008. Following the general election in 2009, the newly formed coalition government led by the Awami League (AL) revised and approved the current version of the document referred to as the BCCSAP 2009. The objective of the BCCSAP is to integrate climate change constraints and opportunities into the overall plan and programs involving all sectors and processes for economic and social development. The document is prepared for only 10 years (2009–2018) and estimated USD 5 billion for first 5 years for the implementation of selected adaptation activities. Putting finance and technology as means to achieve adaptation and mitigation the documented adopted a broad principle that "present day climate change is the result mainly of historical Greenhouse gas emission by the western and other industrialized countries and finance has to come from them"(MoEF 2009). Thus, the document adopted a principle for adaptation funds that should be 'purely grant basis'. The BCCAP identified the following impact areas (Figure– 6.1) of climate change and also recognized the corresponding priority areas of investments (MoEF 2009).

## Actor-Network in the Making of BCCSAP

A wide range of actors of home and abroad have played significant role in the making of BCCSAP. The role played by each entity can be explained in terms of Actor-Network Theory (ANT), which would help us to understand the complex socio-technical/ political/ economic systems that comprise the problem space (Masys 2009). Besides, we also have to expand our 'world view' of 'climate' change beyond physical climate to include the 'social' climate, 'political' climate, 'security' climate, and 'economic' climate with particular emphasis on the socio-technical domain and its cross domain influences to explain the climate change policy-making in Bangladesh (Colston 2014; Masys 2009). According to ATN, knowledge on climate change is understood as translated by various actors across complex networks including the processes and moments in the circulation of interactions among various actors across complex networks. Following from ANT, we would seek to identify the nodes of action and trace the configurations of actors, which drive the making of BCCSAP. Actor-networks are composed of multiple actors, or actants, engaged in mobilizing others. Actants, form heterogeneous networks, are aligned in terms of common interests and engaged in convincing others to enroll in, or accept, the interests defined by the actor-network (Colston 2014). Public climate change controversies results in developing social spaces, where power is enacted and performed, and formation of different actants or groups with common interests. ANT aims to trace the ways these heterogeneous groups function to sustain or inhibit, in this case, climate change policy actors in Bangladesh.

ANT theorizes climate change actor-networks within a complex web of relations, which will identify the intricate linkages across different enactments of climate change policy and practices. Following from Latour (2005), we will map out the existing controversies as a guiding method for identifying important nodes of social negotiation, which subsequently influenced the advancement of climate change policy in Bangladesh (Latour 2005). However, Latour distinguishes intermediary actors from mediators by suggesting that intermediary actors transport meaning without influencing transformations, whereas mediators "transform, translate, distort, and modify meanings" (Latour 2005: 39). Critical Political Ecology (CPE) is another significant perspective to assess the polarizing effects of manufactured climate change controversies. The CPE repositions these controversies as translations and negotiations with reference to: (a) what counts as scientific knowledge; (b) who controls its production, dissemination, and use, and; (c) how actors challenge, reinforce, or reframe the symbolic boundaries of science (Cox 2012; Forsyth 2004; Vogel, et al. 2007; Walker 2005).

Given these theoretical backdrop, now we will try to explain how social and political contexts have influenced the 'making' of climate change policies in Bangladesh with particular reference to BCCSAP. The development of climate change policy in Bangladesh has been stimulated and driven by international actors and networks. The majority of the foreign donors have been engaged in climate change policy-making in Bangladesh. The activities, modes of operations and engagement, in the context of climate change impacts in Bangladesh, can be categorized under four dimensions (Alam, et al. 2013; GoB 2012c; O'Donnell, et al. 2013):

- **Evolving Development Approaches:** Some donors recognize their engagement into climate change as an evolving trend of their ongoing operations on poverty reduction, food security, DRR and, most importantly, environmental management. The Danish International Development Agency (DANIDA) has been running in Bangladesh for 40 years but started working on climate change since 2007 within a broader framework on environment management and development.
- **Response to Country Drivers (Aid Effectiveness):** The Gob's commitment to aid effectiveness as a high priority, in recent years, has increased leadership in aid coordination to enhance the impact of aid. Donors have also complemented the internal country drivers and aligned their respective investments on climate change issues(Hedger 2011).

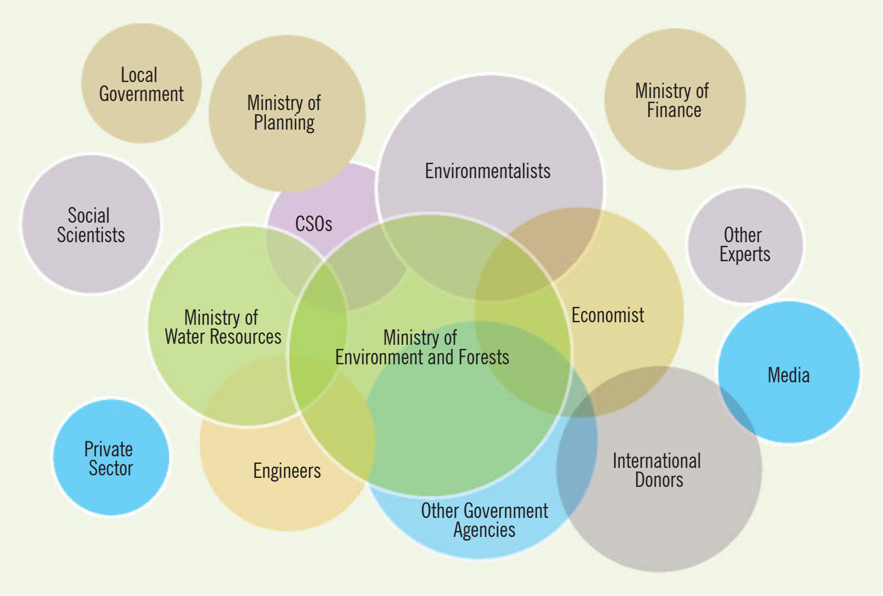
- **Response to Donor Country Politics:** Changes in the donor countries policies and politics have shaped their respective priorities for extending supports to Bangladesh.
- **Response to International Political Developments:** The engagement of multilateral donors, such as the Asian Development Bank (ADB), the World Bank, and the International Finance Centre (IFC), has been driven by a step change with revised regional and country strategies for Bangladesh. These have included climate change as a pillar of action and increased their work on climate change in relation to international developments. The shifting landscape of international political processes has led some European donors to fund climate change activities in Bangladesh.

The key actors in the making of climate change policies and programs in Bangladesh include national and local government, CSOs, CBOs and NGOs, academic and research institutions, international donor agencies, bilateral and multilateral international financial institutions, and the media. The Ministry of Environment and Forests (MoEF), as the lead government agency, represents the government in international negotiations under the UNFCCC. The MoEF is also overseeing the implementation of BCCSAP through channelizing funds from BCCRF and BCCTF – the two funding mechanisms for addressing climate change impacts in Bangladesh. The private sector agencies are slow in addressing the climate change issues, in the context of Bangladesh. The environmental experts, donors, bureaucrats and politicians in Bangladesh have played key roles and functions in the making of BCCSAP. The engagement of front-line people, vulnerable groups, local government institutions, community based organizations, NGOs, media and market was very low in the policy process. The political parties maintained formal and critical engagement with all other actors although they were engaged in a later stage of BCCSAP planning. The AL included climate change concerns into their election manifesto. After the election, they had negotiated with donors to secure power over and shaped to MDTF management and governance. The civil bureaucrats worked independently with donors and experts since the beginning of the BCCSAP process and led negotiation with donors and WB on MDTF and loan agreement at the later stage. The environmental experts played key roles in formulating and deciding on BCCSAP content and programs. Donors and lending agencies worked closely with bureaucrats and experts in all stages. The DFID provided financial assistance in the launching of BCCSAP and negotiated with GoB on WB's role in MDTF. The environmental and other activists and campaigners, pursuing climate justice discourse,raised criticism on the process and content of climate change planning. They had demanded revision in BCCSAP process and content, while criticized the role of WB in MDTF governance. The interest and influence of policy actors and networks in BCCSAP planning are represented below (Table– 6.2):

**Table– 6.2: The Role of Policy Actor-Network in BCCSAP Planning**

| Key Policy Stakeholders | Interests | Incentives | Relative Level of Influence | |
|---|---|---|---|---|
| | | | Expected | Actual |
| Political Parties | State Power | Popularity | High | Low |
| Political Leaders | Securing Own Power Position | Relative Visibility | High | Average |
| Political Leaders with somehow expertise in CC | Political Leadership within Environment and Climate Change | Both Goodwill and Influence over Decision-making | High | High |
| Member of Parliaments | Parliamentary Power | Popularity, being Re–elected, Securing Power | High | Average |
| Bureaucrats | Official Authority | Rewards, Decision-making Power | Low | High |
| Bureaucrats with CC expertise | Official and Technical Authority | Goodwill, decision-making Power, Enhancing Social Capital | Average | Very High |
| Ministry of E&F | Environmental Protection | Goodwill and Leadership in Climate Change, Growth | High | Very High |
| Ministry of Planning | Economic Growth | Coordination, Growth | Very High | Low |
| Ministry of Finance | Fiscal Security | Coordination, Growth | High | Low |
| Sectoral Ministry | Sectoral Growth | Projects, Sectoral Growth, Good will | High | Very Low |
| Climate Change Experts | Diverse (Market, Justice, Technical, Developmental) | Intellectual Authority, Recognition, Consultancy, Influence over Decision Makers | High | Very high |
| Academia | Diverse (Market, Justice, Technical, Developmental) | Good will, Intellectual Authority, Recognition, Academic Projects, Consultancy, Influence over Decision Makers | Average | Low |
| Media | Justice, Corruption, Transparency | Goodwill, Career | Average | Average |
| NGOs/CSOs | Justice | Projects, Goodwill | High | Very High |
| Business Community | Market | Protection from Climate Exposures, less Interfere in Environmental Pollutions, Market Potentials (CDM) | Average | Low |
| Local Government Institutions | Justice; Autonomy of Planning, Finance and Implementation of CC Program | Possibility of being Reelected;Being able to Address Community Needs | Very High | Low |
| CBO | Justice& Demand | Collective Reduction of Vulnerability | High | Very Low |
| CC Victim Community | Justice& Demand | Reducing Vulnerability | High | Very Low |

**Figure–6.3: Influence of Actors and Agencies in the Making of BCCSAP**




The role of Ministry of Environment and Forests has significantly overshadowed the roles supposedly played by the Ministry of Planning, Ministry of Finance, Ministry of Local Government Rural Development and Cooperatives. The MoEF has overwhelmingly become a parallel entity for parallel planning, financing, implementing and monitoring, while the country already has an existing planning and development architecture in place (please see preceding discussion). On the other hand, the role of civil bureaucrats has surpassed the expected roles of Civil Society organizations (including NGOs), Media, Private Sector and Local Governments Institutions (see Figure– 6.3). In terms of disciplinary boundaries and epistemologies, environmental sciences, engineering and economics have outweighed the contribution of any other knowledge traditions, including social and human sciences, in the current climate change planning, financing and implementation process.

## ASSESSING CLIMATE CHANGE INSTITUTIONAL ARRANGEMENTS

### The Institutional Structure of MoEF

The institutional landscape in Bangladesh has undergone significant changes in recent time(Alam, et al. 2011). The establishment of new institutions within government, political system, private sectors, research, academic, NGOs, network and campaigns has taken place. Within the government, strengthening the institutional approaches to Climate Change, has taken place. A National Steering Committee on climate change(NSCCC), chaired by the Minister of MoEF, has been established to coordinate and facilitate national actions on climate change and this NSCCC reports to the National Environment Committee (NEC).

The MoEF is the focal ministry for maintaining direct coordination with the UNFCCC and its related activities at global and national levels. The MoEF has now several agencies and institutional mechanisms to implement its mandate of environmental, natural resource and climate change management. These include: (1) Department of Environment (DoE); (2) Department of Forest (FD); (3) Bangladesh Climate change Trust (BCCT); (4) Bangladesh Forestry Research Institute(BFRI); (5) Bangladesh National Herbarium; and (6) Bangladesh Rubber Board. The organizational structure of the MoEF, under revenue budget, comprises 123 positions distributed by 36 Class– I and 27 Class– II officers as well as 27 Class– III and 33 Class– IV support staffs. According to the annual report 16-17 of MoEF, there is a significant number of positions were vacant (MoEF 2017). The report reflects that out of 123 posts, 36 positions are active and the rest 65 posts remain vacant, which is nearly 29.3% of total sanctioned posts.

The Department of Environment is mandated to implement the policies to ensure sustainable development, conserve and manage the environment of Bangladesh. Aligned with this mandate, the DoE has hosted the Climate Change Cell (CCC) since 2004 under the auspices of DFID and UNDP–funded project. CCC is tasked with integrating climate change considerations into various aspects of national planning. They lobby the Planning Commission to include climate change directives in the national development plan to be implemented by professionals and funded by the line ministries. In January 2010, the MoEF established a 'Climate Change Unit' under its own setup to facilitate the financial and institutional mechanism for implementation of the Bangladesh Climate Change Trust Fund, what the Government endowed with the Ministry through creating a Trustee for the implementation of BCCSAP 2009.

## Climate Change and Institutional Mandate of MoEF

The MoEF is the GoB's central apex body responsible for the policy, planning and administration of all forestry and environment related issues and development programs. It is the custodian of country's environment and ensures its protection and development through appropriate laws and regulations. Sustainable management and conservation of natural resources including land, air, water and forests in an environmentally sound manner are the prime responsibilities. These functions have been distributed among different units (Wings, Branches and Sections) in the Ministry. The functional responsibilities of MoEF have been distributed over four wings consisting of branches and sections in the Ministry.

The MoEF's role is, "as the designated environment ministry, the MoEF has a key role in planning, reviewing and monitoring environmental initiatives and ensuring that environmental concerns are properly integrated into the national development process. The Ministry also bears the responsibility for working with other Ministries to ensure that environmental concerns are given due recognition in their development programs. The Ministry has an active part to play in policy advice and environmental action planning, in coordinating and overseeing the implementation of action plans, and in reviewing and monitoring the impact of development initiatives on the environment across all sectors"(NEMAP 1995 and GoB 2009a).

Planning, regulation and coordination of environmental and forestry programs are the major activities of Ministry of Environment and Forests (MoEF). In addition, MoEF also undertakes actions to reduce climate change impacts in different sectors. The activities of MoEF in climate change aspects include formulation of policy for climate change adaptation and mitigation; perform national and international negotiations, climate change funds management and related administrative actions. Two climate change policy instruments i.e. the National Adaptation Plan of Action

**Box– 6.1: Allocation of Business (AoB) of MoEF**

Revised up to December, 2014 (GoB 2015a)

1. Environment and Ecology.
2. Matters relating to environment pollution control.
3. Conservation of Forests and development of Forest Resources (Government and Private), forest inventory, grading and quality control of forest products.
4. Afforestation and regeneration of forest extraction of forest produce.
5. Plantation of exotic cinchona and rubber.
6. Botanical Gardens and Botanical Surveys.
7. Tree plantation.
8. Planning Cell- Preparation of schemes and co-ordination in respect of forest.
9. Research and Training in forestry.
10. Mechanized forestry operations.
11. Protection of wild birds and animals and establishment of sanctuaries.
12. Matters relating to marketing of forest produce.
13. Administration of B. C. S (Forest).
14. Liaison with International Organizations and matters relating to treaties and agreements with other countries and world bodies relating to subjects allotted to this Ministry.
15. All laws on subjects allotted to this Ministry.
16. Inquiries and statistics on any of the subjects allotted to this Ministry.
17. Fees in respect of any of the subjects allotted to this Ministry except fees taken in courts.

(NAPA) and the Bangladesh Climate Change Strategy and Action Plans (BCCSAP) were developed through stakeholder consultation process under the auspices of the Ministry. This ministry acts as the permanent member in the Executive Committee of the National Economic Council (ECNEC) to make sure that the environmental interests are taken care of while undertaking development actions. In the similar fashion, the MoEF plays effective roles in mainstreaming climate change in sectoral activities performed by different Ministries and departments. MoEF currently has emerged as project implementation agency by using the funds (like BCCTF and BCCRF), and they are entrusted to spend to address climate change impacts in Bangladesh.

It is very important to note that climate change features nowhere in the mandate of the MoEF even though the ministry serves as the GoB's focal point for communication and negotiation with the UNFCCC (GoB 2015a). It is also important to note that the latest revision dates back to 2010 even though the BCCSAP was approved by the Cabinet Division in 2009 designating the ministry as the coordinating body for implementing the BCCSAP. As per article 18(b) of the amended Bangladesh Constitution, it is incumbent on the government to align and articulate allocation of business of MoEF accordingly.

The Cabinet Division of GoB prepares the rules for allocation and transaction of business among the different Ministries and Divisions in Bangladesh(GoB 2015a). The Allocation of Business (AOB) of the MoEF does not have climate change in any of the allocated 17 businesses. However, the 14$^{th}$business of the MoEF allows the ministry to address climate change affairs, as the AoB says that, "liaison with International Organizations and matters relating to treaties and agreements with other countries and world bodies relating to subjects allotted to this Ministry"(GoB 2015a: 23). Although climate change affairs have not been explicitly allocated business of the MoEF, yet the Ministry is involved with GoB's environmental and sustainability concerns since Bangladesh's preparation for the Rio Earth Summit.

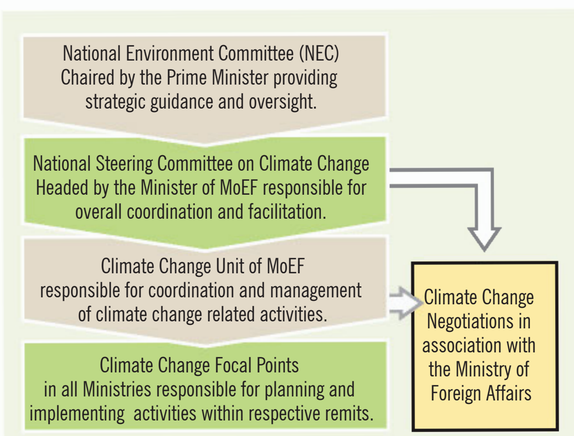
## Evolving Landscape of Institutional Framework

Climate change, as a discourse, has rapidly evolved from the research institutes to the implementers and decision–makers at all scales of governance and across different public policy sectors. A change in institutional dynamics is a priority need for Bangladesh by enabling various levels of government agencies and stakeholders to collaborate more closely in addressing climate change impacts. There is a priority need for capacitating key ministries by increasing the level of knowledge and awareness as well as enhancing financial and technical management capacities on climate change issues.

In recent time, there have been significant transformations in the institutional landscape in Bangladesh. The MoEF's, as the focal point, activities in climate change aspects include formulation of policy for climate change adaptation and mitigation; perform national and international negotiations, climate change funds management and related administrative actions. A National Steering Committee (NSC) on climate change has been established to coordinate and facilitate national actions on climate change. The NSC is comprised of Secretaries of all climate-affected Ministries and Divisions, and representatives of civil society and the business community, while the Minister of MoEF has been appointed as the chair of the committee. The NSC reports to the National Environment Committee (NEC), chaired by the Prime Minister. The NSC also provides guidance on international climate change negotiations, including bilateral, multilateral and regional programs for collaboration, research, exchange of information and development. The MoEF acts as the permanent member in the Executive Committee of the National Economic Council (ECNEC) to make sure that the environmental interests are properly addressed while undertaking development actions.

The MoEF, as the focal ministry, coordinates directly with the UNFCCC and its related activities at global and national levels. The MoEF established a 'Climate Change Unit' (CCU) in January 2010. The DOE is mandated to implement the policies to ensure sustainable development, conserve and manage the environment of Bangladesh. Aligned with this mandate, the DOE has been hosting a Climate Change Cell (CCC) since 2004 under the auspices of DFID and UNDP funded Comprehensive Disaster Management Project (CDMP). The CCC is entrusted with the responsibility of integrating climate change considerations into various aspects of national policies and planning. They are working with the Planning Commission to

**Figure– 6.4: Organizational Arrangement for CC Action Plan**



include climate change directives in the national development plans to be implemented the line ministries. Moreover, the CCC plays a very important role in preparing the MOEF for all international climate negotiations.

The MoEF is currently the GoB's coordinating body to mainstreaming climate change into all development sectors. Under the leadership of MoEF, the following coordination mechanisms are, at present, in place:

- **National Environment Committee (NEC) and National Steering Committee (NSC):** The establishment of the NEC and NSC at the MOEF, which in fact started during the NEMAP process, came from the GoB's recognition that there is a need for greater inter-governmental coordination and integration of activities affecting the environment. The NEC and NSC are activated on ad hoc basis rather than having installed as permanent and functional institutions.
- **Climate Change Unit (CCU):** The MoEF established a CCU in 2010 to oversee the BCCSAP implementation. The CCU as envisioned in the BCCSAP to be the national entity that would coordinate all climate change affairs in the country is virtually non-existent at MoEF. Currently, the BCCTF is loosely termed as the CCU. The non-existence of the CCU has recently been recognized also in the CFF.
- **Climate Change Cell (CCC):** The existence of the only CCC is found at the DOE that has been established in 2004 under the auspices of the CDMP. The CCC has been given formidable tasks of integrating climate change considerations into various aspects of national planning. Moreover, the CCC plays a very important role in preparing the MoEF for all international climate negotiations. The DoE is planning to transformation the CCC into a full-fledged Climate Change Wing, which is expected to be the CCU that was envisioned under the BCCSAP. The DoE has created a new position of Director, Climate Change.
- **Climate Focal Point at Line Ministries:** The MoEF also claims that the establishment of climate focal points in important line ministries, as envisioned in the BCCSAP, is underway. The existence of those institutions is, however, not visible.

Although MoEF is the country's core entity on the formal management of environment and climate change, yet it would be hard to claim that the ministry alone has the full control over or leadership of managing all related affairs. Even within the Government systems, systematic approaches in climate finance management have been developed not under the leadership of MoEF (e.g., CPEIR and CFF). The ministries with larger portfolio than that of MoEF with newly emerging institutions and systems do not consider MoEF to be strong enough to coordinate the climate change activities. The MoEF does not get a high rating for its coordinating capacity to implement climate change actions within its own jurisdiction or coordinate the mainstreaming process. The Parliamentarians, as the latest entrants, have the potential to exert significant influence on institutional processes within the whole framework of institutional arrangements on climate change (AF 2012). An All Party Parliamentary Group (APPG) has been formed on environment and climate change in 2009 and provided orientation training to about 140 members of parliament (MPs) on climate change issues. The trained MPs were vocal within the national parliament on climate change issues during subsequent period.

## Human Capacity Needs to Implement BCCSAP

Although climate change impinges on the responsibilities of a wide range of other Ministries and agencies, but MoEF is designated to take the lead in setting policy agenda for climate change as the GoB's focal point. The human resources and skills available at the MoEF as well as climate change related focal positions at different government agencies suggest the needs of capacity development and training programs for the officers to perform their mandated functions (FAO 2012). Besides, depending on the positioning and respective functions, human resource and skill needs would vary in terms of agencies and wings to enhance the capacities of officers for improved coordination, oversight and integration. Increasing capacities of professional and technical staffs in civil service can be challenging because of the slow procedures of creating new positions and frequent transfer of key staffs. Therefore, there is also a clear need of retaining of trained human resources in MoEF and other relevant positions for long-term. The situation demands having a clear policy and strategy with regard to human resource development and management consistent with the functions of each unit in the Ministry as well as identifies some critical training needs at different levels. The MoEF developed a Capacity Development Action Plan (CDAP) for Sustainable Environmental Governance in 2007. The plan comprises 136 activities in 15 climate change thematic areas along with earmarking of implementation agencies.

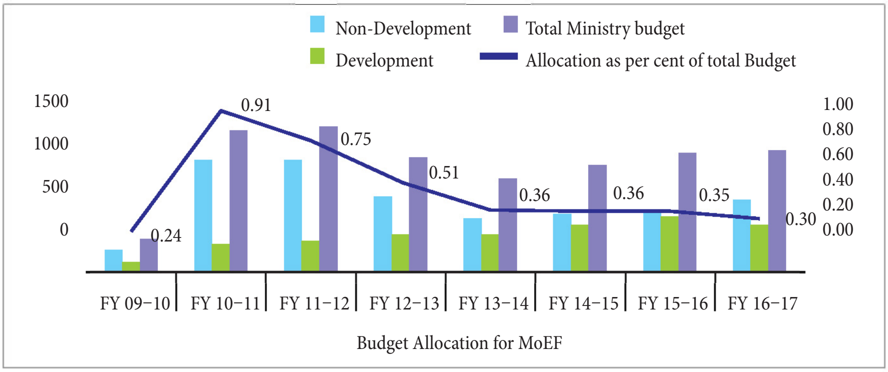
A recent assessment of MoEF's capacity identifies, "inadequacy of relevant sector skills and training, the aspirations of policy formulation, coordination, monitoring and evaluation, oversight and integration have yet to be achieved in a major way" (MoEF 2013). The assessment also identified some fundamental capacity needs of MOEF in all its mandated areas, including climate change in order to strengthen the policy and regulatory, program and process management functions, and enhance integration of forest and environment related issues across sectors.

The existing capacities of MoEF for monitoring and independent evaluation constitute significant requirements of the Adaptation Fund and other funding sources. The monitoring and evaluation of the ongoing and completed projects and programs implemented by the MoEF and its agencies are carried out to assess achievement against the set objectives as well as to evaluate strengths and weaknesses of ongoing projects. Monitoring and evaluation mechanism of the MoEF include monthly coordination meeting, monthly ADP progress review meeting (Physical & Financial), IMED evaluation, Government audit, development–partners' mission for DP supported programs. Independent monitoring and evaluations are also undertaken by the MoEF. In addition to the above regular mechanisms of monitoring, some projects have special mechanisms to monitor project activities through National Steering Committee chaired by the Secretary, MoEF. The steering committee has member representatives from various line departments and Ministries including planning commission. The steering committee mainly oversees project implementation, reviews the progress of the project to improve project's effectiveness, which require Government's attention. The existing system, however, at the MoEF is limited to reporting physical progress and expenditures on a monthly and annual basis and discussing the same in the monthly coordination meeting and ADP progress review meeting. Progress is measured in terms of the percentage of allocated budget spent. Monitoring technical issues like forests and biodiversity, environmental quality, pollution levels or environmental degradation, project performances require a certain combination of technical and planning knowledge together, which the MoEF is currently lacking. Therefore, institutional capacity of MoEF needs to be enhanced by improving the technical, planning and financial management capacities of existing human resources.

## Financial Projection Capacity and Budget Allocation of MoEF

The MTBF is one of the core budget documents of the Government that contain the Ministry Budget Framework (MBF) of 71 ministries/ divisions.

**Graph– 6.1: Budget Allocation of the MoEF between FY 10 to FY 17**




*Source: CPD (2016): An Analysis of the National Budget for FY2016–17*

Strengthening the MTBF process is expected to have accelerating impact in achieving the development goals of the Government. This will, at large, provide an overview of the overall budget strategies of the government and its linkages to the 7thFive Year Plan and Sustainable Development Goals (SDGs). Besides,linkages between planning documents, policies/strategies of concerned line ministries/divisions and other institutions as well as estimates and projections of two following years can also be understood from this budget document. The government has already introduced new software, Integrated Budget and Accounting System (iBAS++), and approved the new Budget & Accounts Classification System(BACS) to ensure more transparency in public expenditure. These reforms and new initiatives will help enhance the overall efficiency in resource allocation and utilization with more transparency and accountability in public sector. The Sectoral ADPs are prepared under the MTBF, which is the architecture that matches policy with budget and sets out the performance framework by way of Key Performance Indicators (KPIs) and specific intentions for each of the line Ministries.

MoEF's ADP allocations from FY 2009-2010 to FY 2016-2017 are shown in Table– 6.3 and Graph– 6.1 (CPD 2016). The ADP allocations show a clear jump in the FY 2010–2011 and FY 2011–2012. This has happened because of the BCCTF allocations. However, available data records the poorest ADP performance in FY 2010–2011. Although the number of projects increased, the disbursement levels of the BCCTF funds showed poor performance. Total allocation for the Ministry of Environment and Forests in FY 2016–17 budget is Tk. 1033 Cr., which is 5.2% higher than that of Revised FY 2015–16 i.e. Tk.982 Cr.(GoB 2017b). Allocation (as % of total budget) followed a declining trend since FY2010–11 (from 0.91% to 0.29% in FY 2016–17).

**Table– 6.3: Medium Term Expenditure of MoEF**

| Description | Budget 2017– 18 | Projection | |
|---|---|---|---|
| | | 2018– 19 | 2019– 20 |
| Non-Development | 5359.70 | 5895.70 | 6485.20 |
| Development | 5845.90 | 6430.50 | 7073.50 |
| Total | 1205.60 | 12326.20 | 13558.70 |
| Revenue | 8353.87 | 10885.710 | 12208.08 |
| Capital | 2851.73 | 1440.49 | 1350.6 |
| Total | 11205.60 | 12326.20 | 13558.7 |

*Source: GoB 2017: 545.*

The MoEF's Medium Term Expenditure estimates and projection (FY 2017–18 to FY 2019–20) and actual allocations in FY 2016–17 are represented in

Table– 6.3. The MoEF itself and distribution among the technical agencies are revealed in the Table– 6.4. The MoEF Secretariat uses about 38% of the current allocations while, with a minimal amount attributed to international organizations, the technical agencies get the rest of the allocations. The Planning Cell of the MoEF, with help from the technical agencies, helps develop the ADP and contributes to the development of MTBF.

**Table– 6.4: Expenditure by Departments, Agencies and Units of MoEF**

| Description | Budget 2016– 17 | Revised 2016– 17 | Budget 2017– 18 | Projection 2018– 19 | Projection 2019– 20 |
|---|---|---|---|---|---|
| MOEF Secretariat | 3061.12 | 11502.00 | 4249.75 | 3067.93 | 3023.30 |
| Int. Organizations | 9.74 | 9.74 | 14.05 | 10.37 | 10.50 |
| Dept. of Forests | 2793.10 | 2756.71 | 1693.76 | 3138.00 | 3645.50 |
| Regional Offices | 2998.01 | 3088.97 | 3394.09 | 3560.00 | 3805.30 |
| BD Forest Research Inst. | 320.50 | 295.66 | 420.00 | 525.00 | 628.00 |
| BD National Herbarium | 97.83 | 59.08 | 71.60 | 129.50 | 231.00 |
| Dept. of Environment | 1054.71 | 795.93 | 1362.40 | 1895.40 | 2215.10 |
| Grand Total | 10335.00 | 18508.09 | 11205.60 | 12326.20 | 13558.70 |

*Source: GoB 2017: 548 – 549*

The trend of climate relevance in the budget for the Ministry Environment and Forests, distributed over the BCCSAP themes, is shown in the Table– 6.5 (GoB 2017a: 34). Total climate relevant budget remained almost stable over the years and the total CC relevant allocation remained almost same across the years with a decrease in FY 2016–17.

**Table– 6.5: Budget Allocation of MoEF by BCCSAP Thematic Areas**

| BCCSAP Themes | CC relevant Allocation 2017– 18 | 2016– 17 | 2015– 16 | 2014– 15 |
|---|---|---|---|---|
| Food Security Social Protection and Health | 229.24 | 254.48 | 246.02 | 409.66 |
| % of total CC relevant allocation | 5.41 | 6.54 | 6.04 | 9.89 |
| % of Ministry budget | 2.05 | 1.37 | 2.5 | 4.38 |
| Comprehensive Disaster Management | 344.61 | 472.80 | 501.00 | 607.32 |
| % of total CC relevant allocation | 8.14 | 12.15 | 12.3 | 14.66 |
| % Ministry budget | 3.08 | 2.55 | 5.09 | 6.49 |
| Climate Resilient Infrastructure | 199.38 | 171.37 | 192.09 | 289.97 |
| % of total CC relevant allocation | 4.71 | 4.41 | 4.71 | 7 |
| % of Ministry budget | 1.78 | 0.93 | 1.95 | 3.1 |
| Research and Knowledge Management | 651.58 | 376.33 | 482.71 | 457.93 |
| % of total CC relevant allocation | 15.39 | 9.67 | 11.85 | 11.06 |

| BCCSAP Themes | CC relevant Allocation | | | |
|---|---|---|---|---|
| | 2017– 18 | 2016– 17 | 2015– 16 | 2014– 15 |
| % of Ministry budget | 5.81 | 2.03 | 4.91 | 4.89 |
| Mitigation and Low Carbon Development | 640.05 | 581.41 | 605.87 | 589.06 |
| % of total CC relevant allocation | 15.11 | 14.95 | 14.87 | 14.22 |
| % of Ministry budget | 5.71 | 3.14 | 6.16 | 6.29 |
| Capacity Building and Institutional Strengthening | 2,170.12 | 2,033.61 | 2,046.53 | 1,788.29 |
| % of total CC relevant allocation | 51.24 | 52.28 | 50.23 | 43.17 |
| % of Ministry budget | 19.37 | 10.99 | 20.8 | 19.1 |
| Total CC Relevance (Tk) | 4,234.98 | 3,889.99 | 4,074.22 | 4,142.23 |
| % of Total Budget | 37.79 | 21.02 | 41.41 | 44.25 |

*Source: GoB 2017: 34*

The data presented in the Table– 6.5 shows that the maximum amount has been allocated to the thematic area of Capacity Building and Institutional Strengthening, which is 19.37% of the ministry budget in FY 2017–18. Since FY 2014–15 it remained approximately the same percentage of total ministry budget with an exception in FY 2016–17, which is 10.99%. In FY 2015–16 and FY 2014–15, the respective percentages are 20.80% and 19.10% respectively. Research and Knowledge Management thematic area accounts for 5.81% of FY 2017–18 ministry budget, while in FY 2016–17, it was 2.03% of the total ministry budget. It is also noted that the climate related capacity building and institutional strengthening received the highest allocation 19.37% of Ministry budget in the FY 2017–18.

## Capacity Needs for Fiduciary Standards and Financial Integrity

The Adaptation Fund's eligibility criteria can be a point of reference to understand the MoEF's capacity needs as they rejected MoEF's recent application for accreditation as a National Implementing Entity (NIE). The MoEF did not fulfill the conditions and principles established for the Adaptation Fund's accreditation. Their accreditation eligibility requires the applicant entity's capacities for sound financial management, including the use of international fiduciary standards covering three broad areas: financial integrity and management, institutional capacity, and transparency and self-investigative powers (please see Box– 6.2). However, the fiduciary standards set forth by Adaptation Fund go well beyond purely financial considerations, to cover both institutional capacity and the need to meet standards of transparency and internal accountability.

The MoEF lacks in capacity to maintain international fiduciary standards by accurately and regularly recording transactions and balances to an appropriate standard as expected from a competent entity. There is no

**Box– 6.2: Standards for NIE Accreditation.**

The Adaptation Fund Board (AFB) requires that all applicant organizations meet strict fiduciary standards. The AFB adopted the following fiduciary standards in 2009:

1. Financial Integrity
   - The ability to accurately and regularly record transactions and balances to an appropriate standard as attested by a competent entity;
   - The ability to safeguard, manage and disburse funds effectively to recipients on a timely basis;
   - The competency to produce forward-looking plans and budgets
   - Legal status to contract with the Adaptation Fund and third parties.
2. Requisite Institutional Capacity
   - Procurement procedures which provide for transparent competition including effective means of redress;
   - Capacity to undertake monitoring and evaluation;
   - Ability to identify, develop and appraise projects;
   - Competency to manage or oversee project execution.
3. Transparency and Self-investigative Powers
   - Freedom to whistle-blow on issues of fraud and gross mismanagement;
   - Objective policy for self-regulation.

*Source: AFB 2012 cf. Bugler and Rivard 2012.*

functional automated financial management system in place. MoEF's lack of fiduciary management capacity that includes "the ability to safeguard, manage and disburse funds effectively to recipients on a timely basis" was the sole reason that the DPs wanted the WB to take the responsibility (GoB 2012c). The MoEF does not have adequate competence to produce forward-looking projections of plans and budgets. On these matters, MoEF has large reliance on commissioning consultants, technical agencies and the civil society. Moreover, the bilateral and multilateral funded projects rely on consultants, who get paid more than civil servants, and who usually move to other projects, and thereby the processes of building organizational learning and institutional memory is undermined (GoB 2012c). The present training programs are largely project-based and development partners driven, which do not necessarily complement the real capacity needs of the MoEF or other line ministries. Therefore, it can be said unequivocally that the MoEF needs technical as well as fiduciary management capacity immediately in order to access international climate funds and also to become the trusted, credible institution to coordinate climate finance and activities. To ensure that adaptation finance provided through the AF is used appropriately and effectively, organizations wishing to be accredited as NIEs must be approved by the AFB and must be able to show that they meet the fiduciary standards laid out by the AF.

Although quality of governance across different sectors is gradually improving, but weaknesses in democratic accountability in Bangladesh are pervasive characterized by low levels of citizen participation as well as weak management of revenue, public expenditure, audit and procurement. Audit reporting by the office of the Auditor General is subject to long delays. For instance, as for February 2011, the Public Accounts Committee of the Parliament has reviewed annual audited accounts through 2006. In cases of audit objections, auditors and auditees come together to mutual agreements on steps to be taken. Recommendations are made for disciplinary action in only about 5 percent of cases (WB 2006; WB 2008). Competency to manage or oversee the execution of the project and program delivery and implementation are important criteria to receive foreign fund for climate finance in Bangladesh. In this context, the MoEF needs to enhance its capacity to understand and oversee the technical, financial, economic, social, environmental and legal aspects of the project and their implications.

The Anti-Corruption Commission (ACC), created by Parliamentary Act in 2004, is an independent body reporting to Parliament with wide support from the development partner community and civil society. The ACC took some time to be established, facing many challenges, including an unclear mandate in relation to other agencies. The ACC gained considerable momentum under the Caretaker Government but after the election of 2009, the current government, has taken steps to reduce the independence and authority of the ACC. Moreover, the efficiency and effectiveness of public service delivery significantly rest on Grievance Redress Mechanism to resolve public grievances, which is not efficient enough to address the grievances received.

### Linkages and Coordination Capacity Needs

The National Environment Council (NEC), headed by the Prime Minister, and the Executive Committee of the National Environment Council, headed by the Minister of MoEF, came into existence in 1993, in response to the needs of developing effective collaboration and integration of activities between Ministries and agencies of the Government. The National Environmental Policy of 1992 accelerated the formation of the National Environment Council to provide guidance to line Ministries on national environmental issues. Besides, the Planning Commission of the Ministry of Planning had been authorized to supervise and coordinate cross-sectoral and inter-ministerial activities influencing the sustainable use of environment and natural resources.

The institutional landscape shaping the Country's environmental management comprises, many national institutions including, the Ministry of Planning, Ministry of Finance, Ministry of Land, Ministry of Agriculture, Ministry of Disaster Management and Relief, Ministry of Fisheries and Livestock, Ministry of Industries, Ministry of Water Resources, Ministry of Power, Energy and Mineral Resources, Ministry of Health and Family Welfare, Ministry of Education, Ministry of Housing and Public Works, Ministry of Local Government, Rural Development and Cooperatives, Disaster Management Bureau, Department of Fisheries, Department of Agriculture, Department of Agriculture Extension, Local Government Engineering Department, Bangladesh Water Development Board, Roads and Highway Department (RHD), Barind Multipurpose Development Authority (BMDA), etc. Coordination among these Ministries and agencies for project implementation is done through formation of steering committee comprising members from relevant Ministries and line agencies. The successful implementation of the programs of MoEF needs closer interactions, support and cooperation of all relevant Ministries and line agencies having stake with forestry, environment and climate change. The MoEF is also responsible for reviewing and monitoring the impact of development projects on the environment across all sectors. Shortage of manpower significantly impedes the performance of MoEF.

The intra-government coordination mechanism is a limitation. Bureaucracy appears to have impeded the implementation of the BCCSAP (GoB 2012c). The CPEIR study has identified three aspects of co-ordination gaps within Government:

- **Policy Co-ordination:** This refers to the achievement of balanced influence between sector policy and climate change policy given the evident level of integration of climate change and climate in the delivery of services. There is a need to balance the influence between sectoral policy and national Climate Change strategy, which can be done by the Planning Commission.
- **Technical Co-ordination:** This role lies with MoEF, which addresses the coordination between technical elements of the climate response including adaptation strategies, ranging from infrastructure to social protection programs, and their links to disaster reduction programs.
- **Financial and Performance Co-ordination:** This role lies with Finance Division, which acts as governance and performance management mechanism as well as matching resources to policy through MTBF.

The interfaces between these mechanisms are essential to improve the flow of funds and to ensure that climate change is reflected properly in implementation. The performance of the MoEF, as the lead institution to foster adaptation, appears to have been limited for many reasons, such as weak structure, duality in mandate, lack of manpower, trained human resources, absence of clearly delineated Rules of Business to lead all the activities centered on climate change and weak legal framework(GoB 2012c: 80). Public sector projects under consideration by different Ministries are in principle passed to the MoEF for environmental review. The MoEF needs strong technical expertise to fulfill this vital role.

### Capacity Needs to Address Climate Change

There has been a widespread awareness about the inter-relationship of climate change and development, and the dangers that climate change poses for its economic growth, which is reflected in the new 7th Five Year Plan (2016). The SFYP has identified benchmarks, targets and implementation strategies for the mentioned period and has stressed the need for result–based M & E. The Plan emphasized that the result based system moves beyond the traditional input–output focused M&E and when used effectively helps policy makers analyze outcomes and impacts. The sectoral development strategies of the 7th FYP have been structured to align with the recently adopted 14 uniform sectoral divisions unlike the previous discrepancies in sectoral divisions. The sector eight of the Plan exclusively mandated to environment and climate change. The Plan has set national environmental targets and goals to move the country towards more sustainable development. The main objective of the Seventh Five Year Plan is to ensure environmental sustainability through conservation of natural resources, and reduce air and water pollution. The Seventh Plan has recognized the need to take into account environment, climate change adaptation and mitigation in a wider development context. In this regard, this Plan says that "climate change as an added challenge to reduce poverty and environmental degradation" (GoB 2015b: liii).

The Plan also recognizes the crosscutting attributes of climate change demanding an integrated approach involving many different ministries, agencies, civil society and the business sector. Investments in 'climate proofing' have a significance in generating results in major impacts on economic growth and poverty reduction. The 7thfive-year plan states that:

> *Sustainability has been a conscious and overarching strategy of the present government since 2009. Natural calamities such as storms, cyclones, floods, and droughts have acted as a persistent drag on the country's progress. Bangladesh, being one of the most vulnerable countries to the adverse effects of climate change, promoted innovation, designed and implemented its own programs spanning agriculture, energy, water resources etc. from its own resources. Prime Minister Sheikh Hasina received the United Nation's highest environmental accolade 'Champions of the Earth' in recognition of Bangladesh's far-reaching initiatives to address climate change during UNGA 2015 (GoB 2015b: xlv).*

According to the Plan, creation of alternative livelihoods and building resilience for community to lessen anthropogenic pressure on resources will be enhanced. Relevant programs for environmental and climate change capacity building at local and national level will be the main interventions of this Plan. Government will offer greater attention to the areas in research for knowledge generation concerning environment and climate change. This policy document also suggests the need for strengthening of the capacities of line ministries for planning and budgeting to develop and propose projects and programs aligning with the objectives and framework of the Seventh 5 year Plan. At the same time, project implementation capacity needs to be enhanced for improved project quality through more realistic project design and efficient budgeting. Moreover, the M&E effort, in the area of environmental management and climate change, is weak that makes it much more difficult to assess progress adequately. A more focused and results oriented strategy combining elements of policies, regulations, incentives, investment and capacity building are needed. An integrated approach to climate proofing of Bangladesh development strategy is the way to move forward, as the Plan suggests(GoB 2015b: 19).The MoEF requires enhanced capacity to formulate policies and programs, coordinate climate change issues, monitor and evaluate for more efficient and effective operations (MoEF 2013). Increased accountability, transparency and measurable results from governments Ministries and agencies are the key challenges and require capacity enhancement in order to attain the vision 2021 and Seventh 5 year Plan.

The present assessment identified major lacks in climate risk management capacity of all the ministries and departments encompassing all levels. Although different institutions are already implementing large scale climate change projects, mainstreaming climate change has remained to be an obscured idea. Even though all the line ministries are implementing various sizes' climate change adaptation and resilience programs, including programs funded under the BCCRF and BCCTF (Annex 2), except for the MoDMR, none of the ministries has any mention of climate change in their AoBs. This suggests the absence of coherence framework and central coordinating mechanism to address climate change. Climate change capacity gaps in the line ministries are summarized in Table– 6.6.

**Table– 6.6: Policies and Management Levels Capacity Gaps in Climate Change**

| Levels of Management | National Development Policies | Supportive Sectoral Policies | Environment Policies |
|---|---|---|---|
| Individual | o Decision-makers perceive adaptation as an exclusively "ecological/ environmental" issue rather than a development issue. | o Decision-makers perceive adaptation as an exclusively "ecological/ environmental" issue rather than a development issue. | o Decision-makers and staffs lack specialized knowledge and skills to design and implement climate change adaptation programs. |

| Levels of Management | National Development Policies | Supportive Sectoral Policies | Environment Policies |
|---|---|---|---|
| Organizational/ Institutional | ○ Reporting on climate-related issues in the NDS and the PRS is not consolidated; the adaptation-related "portfolio" is not seen as a whole | ○ Ministries and other agencies in climate-sensitive sectors do not have a legal mandate to conduct work on adaptation.<br>○ Lack of cross-referencing between policies and plans.<br>○ Sectoral agencies may lack the skills to analyze the data they collect and utilize the findings from adaptation-related projects. | ○ The portfolio of the Committee on Environmental Protection is relatively weak compared to other agencies.<br>○ Need to develop capacity to implement the Climate Fiscal Framework that explain the development linkages of environmental programs.<br>○ Low retention rate of trained staffs lead to inefficiency; loss of data, reports, and institutional memory.<br>○ Government agencies may report on program implementation but not necessarily incorporate lessons learned into program design. |
| Systemic Level | ○ Climate change adaptation are not mainstreamed into national development strategies. | ○ Laws in climate-sensitive sectors (agriculture, water, health) do not mention climate change and/or adaptation. | ○ Action Plan on Climate Change Mitigation lacks funding.<br>○ Low government salaries make it difficult to attract and retain qualified staff. |

## Scoping the Frontline Public Services Related to Climate Change

The local people in the study areas have prioritized the need for addressing underlying social and economic vulnerabilities, such as improved infrastructure through better roads, embankments and access to water and electricity and access to alternative livelihoods. These views reflect the strong relationship between climate impacts and existing vulnerabilities of communities. This also suggest the needs to enhance and improve existing development strategies for vulnerable communities in areas such as agriculture, livelihoods transport, health and education. The local people do not distinguish between climate specific interventions from ongoing development and service delivery interventions. The following discussion intends to outline the public service delivery at the four study areas as reported by the local stakeholders.

**Department of Health and Family Welfare (DHFW):** The DHFW has been running different programs including Community Clinic Program to provide health care for the children since 2007, the IMCI program for the welfare of women and children, the EPI program for the welfare of all the people of the area since 1985, and the MNH Program since 2013. The department provides health facilities of mother and child, take measures to prevent diseases like tuberculosis and malaria, and operates family planning and emergency health care facilities during disasters.

**Program Implementation Officer (PIO):** The PIO of upazila Parishad takes and implements programs to face climate change such as developing and forwarding projects to line Ministries, oversees the implementations of different projects and monitor of the Kabikha, Kabita, and TR programs. The project implementation Officer (PIO) of Chakaria upazila Parishad takes different initiatives to face climate change or natural disasters such as projects implementation, road, dam, and different infrastructure construction etc. The PIO implements different programs on climate change and disaster reduction.

**Department Public Health Engineering (DPHE):** The DPHE works for the management of sanitation and safe drinking water through building tube wells, examination of arsenic in water, and providing building materials for sanitation. The DPHE implemented rural water supply and sanitation programs successively in different phases, which installed latrines in all the study areas. They also make people aware of using the sanitary toilet.

**Department of Agriculture Extension (DAE):** The DAE has been running Disaster and Climate Risk Management in Agriculture (DCRMA) project since 2010–2014 fiscal year. The DAE provides high yielding paddy, wheat and jute seeds. The department undertook a project, which benefited farmers through providing seeds and fertilizers. Increasing yield through mechanizing the farms project, Integrated Farm project, and Safe Harvest project using the IPM technique have been running since 2014–15 fiscal year. The DAE is providing trainings on agriculture and climate change through field climate school and paddy cultivation in saline prone areas. They also distribute various agricultural equipment, providing supports to the affected farmers, distributing seeds and fertilizers, and undertake arrangements for suggestions through agricultural block supervisors. The DAE also undertook projects to provide training to the livestock farmers and treatment to the livestocks.

**Fisheries Department (FD):** Fisheries Department works for the production of fish and fish resources management such as delivering fishes in the ponds of government schools and mosques, providing training to the fishermen, and registering shrimp enclosures. In Tarash upazila, the FD has initiated the Beel Nursery Installation Program in 2012-15, Beel Sanctuary Program in 2014 - 16 and the Beel FCDI program in 2013– 15 to accelerate the development of marginalized people in the upazila. In Chakaria, the department has implemented the Marine Fisheries Capacity Building

Project and Freshwater Fish Farming Project and extension project for Fish Farming Technology Services.

**Department of Women and Children Affairs (DWCA):** The department directly operates climate change related activities and launched projects for the development of vulnerable women, who are environmentally and ecologically vulnerable, distressed, widow and helpless. The department generated employments related to the constructions of roads and dams for vulnerable women). The DWCA has also provided the poor women with rice and the poor mother with Maternity allowance.

## LANDSCAPE OF CLIMATE FINANCE IN BANGLADESH

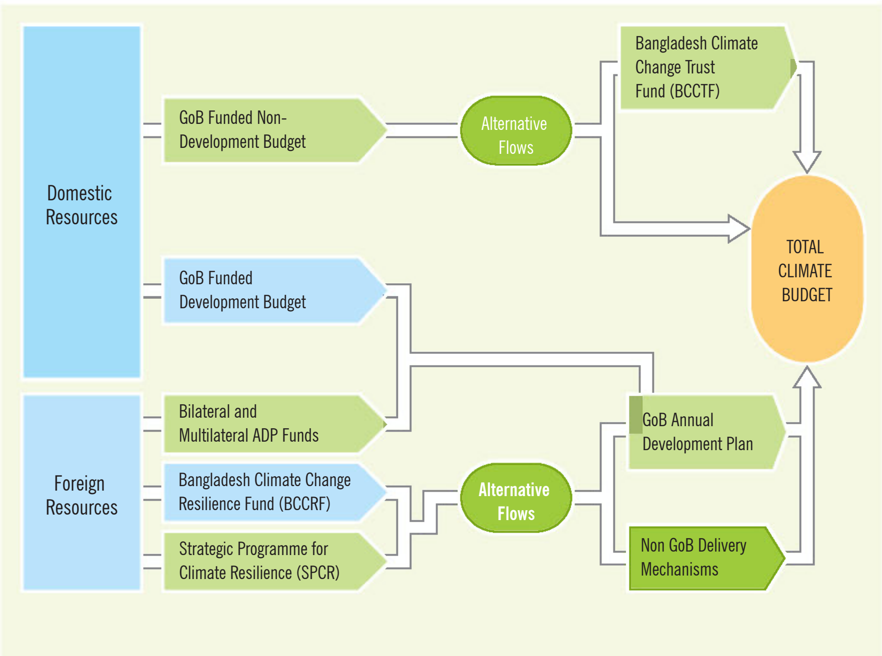
### Climate Public Finance

Climate finance involves a complex web of connections among public and private institutions including banks, other financial institutions, international institutions, transnational agencies and so on. The diversity of institutions involved in channelizing climate finance has their respective governance and financial arrangements. In Bangladesh, like many other developing countries, climate change has yet to develop any strong institutional base in the government administration. Hence, budget-tracking of the sectoral administrative ministries does not allow to assess the performance and financial integrity of these entities segregated by climate change expenditure. The climate change expenditures, therefore, are accounted, in part, on program-based budgeting reforms, with the identification of spending by outputs and strategic objectives. Even with such reforms, climate change actions and expenditures are difficult to distinguish from other development interventions.

The concept of 'climate finance' has gained considerable attention, in recent time, following commitments from developed countries to provide new and additional funding for action on climate change. The World Resources Institute (WRI) defines 'climate finance' as the flow of funds toward activities aimed either at (i) 'mitigation', for example reducing greenhouse gas (GHG) emissions, or (ii) 'adaptation', i.e. helping societies to develop resilience in adapting to the negative effects of climate change(GoB 2014).A series of studies has explored the context of estimating the size of the financing need and assessments of how the international financing architecture can meet those needs. Sources of 'climate finance' includes the private finance for private actions in addition to the finance that governments spend on climate change (Miller 2013). These studies have pointed out the significance of mobilization and effective use of increased international resources for action on climate change. Additionally, they exhibit growing interest in understanding 'climate finance' from the perspective of recipient countries and building 'readiness' to plan for, access, deliver and monitor 'climate finance'. However, this section aims at exploring how the Bangladesh government might make use of the national budget system to prioritize a response to climate change and can make effective use of domestic and international sources of public finance for climate change response.

The 'readiness' of countries like Bangladesh has become significant concerns to receive increasing international financial flows to address the challenges of climate change. UNDP have developed a framework, which can be used to assess 'readiness', which they define as the capacities to (i)plan for finance for climate changes, (ii) access different forms of finance, (iii) deliver finance for implementation of activities, and (iv) monitor, report and verify climate related expenditures and their impacts (Miller 2013; Vandeweerd, et al. 2012). The national capacities to manage the increased financial flows have become preconditions of mobilizing additional finance for national response to climate change. However, Miller suggests that "in practice governments manage public policy, not 'climate finance' and public policy is operationalized through the national budget process based on the resources available, not on the size of the financing need" (Miller 2013: 7). As discussed, towards the beginning of this chapter, that government use

**Figure– 6.5: Outline of Climate Fund Streaming in Bangladesh**




*Source: GoB 2012*

a range of policy instruments to achieve the objectives and have limited resources to finance those policies.

Climate finance, in the context of Bangladesh, refers to flow of funds on to adaptation programs primarily and, to a limited extent, to mitigation activities. However, the 7$^{th}$ Five year Plan documents the Government's commitment to undertake both adaptation and mitigation efforts as part of setting sustainable development goals. The Government of Bangladesh is increasingly streaming significant amount of financial flows for investments in building climate resilience as well as in mitigation efforts including solar energy projects and afforestation programs in climate hotspots (see Figure– 6.5).

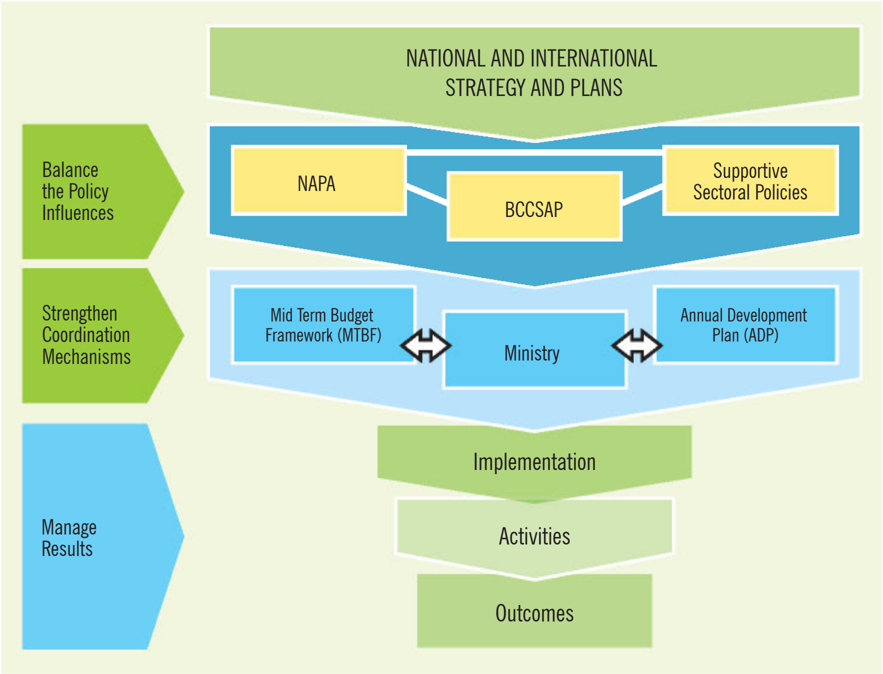
Public finance for climate change can make use of either government or non-government systems. Currently, 71 Ministries and Departments of GoB are preparing the ADP, while the co-ordination is conducted by the Planning Commission. Since 2005-06, the budgetary process is following the Medium Term Budget Framework (MTBF) approach to ensure optimum utilization of resources consistent with the strategic goals and objectives of the Government. The MTBF of the ensuing budget year contains estimates of revenue and expenditure for present and projections for the two upcoming years. The Government Money and Budget Management Act of 2009, mainly article 4 and 5 under clause 10, establishes the linkages between Ministry Budget Frameworks (MBFs) and the Government's strategic objectives, and policies to resource allocations and resource allocations to performance. Nevertheless, scales and complexities of the allocative and planning processes are highly formidable.

The Medium Term Budget Framework (MTBF) outlines the responsibilities of different Ministries and identifies the ways and means of achieving Government objectives. The format of the MTBF allows scope for narrative explanation to capture and understand the rationale of monetary allocation in order to implement a program may be valuable for making a systems, infrastructure or community climate resilient. The interaction between the ADP and MTBF is of high significance for successful implementation of BCCSAP in relation to the implementation and performance frameworks of the respective ministries. However, climate change policy objectives can be achieved by ensuring an adequate balance between sector policies and national strategy.

The priority areas of the Government are outlined in the Vision 2021, Perspective Plan 2010-2021, and the Seventh Five Year Plan. The annual budget and associated projections are prepared in line with these goals, objectives and priorities. Resources are allocated to the identified priority sectors without affecting the macro fiscal stability. Consistent to this, the expenditure of the Government has increased significantly in recent years and the allocation to high priority areas has also been increased substantially.

At the same time, Government is also emphasizing on the achievement of desired goals by enhancing capacity of resource utilization. The government has adopted several reform initiatives in order to ensure proper utilization of resources. Along this course, the Medium Term Strategy and Business Plan (MTSBP) has been introduced for some large spending ministries. The MTSBP is expected to be an effective instrument for establishing linkages

**Figure– 6.6: Integrating Climate Change into National Development Arrangement**




*(Source: Adopted from GoB 2012a: 56)*

between the Five Year Plans and sector strategies to policies at individual ministry level. However, Annual Operational Plan will be prepared within the framework of MTSBP, which will play effective roles in allocating adequate resources against specific projects and activities.

The analysis of sectoral resource allocation provides the context for policy analysis and the overall policy priorities in Bangladesh. There has been a successive increase of resource allocation towards the Power sector since FY2010– 11suggesting a government priority to allocate substantial resources to achieving greater capacity in energy sector. This shift in policy priorities has significant lessons for climate and other policy initiatives implying that the policy environment is likely to be competitive between compelling demands. The present budget also emphasized on physical infrastructure, particularly on 'Transport and Communication' and 'Fuel and Energy' sectors (see Table– 6.6). Another significant aspect of the present allocation is that the Planning Division receives a lump allocation of Tk.1,065.83 crore as special development assistance to different ministries/divisions. Tk. 9,000 crore has been allocated for fertilizer and other agricultural incentives.

**Table– 6.7: Sectoral Comparison of Public Expenditure (FY17R to FY18B)**

| Sector | % Share in BFY18 | %Share in RBFY17 | Change in FY18B over FY17R | | |
|---|---|---|---|---|---|
| | | | Crore Tk | % | Rank (Growth) |
| Education and Technology | 16.40 | 15.90 | 15152.00 | 30.10 | 7 |
| Public Service | 13.60 | 10.70 | 20633.00 | 61.00 | 1 |
| Transport and Communication | 12.50 | 11.40 | 13815.00 | 38.10 | 5 |
| Interest | 10.40 | 11.10 | 6099.00 | 17.20 | 10 |
| LGRD | 6.90 | 7.00 | 5451.00 | 24.50 | 8 |
| Defense Services | 6.40 | 7.30 | 2544.00 | 11.00 | 12 |
| Agriculture | 6.10 | 6.30 | 4397.00 | 21.90 | 9 |
| Social Security and Welfare | 6.00 | 6.70 | 2944.00 | 13.90 | 11 |
| Public Order and Safety | 5.70 | 6.50 | 2124.00 | 10.20 | 13 |
| Fuel and Energy | 5.30 | 4.60 | 6557.00 | 45.00 | 2 |
| Health | 5.20 | 4.70 | 5823.00 | 39.30 | 4 |
| Others (Memorandum Item) | 2.70 | 4.40 | –3082.00 | –22.30 | 14 |
| Industrial and Economic Services | 1.00 | 0.90 | 1232.00 | 43.30 | 3 |
| Housing | 0.90 | 1.60 | –1441.00 | –27.90 | 6 |
| Recreation, Culture and Religious Affairs | 0.90 | 0.90 | 844.00 | 30.50 | 15 |
| Total Expenditure | 100 | 100 | 83092.00 | 26.20 | |

*Source: CPD (2017): An Analysis of the National Budget for FY2017-18*

The ADP projects, however, are rarely developed basing on public consultation rather follow a top–down approach. At the same time, there are gaps between policies and practices because of the absence of any guidelines to translate national policies into sectoral development planning at institutional level. Government Ministries and agencies tend to plan for their own domain following the guidance of respective sectoral policies and strategies rather than national climate change strategies to drive the preparation processes. Currently, there are 71 Ministries and Departments who are responsible for preparing the Annual Development Plan (ADP) and co–ordination is conducted by the Planning Commission– a very complex and difficult task to accomplish.

### Climate Fiscal Framework

The concept of Climate Fiscal Framework (CFF) is of relatively recent origin and it is still in an incipient stage. The framework is designed to maximize the efficiency of public finance system for utilizing the national and international climate finance. The financial landscape comprises a diverse range of intermediaries, instruments and planning systems. Yet, the challenge remains in mobilizing and channeling resources to climate-related investments in Bangladesh. There exists a significant deficit between the needed and leveraged financial resources. Bangladesh needs to develop economic and financial instruments and use financial planning systems to boost synergies across intermediaries in the financial landscape (Pervin and Moin 2014). Given this backdrop, in 2014, the Finance Division of MoF has developed the Climate Fiscal Framework (CFF).

The CFF provides principles and tools for climate fiscal policy-making, helping to identify the demand and supply sides of climate funds and to ensure that climate fiscal policy (CFP) is transparent and sustainable in the longer term. It also provides an account of fiscal developments and resource estimates for climate expenditures; and supports analysis of how CC-related expenditures are being integrated into national budgetary processes. The CFF aims to promote an update-able country system to (1) cost and prioritize climate actions; (2)access international and national sources for climate finance; (3) deliver climate finances; (4) track climate expenditures; and (5) make climate finance and expenditure accountable (GoB 2014).The CFF is expected to provide incentives and guidance for prioritized climate actions reflected within the existing national budgetary framework (i.e. MTBF) including estimation of potential long-term financing requirements. The framework will create an enabling environment for GoB to access international climate finances and establish national funds for climate change. The framework will help identify the weakness in institutional arrangement along with capacity gaps, and recommend further development of institutional and human resource capacity in the Planning Commission and the Finance Division (FD), aiming to develop long-term revenue expenditure plans in accordance with key policy instruments e.g. BCCSAP, NAPA, NAP, and other supportive sectoral CC planning instruments.

## ANTHROPOLOGICAL PERSPECTIVES AND POLICY IMPLICATIONS

This chapter also highlights the significance of anthropological research for addressing the complex challenges of climate change and supporting adaptation by reducing the vulnerability of people at the policy level. The global modeling perspectives of climate change are lacking in capturing the micro-level insights and localized scales of analysis. These macro-modeling and perspectives cannot ever fully capture the complexities of real life and how decisions are made at the frontline. Anthropological understanding of culture, as an adaptation tool and a knowledge base, can effectively mediate the micro and macro levels of analysis and enhance our understanding of the interaction between humans and climate. Anthropology has a long-standing tradition of making contributions to the understanding of vulnerability and adaptation to environmental stresses. Political economy and political ecology approaches in anthropology can provide significant insights into the context of climate risk portfolios, policy solutions and governance challenges.

The analysis of risk management, at the local level, in relation to people's protection motivation and decision-making strategies has the potentials of effective policy formulations to address the needs of frontline people. Psychological anthropology can explain the cognitive mechanisms that influence the perception of climate risk that shapes people's protection motivation to generate and adopt appropriate course of actions and adaptive behavior. Anthropology is, however, "well-positioned in the interface between human culture and behavior and the earth sciences to comment on climate and climate change. We have a clear understanding of the human-associated nature of climate drivers and impacts, as well as the culturally-bound framing of international governance regimes…. Anthropology is uniquely placed to question the meaning of climate change, how it is constructed by different parties including science and political actors, and how it is maintained" (Fiske, et al. 2014: 18–19). Anthropological scholarship can also help us understand the political and public resistance to the science of climate change as part of a cultural and political divide, and the historical occurrence of such contestation since the development of natural science paradigms. In the context of Bangladesh, climate change policymaking needs to account the anthropological perspectives of culture as to be the key mediating factor shaping the interaction between humans and climate.

*Image–17: Coastal Island Moheshkhali during Low Tide (Photograph by S M Mahfuzul Islam Rahat).*

*Image–18: Before the Rain (Photograph by Mohosin Kabir).*

*Image–19: Newly Accreted Charland (Photograph by Hasan Shafie).*

Chapter Seven

# Indigenous Coping and Adaptation Practices

## COPING AND ADAPTATION PRACTICES IN CHAKARIA UPAZILA

### Coping and Adaptation to Climatic Hazards

Coping and adaptation strategies to climatic hazards in Chakaria upazila, along with the rate and intensity of their usage, are determined based on different climatic hazards and severity of damages caused by them.

**Flooding and Flash Flood:** Flood causes damages to different sectors of Chakaria upazila. In the agriculture sector, agricultural field or cultivable land goes under water causing high damages to the seedbeds and medium damages to the crops. Lack of proper drainage system caused medium level damages to vegetables. Almost every year flash flood causes medium level of damages through breaking the banks of ponds and shrimp *ghers*[1] (Kendrick 1994) and overflowing and sweeping away their fishes and shrimps. Sluice-gates and dams are damaged by overflow of flood waterand causes low–level loss to the salt *gher*. Sufferings of the local business persons are medium to

1 *Gher- the Bangla term 'gher' is an enclosure made for prawn cultivation by modifying rice fields through building dikes around the field and excavating a canal several feet deep inside their periphery to retain water during the dry season (Kendrick 1994).*

low. Because of flood and flash flood their commodities are damaged and cost of transportation increases. In addition to these, due to the presence of a small number of customers in the market their sale goes down. Flood is one of the major problems for the health and lives of people causing medium to low level of damages. Due to the shortage of safe drinking water, the occurrence of water borne diseases such as: diarrhea, cholera and typhoid increases at a medium rate and the rate of death and injury caused by these diseases is low. Sufferings for animals and plants are medium such as death of livestock due to living under open sky during flood and loss of trees and plants due to soil erosion. On the other hand, in the occupational sector wage laborers face medium rate of loss as they remain unemployed due to lack of job opportunities. Infrastructural damages are very common with medium loss during disasters in Chakaria upazila. Houses located on low land, roads, bridges, culverts and protection embankments are submerged and significantly damaged. Among others, People suffer with high mental pressure due to the loss of their resources, riverbank erosion, lack of drainage system, landslide in the hills, and destruction of forest resources are also found in Chakaria upazila.

Local people use different types of adaptation strategies against their disasters and vulnerable conditions. To reduce the loss of seedbeds due to flood farmers try to prepare their seedbeds relatively on higher places and the rate of this preparation is medium. During this time, they do not buy much plants and seeds from outside markets. To protect their crops from flood the rate of advance cultivation is very low and to save their vegetables the rate to keeping drainage system in the vegetable field is medium. The fishermen take several initiatives to protect the pond bank and fish stock, while the frequency of practicing such initiatives varies to a large extent. The practice of elevating the pond bank is medium or average, while the practice of net fencing around the pond is quite high. The frequencies re-excavating pond in dry season and planting trees on the bank of these ponds are medium. They practice different measures to protect their shrimp and salt *ghers*. The use of using concrete blocks to protect the river banks is relatively less popular among them and the frequency of using sticky (*atel)* to elevate the perimeter of shrimp *gher* is medium. During flood, local businessmen take various preparedness measures to protect their commodities, goods and raw materials. The place all these items on scaffolds made at higher elevation. A few of them transport their commodities by river-ways to reduce the carrying cost. Safe drinking water become scarce during flood, which is am important source of health risks. Water purification practices include boiling of water and use of water purification tablets, while the frequencies of practicing these measures are medium and low respectively. During flood they transfer their livestock to safe shelters on elevated places. The frequency of tree plantation on the banks of the river and dam is medium. However, day laborers also take different types of adaptive strategies to overcome the sufferings. The rate of engaging them with various development works of union parishad (TR, *Kabi Kha,* etc.) is medium, and migrating to other areas in search for alternative short-term employment is medium. Local people take a few strategies to reduce their infrastructural losses, such as: the rate of building houses on higher places is high, rate of using schools and colleges as shelters is medium, re–construction of roads, bridges and culverts is medium, and the rate of constructing the dams of river is low.

**Cyclone:** Some local influential people have brought saline water into the agricultural land for shrimp and salt cultivations and this has caused several damages to the normal agricultural practice in this area. The rate of damages to seedbeds and vegetable fields due to cyclone is medium to high, and the rate of damages done to the land and its crops due to the intrusion of saline water through tidal surge is medium. Due to opening the sluice-gates, fishes of sweet water die and the rate of this is medium, and the rate of reduction of the species of different types of fish is very high. Local businessmen also suffer a lot due to cyclone. The amount of damages done to the products due to the intrusion of saline water and heavy wind is much, and the presence of customer lessens due to heavy wind. People, living in an unhealthy environment, suffer from various diseases and the rate of this is very high. Due to the scarcity of safe drinking water, people suffer and die. Besides people, animals and plants also suffer badly with a medium magnitude of damages, such as: livestock dies due to living in open place during flood and the trees fall down due to soil erosion. Infrastructural damages are very common in Chakaria during disasters with a medium magnitude of damages. The roofs of semi–*pucca* and *kacca* houses are blown away due to heavy wind, houses fall down, schools, colleges and cyclone centers are damaged, and the dams of river are washed away due to heavy current in the river.

Local people adopt different types of adaptive strategies and coping mechanisms. To reduce the loss of seedbeds farmers try to cultivate saline resilient seeds and crops but prevalence rate of this is significantly low, and to reduce the loss of vegetables and crops, the cultivation of shrimp and salt is gaining popularity. To protect the pond bank and fish stock of ponds, they make use of concrete blocks for protection block and try to keep the sluice-gates closed for preventing the intrusion of river water and protecting different fish species. During cyclone, local business persons preserve their goods and raw materials on scaffold placed in higher level. Apart from that they may be involved temporarily into other types of businesses, and they reduce their spatial mobility for those period of time. They do not go outside of their houses unless it is an emergency. Reduction of health risks of frontline people related to cyclone, they usually keep their cyclone shelter clean and try to ensure the supply of safe drinking water. Most of them try to move their poultry and livestock to safer places at times of disaster because poultry and livestock are considered as to be one of the most important productive assets for the local people. As a mitigation measure, they try utmost to plant suitable trees on the bank of river and protection embankment. They also adopt different adaptive measures to protect their houses against cyclone. A good number of people try to build cyclone resilient housing, while the practice of using rope to tying down the roof with the mainframe of the house or with some ground sources are significantly popular among the local people. Moreover, in a very limited case, they take initiatives to protect the embankments.

**Salinity Intrusion:** Intrusion of saline water into the agricultural land for shrimp and salt cultivations has caused several damages. The magnitude of damages to seedbeds and vegetable field due to salinity is significantly high. Due to the opening of sluice gates, fishes of sweet water die and the rate of fish species variety reduction is also quite significant. Living in an unhealthy environment, people suffer from various diseases with a gradual increase in the prevalence of such diseases. This situation gets worse due to the unavailability of safe drinking water. Apart from people, different flora and fauna also suffer from medium rate of damages such as outbreak of livestock diseases and loss of different species of trees.

Local people use different types of adaptive strategies. To reduce the loss of seedbeds, some farmers try to cultivate saline tolerant seeds and crops, and to reduce the loss of vegetables and crops, they introduce cultivation of shrimp and salt. Protecting the pond bank is an important concern for them. They try to protect the fish stock from overflowing with the flood water. Construction and maintenance of protection embankment, plantation on embankment and water flow management through regulating sluice gates are significant measures adopted by local people.

**Storm Surge and Tidal Surge:** The magnitude of damage to seedbeds rate of damages to seedbeds and vegetable fields due to tidal surge is significantly high. Additionally, the intrusion of saline water through tidal surge also causes damages to agricultural land and the crops therein. Saline water intrusion causes the extinction of sweet water fish species along with the reduction of species diversity in the study area. The flooding of shrimp *gher* due to tidal or storm surges can also cause significant damage to them. The local businessmen suffer a great deal due to the intrusion of saline water and high wind. People suffer from various diseases such as diarrhea, cholera and typhoid due to living in unhealthy environment and scarcity of fresh drinking water. People may also die due to the unavailability of safe drinking water and the rate of this is low. Apart from people, other flora and fauna sustains damages due to salinity intrusion. Besides, livestock dies due to the lack of food and drinking water, while prevalence of diseases increases due to saline water. Infrastructural damages are very common during disasters in Chakaria upazila. Due to heavy water flow with tidal surge, roads are damaged, rubber dam–bridge–culvert breaks down, and schools, colleges and cyclone centers are also damaged.

Local people use different types of adaptive strategies. To reduce the loss of seedbeds farmers try to cultivate saline resilient seeds and crops, and to reduce the loss of vegetables and crops, they introduce cultivation of shrimp and salt. Protecting the pond bank is an important concern for them and they elevate the level of pond bank to protect the fish stock from overflowing with the flood water. Construction and maintenance of protection embankment, plantation on embankment and water flow management through regulating sluice gates are significant measures adopted by local people. The local people also use net fencing around the pond and gher to protect the fish stock. The businessmen keep their goods and raw materials on scaffold placed in higher shelf as a protective measure against storm surge. The local people try to move their livestock to safer places at the time of disaster.

**Erratic and Less Rainfall:** Both erratic and less rainfall cause maximum damages to agricultural crops which include drying up of crops, lessgrowth, and delayed time for their maturity. Scarcity of water has multifarious impacts including decreases the natural food resources for fish, decreases the total production of fish, increases fish diseases, and significantly increases the production or cultivation cost of fish stock. Livestock also faces risks at this situation. Some of these damages are increase of water borne diseases, death of livestock, decrease in the rate of production, and damages to the grass of their grazing ground. Water borne diseases become wide spread during this period. Living in unhealthy environment and scarcity of fresh drinking water can cause the outbreak of diseases and sometimes people may die out of these diseases.

Local people use different types of coping strategies. They use shallow machine for irrigation to agricultural land. They keep the livestock in cooler place, preserve dry food and water, and cultivate of Nepier and German grass for the livestock.

**Table– 7.1a: Adaptive Response to Cyclone in Chakaria**

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| **Sectors** | **Description** | **Causes** | **Likelihood** | **Activities** | **Practice Frequency** |
| Agriculture | Seedbed damages | High wind & Saline water intrusion | Likely | Adoption of salinity resilient crops | Low |
| | Damage of vegetables field | High wind & Saline water intrusion | Extremely Likely | Introduction of innovative cultivation processes (shrimp, salt and vegetable) | Low |
| | Crop damages | High wind & Saline water intrusion | Very likely | Introduction of innovative cultivation processes (shrimp, salt and vegetable) | Medium |
| Fishing | Death of sweet water fish species | Damages and opening of sluice-gate | Likely | Construction and reinforcement of protection embankments on river banks | Low |
| | | | | Maintenance of sluice-gate | Medium |
| | Decrease of fish species | Storm surge with saline water | Very likely | Tree plantation on river banks | Medium |
| | | | | Construction and reinforcement of protection embankments on river banks | Low |
| Business | Product damages | High wind speed and water surge | Very likely | Keeping goods and products in higher places | Medium |
| | Sales decreases | Decrease of customers | Very likely | Income and occupation diversification | Low |
| | Communication and Transportation Problem | High wind speed and water surge | Unlikely | Delimiting movements to necessary places and only during emergency | Low |
| Health | Increase of diseases | Unhealthy environment | Very likely | Keep the shelter centers clean | Medium |
| | Loss of human life | Outbreak of diseases due to the unavailability of safe drinking water | Likely | Using water purification methods including the use of tablets | Medium |
| Infrastructure | Houses damage | Blowing of rooftops of kacha and semi–pucca houses | Very likely | Construction of cyclone resilient houses with very low rooftop | Medium |
| | Schools, colleges and shelter centers damage | Blowing of rooftops of kacha and semi–pucca houses | Very likely | Tie down the rooftops with rope and ware | High |

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| **Sectors** | **Description** | **Causes** | **Likelihood** | **Activities** | **Practice Frequency** |
| | Destruction of embankments | Due to high tidal surge | Very likely | Construction and reinforcement of protection embankments on river banks | Low |
| Animals and Plants | Breakdown of trees | Lack of solid soil | Very likely | Tree plantation on river banks and embankments | High |
| | Domestic animals die | Domestic animals in open places | Likely | Domestic animals are taken to different places | High |

**Table– 7.1b: Adaptive Response to Tidal Surge in Chakaria**

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| **Sectors** | **Description** | **Causes** | **Likelihood** | **Activities** | **Practice Frequency** |
| Agriculture | Seedbed damages | Saline water intrusion | Very likely | Adoption of salinity resilient crops | Low |
| | Vegetables field damages | Illegal excavation of canals for salt and shrimp cultivations | Very likely | Introduction of innovative cultivation processes (shrimp, salt and vegetable) | Medium |
| | Crop damages | Illegal excavation of canals for salt and shrimp cultivations | Very likely | Introduction of innovative cultivation processes (shrimp, salt and vegetable) | Medium |
| | Submerged shrimp cultivation field (*gher*) | High tidal surge | Very likely | Construction of dams around shrimp enclosure with sticky (aetel) mud & elevation of pond banks | High |
| Fishing | Floods in ponds | High storm surge | Likely | Construction of dams around shrimp enclosure with sticky (aetel) mud and elevation of pond banks | Medium |
| | Death of sweet water fish species | High storm surge | Likely | Construction of dams around shrimp enclosure with sticky (*aetel*) mud and elevation of pond banks | Medium |
| | Fishes washed away from overflown ponds | High storm surge | Very likely | Net fencing around ponds | High |

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| Sectors | Description | Causes | Likelihood | Activities | Practice Frequency |
| Business | Goods and product damages | High storm surge | Very likely | Keeps products on higher places | Medium |
| | Sales decreases | Decrease of customers | Very likely | Engagement with other occupations | Low |
| | Communication and Transportation Problem | Water surge | Unlikely | Delimiting movements to necessary places and only during emergency | Low |
| Health | Increase of water born diseases | Unavailability of pure drinking water | Extremely Likely | Rain water harvesting | Low |
| | | | | Using water purification methods | Medium |
| | Loss of human life | Unhealthy environment and snake bite | Very likely | Keeping shelter centers clean | Medium |
| | | | | Taking medicine from local pharmacies | High |
| Infrastructure | Damage of roads and walkways | Storm surge | Very likely | Raising of the plinth level of houses | Medium |
| | Dams, bridges and culverts break down | High storm surge | Likely | Re–construct roads, bridges and culverts | Medium |
| | Schools, colleges and shelter centers damage | High storm surge | Likely | Tie heavily with rope and ware | High |
| | | | | Build pacca houses | Low |
| Animals and Plants | Domestic animals die | Lack of fodder and water for domestic animals | Likely | Domestic animals are taken to high places | Medium |
| | Increase of domestic animal diseases | Saline water intrusion with storm surge | Likely | Use of medicine | High |
| | Breakdown of trees | High storm surge | Very likely | Plantation of trees | Medium |

**Table– 7.1c: Adaptive Response to Flash Flood in Chakaria**

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| Sectors | Description | Causes | Likelihood | Activities | Practice Frequency |
| Agriculture | Seedbed damages | Agricultural land remains under water due to flood | Extremely Likely | Preparing seedbed on relatively high land | Medium |
| | | | | Preparing new seedbed | Medium |
| | | | | Buying seed plants from market | Low |
| | Crop damages | Submerged agricultural land | Very likely | Cultivation of fast maturing crops | Low |
| | Rotting of Vegetable | Poor water drainage system | Very likely | Excavating canals for drainage of water from vegetable field | Medium |
| | Submerged agricultural land | Agricultural land remains under water due to flood | Very likely | Cultivation of fast maturing crops and harvesting before rainy season | Low |
| Fishing | Fish overflow due to damages of pond banks | Flash flood (heavy water flow from the hill) | Very likely | Raising the level of pond banks | Medium |
| | | | | Fencing the pond with net | High |
| | | | | Excavating ponds during dry season | Medium |
| | | | | Plantation of trees on the banks of ponds | Medium |
| | Flood in salt enclosure | Damage of sluice-gates | Likely | Construction of protection embankments on river banks | Low |
| | Flood in Shrimp enclosure (*gher*) | Heavy rainfall in the upstream | Very likely | Construction of dams around shrimp enclosure with sticky (*aetel*) mud | Medium |
| Business | Damages of product and raw materials | Roads and pathways remains under water | Likely | Preserve the products in higher places (use of bamboo made scaffold or *macha*) | High |
| | Increase in products transportation cost | Roads and pathways remains under water | Extremely Likely | Transportation of products through river ways | Low |
| | Business abated | Decrease of customers | Very likely | Engaged in other businesses | Medium |

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| Sectors | Description | Causes | Likelihood | Activities | Practice Frequency |
| Health | Increase of water born diseases (diarrhea, cholera and typhoid) | Unavailability of pure drinking water | Very likely | Establish water reservoir | Medium |
| | | | | Drink boiled water | Medium |
| | | | | Use water purifying tablets | Low |
| | Loss of human life | Due to disease and injury | Likely | Take medicine from local pharmacies | Medium |
| | | | | Go to local medicinal practitioners | Medium |
| Infrastructure | Submerged houses | Houses in lowlands and heavy rainfall in upstream | Very likely | Constructs the homestead area relatively higher | High |
| | | | | Usage of schools and collages as shelters | Medium |
| | Damages of roads, bridges & culverts | Unplanned and weak construction of infrastructure | Very likely | Re–construction of roads, bridges and culverts | Medium |
| | Break down of river protection embankments | Unplanned and weak construction | Very likely | Repair, reconstruction and maintenance of river protection embankments | Low |
| Employment and Income | Earning decreases | Serious unemployment due to flood | Extremely Likely | Enrollment into Govt. social protection and safety-net programs (*kabi kha, TR*) | Medium |
| | Lack of works | Serious crisis of works due to flood | Very likely | Migration to other regions in search for works | Medium |
| Poultry and Livestock | Loss of domestic animals | Keep the domestic animals under open sky | Very likely | Domestic animals are taken to different places | High |
| Tree & plant | Destruction of Trees and plants | Lack of solid soil base | Very likely | Tree plantation beside the rivers and dams | Medium |

**Table– 7.1d: Adaptive Response to Salinity in Chakaria**

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| Sectors | Description | Causes | Likelihood | Activities | Practice Frequency |
| Agriculture | Seedbed damages | Illegal excavation of canals for salt and shrimp cultivations | Very likely | Adoption of salinity resilient crops | Low |
| | Vegetables field damages | Intrusion of saline water | Very likely | Introduction of innovative cultivation processes (shrimp, salt and vegetable) | Medium |
| Fishing | Death of sweet water fish species | Damage of sluice-gates | Very likely | Repair, reconstruction and maintenance of river protection embankments | Low |
| | | | | Repair and maintenance of sluice gates | Low |
| | Decrease of fish species | Saline water | Very likely | Tree plantation on the river banks | Medium |
| | | | | Repair, reconstruction and maintenance of river protection embankments | Low |
| Health | Increase of diseases | Unhealthy environment | Very likely | Keeping the shelter centers clean | Medium |
| | Loss of human life | Unavailability of safe drinking water | Likely | Using water purification methods | Low |
| | | | | Take medicine from pharmacies | High |
| Animals and Plants | Diseases of domestic animals increase | Saline water intrusion with storm surge | Very likely | Collect fodder and medicine for animals | Medium |
| Trees and plants | Destruction of Trees and plants | Saline water intrusion with storm surge | Very likely | Tree plantation | Medium |
| | | | | Repair, reconstruction and maintenance of river protection embankments | Low |

**Norwester:** Norwester *(Kalboishakhi)* causes huge damages to different sectors. Significant damage occurs in fisheries and livelihood sectors. Trees are uprooted, and the branches of these trees are also destroyed. The fallen tree and branches cause damage to the roofs of the tin shed houses in this upazila. The magnitudes of these damages are very high. Local people use different types of adaptive strategies, such as: they build strong houses and plant heavy wind resistant trees and remain prepared alert for the safety of people and livestock.

**Coastal and River Erosion:** In Chakaria upazila, due to river erosion both the agricultural land and the crops are washed away and the rate of this loss is medium. The damages done to the houses, property and roads on the bank of river are quite high. River erosion also causes damage to the roads and normal water flow in the channels through over siltation and the rates of these loses are medium. However, with excessive rainfall river overflows causing damages to dams, houses and trees on the bank of the river. Many of the houses and trees are washed away in the river and in many cases over siltation reduces the depth of river. The rates of these damages are also high in Chakaria upazila.

Local people use different types of adaptive strategies. To protect their houses and other properties some of the strategies taken are building protection dams around the agricultural lands on the bank of the river relatively higher, moving removable goods from the houses to the shelter, constructing brick built roads higher than usual, and putting mud on the bank of the river to restrict the overflow of water. The rates of all these activities are very high. During crisis moment people cope up with the situations either through making their living on higher places or migrating to other safer areas of the upazila. The rates of these practices are also high. Some other adaptive strategies are tree plantation on the banks of the river, dredging of the channels for smooth flow of water to and from the river, opening the sluice-gate so that there should not be any water logging, planting more trees on the sides of the roads, building proper dams so that the river water cannot enter human habitation areas, and repairing the damaged houses with the help of loan received from different GO and NGO sources. The rates of these activities are relatively high in Chakaria.

## Adaptive Response of Livelihood Groups

**Farmer and Cultivators:** In Chakaria, less rainfall during the months from June to September causes drought. This reduces the growth of paddy and ultimately their roots dry up. There is also an increase in the attack of insects. To keep the production of vegetables and betel leaf most of the farmers collect water from rivers and underground aquifers and supply it to the agricultural lands. They put roof on the betel leaf, set new deep tube wells for irrigation, build concrete drainage system, dredge the channels, and renovate the drainage system for irrigation. These initiatives have been highly useful to increase the growth of paddy and protect their roots. Along with this, reduction of the attack of insects and increase to the production of vegetable and betel leaf have been very high. Saline water from the sea enters the land during the months from March to May and November to December. This saline water is causing damages to the crops and reducing agricultural lands in Chakaria upazila. To overcome these problems the farmers take several initiatives and some of these are increasing the height of the island of the agricultural field, repairing the damaged rubber dam, mud dam and sluice gate, production of saline resilient seeds and crops, and introducing new cultivation processes (shrimp, salt and vegetables) among others. They have been able to reduce the damages of crops more than half and, at a very low level, they have been able to protect their cultivable lands from loss.

Cyclone occurs, in this area, during the months from March to May. As a result, their agricultural lands and crops go under saline water. This saline water is causing damages to the crops reducing both productivity and amount of agricultural lands in Chakaria. Some of the strategies to solve problems are seeking suggestions from the experts on agriculture, collecting crops in advance and cleaning agricultural lands, keeping themselves aware of the dangers of cyclone, and producing saline resilient crops. They have succeeded, to some extent, to save their lands and crops from going under saline water. Flood occurs during the months from May to August. But it becomes intense during the months of June and July. Flood damages their crops and seedbeds. Initiatives taken by them in this case are preparing new seedbeds (if possible), collecting paddy from outside, sometimes cultivating advanced species of paddy, preparing seedbeds on higher places, and opening the sluice gate to remove water from their agricultural land. Slightly less than a half of them have been able to protect their crops from going under floodwater and save their seedbeds.

Waterfall from the hills occurs during the months from May to July with excessive rain. Ripe crops and agricultural lands become over flooded. To overcome these problems farmers try to take care of the river dams and plant trees on the banks and dams of the river with minimum success. Usually river erosion occurs during the months from June to August. However, this can happen during any months of the year through the changes in the direction of the river. Farmers lose their agricultural lands with crops in the river. At a low rate, they have been able to protect their agricultural land through building river dams (polder and block) and planting trees on the banks of the river. *Kalboishakhi* occurs during the months from March to May causing damages to crop and vegetable fields. Farmers try to go to safer places during *Kalboishakhi* and also collect the crops from the field in advance. With these initiatives, they have been able to reduce rates of loss of their agricultural products on a medium scale.

**Shrimp Cultivator:** In Chakaria upazila, during drought and excessive heat water of shrimp enclosure dries up and salinity and virus of shrimp *gher* increase. Shrimp cultivators take several initiatives to overcome these problems, such as: raising the perimeter of shrimp *gher* relatively higher, digging these *ghers* at least 3–5 feet deep, seeking suggestion from the experts of shrimp cultivation, discussing with the upazila fisheries officer, changing water in morning and evening (i.e. increasing the rate of changing the water), protecting the shrimps through using coconut leaf, using vaccine to reduce the attack of shrimp virus in consultation with upazila fisheries officer, using lime in the enclosure, if the problem persists selling the shrimps, and collecting coral and other fishes from the *gher* for their livelihood. With these, they have been slightly successful in creating favorable environment for the shrimps and reduce salinity and viruses of shrimp *gher* and shrimp.

Salinity of shrimp *gher* increases during the months from March to May and November to December causing damages to the shrimps. Some of the damages are reduction of the growth rate of shrimps (it happens if the amount of salinity in water increases from 25 to 27 pp), increase the prevalence of diseases, and death of shrimps. To overcome these problems initiatives taken by the shrimp cultivators are: taking lessons from their past experiences, raising the islands of shrimp *gher* relatively higher, seeking suggestion from the experts of shrimp cultivation, discussing with the upazila fisheries officer, blocking the channels of water, releasing relatively larger shrimps for cultivation, supplying sweet water to reduce salinity, closing the sluice gate to block the entry of saline water, and using lime in the *gher*. Through these initiatives, they have been capable enough to block the entry of saline water and reduce the rate of salinity of water through mixing sweet water in the *gher*.

Tidal surge occurs during the months from March to May causing damages such as breaking down of the islands of *gher*, over flooding of *gher* with saline water and washing away of shrimps. Initiatives taken by the shrimp cultivators to face these problems are: taking lessons from their past experiences, raising the islands of shrimp *gher* relatively higher, seeking suggestion from the experts of shrimp cultivation, discussing with the upazila fisheries officer, blocking the channels of water, closing the sluice gate to block the entry of saline water, selling shrimps if needed, and collecting coral and other fishes from the *gher* for their livelihood. All these initiatives have brought very limited success for them to protect their shrimps.

Flood occurs during the months from May to August and it becomes intense during the months of June and July. As a result, shrimp *gher* becomes over flooded and over silted, fishes float away, and the islands of *gher* break down. Initiatives taken by the shrimp cultivators to face these problems include taking lessons from their past experiences, binding the islands of shrimp *gher* relatively higher, seeking suggestion from the experts of shrimp cultivation, discussing with the upazila fisheries officer, blocking the channels of water, closing the sluice gate to block the entry of saline water, selling shrimps if needed, and collecting coral and other fishes from the *gher* for their livelihood, and preparing new *gher* after flood. They have been able to protect their shrimps with these efforts a little less than medium level. Waterfall from the hills occurs during the months from May to July. Due to this, shrimp enclosures become over–flooded, shrimps get washed away, prevalence of diseases of shrimp and salinity concentration of *gher* increases. To overcome these problems, shrimp cultivators take several initiatives such as raising the islands of shrimp *gher* relatively higher, seeking suggestions from the experts of shrimp cultivation, discussing with the upazila fisheries officer, blocking the channels of water, closing the sluice gate to block the entry of saline water, fencing the *gher* with net, and reducing the rate of shrimp cultivation. All these efforts have been less effective to protect their shrimps from this disaster.

**Fish Cultivator:** During drought, ponds dry up, cultivation of fish is hampered, and intensity of diseases increases. To overcome these problems some of the initiatives taken by the fish cultivators are: discussing with the upazila fisheries officer, supplying water to the ponds from deep tube wells, digging of ponds during winter, seeking suggestion from the experts, putting branches of trees on the surface of pond water, using different medicines in the ponds, and giving lime to the ponds to protect the cultivated fish. Through these efforts, they have been able to protect their fish cultivation and reduce the disease of pond fish at a medium level. Salinity is responsible for the problems of pond fish cultivation such as death and decrease of pond fish. To face these problems they discuss with the upazila fisheries officer, take initiatives to discuss with the officers of Bangladesh Water Development Board regarding the management of dam, sluice gate and rubber dam, close the sluice gate, clean saline mixed water from the pond as this destroys the habitats for sweet–water fish, take care of sluice gate so that no one can damage it, keep concrete blocks on the bank of the river, raise the bank of pond relatively higher, and plant trees on the banks of the river. They have been able to reduce the death and loss of fish stock at a medium level.

Tidal surge occurs during the months from March to May causing over flooding of ponds, and washing away and dying of sweet water fishes. Some of the initiatives taken by pond fish cultivators include discussing with the upazila fisheries officer, taking initiatives to discuss with the officers of Bangladesh Water Development Board regarding the management of dam, sluice gate and rubber dam, fencing the ponds with net to protect the fish from washing away, cleaning the saline mixed water from the pond as this destroys the habitats for sweet water fish, and discussing about the negative impacts of tidal surge with others for their awareness. They have been able to protect fish from washing away and reduce the rate of death of sweet water fish at a very minimum level.

Flood causes damages to the banks of their ponds, and fishes of these ponds are washed away. To overcome these problems they discuss with the UNO and upazila fisheries officer to take necessary actions, open sluice-gates to remove flood–water, dig their ponds during dry season, build the bank of ponds relatively higher, and fence these with net. They have been able to protect their fishes from washing away and save their ponds from erosion at a very minimum level. Excessive rainfall causes waterfall from the hills and as a result, ponds become over flooded, over siltation damages these ponds, and fishes float away. Some of the strategies taken to overcome these problems are building the banks of ponds higher, creating awareness among fish cultivators regarding flash flood, opening rubber dam and sluice gate, putting bamboo and wood on the dams, selling fishes before rainy season, fencing pond with net, and digging ponds during winter. Reduction of siltation in the ponds and protecting fishes from being washed away has been possible at a low rate. River erosion causes ponds to be over flooded with siltation and floating away of pond fish. To overcome the problems people used to build the banks of ponds higher, request UNO and upazila fisheries officer to take necessary actions, put polder blocks on the banks of the river, renovate the damaged dams, identify the risky areas of river, and construct dams on the danger zones of the river. These strategies have less effect to protect the ponds and fishes.

## COPING AND ADAPTATION PRACTICES IN ASSASUNI UPAZILA

### Coping and Adaptation to Climatic Hazards

Coping and adaptation strategies to climatic hazards in Assasuni upazila, along with the rate and intensity of their practice, are determined by different climatic hazards and severity of damages caused by them.

**Erratic and Excessive Rainfall:** Erratic and excessive rainfall as well as water logging cause damages to different sectors of this upazila. People use various adaptive strategies to cope up with hazardous situations. Such as farmers change the time of cultivation and depend on market for agro–product during these disasters. Several other strategies are taken by local people to avoid the effects of excessive rainfall and water logging such as strengthening the shore of pond, raising the elevation level of pond banks to protect it from overflowing, and placing houses and tube wells in comparatively elevated places. To resist the erosion of mud road reeds are planted at the roadside. As excessive rainfall causes cowshed or poultry habitats submerged by water, these places are elevated to higher positions and ailing animals are sent to the rural veterinary doctor. If the water sources of nearby places are damaged then the water of relatively elevated places is collected for drinking. Rainwater is preserved and PSF water is used. Medicines are collected from the local bazaar to cure the mosquito and water–borne diseases during excessive rainfall. Apart from these, the day laborers become scarce and a few of them migrate to other areas of the country in search of work.

**River and Embankment Erosion:** River and embankment erosion causes damages to different sectors of this upazila. People use various adaptive measures to cope up with hazardous situations. To resist the effects of river erosion and protect shrimps from floating away to other *ghers* walls of *ghers* are elevated, net fence is made surrounding the *gher* and walls of *gher* and pond is made with clayey soil. Again, the boundary or isle of *gher* is elevated and vegetables are cultivated so that water cannot penetrate during riverbank erosion.

In agriculture, farming is carried comparatively in elevated places that can hardly be submerged under water and the timing of farming is altered to avoid river erosion. People have to prepare themselves to rush to any elevated places because river erosion can occur at any moment. Children, old, and physically challenged people are given priority in this situation. Many people migrate to other places of the country to retain their livelihoods. If crops are damaged due to river erosion, people depend on the market for essential foodstuffs. To resist the erosion of mud road, reeds are planted at the roadside. If water sources of nearby places are damaged, people collect drinking water from relatively elevated places. Rainwater is preserved and PSF water is used. In most of the cases, people collect medicines from local market to cure the mosquito and water–borne disease.

**Salinity Intrusion:** Intrusion of saline water in agricultural land causes harm to the land and cultivation practices of this upazila. Local people use several adaptive strategies to counter the effect of salinity. At a very minimum level, people use rainwater to minimize the salinity of the land and cultivate crop during rainy season. Vegetables are cultivated in relatively elevated places and its rate of application is high. In most cases, shrimp farming replaces the practice of crop cultivation because of salinity. It takes a few years to remove salinity from the pond or water reservoir. As a result, fresh and salt–water tolerant fishes *(i.e. Tilapia, Tengra)* are cultivated in the saline affected ponds at a medium rate. Along with these goats and sheep are fed with the roadside grasses than that of grasses from marshland at a medium rate. People usually do not collect grass from other areas. People frequently use safe drinking water for cattle. It is a common practice to plant fruit trees (like coconut, date and palm) and fuel herbs on the higher places of homestead areas. Use of tiles on the walls of buildings, mosques or temples, government and non–government infrastructures to protect them from salinity is not frequent enough. Because of excessive heat, use of umbrellas, harvesting of rainwater in water reservoir, and drinking water from tube wells are most frequent in the upazila.

**Norwester:** Local people follow different adaptation strategies to cope up with norwester *(Kalboishakhi)*. Farmers cultivate wind tolerant BR rice at a medium rate to counter *Kalboishakhi*. Farmers usually do not cut the branches of trees to protect their cropland. To protect their resources from erosion, building strong and wide isle is more common. Low height houses are not very common. Building houses tolerant of wind velocity of 62 km and the common cyclone is a medium level adaptation strategy. The most common strategy is to stay away from the trees during *Kalboishakhi.*

**Thunderstorm:** Thunderstorm is a disaster causing damages to people , trees and livestock of this area. During thunder storm thunderbolt becomes a risk and, in most cases, people take shelter in houses, shops, mosques, and temples. If people are injured, it is a common strategy for them to go to the health complex or doctor for treatment. This is a very common strategy for the shrimp farmers to build low and small houses inside their *gher* so that people can take shelter during thunderstorm and thunderbolt.

**Temperature Rise:** Drought caused by rise in temperature and excessive heat wave has become a common threat for people and their livelihood. People take different strategies to cope up with this climatic hazard. Agricultural farmers place a shed over seedbed to save it from the drought and direct sun, but this strategy is not very common. This is a medium practice for them to install deep tube well for irrigation with the help of cooperatives. Very few of the farmers prepare water reservoirs beside their farmlands as an adaptive strategy to drought. In most of the cases shrimp farmers bring river water into their *gher* through canals so that the *ghers* should not dry up. Fish farmers of sweet water raise the altitude of their ponds or water reservoirs and irrigate into the ponds. These strategies are not very common in this upazila to cope up with excessive heat and drought. People are moderately concerned about their health. They do not use umbrella to protect skin from excessive heat. However, using of mosquito net is very common. Drinking homemade saline and taking drugs from local pharmacies are very common to sustain their life in this climatic hazard.

## Adaptive Response of Livelihood Groups

**Day Wage Laborer:** Excessive rainfall in the months of Asar, Srabon and Vadro results in unemployment in the brick-field sector. The unemployed day laborers work in fish and agriculture farms. This occupational adaptation is very common because of the abundance of shrimp farming in the area. Again, to sustain their livelihood many brick-field workers take interest–free loan from their employers, which they adjust from their later earning from brick-field. This is a common type of practice for them. Workers often suffer from heat stroke, dehydration and fatigue because of the scorching heat during the months of Chaitra, Baishakh and Jyestha. To avoid this problem, they choose to work at early morning with consent from their employers. Another common coping strategy for them is to wear cap made of *goalpata*. Workers drink Tokma Grain mixing with water. Tokma Grain is available in market and is not costly. If they become sick, they go to the community clinic, health complex, and hospital for treatment. During water logging, physically strong workers migrate to other areas of the country in search of works and this is a very common strategy for them as a coping strategy.

**Farmer and Cultivator:** Salinity exists throughout the year in Assasuni and as a result, shrimp farming replaces agricultural farming. In rainy season, cultivation of crop can be materialized because rainwater reduces the level of salinity in land. If salinity impedes cultivation, the land is left out for 2/3 years. During this time, fishes of fresh water and salt water are cultivated. The minnows of these fishes are locally available. In the months of Baishakh, Jyestha and Asar, paddy plants get smashed by the *Kalboishakhi* storm and the branches of land side trees break down on the land. To minimize these sorts of damages, the practice of cultivating strong wind resistant BR rice is very high. The upazila Agriculture Office promotes this variety of rice seed available in the local market. BR rice reduces maximum damage. In the months of Chaitra, Baishakh, Jyestha, Vadra and Ashwin, insects attack the crops diminishing the quality of crop. Pesticide and sex trap, available in the local market, are used to kill those insects. Upazila Agriculture Office provides sex trap and its user manual.

Due to excessive rainfall in the months of Asar, Srabon and Vadra vegetables are rotten and the seedbeds are washed away. To minimize this loss, the time of crop cultivation is altered. Upazila Agriculture Office helps in this respect. A shed is placed over the nursery and rain tolerant crops such as *Ipomoea aquatica* spinach, *pui* spinach and jute are cultivated. The slab is removed from the gateway to canal so that water can be drained out. Water is drained out by drilling the dam inside the beel. If excessive rainfall makes the seedbed submerged under water, mosquito net is placed at the mouth of the drain. Farmers depend on market for agro–products and sell the damaged vegetables in local market. All these strategies reduce the decomposition of vegetables and washing out of seedbeds at a minimum level. Timely cultivation and maturity of the crop seem unlikely due to the temperature rise in Chaitra, Baishakh and Jyestha. To overcome this problem, during dry season (i.e. at the beforehand of the cultivation), water reservoir is dug up adjacent to the cultivable land. This water reservoir is used for fish farming as well.

During drought, farmers jointly (i.e. on a cooperative basis) install deep tube well to irrigate farmlands. NGOs give loan to get modern irrigation equipment. Crops remaining unripe are harvested earlier and this practice reduces the cultivation hazard at a medium level. River erosion occurs from the months of Baishakh to Falgun. This river erosion brings saline water into the farmland, which ultimately turn into shrimp *gher*. To protect land from river erosion several strategies are taken such as building dams with geo tex, fencing the mouth of dam with bamboos, and using boats filled with soil and palm leaves into the dam to make it stronger. These strategies have reduced the damages at a medium level. Water logging occurs in the months of Baishakh, Jayestha, Asar, and Srabon. To escape from water logging, crops are cultivated in relatively higher places with drainage facilities to remove excess water.

**Shrimp Farmer:** In the months of Chaitra, Baishakh and Jayestha epidemic through an increase in temperature becomes very common in shrimp farming and this impedes the regular growth of shrimp. During this crisis, adequate water is preserved in *gher*, the depth of *gher* is increased, and the isles of *gher* are heightened. Many of the workers are engaged to do these works. During heavy temperature, collective irrigation is made and river water is channeled to the *gher*. During water logging in the months of Baishakh, Jayestha, Asar, and Srabon, it becomes difficult to remove excess water from *gher*. Some of the strategies taken to overcome this crisis, drains are dug up along the *gher* (locally called *gonomukh*), net fencing is made around the *gher*, and a centralized draining system is developed to remove excess water.

River erosion, occurring in the months of Baishakh, Jayestha, Asar, Srabon, Vadra, Kartik, Agrahayan, Paush, Mugh and Falgun, washes shrimps out of the *gher*. To reduce this loss, *gher* is made with clayey soil, Upazila Fishery Office provide training on how to use geotex in this process, wall of *gher* is heightened, and fencing (made with net and bamboo) is used around the *gher*. On many occasions, during river erosion and water logging, shrimp farmers have cultivated fish that come along with river water. In the months of Baishakh, Jyestha, Asar and Srabon shrimp virus occurs resulting in the death and interruption of shrimps. Strategies taken to face the attack of virus, lime or fertilizer is used in the *gher*, dirty mud is removed from the bottom of *gher*, different pro–biotic is applied, dead shrimps are collected, and if needed other salt water fishes are cultivated. NGOs provide loan for all these purposes. With these strategies a very few number of shrimps can be saved from virus attack, but the interruption to the growth of shrimp can be reduced to a medium level.

**Table– 7.2a: Adaptive Response to Salinity Intrusion in Assasuni**

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| Sectors | Description | Causes | Likelihood | Activities | Practice Frequency |
| Agriculture | Crop failure and harvest loss | Soil salinity reduce productivity and crops damage | Extremely likely | Waiting for rain water to washout and decrease the soil salinity and then cultivate it | Low |
| | Reduction of cultivable lands | Gradual increase of soil and groundwater salinity | Very likely | Initiating alternative livelihood practices like aquaculture e.g. shrimp and crab farming | High |
| | | | | Cultivation of vegetables in the up lands or in the homestead | High |
| Fisheries | Extinction of fresh water fish species | Intrusion of salinity into fresh water ecosystem | Extremely likely | Cultivating fishes like corbelling, telapia which can survive in saline water | Medium |
| | Disease and death fresh water fish species | Intrusion of salinity into fresh water ecosystem | Extremely likely | Waiting for couple of years for rain water to washout and decrease the surface salinity | Low |
| Poultry and Livestock | Shortage of animal fodder | Grass and forage plant species do not grow in brackish ecosystem | Very likely | Collecting grass from the swam areas to feed cows, goats | Low |
| | Shortage of grazing land | Grass and forage plant species do not grow in brackish ecosystem | Very likely | Collecting grass from the swam areas to feed cows, goats | Medium |
| | Shortage of water for the poultry and livestock | Salinity intrusion increased shrimp farming, which, in turn, reduced grazing land | Likely | Collecting drinking water from distant places | High |
| | | Reduced crop cultivation due to salinity resulted shortage of straw | Extremely likely | Collecting and purchasing grass from other places | Low |
| Trees | Gradual extinction of plants and trees | Increased salinity destabilizes soil nutrient content | Extremely likely | Planting trees in the high land or in the homestead | High |
| | Shortage of firewood. | Salinity of soil | Very likely | Planting saline tolerant shrubs to be used as firewood | Medium |

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| **Sectors** | **Description** | **Causes** | **Likelihood** | **Activities** | **Practice Frequency** |
| Infrastructure | Shortage of trees that provide firewood | Salinity of soil. | Very likely | Planting saline tolerant trees like coconut trees | Medium |
| | Earthen houses are damaged | The base become weak and unstable. | Likely | Using different housing materials | Medium |
| | Pucca houses (outer layer) are damaged | Reduced strength of cement and plaster | Very likely | Using tiles instead of plaster in the walls of pucca houses, mosques and temples | Low |
| Health | Skin lesion and loosing hair | Exposure to saline environment and using saline water | Very likely | Properly dress up when outdoor | Low |
| | | | | Collecting water from distant places | High |
| | | | | Rainwater harvesting | Medium |
| | Illness due to lack of safe drinking water | Salinity intrusion | Very likely | Drinking water from deep tubewell | High |
| | Warm surroundings | Gradual extinction of trees | Very likely | Using umbrella | Low |

**Table– 7.2b: Adaptive Response to High Precipitation and Waterlogging in Assasuni**

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| **Sectors** | **Description** | **Causes** | **Likelihood** | **Activities** | **Practice Frequency** |
| Agriculture | Saturated soil, and loss of arable soils due to erosion and flooding | Obstructed natural drainage | Very likely | Changing cultivation cycle and seasonality by crop diversification | Medium |
| | | Increased water volume | Very likely | | |
| | Crops damage and harvest losses | Submerged crops field | Very likely | Purchasing agricultural products from market | High |
| | | Flooding due to silted river bed and obstructed drainage | Very likely | | |

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| Sectors | Description | Causes | Likelihood | Activities | Practice Frequency |
| Fisheries | Shrimps *gher* become flooded | Due to low elevation level of *ghers* compared riverbed elevation level | Very likely | Elevation of pond banks and shrimp *gher* perimeter | Medium |
| | Submerged low lands ponds and *ghers* | Due to low elevation level of *ghers* compared riverbed elevation level | Likely | Elevation of pond banks and shrimp *gher* perimeter | Medium |
| Infrastructure | Earthen houses are damaged | Heavy rainfall and waterlogging | Very likely | Building house on the high lands. | Low |
| | Submerged tubewells | Heavy rainfall and waterlogging | Likely | Raising the plinth level of tubewells | Medium |
| | Damaged earthen roads | Heavy rainfall and waterlogging | Very likely | Plantation of shrubs type species on the road sides (reed type plants) | Medium |
| Animal Resources | Shortage of fodder for cows, goats etc. | Heavy rainfall and submerged areas | Very likely | People collect grass from the swam areas to feed cows, goats | Medium |
| | Submerged grazing land | Heavy rainfall and submerged areas | Very likely | People collect grass from the swam areas to feed cows, goats | Medium |
| | Outbreak of diseases | Flooding causes the spread of water borne diseases | Likely | Building house, cowshed on high lands and taking the affected animals to veterinarian | Medium |
| Health | Outbreak of diarrhea and other waterborne diseases | Due to shortage of fresh drinking water | Likely | Collection of drinking water from high lands | Low |
| | | | | Harvesting rainwater | Medium |
| | | | | Using PSF water | High |
| | Spread of mosquito borne diseases | Stagnant polluted water | Likely | Collecting medicine from local market | High |
| | Reduced employment | Heavy rainfall and waterlogging | Likely | Temporary migration in search of employment | Medium |

**Table– 7.2c: Adaptive Response to Drought and Heatwave in Assasuni**

| Sectors | Loss and Damage | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| | Description | Causes | Likelihood | Activities | Practice Frequency |
| Agriculture | Seedbed get damaged | Due to shortage of enough water | Likely | A type of shed is built to protect the seedbed from direct sunlight | Low |
| | Crops in the field get burned | Due to shortage of enough water | Likely | A type of shed is built to protect the seedbed from direct sunlight | Low |
| | Timely cultivation become impossible | Being unable to irrigate as the water level goes down in drought | Likely | Building co-operative society to irrigate using deep tube well and modern technologies | Medium |
| | Reduced growth of crops | Due to shortage of enough water | Likely | Building water resources near agricultural field we store water | Low |
| Fisheries | Pestilence occurs due to excessive temperature | Due to the rise in temperature and humidity | Very likely | River water is imported into the Gher | Medium |
| | The normal growth of shrimps are hindered | Because the temperature rise of the water | Very likely | River water is imported into the Gher | High |
| | Fresh water fishes get affected with pestilence | Due to the shallow water depth of water sources | Likely | Increasing the depth of the water sources | Medium |
| Poultry and Livestock | Shortage of fodder for cows, goats etc. | Shortage of water causes no or less grass | Very likely | People collect and buy grass from other places | Low |
| | Shortage of drinking water for the animals | Due to drought/summer heat | Very likely | Collecting drinking water from distant places | High |
| | Natural growth of animals are hindered | Aridity reduces grassland and grazing lands | Likely | Selling of animals | Medium |
| Health and life | Problem in sanitation | Shortage of water causes limited use of water in sanitation | Very likely | Surface water sources like ponds are used for sanitation | High |
| | Shortage of safe drinking water | Drying up of ponds and tubewells due to raising temperature | Very likely | Using Alim (*phitkari*) in water | High |

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| Sectors | Description | Causes | Likelihood | Activities | Practice Frequency |
| | The skin get burned | Due to Summer heat | Very likely | Using umbrella | Low |
| | Outbreak of allergy, Diarrhea and other diseases | Due to rise of the temperature the increasing number of mosquito or this type of insects | Likely | Using mosquito net | High |
| | | | | Using medicines from local stores given generally by shopkeepers for allergy | High |
| | | | | In case of diarrhea use homemade or purchased saline | High |

**Table– 7.2d: Adaptive Response to Tidal Surge in Assasuni**

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| Sectors | Description | Causes | Likelihood | Activities | Practice Frequency |
| Fish | The banks of shrimp enclosure washed away | Riverbed filled with silt | Very likely | Elevating the banks of *gher*, pond etc. | High |
| | | Saturated soil gets washed away | Very likely | Fencing around *gher* with net | High |
| | | Reduction of the navigability | Very likely | Working on re-excavation | Low |
| | The freshwater fishes washed away from the ponds | Weak embankment | Likely | Elevating the banks of *gher*, pond etc. | High |
| | | Lack of river dredging | Likely | | |
| | | High/ low tide | Very likely | | |
| Agriculture | Land erosion occurs | Tidal surge | Medium | Making dam using Geotax | Medium |
| | Intrusion of saline water in the fields | Because of the tidal surge the salt water enters | Very likely | Elevating *gher* perimeter and cultivating vegetables on it | High |
| | | | | Cultivating crops in the high lands | Low |

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| Sectors | Description | Causes | Likelihood | Activities | Practice Frequency |
| | | | | Changing the time of cultivation (cultivating when the tidal surge does not occur) | Low |
| Health and Life | Physical injury | Water from river erosion | Likely | Learning preparedness and emergency measures for sudden tidal surge | Medium |
| | Reduced employment of day laborers | Water logging caused by the water from tidal surge | Very likely | Moving in other districts of the country to sell labor. | Medium |
| | Loss of shrimps stock due to overflown *gher* | Enclosure submerged due to water from tidal surge | Very likely | Elevating *gher* banks | High |
| | Normal lifestyle is hindered | Flooding from river erosion | Very likely | For daily commodities, people become depended on market. | High |
| Infrastructure | Earth houses are damaged | The earth houses collapse because of the water. | Likely | Building strong and comparatively water resistant house. | Low |
| | Destructed earthen roads | Soil erosion caused by the waterflow | Very likely | Reed type shrubs are grown to protect earthen roads from erosion | Medium |
| | The asphalt of the road become weak | Being submerged in the water | Very likely | The roads are repaired by using small pieces of bricks | Medium |
| | Educational institutions, mosque & temples are damaged | Being submerged in the water | Likely | By building mosques, temples and educational institutions on high land. | Low |
| | Submerged tubewell | Tube well become submerged | Likely | Setting up tube wells in high lands. | High |
| Trees | Trees are dying | Soil salinity causes extinction of trees | Very likely | Planting trees that can survive these, like caraway, mangrove, fan palm etc. | Medium |
| Animal Resource | Cows, goats, chickens become shelterless. | Villages are submerged because of the embankment erosion | Likely | Building house, cowshed on high lands. | Medium |

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| Sectors | Description | Causes | Likelihood | Activities | Practice Frequency |
| | Water borne diseases | Water borne diseases are seen due to flooding and salinity | Very likely | They are taken to local veterinarian | High |
| | | | | Animals are set free during rising water level | High |

**Table– 7.2e: Adaptive Response to Norwester and Thunder Storm in Assasuni**

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| Sectors | Description | Causes | Likelihood | Activities | Practice Frequency |
| Agriculture | Paddy fields are trodden to the ground | High wind | Very likely | Cultivating paddy that can survive high wind like BR paddy | Medium |
| | Broken branches damage crops | High wind | Very likely | Cutting down branches of the trees | Low |
| Fisheries | Damage *gher* perimeter | High wind causes *gher* overflow | Likely | Building strong and broad perimeter | High |
| Infrastructure | Damages *kacha* house | High wind | Very likely | Building house as short as possible | Low |
| | Damaged housing structures | The rooftops of earth houses, half earth houses are carried off by the high wind | Likely | Using indigenous knowledge to build house that can survive wind as fast as 62 km per hour or general cyclone | Medium |
| Health and life | Injury due to panic | High wind | Likely | Building high bench or bed in house. | Medium |
| | Physical injuries due to uprooted rooftops, houses and trees | High wind | Likely | Keeping safe distance from trees in storm | Medium |
| Health and life | Death of human and animals due to lightning | If lightning hits them | Very likely | Take shelter in the safe places, like mosques, temples, houses | High |

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| **Sectors** | **Description** | **Causes** | **Likelihood** | **Activities** | **Practice Frequency** |
| | Physical disability | If the lightning strikes near human body then disability may happen | Less likely | Take shelter in the safe places, like mosques, temples, houses. If any problem in body found go to doctor. | High |
| | Impossible to work on the field | In Baishakh, if the sky is cloudy and black, it is not recommended to work outdoor or in the field. | Likely | To remain safe during the thunderstorm, in shrimp *ghers* short and small rooms and shelters are made. | High |
| | Loss of hearing | The excessive sound generated while lightning causes deafness | Less likely | Take shelter in the safe places. If any problem in hearing found go to doctor | High |

## COPING AND ADAPTATION PRACTICES IN TARASH UPAZILA

### Coping and Adaptation to Climatic Hazards

Coping and adaptation strategies to climatic hazards in Tarash upazila, along with the rate of occurrence and intensity, are determined by different climatic hazards and severity of damages caused by these.

**Flooding:** In Tarash, the level of damages done to croplands and seedbeds due to floodwater is medium to high, while road side erosion causes low level damages to the residences and medium level damages to the roads. Besides human beings, animals and plants are also affected by flood and other disasters. Livestock are kept under open sky leading them to die. Fodder crisis intensifies because of the scarcity of pastures. Because of soil erosion, trees fall down, and fishes of pond are swept away causing medium level damages. During this time outbreak of water–borne diseases like diarrhea, cholera, and typhoid break out to a medium level. To keep safe from the flood, some of the common adaptation strategies are to prepare seedbeds on higher places, and to make new seedbeds. When croplands are submerged under floodwater, one of the medium level adaptation strategies is to cultivate Bona Aman paddy. Ensuring enough drains for the drainage system of croplands is another medium level strategy.

To protect infrastructures, homesteads are elevated, making houses with RCC pillar, and constructing guide walls along the roadside. These are medium to high–level adaptation strategies in this upazila. During flood, owners shift their livestock to safer places, take advice from veterinary doctors, keep livestock in high sheds, straw, oil cake, rice starch and chaff are used as feed as alternatives of green grass. All these strategies are considered as high to medium level adaptation strategies. Some other adaptation strategies during flood are bringing livestock to dry places to feed them grass, planting adequate trees near river and embankment, putting soil on the root of trees, and cutting their big branches. These adaptation strategies are medium in this upazila. To save fish from sweeping away, fish farmers elevate the surroundings of the pond and put external support to the surroundings. Net is used as fencing all around the ponds along with bamboo to reduce erosion of the ponds. To solve the problems of pure drinking water strategies followed at a medium level are boiling water, using water purifying tablet, and collecting water from nearby tube wells.

**Water logging:** Flood–induced water logging is responsible for the medium damage of seedbed and crop, and low damage of cropland. Medium level damages are also caused to roads, trees and plants. To remain safe from water logging, one of the common strategies is to prepare seedbeds on higher places. Cultivation of Bona Aman paddy is a medium level adaptation strategy to counter the water logging crisis. Some other medium level adaptation strategies are ensuring proper drainage system of croplands, using boat to adapt to the infrastructural damages, and planting water tolerant trees.

**Drought:** Agriculture, livestock, trees and plants, fishery, and health are damaged by drought. In most of the cases, medium level damages are done to different sectors. Excessive heat makes tender plants of seedbed and crop withered, livestock die of heat stroke, trees get withered, gas generating ponds with a decline of oxygen and drying up of pond water, and people are attacked with heat stroke. Several adaptation strategies are followed by people such as irrigation with ground water through deep tube well to save seedbed at a minimum level, to save crop the same process is highly flowed, to save from heat most of the livestock are kept under shadow of trees along with electric fan, watering is made at a minimum level to keep trees live along with planting trees around the pond, and keeping water hyacinth in the pond to keep water cool at a medium level.

**Norwester:** Sectors usually affected by norwester are agriculture, infrastructure, communication, livestock, electricity, and lives. Agriculture endures a medium level damage. Tin sheds of fragile infrastructures are blown away by the strong wind causing medium damages and roads are blocked with trees fallen causing low level of damage. In a very few cases animals get wounded by the collapsed branches of trees, but a huge damage is done to electric cables. Both of these events cause some casualties of people. Several adaptation strategies are followed to face the danger of norwester such as highly taking care of survived crops after storm, maximum use of bamboo and wire to tie infrastructures with pillars, medium action for the pillars of houses to be tightened and putting bricks on the roof of tin shed house to make it firm, removing collapsed trees from road and trimming branches of trees to prevent collapse at a low level. However, following strategies are highly practiced by people such as shifting livestock to safe places, alternative light is managed by candle or kerosene lamp, torn cables are repaired by Power Division, and people take shelters as quickly as possible.

**Hailstorm:** Sectors affected by hailstorm are agriculture and trees. High to medium level damages are done to the seedbeds, tender plants, and fruits. Medium to low level adaptation strategies are taken by people to face the danger of hailstorm such as using storm resistant plants, preparing new seedbeds, and remaining paddy plants taken care to reduce the loss.

**Cold Wave:** Cold wave causes damages to agriculture, livestock and health at a medium level such as tender plants of seedbeds get shrunk, withered or die, increase of diseases like fever, cough and pneumonia for human, and diseases for livestock. Some of the strategies followed, the degree of which is from low to medium, to face cold wave are: protecting seedbed with cover (polythene) at night and pouring them with water, putting sticks on croplands to reduce the attack of insects with birds, and high use of pesticides. Medium level strategies are taken to protect livestock such as covering them with sacks at night, keeping them in dry and warm places, and putting fireplace and lighting bulb in the cowshed and hen house to create warm. It is a very common practice for local people to wear warm clothes.

**Thunderstorm:** Thunderstorm causes damages to agriculture, human being, trees and plants, and livestock due to moving in open places. Several medium to high–level adaptation strategies are followed such as increase of tree plantation, staying inside the house during lightning, keeping livestock in safe places, and cutting down the damaged trees and their branches.

## Adaptive Response of Livelihood Groups

**Day Laborer:** The rise of outside temperature during summer has become a problem for daily laborers. They consider climate change-driven increasing temperature as a hazard for their livelihoods because they encounter difficulties while working outside. In Tarash upazila, rainfall is less in the months of Falgun, Chaitra, and Baishakh causing rise of high temperature. This condition raises health risks and causes heat stroke. To protect themselves from heat the laborers use *mathal* (one kind of cap) and umbrellas, drink lots of water and take necessary medication in case of ailment. These are very common strategies followed by them. People plant trees around their houses, which reduces their health risk/ heat stroke at a medium level. Flood, occurring in the months of Asar, Srabon, Vadra, Ashwin and Kartik, hinders livelihood and occupation of the day labourers. They take different strategies during flood, such as searching for alternative occupation, catching fishes in Chalan beel, boating, van pulling, and migrating to other areas for day laborer works. These are very common strategies for them. In the aftermath of flood, they are advised to take necessary medication and keep houses and their homestead areas clean. These initiatives reduce their risks related to livelihood and occupation at a very high degree.

**Farmer:** In Tarash upazila, during less rainfall and heavy temperature, the leaves of trees, tender plants in seedbed and crops get withered. All these increase the attack of insects. To reduce insect's attack, sticks are planted on agricultural land so that birds can sit on those sticks and devour the insects. This is a common practice for the farmers. To avoid the damages caused by extreme temperature, some of the strategies taken are irrigating land with ground water, watering seedbed, and putting straw on seedbed so that tender plants can get less heat and seeds can grow easily through the gaps of straw. These strategies are also common in this area. For more care, farmers use pesticide to prevent insects.

To avoid health risks most of the common strategies for the farmers to take rest in excessive warm condition, wear towel or *mathal* during work, and drink more water. During heavy crisis of water they use deep tube wells for more water. Upazila Agriculture Office provides farmers with advice and training on the procedures to prevent insect attack, irrigation, and selecting perfect crops for drought weather. These initiatives reduce the damages at a medium level. During storm majority of paddy plants are grounded and advice is provided by Upazila Agriculture Office to give necessary fertilizer and pesticide for the plants survived. This is not a very common practice. During flood seedbed, cropland, and harvest are submerged by the flood water and diseases break out. To face the challenges of flood some of the strategies taken are shifting agricultural equipment (shallow machine) to a safe place, roadside drains are shoveled to remove water, seedbeds are made in high places, and Bona Aman paddy is cultivated. These are common practices in this upazila. If agronomy becomes impossible during flood, farmers go fishing, boating or go to other areas in search of agricultural or day laborer works. These are common adaptation strategies for the farmers. As soon as the floodwater goes down they cultivate both maize and garlic. Thus, two crops are cultivated in a year. Those who left a job for other occupations or went to other areas, return to agronomy. Some other initiatives taken are: construction of flood tolerant roads, plantation of trees alongside roads, construction of guide wall, and providing water purification tablets. These are very common practices during flood to reduce the loss and damages.

Hailstorm occurs during the months of Chaitra, Baishakh, Jyestha and Asar causing several damages such as tender plants are broken, paddy plants are withered, and fruits get damaged. To cope up with this farmers try to pull the tender plants just before hailstorm and plant in cropland. If hailstorm occurs within 30 days of planting, they plough the total land again. Maize and cucumber are cultivated as these survive more during hailstorm. With these strategies, farmers are able to save their cultivation at a medium level. Cold wave is mostly seen from the end of Agrahayan to Poush and Magh. The tender plants in seedbed shrink because of excessive fog. Some of the strategies taken during this crisis: are covering seedbeds with polythene at night, and spraying ash and toxic on seedbed to kill Majhra Beetle. Through these steps, they are able to minimize the loss at a medium level.

**Fisher:** During the months of less rainfall, several damages are done to the fish sector such as pond water dries up, gas rises in the pond, and fishes die from heat stroke induced by the crisis of oxygen. Several strategies are taken to minimize their loss such as putting water hyacinth in the pond to keep the water cool, increasing the depth of pond to contain more water, joining deep tube well with a shallow machine to irrigate ground water, tying bricks with rope to remove gas from pond, placing banana trees in the pond water, creating artificial wave in pond with pans or pots, and using lime. These are very common practice for the fishers in this upazila. Upazila Agriculture Office also provides the fishers with advice and training on digging pond, measuring the depth of the pond, and perfect fish selection for a pond. They advise to attach deep tube well with a shallow machine in order to irrigate ground water. To increase the level of oxygen in the pond they advise to use Oxy flow and other necessary medicines in the pond. All these strategies highly minimize the level of damages caused by gas and heat. Flood is also a curse in this area taking away fishes from ponds. To save fishes of ponds its surroundings are elevated, trees are planted to prevent erosion, net fencing is set through the surroundings so that fishes cannot be swept away, and big fishes are sold in the market before flood hits. These strategies are highly sustainable in this area.

**Table– 7.3a: Adaptive Response to Flood in Tarash**

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| Sectors | Description | Causes | Likelihood | Activities | Practice Frequency |
| Agriculture | Seedbed damage | Seedbed are prepared on low lying land thus are submerged | Likely | Preparing seedbed on relatively high land | High |
| | Crop damage | Agricultural land remains under water due to flood | Very likely | Cultivating flood resistant crop (Bona Aman) | Medium |
| | Agriculture land remains under water | Sedimentation in canal | Very likely | Dig ways to pass water through canals beside the roads | Medium |
| Infrastructure | Homestead become submerged | Flood water stays for long time | Likely | Raising plinth level | High |
| | | | | Building house using high concrete pillars | Medium |
| | Roads become submerged | Soil of the adjacent lands are washed away | Likely | Building guide wall with bamboo or rocks so that soil of the road are not washed away | Medium |
| Poultry & Livestock | Increase in disease prevalence | Foot–and–Mouth Disease (FMD) or Khurarog, PPR and Ranikhet | Likely | Follow suggestions of the veterinary | Medium |
| | | | | Raising the plinth of the cattle's place | High |
| | Shortage in grazing land | Flooding of graze land | Very likely | Feeding hay and wheat or paddy bran, rice water | High |
| | | | | Taking the cattle to other dry place to fro grazing | Low |
| Fisheries | Fish stock of the pond | Fishes of the pond escapes when the ponds are submerged in flood water or pond boundary is broken | Less likely | Construction of the banks of pond relatively high and fencing the pond with net and bamboo (when the flood water increases) | High |
| | | | | Planting trees on the banks of the pond | Low |
| Plants and trees | Trees fall because of the wave of the flood water | Soil of root are washed away by wave | Less likely | Adding soil at the root of the trees | Medium |
| | | | | Cutting big branches of trees before flood so that it does not fall easily | Low |

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| Sectors | Description | Causes | Likelihood | Activities | Practice Frequency |
| Health | Increase water borne disease prevalence | Water is contaminated by flood water | Very likely | Using water purifying tablet | Low |
| | | | | Boiling drinking water | Low |
| Water | Deep Tubewells are submerged and water is contaminated | Deep tubewell is submerged into flood water in the low lying areas | Likely | Bringing drinking water from Deep tubewell of other areas | Medium |

**Table– 7.3b: Adaptive Response to Heat Wave in Tarash**

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| Sectors | Description | Causes | Likelihood | Activities | Practice Frequency |
| Agriculture | Seedbed damage | Seedbed dries up due to extreme heat and shortage of water | Very likely | Using sub–surface underground water for irrigation by deep tubewell | Low |
| | Crop damage | Crops dry up due to extreme heat and shortage of water | Very likely | Using sub–surface underground water for irrigation | High |
| Poultry & Livestock | Heat stroke | Excessive heat | Likely | Keeping under shade and feeding enough water | High |
| | | | | Using electric fan where the cattle are kept | Low |
| Plants & trees | Trees die | Excessive heat and lack of water | Very likely | Watering the roots of the trees | Low |
| Fisheries | Fish dies | Due to excessive heat, water temperature increases, thus gas increases and oxygen decreases | Likely | Planting trees on the banks of the ponds | Medium |
| | | | | Using Hyacinth in the pond | Low |
| Health | Heat stroke | Excessive heat and lack of water | Likely | Staying in shade | Medium |
| | | | | Drinking enough water | High |
| | | | | using umbrella during work | Medium |

**Table– 7.3c: Adaptive Response to Cold Wave in Tarash**

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| Sectors | Description | Causes | Likelihood | Activities | Practice Frequency |
| Agriculture | Seedbed damage | Due to fog at night and warm temperature at day | Very likely | Seedbeds are covered with polythene at night | Low |
| | | | | Seedbed s are kept watery | Medium |
| | Crops damage | Increase in pests | Very likely | Sticks are set in the crop field so that birds can sit there, thus birds eat insects and pests | Low |
| | | | | Use pesticides | High |
| Poultry & Livestock | Cattle suffer from disease | Due to excessive cold during night | Likely | Animals are covered with sacks/ jute bags | Medium |
| | | | | Animals are kept in dried and warm place | Medium |
| | | | | Use fire to increase temperature | |
| | Disease of chicken | Due to excessive cold | Likely | Use electric light to increase temperature | Medium |
| Health | Fever, cold and cough, Pneumonia | Due to excessive cold | Likely | Wearing warm clothes, keeping one's head covered | High |

**Table– 7.3d: Adaptive Response to Norwester, Hail Storm and Thunder Storm in Tarash**

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| Sectors | Description | Causes | Likelihood | Activities | Practice Frequency |
| **Norwester** | | | | | |
| Agriculture | Crop damage | Paddy crops are trodden to ground | Very likely | Try to nurture damaged crops after the storm | High |
| Infrastructure | House damage | Roofs are blown away by high speed wind | Very likely | Roofs are tied strongly with the beams | High |
| | | | | Beams are tied strongly | Medium |
| | | | | and placing bricks over the joints | Medium |

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| **Sectors** | **Description** | **Causes** | **Likelihood** | **Activities** | **Practice Frequency** |
| Communication | Road damage | Trees fall on the road | Likely | Broken trees are cleared from the roads quickly | Medium |
| | | | | Cutting bigger branches of tree to keep it small | Low |
| Poultry & Livestock | Suffer injury | Broken trees sometimes fall on the animals | Very likely | Immediately transferring in safe place | High |
| Electricity | Wire is torn, thus, electricity supply is interrupted | Broken branches of the trees fall on the wire | Very likely | Using candle and hurricane | High |
| | | | | Damaged wire is repaired with the help of electricity department | High |
| Health | Suffers injury | Hit by broken trees or electricity wire because of staying outside | Likely | Immediately take shelter in safe place | High |
| **Hail Storm** | | | | | |
| Agriculture | Seedbed | Seedlings are broken and damaged | Very likely | Try to nurture alive seedlings | Medium |
| | | | | Prepares new seedbed | Low |
| | Crop damage | Hails damage crop | Likely | Try to nurture remaining crop | Medium |
| Plant and trees | Damage of fruits | Excessive hail | Very likely | Collecting damaged fruits before it is rotten and which are not damaged are nurtured | Medium |
| **Thunder Storm** | | | | | |
| Human Health | Death of human | Staying in the open | Likely | Staying inside house during lightening | High |
| | | | | Planting more trees | Medium |
| Poultry & Livestock | Death of animals | Keeping in the open | Less likely | Keeping animals in safe place during lightening | High |
| Trees | Burnt and dead | Lightening hits big trees | Likely | Planting lot of trees | Low |

## COPING AND ADAPTATION PRACTICES IN PORSHA UPAZILA

### Coping and Adaptation to Climatic Hazards

Coping and adaptation strategies to climatic hazards in Porsha upazila, along with the rate of occurrence and intensity, are determined by different climatic hazards and severity of damages caused by them.

**Drought:** In this upazila, drought causes scarcity of water. Because of drought, water level goes down and the tube wells lack water. The rivers and reservoirs dry out and, many a time, the tube of the tube wells get cracked. This makes the damage more serious. To cope with it some of the strategies very common in this upazila are: using water from ponds and deep tube wells, re–digging ponds and wells, carrying drinking water from far places, and using a thin pipe inside of a thicker pipe so that the pipes do not crack.

There are other health hazards. Dehydration, fever, diarrhea, dysentery, jaundice, skin diseases, and heat stroke are caused by drought. Due to excessive heat, the body dehydrates and the risks of heat stroke increases. Because of drought, the reservoir and the well dry up and there is no water for sanitation. To minimize these health risks means like using water–cooling utensils (earthen pitcher/ jar) are used. The muddy water of the ponds is stored overnight and it is filtered to drink in the morning. During drought, the seasonal fruits are eaten to deal with the food shortage. Wells are dug and people drink more water and saline. Besides, people rest under the shades of threes and set up more latrines. These strategies are very common in this upazila.

Skins burn up, at a minimum level, due to heat during work on the farm. To cope up with this problem, some of the strategies followed are: building huts in the middle of the fields, using headgear, resting under the shade of trees, and less movement in the sun outside of house, drinking a lot of water and saline, and using umbrella and headgear. Drought is very dangerous for the cattle and the fields lose their lush. The cattle cannot find grass to feed on. Due to the lack of water no new grass is grown and lack of rainfall causes the harvest to hamper which leads to a lack of hay for the cattle. To cope up with this problem, the cattle are fed with hay, husks and grass bought from other areas, and often they sell their cattle. These strategies are not very common in this upazila.

Lack of drinking water for cattle is also a great disaster. All the water reservoirs dry up due to heat. People give their own drinking water to the cattle. The cattle are afflicted with diseases. Both heat and lack of drinking water may be the reasons behind this. As an adaptive strategy, the cattle are given vaccines, taken to the veterinarian, and sheltered in a cooler place. But the tendency to contact the veterinarian is less and these strategies are not very common as well. Also during drought, the water reservoirs such as ponds and streams dry up causing fishes to die. To cope up with this problem the ponds are irrigated with water from the deep tube wells, and fishes are sold before the drought season. With the increase of temperature of water amount of gas increases and to get rid of this problem gas tablets, calcium sulphate, and banana trees are used in the pond. These are medium level practices in this upazila.

Drought causes scarcity of water for irrigation. This causes the seedbeds and saplings to die. This, in turn, destroys the seasonal harvest. Without the irrigation system, it is not possible to cultivate. Lack of water causes immature harvest coupled with infestation and the lowering of the water level, the harvest decreases. Various local practices are commonly used to make a better harvest such as using compost to grow crops, re–digging and conserving water for the drought season, selecting crops on the basis of water availability, cultivating drought resisting crops (wheat, maize, mustard, Mango, Mug mashkolai, vegetables), using ground neem seeds mixed with water as an insecticide, using bovine urines to fashion an insecticide, using various herbs and compost as insecticides and fertilizers.

**Northwester:** Excessive heat and lack of water causes the trees to lose their flowers, and the trees die out as well. As an adaptation strategy, trees are irrigated and the roots are often protected by the cover of greeneries. But these are not always followed in this upazila.

**Hailstorms:** Because of hailstorms and rainfall, seedbeds and the crops are destroyed. Mangoes fall off and seedbeds have to be made again. There are no strategies followed to face the problems caused by hailstorm.

**Thunder Storms:** Due to thunderstorms, people cannot work in the fields, people and cattle lose their lives, and the trees get burnt and dead. To cope with it, people do not leave house during thunderstorms, and increase tree plantation. These are quite common among the people of this upazila.

**Cold Wave:** Cold wave shrinks and destroys the seedbeds. Cold wave and excessive cold kills the poultry and cattle. As an adaptation strategy, seedbeds are plied with more water so that the cold cannot wrinkle the bed. During cold wave, ashes and fungicide are used to protect the seedbeds and mangoes. These are medium level adaptation strategies followed by local people.

**Erratic and Excessive Rainfall:** Erratic and excessive rainfall causes several damages to trees, plants and humans such as trees are uprooted, shortage of food for cattle, decrease of income as people cannot work in the fields, and harvest and the corps are submerged. To cope up with this, the roots of the mango trees and other trees, plants and crops are elevated to keep those safe. These are very common strategies in this upazila.

**Heat Wave:** Heat wave causes several damages to different sectors of this upazila such as dry up ponds, water reservoirs, and tube wells, less movement of people outside home, burning of corps, and problem of sanitation due to lack of water. But the magnitude of damage is less. As a means of adaptation, people set up more water reservoirs and latrines.

People burn their skin while working in the field. To cope up with this problem, they build huts in the middle of the fields, use headgear, rest under the shade of trees, reduce their movement outside of house, drink a lot of water and saline, and use umbrella and headgear. These are common strategies to survive during heat wave. Cattle also suffer from diseases due to extreme heat and lack of drinking water. As an adaptive strategy, cattle are given vaccines, taken to the veterinarian, and kept in cooler places. These are very common practices in this upazila.

**Table– 7.4a: Adaptive Response to Drought and Aridity in Porsha**

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| **Sectors** | **Description** | **Causes** | **Likelihood** | **Activities** | **Practice Frequency** |
| Water | Scarcity of pure drinking water and water for domestic use | Tubewells cannot supply water as water level wend down | Very Likely | Using the water of pond and deep tube well | High |
| | | Water bodies dry up due to extreme heat | Extremely likely | Re–excavating the ponds and wells | Medium |
| | | | | Fetching water from distant areas | High |
| | | Tubewell pipe burst during drought | Likely | Using two pipes covering one another | Low |
| Health | Higher disease prevalance like dehydration, fever, diarrhea , dysentery, jaundice, skin lesion, heat stroke, etc. | Human body dehydrates and the risk of heat stroke increases.<br>Scarcity of water for hygiene and sanitation.<br>Lack of pure drinking water | Likely | Using earthen pitcher to preserve drinking water and to keep the water cool | High |
| | | | | Collecting muddy water of pond and keep it whole night in the pitcher, and in the morning they collect the upper portion of the water leaving the mud below | Medium |
| | | | | Digging the well | High |
| | | | | Drinking saline during drought and take shelter beneath the tree and in cool places | High |
| | | | | Re-excavating the ponds and wells | Medium |
| | | | | Buying medicine from the local pharmacies | High |
| | Problems in the sanitation | Scarcity of water for maintaining personal hygiene and sanitation | Very likely | Collecting water from distant places | High |
| | | | | Making sanitary latrines | Medium |
| | Lack of pure drinking water | Human body dehydrates and the risk of heat stroke increases | Very likely | Using earthen pitcher to preserve drinking water and to keep the water cool | High |
| | | | | Using the water of pond and deep tube well for drinking | High |

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| Sectors | Description | Causes | Likelihood | Activities | Practice Frequency |
| | People cannot work in the agricultural field | Due to increase of the temperature | Very likely | Making small hut beside the agricultural field to take shelter during extreme temperature | Low |
| | | | | Stay inside the home during extreme temperature | High |
| | | | | Drinking saline and water during the drought and take shelter beneath the tree and in cool places. | High |
| | | | | Using umbrella and *mathal* (bamboo made hat) to stay safe from extreme heat | High |
| | Skin lesion due to sunburn | Due to increase of the temperature | Likely | Making small hut beside the agricultural field to take shelter during extreme temperature | Low |
| | | | | Stay inside the home during extreme temperature | High |
| | | | | Drinking saline and water during the drought and take shelter beneath the tree and in cool places. | High |
| | | | | Using umbrella and *mathal* (bamboo made hat) to stay safe from extreme heat | High |
| Poultry and Livestock | Lack of enough grass and other fodder | Grasses die due to lack of moisture in the soil | Very likely | Feeding the cow straw and bran during drought | High |
| | | | | Collect and buy grasses from distant places | Medium |
| | | Less straw because of decreased paddy cultivation | | They sell the livestock's | Medium |
| | Lack of pure drinking water | Due to drought the water level of pond, lake and well decreases | Very likely | Feeding the livestock the drinking water preserved for humans | High |
| | Disease of livestock | Extreme heat and shortage of water | Very likely | Vaccination of the livestock's | Low |
| | | | | Taking treatment from local veterinary experts | Low |
| | | | | Keeping the livestock in cool and shadowy place | High |

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| Sectors | Description | Causes | Likelihood | Activities | Practice Frequency |
| Fisheries | Ponds, wells, lakes dry up | Due to extreme heat | Very likely | Digging deep tube well to supply water | Low |
| | | | | Re–excavating the ponds and lakes | Medium |
| | Dying of fish stock | Due to excessive heat water temperature increases, thus gas is increased and oxygen is decreased | Likely | Digging deep tube well to supply water | Low |
| | | | | Selling premature fish stock | High |
| | | | | Re–excavating the ponds and lakes | Medium |
| | The water of pond become turbid, while gaseous substances increase and oxygen content decreases | Increase of temperature of water | Very likely | To reduce gas banana trees are put into the pond | High |
| | | | | Re–excavating the ponds | Low |
| | | | | Using gas tablets to reduce gas | High |
| | | Decrease of water level in pond | | Waves are created in the pond manually | Low |
| | | | | Binding brick with a rope and moving it from one side to the other of the pond | Low |
| Agriculture | Seedbed damage | Irrigation is not possible due to decreased of water level in surface and ground water | Very likely | Try to use remaining water of pond and deep tube well for irrigation | Low |
| | | | | Raw dung, limestone, cow urine and water mixture are in use for seed treatment | Low |
| | | | | Excavating pond and lake to enhance water preserving capacity | Medium |
| | Crop damage | Irrigation is not possible due to decreased of water level in surface and ground water | Very likely | Try to use remaining water of pond and deep tube well for irrigation | Low |
| | People cannot cultivate | Lack of drought–resistant seeds and crops. | Very likely | Crop diversification | High |
| | | Lack of water for irrigation | | | |

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| **Sectors** | **Description** | **Causes** | **Likelihood** | **Activities** | **Practice Frequency** |
| | | | | Cultivating drought–resistant crops, like wheat, maize, mustard, mango, lentils, vegetables etc.) | Low |
| | Product maturity does not come at harvest | Irrigation is not possible due to decreased of water level in surface and ground water | Very likely | Using vermicompost | Low |
| | | | | Cultivating drought–resistant crops, like wheat, maize, mustard, mango, lentils, vegetables etc.) | Low |
| | Decreased production of crops | Increased insect attacks | Very likely | Preparing pesticides from neem seeds | Low |
| | | | | Using processed cow urine as pesticide and to bolster the immune system of the crop | Low |
| | | | | They boil the buckles and leaves of neem tree and use it as pesticide | Low |
| | | | | They the soap–water solution to kill insect of fodder | Low |
| | | Irrigation is not possible due to decreased of water level in surface and ground water | | Using vermicompost | Low |
| | | | | Making a dissolution by grinding onion, garlic, cow urine, green pepper, neem leaf, akhand tree leaf, tulsi leaf all together and use it as pesticide | Low |
| | | | | Leaves of legumes (bean, French bean, cowpea, *dhaincha*, pigeon pea, pea, epil–epil, black gram, pulse, mung) are decomposed with water in an air tight jar and use this fertilizer in the soil to reduce amount of irrigation | Low |
| Plants and Trees | Trees die | Extreme heat and shortage of water | Likely | Watering the roots of the trees | Low |
| | | | | Straw, leaves are spread over the ground near the root of the tree to preserve moisture content | Medium |

**Table– 7.4b: Adaptive Response to Heat Wave and Cold Wave in Porsha**

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| Sectors | Description | Causes | Likelihood | Activities | Practice Frequency |
| **Heat wave** | | | | | |
| Human Health | Scarcity of pure drinking water | Drying up of tubewells as water level goes down<br>Drying up of waterbodies | Very likely | Use the remaining water of pond and deep tube well | Medium |
| | People cannot work in the field | Due to extreme heat and sunlight | Very likely | Using umbrella and *mathal* (bamboo made hat) to stay safe from extreme heat | High |
| | | | | Stay inside the home during extreme temperature | High |
| | | | | Making small hut beside the agricultural field to take shelter during extreme temperature | Medium |
| Agriculture | Crop damage | Due to extreme heat and lack of water | Very likely | Cultivating drought–resistant crops, like wheat, maize, mustard, mango, lentils, vegetables etc.) | Low |
| | Maturity does not come at harvest | | | Re–excavating the ponds and lakes, and use them to preserve water with view to use this water to irrigate when necessary | Medium |
| Poultry & Livestock | Lack of grazing field, fodder and pure drinking water | Grasses dies due to lack of moisture in the water. | Very likely | Keeping the livestock in cool and shadowy place | High |
| | | | | Feeding livestock from water preserved for other family members | High |
| | | | | Feeding the cow straw and bran during drought | High |
| **Cold wave** | | | | | |
| Agriculture | Seedbed damage | Due to fog at night and warm temperature at day | Likely | Seedbeds are covered with polythene at night | Low |
| Poultry & Livestock | Outbreak of disease | Due to excessive cold | Likely | Animals are covered with sacks and jute fabric at night | Medium |

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| Sectors | Description | Causes | Likelihood | Activities | Practice Frequency |
| | | | | Animals are kept in dried and warm place | Medium |
| | | | | Burning firewood to increase temperature | Low |
| | | | | Use electric light to increase temperature | Medium |
| Health | Due to excessive cold suffer from disease | Fever, cold and cough, pneumonia etc. | Very likely | Wearing warm clothes, keeping one's head covered | High |

**Table– 7.4c: Adaptive Response to Norwester, Hail Storm and Thunder Storm in Porsha**

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| Sectors | Description | Causes | Likelihood | Activities | Practice Frequency |
| **Norwester** | | | | | |
| Agriculture | Crop damage | Paddy fields are trodden to ground | Very likely | Try to nurture damaged crops after the storm | High |
| | Seedbed damage | Seedlings are damaged | Likely | Buying seedlings from other places | Low |
| Infrastructure | Houses damage | Roofs are blown away by high speed wind | Very likely | Roofs are tied strongly with the beams and to the corner of the house | High |
| | | | | Bamboos are placed on the tin roof and tied strongly | Medium |
| Poultry & Livestock | Suffer injury | Broken trees sometimes fall on the animals | Less likely | Immediately transferring in safe place | High |
| | | | | Building strong hut for the cattle | Medium |
| Trees and Plants | Trees are broken | Due to high speed wind | Very likely | Cutting of big branches of trees | Low |
| | | | | Planting more trees with strong base | Medium |
| | Interrupted electricity supply due to torn wire | Broken branches of the trees fall on the wire | Very likely | Damaged wire is repaired with the help of electricity department | High |

| Loss and Damage | | | | Adaptive Response Strategy | |
|---|---|---|---|---|---|
| **Sectors** | **Description** | **Causes** | **Likelihood** | **Activities** | **Practice Frequency** |
| | | | | Using candle and hurricane | High |
| **Hail Storm** | | | | | |
| Agriculture | Seedbed damage | Seedlings are broken and damaged | Very likely | If hail storm affect within 30 days of sowing then the land is ploughed again | Medium |
| | Crop damage | Hails damage crop | Very likely | Try to nurture remaining crop | Medium |
| Infrastructure | Roof of houses | Tin roof damaged and rust is created | Very likely | Use strong and rust resistant tins | Medium |
| **Thunder Storm** | | | | | |
| Human Health | Death of human | Staying outside in open areas | Likely | Staying inside house during lightening | High |
| | | | | Planting more trees | Medium |
| Poultry & Livestock | Death of animals | Keeping in the open | Less likely | Keeping animals in safe place during lightening | High |

## Adaptive Response of Livelihood Groups

**Farmer:** In Porsha upazila drought occurs from the middle of Falgun to Joishtho. During this disaster, crops face a lot of problems, such as: crop failure, immature growth of crops, and lack of irrigation. To cope up with this problem farmers take different adaptive strategies, which are very common in this upazila. They plant drought resistant trees, replenish the water reservoirs, take support from agricultural department, build huts in the field to avoid heat stroke, elevate the roots of mango trees, and intake more water and saline to fight dehydration. The rates of these adaptation strategies are medium to high.

**Mango Farmer:** In Porsha upazila, droughts can also be felt during rainy season. This causes damages to the production of mangoes such as loss of size and sweetness. Some other damages are loss of leaves and branches of mango trees, burning of trees by thunderstorm, and uprooting of mango trees with an effect on its yield. Excessive rainfall creates stagnation of water around the roots of the mango trees and this kills the trees. During drought, the rate of attacks by insects increases.

Mango farmers cope up with these problems through various adaptive strategies. Those strategies are: farmers add extra soil to the roots of mango trees before drought, seek advice from the department of agriculture, remove and sell those trees destroyed by thunderstorm, use insecticides for a better production, and elevate the roots of mango trees before monsoon. The rates of these adaptive strategies are medium to high.

**Day laborer:** Day laborers face a number of threats by natural disasters in Porsha upazila. Direct impact on harvest reduces work for the day laborers. Even if work is found, the payment is considerably low. Non–agricultural works are not common here. Thus, they migrate in search for work and during post–drought period, they return home. They make a good connection with local brokers in search for work. The rates of these adaptation strategies are medium to low.

During the months of Boishakh and Joishotho, the thunderbolts increase and cause people to die. If people stay in an open field, they might be struck with lightning. So, they take shelter under large trees. There are no ways to cope up with this. The day laborers take different adaptive strategies, such as taking shelter in the nearby huts during storms and rains, taking enough water, saline, and light clothes during heat wave, taking rest after the work is done, and seeking medical attention if they have heat stroke. The rates of these adaptive strategies are medium to high. Extensive cold is a problem in this area and there are no tangibly adaptations for this.

*Image–20: Stone Collection from Hilly Watercourse (Photograph by Shuvashish Sarker).*

*Image–21: Fishing in River (Photograph by Hasan Shafie).*

Chapter Eight

# Assessment of Adaptation Options

## SETTING THE ASSESSMENT CRITERIA

The following criteria of replicability of the intervention have been suggested by the people exposed to different climatic variability and hazards in Bangladesh:

**Table– 8.1: Setting the Assessment Criteria**

| Criteria | Measurement Areas | Scope of Measurement |
|---|---|---|
| Feasibility and Viability | Dynamic Climate Feasibility | Applicability of adaptation option based on built–in contingency for a projected long–term and dynamic climate system. |
| | Social Feasibility | Potentials for social acceptability based on sensitivity to everyday life, attitudes, values and culture of local community. |
| | Administrative Feasibility | Complexity of governance, difficulty of administration or high capacity or expertize needed to administer. |
| | Structural Feasibility | Determination of acceptable risk levels for different types of structures. |
| | Intervention Feasibility | Potentials for large-scale interventions. |

| Criteria | Measurement Areas | Scope of Measurement |
|---|---|---|
| Relevance and Effectiveness | Policy Relevance | Compliance with the national policy guidelines. |
| | Climate Relevance | Relevance of adaptation outcome that improve climate resilience or contribute to climate change adaptation. |
| | Cost Effectiveness | Cost–benefit analysis of the adaptation option. |
| | Management Effectiveness | Process evaluations in terms of the appropriateness of systems and standards. |
| | Outcome Effectiveness | Likeliness of the adaptation option in terms of generating the intended impacts and outcomes. |
| Efficiency and Productivity | Eco–efficiency | Adaptation option that produce less waste, pollution and/ or emissions, while strive to maximize output at the cost of minimum environmental degradation. |
| | Productive Efficiency | Adaptation option that ensure the highest possible outputs for the available inputs. |
| | Technical Efficiency | Adaptation option ensuring that desired output is produced with the least cost combination of inputs. |
| | Allocative Efficiency | Level of allocative efficiency i.e. the goods or services produced by the adaptation option are of most value to local community. |
| | Social Efficiency | Adaptation option that maximizes social welfare and social marginal benefits. |
| Equitability and Distribution | Distributive Equity | Adaptation option that ensures equitable distribution of benefits i.e. the allocation of outputs according to who needs them most. |
| | Risk Creation | Adaptation option that is safe from producing or transferring risk to another area, different sections of the community, particularly towards poorer groups. |
| | Affordability | Adaptation option that is affordable by all the cross section people of the community including the most vulnerable groups. |
| | Gendered Equity of Benefits | Benefits of the adaptation options can be shared equally between male and female. |
| | Equitable Accessibility | Adaptation option that adequately addresses equitable chance and access to the major production factors for all segments. |
| Sustainability Assessment | Intergenerational Sustainability | Adaptation option that generates continuous benefits for long–term. |
| | Social Sustainability | Adaptation option that ensures equitable living conditions in keeping with social well–being. |
| | Environmental Sustainability | Adaptation option that ensures the protection of environment and biodiversity. |
| | Resource Use | Adaptation option that exploits resources in sustainable way. |
| | Freedom and Human Rights | Adaptation option that recognizes individual freedom and safeguards human rights. |

## ADAPTATION TO CYCLONE AND STORM SURGE

### Proposed Adaptation Interventions

In this study, five packages of adaptation intervention options have been proposed for cyclone storm surge prone areas and these are: (1) Option– 01: Coastal Afforestation, (2) Option– 02: Coastal Embankment, (3) Option– 03: Cyclone Shelter, (4) Option– 04: Cyclone Resilient Housing, and (5) Option– 05: Land Use Zoning. These are already there in varying degrees, but the proposal is to upscale them, based on past learning. The proposed options and sub–options are described in the table below:

**Table– 8.2: Adaptation to Cyclone and Storm Surge**

| Intervention Option | Intervention Types | Project Types |
|---|---|---|
| Option – 01 | Coastal Afforestation | Mangrove Plantations |
| | | Non–Mangrove Plantations |
| | | Coastal Embankment Plantations |
| Option – 02 | Coastal Embankment | Construction of Embankment (Sea dike, Interior dike and Marginal dike) |
| | | Coastal Embankment Improvement |
| Option – 03 | Cyclone Shelter | Construction of Cyclone and Tsunami Shelter |
| Option – 04 | Cyclone Resilient Housing | Construction of Resilient House |
| Option – 05 | Land Use Zoning | Planning and Changing Land Use Pattern |

### Coastal Afforestation

Afforestation is the planting of trees or their seeds to protect the shore and embankment. The development of sustainable forests along the coastline of Bangladesh is of utmost need to reduce the impact of climate change. Mangroves and non–mangrove coastal forests can play significant role in reducing the damages and protect human lives by acting as a protective shield during extreme natural events. Mangrove afforestation, as an adaptation measure, has significantly contributed to reduce the loss of lives and livelihoods against tropical cyclones and storm surges in the coastal areas (Nandy and Ahammad 2012). Bangladesh Forest Department (BFD) started afforestation program in 1966 along the coastline of Bangladesh (Das and Siddiqi 1985). Nearly two hundred thousand hector of accreted lands have been brought under coastal mangrove plantations by 2010 (Islam, et al. 2013).

**Mangrove Plantations:** The *Sonneratia apetala* (keora) is the most successful species, among the coastal mangrove plantations (Siddiqi 2001), which accounts for 94.4% of the total established plantations followed by only 4.8% plantation of *Avicennia officinalis* (baen) (Siddiqi and Khan 2004). Based on survival, height and diameter growth, the prospective other mangrove species are: Heritiera fomes (sundri), *Excoecaria agallocha* (gewa), *Xylocarpus mekongensis* (passur), *Aegiceras corniculatum* (khalshi), *Nypa fruticans* (golpata), etc. (Hossain, et al. 2003; Islam, et al. 2013; Siddiqi 2001).

**Non–Mangrove Plantations:** In the mainland, non–mangrove species, tree species such as *S. saman, C. equesetifolia, P. dulce, A. nilotica, Albizia lebbeck* (kalo koroi) and *A. procera* are found promising for planting in the elevated coastal lands (Islam, et al. 2014; Siddiqi 2002) Some other palm species like *Cocos nucifera* (coconut), *Phoenix sylvestries* (date palm) and *Borassus flabellifer* (palmyra palm) are also found suitable in the foreshore coastal areas of Bangladesh (Islam, et al. 2014).

**Coastal Embankment Plantations:** The coastal embankment plantation had begun with planting non–mangrove species on the slopes of embankment and roadside under the Green Belt Project in 1995 and Coastal Embankment Rehabilitation Project in 1997. Different types of timber, fuel wood and fruit tree species are planted on inner and outer slope of the embankment. An assessment study of growth performance and adaptability on the coastal embankment of the planted species has revealed that *Leucaena leucocephala* (ipil ipil), *Acacia mangium* (mangium), *Terminalia arjuna* (arjun), *Embelica officinalis* (amloki), *C. equsetifolia, P. sylvestris,* and *C. nucifera* species are promising (Nandy, et al. 2002).

| Likely Positive Impacts | Likely Negative Impacts |
|---|---|
| ○ Afforestation is likely to be ecologically more beneficent compared to any other adaptation measures to protect the coastal areas and offshore islands from cyclone and storm surges. Coastal forests will reduce wind speed and storm wave impacts as natural barriers against storms, storm surges and tsunami.<br>○ Mangrove forests are highly productive ecosystem in terms of useful ecological, bio–physical and socio–economic functions and likely to bring about equitable benefits to coastal populations (Siddiqi 2001).<br>○ The mangrove species, some of them, are likely to survive against natural disaster and cope with different scenarios of sea level rise (MoL 2011b).<br>○ The mangrove plantations are likely to accelerate accretion and stabilize newly accreted lands in the coastline of Bangladesh by holding soil particles and sediments with their root system. | ○ Inappropriate afforestation are not likely to generate expected benefits against cyclone and storm surges.<br>○ The mono specific plantations may cause barren spaces inside forests due to high mortality. Diversified mangrove and non–mangrove species needs to be selected to generate their adaptive capacities in withstanding climatic variations and extreme weather event. |

| Likely Positive Impacts | Likely Negative Impacts |
|---|---|
| ○ The root system can also protect river/canal banks from soil erosion.<br>○ Mangrove forests will play significant roles as breeding grounds of a variety of fishes and other marine species of high commercial value, including mud crabs, mollusks, and prawns. | |

## Coastal Embankment

Embankment is a man-made high edge built with earth or rock to protect over flow of the river. In coastal areas, BWDB has provided some embankments in order to protect coastal water inundation.

| Likely Positive Impacts | Likely Negative Impacts |
|---|---|
| ○ Embankment will protect the settlement areas and agric fields from coastal saline water inundation and over flow of river water.<br>○ It will prevent riverbank erosion.<br>○ It will prevent coastline erosion.<br>○ It will facilitate the establishment of good communication (road, electrical poles, telesystem) system and improve the socio–economic condition of the coastal area.<br>○ It supports coastal afforestation planning.<br>○ There will be no flooding by overflow of tidal waves. | ○ Embankments of low height would not resist the high tide water flow and storm surge.<br>○ Embankments increase siltation in the channels and may create waterlogging in the surrounded areas.<br>○ The natural drainage system will also be hampered by earthen embankments if not properly maintained. |

## Cyclone Shelter

Approximately 10 percent of global tropical cyclones occur in the Bay of Bengal (Karim and Mimura 2008). The construction of cyclone shelters had begun in early sixties. The immediate need of shelters have been felt after the 1970 cyclone with 300,000 estimated deaths and a property loss of billions. The project named Coastal Area Rehabilitation and Cyclone Protection was in action under the Public Works Dept. of GoB during 1972– 1979. This project with IDA support was able to build 238 cyclone shelters in 141 unions in 38 upazilas of coastal districts. After the cyclone in 1985, Bangladesh Red Crescent Society initiated building of sixty two (62) shelters. A wide range of national and international NGOs were in the assistance to Bangladesh Government in building cyclone shelters for many years. Among the NGOs Caritas, DANIDA, BRAC, the Christian Commission for Development of Bangladesh, Society for Peace, Muslim Aid, etc have constructed some shelters. Further, 260 shelters constructed on columns with floor slabs were built during the early nineties in Bangladesh (BUET and BIDS 1993). At present, the exact numbers are not known as various governmental and non–governmental organizations have constructed shelters from time to time. A recent study conducted under the auspices of the Comprehensive Disaster management Program (CDMP), disclosed that there are 3715 shelters in the fifteen coastal districts of Bangladesh. Most of the cyclone shelters are not in good conditions at present due to poor maintenance and management. The other factor is the accessibility to shelters which always hamper evacuation. Moreover, a significant number of people are reluctant to go to shelters due to various reasons such as security concerns for their assets, unsatisfied services in shelters, inadequate warning dissemination, transport and distance to shelters, inadequate awareness, issues concerned with women's privacy etc. Village factional politics sometimes create barriers for different social groupings and marginalized people to go to shelter centers during the time of emergency.

The cyclone shelters are mostly used as primary schools during normal times, apart from providing shelters during disaster times. Therefore, the management responsibilities of these cyclone shelters lay with the primary education department and more precisely the school management committees (SMCs) shoulder the key management responsibilities in their respective areas. The cyclone shelters with primary schools are also used by local communities for various other social, cultural and economic purposes (social & religious gathering, training venue, daily markets and so forth). Union Parishads (UPs), as per the SoD, are given the major role to play in disaster risk reduction (DRR) activities. The UP Chairmen and members are thus by default, get involved in cyclone shelters management mainly during disaster times. In addition, the Red Crescent Volunteers in the coastal area also play important role in cyclone shelter management particularly during disaster times in facilitating communities to come to the cyclone shelters for taking shelter. The UNO as the Chair of the Upazila Disaster Management Committee (UzDMC) also has management and coordination roles in all DRR activities including cyclone shelter management. The cyclone shelters need regular maintenance works to keep them usable for the people. The LGED (Local Government Engineering Department) usually take the major responsibilities of maintenance works for the cyclone shelters jointly with the SMCs and primary education department at the upazila level. Besides LGED, primary education department also undertake maintenance works for cyclone shelters through its facilities department. The SMCs also undertake some small maintenance works of cyclone shelters from time to time. The management of cyclone shelters is thus not a job of a single entity rather being managed by multiple organizations and agencies under an overarching management framework of disaster as suggested in the SoD.

The existing numbers of shelters in use are insufficient, even to cater for the present population who demands repair and rehabilitation of existing shelters and construction of new buildings. Cyclone shelter maintenance and management has become a significant challenge to the community or any government agencies owing to insufficient funds. Consequently, shelter maintenance is neglected. Maintaining shelters to acceptable standards is a joint effort of the governing body and the community. The exercise may hamper due to lack of clear demarcation of responsibilities, insufficient funding, lack of community ownership etc. Therefore, enhancement of cyclone shelter management system is essential.

| Likely Positive Impacts | Likely Negative Impacts |
|---|---|
| ○ It ensures safety of human life.<br>○ It provides emergency shelter during disaster.<br>○ Shelters can be used as schools, community centers or for other purposes. | ○ Cyclone shelters are not well designed for PWDs, women and elderly people.<br>○ Cyclone shelters have limited facilities (water, electricity, food, toilet and security) |

## Cyclone Resilient Housing

In the coastal area, the local people make their houses in a special manner so that these may be easily saved from the onslaught of cyclones and water surges. The pattern of these houses is such that the plinths are high, the roofs are relatively low, having small slopes and the houses are surrounded by walls on all sides. The house inside the walls is made very strong to act as the core house against cyclones and water surges.

| Likely Positive Impacts | Likely Negative Impacts |
|---|---|
| ○ This house is encircled by a strong wall and inside of the house 1 or 2 room(s) is/are built strong so that during cyclones and water surges they can act as the core house/s.<br>○ As the roof of a house becomes heavy with rain water, this can not be blown away easily by stormy wind. | ○ The tins of tin sheds could easily blown away by the strong wind during cyclones and act as blades to a poor victim<br>○ The cost of building this house is beyond the ability of poor people. |

## Land Use Zoning

The degradation of land resources is dependent on many issues in the coastal areas of Bangladesh. Flash floods from the hilly areas, storm surges and cyclone damages human lives and properties and agricultural crops. Moreover, agricultural land is rapidly reducing due to unplanned construction of settlements, markets, industries, roads and for different other development infrastructures. Unplanned uses of salt–shrimp and other interventions are causing significant loss of biodiversity, destruction of ecosystem, loss of habitats and environmental degradation. However, unplanned uses of land other natural resources are increasing the vulnerability of different marginal social groups e.g. agriculture labors, small farmers, fishermen, and landless people. However, this assessment suggests several expected benefits of land use zoning. Efficient utilization of land resources would support diversification of agricultural crops and thus ensure food security of the local people. Zoning would protect agricultural land degradation, conversion of both agricultural and wetlands to other uses. Finally, this optimum land use planning would help mitigating the challenges of global warming and climate change as well as ensure sound environment, ecosystem, and enriched biodiversity in the coastal region of Bangladesh.

## Multicriteria Assessment of Adaptation Options

In order to understand the overall comprehensive impact of an adaptation option the following spider diagrams are developed. However, please note that this rating is done based on subjective evaluation by various stakeholder groups at the local level.

**Feasibility and Viability:** This diagram compares the multicriteria assessment of adaptation options based on subjective evaluation by various stakeholders. The stakeholders were asked to rate five types of intervention options (coastal afforestation, coastal embankment, cyclone shelter, cyclone resilient housing, and land use zoning) in five categories for five assessment criteria on a scale of 0 to 5. For assessment criteria feasibility and viability, this diagram shows that for intervention feasibility coastal afforestation and coastal embankment have similar high scaling. The administrative feasibility shows a very different picture with low scaling for coastal afforestation, cyclone resilient housing and land use zoning. In case of social feasibility and structural feasibility both coastal afforestation and land use zoning have high feasibility for adaptation options. However, from all the five intervention options for feasibility and viability coastal afforestation, coastal embankment, cyclone shelter, and land use zoning have the average scaling.

**Relevance and Effectiveness:** Coastal afforestation has high scaling for policy relevance, climate relevance and outcome effectiveness. Both coastal embankment and cyclone shelter have high scaling for policy relevance, while medium scaling for climate relevance and outcome effectiveness. Land use zoning has medium priority for policy relevance, climate relevance, and outcome and management effectiveness. However, cyclone resilient housing has less relevance and effectiveness in the study areas. Overall, for all five–intervention options relevance and effectiveness remains in the high to medium scale area.

**Efficiency and productivity:** For efficiency and productivity, coastal afforestation is highly eco–efficient, while medium scale efficient for productive, social, technical and allocative aspects. Next priority goes to coastal embankment for productive and social efficiencies, while cyclone shelter has medium range priority for social efficiency. Cyclone resilient housing has less efficiency and productivity in the climate change affected areas, while land use zoning has average scaling in all aspects. However,

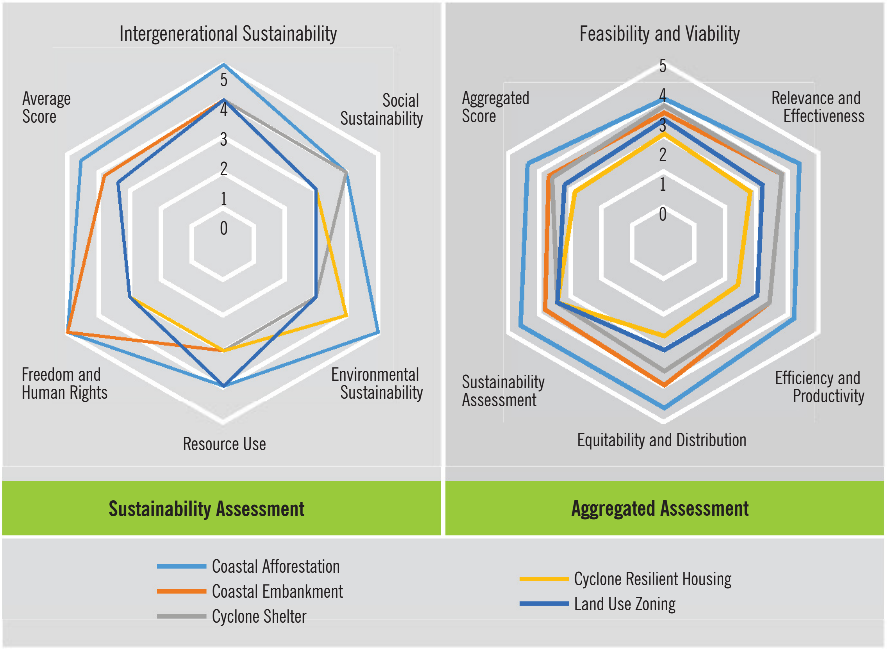
**Figure– 8.1a: MCA of Adaptation Options to Cyclone and Storm Surge**

from all the five intervention options for efficiency and productivity coastal afforestation, coastal embankment, and cyclone shelter construction have the average scaling.

**Equitability and Distribution:** Risk creation, equitable accessibility, and gendered equity of benefits are high for coastal afforestation, while gendered equity of benefits is high for coastal embankment. Coastal afforestation, coastal embankment and cyclone shelter have nest priority for distributive equity. Cyclone resilient housing has the minimum scaling for relevance and effectiveness for adaptation options. Land use zoning has some priority for gendered equity of benefits. Overall, the relevance and effectiveness of coastal afforestation, coastal embankment and cyclone shelter remains in the high to medium scale area, while cyclone resilient housing and land use zoning have medium to low priorities.

**Sustainability:** This diagram compares the multicriteria assessment of adaptation options to cyclone and storm surge based on subjective evaluation by various stakeholders. The stakeholders were asked to rate five types of intervention options (coastal afforestation, coastal embankment, cyclone shelter, cyclone resilient housing, and land use zoning) in five categories for five assessment criteria on a scale of 0 to 5. Intergenerational sustainability, freedom and human rights, and environmental sustainability

**Figure- 8.1b: MCA of Adaptation Options to Cyclone and Storm Surge**



are high for coastal afforestation, while coastal embankment has high priority for freedom and human rights. Both cyclone resilient housing and land use zoning have medium scaling for social sustainability, resource use, environmental sustainability, intergenerational sustainability, and freedom and human rights. However, for all five–intervention options resource use, social sustainability, intergenerational sustainability, and environmental sustainability have greater priorities with medium to high scaling up.

**Aggregated Assessment:** The aggregated assessment for all five–intervention options shows different scenario. Coastal afforestation is highly prioritized in terms of feasibility and viability, relevance and effectiveness, efficiency and productivity, equitability and distribution, and sustainability. For all these adaptation options, cyclone resilient housing has the medium to low score. However, coastal embankment and cyclone shelter are the other intervention options that have medium priority and scores for feasibility and viability, relevance and effectiveness, efficiency and productivity, equitability and distribution, and sustainability. Land use zoning option has good priority for its feasibility, viability, and sustainability. Overall, the aggregated score shows the trend from high to low for coastal afforestation to coastal embankment, cyclone shelter, cyclone resilient housing, and land use zoning.

## Perspective of Local Stakeholders

Different stakeholders were asked to assess the likely impacts of five types of intervention options (coastal afforestation, coastal embankment, cyclone shelter, cyclone resilient housing, and land use zoning) on a scale of highly positive to highly detrimental impacts on different stakeholders. For farmers, marginal farmers and sharecroppers coastal afforestation, coastal embankment, cyclone shelter and land use zoning are highly positive, but fishermen consider cyclone shelter and land use zoning as highly positive for intervention options. Both landless agricultural laborer and non–agricultural laborer have considered coastal embankment as highly positive while resilient housing is not so crucial for them. Fisherman and non-agricultural laborer have regarded coastal afforestation as beneficial for them. Ethnic, indigenous or religious minority, female–headed households, excluded communities, dependent people, female of all ages, and people with disability have considered coastal afforestation, coastal embankment and land use zoning as highly positive intervention options. However, in most of the cases cyclone shelter and resilient housing have received less priority from all the stakeholders at the local level.

**Table– 8.3: Perspective of Local Stakeholders.**

| Stakeholder Categories | Option–01 Coastal Afforestation | Option–02 Coastal Embankment | Option–03 Cyclone Shelter | Option–04 Resilient Housing | Option–05 Land Use Zoning |
|---|---|---|---|---|---|
| Farmer | ++ | ++ | ++ | + | ++ |
| Fishermen | + | + | ++ | + | ++ |
| Marginal farmer and Share Cropper | ++ | ++ | ++ | + | ++ |
| Landless Agri-laborer | ++ | ++ | + | 0 | + |
| Non-Agri-laborer | + | ++ | + | 0 | + |
| Ethnic, Indigenous or Religious Minority | ++ | ++ | + | + | ++ |
| Female Headed HH | ++ | ++ | + | + | ++ |
| Excluded Communities | ++ | ++ | 0 | + | ++ |
| Dependent Population | ++ | ++ | + | + | ++ |
| Female of all Ages | ++ | ++ | + | + | ++ |
| People with Disability | ++ | ++ | + | + | ++ |
| | | | | | *Note: Eudaimonic Well–Being (EWB) Scale* |

| Highly Beneficial | Beneficial | Neutral | Detrimental | Highly Detrimental |
|---|---|---|---|---|
| ++ | + | 0 | – | –– |

## ADAPTATION TO FLOOD AND RIVERBANK EROSION

### Proposed Adaptation Interventions

In this study, five packages of adaptation intervention options have been proposed for flood and riverbank erosion prone areas and these are: (1) Option– 01: Adaptive Agricultural Practices, (2) Option– 02: Flood Proofing, (3) Option– 03: Water Course Management, (4) Option– 04: River Bank Stabilization, and (5) Option– 05: Land Use Zoning. These are already there in varying degrees, but the proposal is to upscale them, based on past learning. The proposed options and sub–options are described in the table below:

**Table– 8.4: Adaptation to Flood and Riverbank Erosion.**

| Intervention Options | Intervention Types | Project Types |
|---|---|---|
| Option – 01 | Adaptive Agricultural Practices | Agricultural Intensification |
| | | Crop Diversification |

| Intervention Options | Intervention Types | Project Types |
|---|---|---|
| | | Local Adaptive Practices |
| | | Crop Cycle Management |
| Option – 02 | Flood Proofing | Raising of Mounds and Plinths |
| | | Raising the Platform of Water and Sanitation Facilities |
| | | Construction of Embankment |
| | | Raising Level of Communication Infrastructure |
| | | Construction of Flood Shelter |
| Option – 03 | Water Course Management | Excavation or Restoration of Dead Channel and Rivers |
| | | Meander Cutoff (Neck Cutoff and Chute Cutoff) |
| | | Hydromodification and Channelization |
| Option – 04 | River Bank Stabilization | Bank Protection |
| | | Articulated Concrete Block Revetment Mattress |
| | | Fascine Mattress Placement |
| | | Tree Plantation |
| Option – 05 | Land Use Zoning | Planning and Changing Land Use Pattern |

## Adaptive Agricultural Practices

Agricultural intensification is centered on three themes: increased yields per land unit for a given crop, increased yields in time and crops per year, and primacy of high–yield or cash crops instead of lower–yielding varieties (Naylor 1996). Intensification is done by transforming agricultural systems from low–energy to high–energy intensive production systems (ibid). It is, however, a process of maximizing productivity or yield (output) of a fixed land area through increasing inputs of capital and/ or labor. Agricultural intensification, in flood prone areas of Bangladesh, needs to make better use of ecosystem functioning aiming to utilize natural processes in a sustainable way for adaptation.

Climate change has altered the length of the crop–growing season, the availability of water for production and brought changes in the temperature regimes. Farmers in different countries have already initiated diversification as a response to climate change. Besides, rice mono-culture in Bangladesh has resulted in a number of problems like reduction of soil fertility, pests and diseases outbreaks in the crop fields and decline in water table etc. Moreover, rice mono-culture also reduces production of other crops, erodes biodiversity, creates nutritional imbalance as well as it is gradually reducing farmers' net margin (Husain, et al. 2001; Rahman and Talukder 2001). Adaptive cropping patterns, based on the idea of crop diversification, aligned with soil suitability and other agro–climatic conditions would significantly increase cropping intensity in the flood prone areas.

### Flood Proofing

Homesteads (*bari*) in rural areas comprise of one or more housing structures and a courtyard surrounded usually by a fence. Poorer households cannot afford more than one house, while the open space, nearer to the house, is used for cooking and livestock keeping purposes. Sometimes, several households may share the same courtyard but each household is an independent unit having a separate cooking place *(chula)*.

Raising the plinth level of homestead compound is one of the most effective adaptation option in flood–affected regions. The plinth elevation level is raised by placing earth in layers on top of the existing level until the elevation level reaches above the last known flood level. The homestead courtyard is also raised above flood level accordingly. Existing housing structures are dismantled and removed prior to raising the compound area, and reconstructed once earthworks are complete. Raising the level of homestead compound directly benefits individual household or groups of households sharing the same compound. The poor communities are better prepared to mitigate the effects of disaster shocks and losses of lives and assets by raising the plinth of houses and homestead compound. People do not need to evacuate rather they can stay on their own homestead during flood and thereby minimize their loss and damage of assets, livestocks and poultry etc.

### Water Course Management

Management of natural watercourses is considered as to be the most effective means for reduction of flood hazard. The channelization of watercourses has significant environmental limitations as well. Management of watercourses has significant positive impacts for safety and security of lives and properties. This option has the potential to reclaimed significant land surface for productive cultivation, which usually remains submerged, always or seasonally, due to river flooding. Channelization of watercourses can also generate employment opportunities as well as income for the poor people in the respective region. Particularly, this effort may generate employment opportunities for women and other vulnerable groups of people. River bed deepening through dredging may be useful in the flood affected regions and would also be beneficial for the aquatic resource management. The management of natural watercourses would reduce fish spawning ground as well as protect biodiversity. In addition, destruction of wetland would also be decelerated. Wetland is the cardinal water recharge spot and it would also give livelihood supports to people living in the catchment areas.

## River Bank Stabilization

River bank stabilization and restoration of natural watercourses have high potentials for social and environmental development because these activities are expected to reduce riverbank erosion during flood, while restored channel can be used as floodwater reservoirs. Stabilization and restoration of natural watercourses would help sustain livelihoods of different groups in the respective localities. Stabilization and restoration of watercourses by means of plantation and re–excavation are considered environmentally sustainable measure. This process involves extensive plantation, which eventually reduce erosion during flood. People can collect leaves and dried tree branches for cooking during and after flood. Given the predicted climate change scenario, the regular floods are expected to increase by the year 2040. This temporal length will be reduced with the introduction of excavation activities in the silted channels. It is expected that the impacts would be beneficial for all the components of the environment, while the level of impacts would be medium to long term.

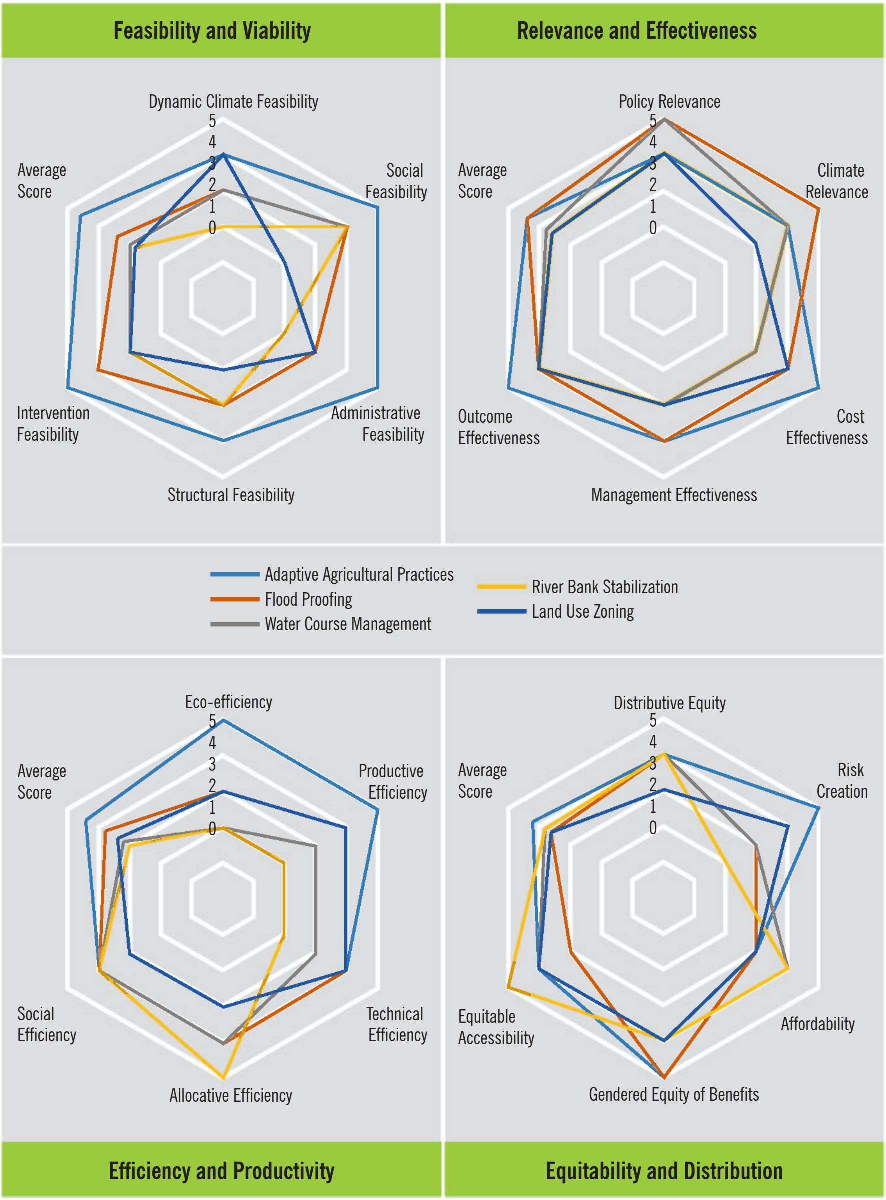
## Land Use Zoning

Zoning is the demarcation of geographic areas with specific combinations of properties and features, which would be chosen for the demarcation of zone based on the purpose of land use. The directives of National Land use Policy –2001 identify the general land use zones: agriculture, fisheries, forestry, rural and urban settlement, industrial/ commercial and other land uses. The land of Bangladesh is complex. Land and its resources are owned, developed, managed and maintained by different agencies in complex ways. Land based conflicts of interest are quite common because of the presence of multi–dimensional stakeholders. A sustainable land use practice in the flood prone areas will increase land productivity and reduce negative impacts on land degradation and environment at the local level.

## Multicriteria Assessment of Adaptation Options

**Feasibility and Viability:** This diagram compares the multicriteria assessment of adaptation options based on subjective evaluation by various stakeholders. The stakeholders were asked to rate five types of intervention options (adaptive agricultural practices, flood proofing, watercourse management, riverbank stabilization, and land use zoning) in five categories for five assessment criteria on a scale of 0 to 5. For assessment criteria feasibility and viability this diagram shows that adaptive agricultural practices has high administrative, social and intervention feasibilities, while flood proofing and land use zoning have medium scale of intervention feasibility and dynamic climate feasibility respectively. Watercourse management has medium priority, while the option for riverbank stabilization adaptation has medium to low scale priority in all the feasibility status. However, from all the five intervention options for feasibility and viability adaptive agricultural practices, flood proofing, and land use zoning have the average scaling.

**Figure- 8.2a: MCA of Selected Adaptation Options to Flood and Riverbank Erosion**

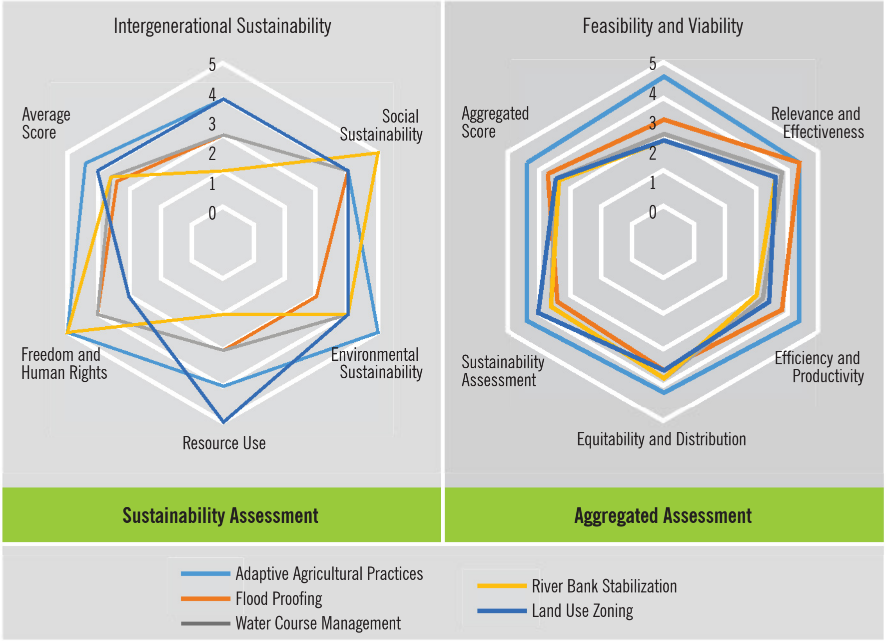


**Relevance and Effectiveness:** Adaptive agricultural practices has high outcome and cost effectiveness, flood proofing has high policy and climate relevance, watercourse management high policy relevance, and riverbank stabilization and land use zoning have medium scale relevance and effectiveness in all respects. Overall, all five–intervention options have medium to high relevance and effectiveness.

**Efficiency and Productivity:** For efficiency and productivity, adaptive agricultural practices is highly eco–efficient and productive efficient, flood proofing is medium to low socially and technically efficient, watercourse management is medium scale socially and allocatively efficient, riverbank stabilization is highly allocatively efficient, and land use zoning is medium scale productively and technically efficient. However, for all five–intervention options efficiency and productivity remains in the medium scale area.

**Equitability and Distribution:** Risk creation and gendered equity of benefits are high for adaptive agricultural practices, while riverbank stabilization has high equitable accessibility. Flood proofing has high gendered equity of benefits. Watercourse management has medium distributive equity and affordability. Overall, all the five intervention options remain in the medium average scale of the relevance and effectiveness assessment.

**Figure- 8.2b: MCA of Selected Adaptation Options to Flood and Riverbank Erosion**



**Sustainability:** This diagram compares the multicriteria assessment of adaptation options to flood based on subjective evaluation by various stakeholders. The stakeholders were asked to rate five types of intervention options (adaptive agricultural practices, flood proofing, watercourse management, riverbank stabilization, and land use zoning) in five categories for five assessment criteria on a scale of 0 to 5. Social sustainability, freedom, and human rights are high for riverbank stabilization, environmental sustainability, freedom, and human rights are high for adaptive agricultural practices, and resource use is high for land use zoning. However, for all five–intervention options resource use, social sustainability, intergenerational sustainability, and environmental sustainability have greater priorities with medium to high scaling up.

**Aggregated Assessment of Adaptation Options:** The aggregated assessment for all five–intervention options shows different scenario. Adaptive agricultural practices are highly prioritized in terms of feasibility and viability, relevance and effectiveness, efficiency and productivity, equitability and distribution, and sustainability. For all these adaptation options, flood proofing, watercourse management, riverbank stabilization, and land use zoning have medium score and showing medium range priority. Overall, the aggregated score shows the trend from high to medium for adaptive agricultural practices to flood proofing, watercourse management, riverbank stabilization, and land use zoning.

## Perspective of Local Stakeholders

Different stakeholders were asked to assess feasibility of five types of intervention options (adaptive agricultural practices, flood proofing, watercourse management, riverbank stabilization, and land use zoning) on a scale of highly positive to highly negative. For farmers, marginal farmers and sharecroppers all these intervention options are highly positive, while fishermen consider adaptive agricultural practices and land use zoning as highly positive for intervention options. Both landless agricultural laborer and non–agricultural laborer have considered flood proofing as highly positive, while the other intervention options are not so crucial for them. Ethnic, indigenous or religious minority, female–headed households, excluded communities, dependent people, female of all ages, and people with disability have considered flood proofing, land use zoning, and watercourse management as highly positive intervention options. However, in most of the cases riverbank stabilization has received less priority from most of the stakeholders. Marginal and excluded communities have considered adaptive agricultural practices, flood proofing, and land use zoning as highly positive adaptive intervention measures for them. Fisher community identifies water course management as detrimental intervention for them.

**Table– 8.5: Perspective of Local Stakeholders**

| Stakeholder Categories | Option–01 Adaptive Agricultural Practices | Option–02 Flood Proofing | Option–03 Water Course Management | Option–04 River Bank Stabilization | Option–5 Land Use Zooning |
|---|---|---|---|---|---|
| Farmer | ++ | ++ | ++ | ++ | ++ |
| Fishermen | ++ | + | – | 0 | ++ |
| Marginal Farmer and Share Cropper | ++ | ++ | + | ++ | ++ |
| Landless Agri-laborer | + | ++ | + | + | + |
| Non-Agri-laborer | 0 | ++ | + | + | + |
| Ethnic, Indigenous or Religious Minority | + | ++ | + | + | ++ |
| Female Headed HH | ++ | ++ | ++ | + | ++ |
| Excluded Communities | ++ | ++ | 0 | 0 | ++ |
| Dependent Population | ++ | ++ | + | + | ++ |
| Female of all Ages | ++ | ++ | + | + | ++ |
| People with Disability | ++ | ++ | + | + | ++ |

*Note: Eudaimonic Well–Being (EWB) Scale*

| Highly Beneficial | Beneficial | Neutral | Detrimental | Highly Detrimental |
|---|---|---|---|---|
| ++ | + | 0 | – | –– |

## ADAPTATION TO SALINITY

### Proposed Adaptation Interventions

In this study, five packages of adaptation intervention options have been proposed for saline and brackish water ecosystem and these are: Option–01: Adaptive Agricultural Practices, (2) Option– 02: Water Course and Siltation Management, (3) Option– 03: Water Treatment and Desalination, (4) Option– 04: Aquaculture and Commercial Farming, and (5) Option–05: Land Use Zoning. These are already there in varying degrees, but the proposal is to upscale them, based on past learning. The proposed options and sub–options are described in the table below:

**Table– 8.6: Adaptation to Salinity Intrusion**

| Intervention Options | Intervention Types | Project Types |
|---|---|---|
| Option – 01 | Adaptive Agricultural Practices | Agricultural Intensification |
| | | Saline–Tolerant Crop Diversification |

| Intervention Options | Intervention Types | Project Types |
|---|---|---|
| | | Local Adaptive Practices |
| | | Integrated farming |
| | | Golpata (Nipa Plam) Cultivation |
| | | Mele cultivation |
| | | Reed Cultivation |
| Option – 02 | Water Course and Siltation Management | Construction of Embankment |
| | | Tidal River Siltation Management |
| | | Restoration of Dead Channel and Rivers |
| | | Hydromodification and Channelization |
| Option – 03 | Water Treatment and Desalination | Rain Water Harvesting (RWH) |
| | | Pond Sand Filter (PSF) |
| | | Conservation of Ponds for Drinking Water |
| Option – 04 | Aquaculture and Commercial Farming | Crab Cultivation |
| | | Shrimp Cultivation |
| Option – 05 | Land Use Zoning | Planning and Changing Land Use Pattern |

## Adaptive Agricultural Practices

Livelihoods of people are severely affected across all major sectors due to increasing soil salinity. Agriculture becomes difficult under increased level of salinity in the soil. Even the middle–income groups of earlier times, with productive land and a livelihood, have now fallen into poverty as they lost all assets and are not able to use their land due to salinity or inundation. Sometimes, intrusion of saline water from low–lying areas is not being drained out because of inadequate natural drainages system. However, soil salinity level and irrigation water significantly restrict agricultural production. Given the soil salinity concentration in the study areas, local people suggested the following adaptive cropping alternatives in the salinity affected areas:

| Crops | Land Suitability | Planting | Harvesting | Duration |
|---|---|---|---|---|
| Sweet Potato | High Land to Medium High Land | Oct 3rd Week | Apr 3rd Week | 06 months |
| Felon | | Oct 3rd Week | Mar 2nd Week | 05 months |
| Pumpkin | | Whole Year | | 12 months |
| Chili | | Whole Year | | 12 months |
| Water Melon | | Oct 1st Week | May 3rd Week | 07 months |
| Wheat | | Nov 2nd Week | Apr 1st Week | 05 months |

| Crops | Land Suitability | Planting | Harvesting | Duration |
|---|---|---|---|---|
| Mustard | Medium High Land | Oct 1st Week | Feb 3rd Week | 04 months |
| Ground Nut | | Oct 1st Week | Apr 3rd Week | 06 months |
| Lentil | | Oct 1st Week | Mar 3rd Week | 05 months |
| Cabbage | | Sep 1st Week | Mar 2nd Week | 06 months |
| Cauliflower | | Sep 1st Week | Mar 2nd Week | 06 months |
| Tomato | | Sep 1st Week | Mar 3rd Week | 06 months |
| Onion | | Nov 3rd Week | Feb 4th Week | 03 months |
| Mustard | | Nov 3rd Week | Feb 4th Week | 03 months |
| Maize | | Nov 2nd Week | Apr 1st Week | 05 months |
| Grass Pea | | Nov 2nd Week | Apr 1st Week | 05 months |

## Water Course and Siltation Management

**Tidal River Silt Management:** Bengal delta is one of the most productive agricultural regions in the world. But crop failure due to saline water intrusion, monsoon flooding and frequent cyclone and tidal surge are common in coastal region. After the devastating flood of 1955, the then government sought advice from the United Nations Technical Mission (Krug Mission) on flood prevention strategies of Bangladesh (Dewan, et al. 2015; Haque 1993; Zaman 1993). The East Pakistan Water and Power Development Authority (EPWAPDA) was created in 1959, based on the Krug Mission Report of 1956, as a project planning, implementing, and monitoring agency. The master plan of EPWAPDA identified 91 projects as flood mitigating measures including embankment construction, channel improvement by dredging, river training and cut–off, and the construction of bypasses or flood-ways (Haque 1993). The USAID funded the Coastal Embankment Project (CEP) has dramatically increased the rice production in the region (Nowreen, et al. 2014). Farmers were able to harvest two or even three bumper crops per year. As aftermaths of this construction of embankments, within 15 years, siltation started at the water entrance point of the sluice gates and rivers and bed height of canals began to increase. As a result, most of the polders have become water logged. To solve the present water logging problem, our proposed packaged is the indigenous knowledge based water management system that is Tidal River Silt Management (TRSM). In TRSM system, there will be balance between sedimentation and subsidence of the area. This natural process of gradual land building by inundation from tidal flow is termed as TRSM process.

In the coastal belt, we have two kinds of silt: one alluvium and the other is fluvial silt. Upstream rivers, which carry water from the Himalayan streams, receive alluvium silt in the rainy season. This silt from the upstream is forced back by the high tide from Bay of Bengal. With this force, the downstream water overflows two sides of the rivers and subsequently silts are deposited in the low flood plain. The alluvial silt is sandy and coarse with less organic contents. These characteristics are common in Bhola, Borguna, Patuakhali and Pirojpur. On the other hand, fluvial silt comes through the seawater during tides in the dry season. The fluvial silt consists of fine particles and with high organic contents. This silt is deposited in the districts of Satkhira, Khulna and Bagerhat. The rivers in these three districts are separated by the Himalayan rivers for more than two hundred years.

In order to manage silt in Khulna, Bagerhat and Satkhira areas, we need to manage silts during dry seasons. By adopting the TRSM scheme, we can manage this silt. There are two types of TRSM. One is regulated and the other is open system. So far, we adopted open TRSM at local levels at different locations such as Beel Dakatia, Beel Bhaina and Beel Kukshia in Khulna and Jessore districts. And, the planned TRSM is yet to happen in the country. There are some problems in implementation of open system TRSM. The problems and prospects are shown below:

| Likely Positive Impacts | Likely Negative Impacts |
|---|---|
| ○ Silt is deposited in uniform ways by controlling the tidal flows.<br>○ We can use coastal biodiversity in more productive ways by planned TRSM. For example, by adopting the natural shrimp cultivation and other saline aquaculture, compensation for the landowners can be met from these productive means.<br>○ There will be no flooding by overflow of tidal waves. | ○ Silt is not deposited in locations uniformly. It only stays in the entrance of the water, thus the deposition is concentrated in certain areas leaving other areas untouched.<br>○ The time it takes usually is 10–15 years. So, without compensations, land owners usually are not willing to adopt this open TRSM.<br>○ Water/flood flows to the human habitat and settlement, causing huge loss to crops, livelihood and property. |

## Water Collection, Treatment and Desalination

**Rain Water Harvesting:** This practice is very much common to the inhabitants of Assasuni, Shayamnagar, Kaliganj Sadar, Kalaroa, and Debhata upazilas of Satkhira district; Koyra, Paikgacha, Dacope, Batiaghata and Dumuria upazilas of Khulna district; and Mongla, Rampal, Morelganj, Sharonkhola, Kachua and Sadar upazilas of Bagerhat district.

Government has taken initiative to expand the rain water harvesters across the coastal belt and arsenic prone areas as a key strategy for adaptation to climate change and environmental hazards. The inhabitants construct the plant at a suitable place, near the place where roof water can be drained conveniently through pipes and other means. In constructing a plant, varieties of raw materials like several rings of definite diameter, 3 pieces of pipes 10 ft long each ($3^2$ dia), 2 pieces of 4ft long pipes, 2 taps, construction of suitable platform slab for the top etc are needed. These are available locally.

By employing a number of laborers, a RWHP can be raised within 4 days. Rainwater harvesting techniques and construction of a plant involves simple technology. Taking the advantage of rain water falling down the roof of a building or a tin roofed house, a tank like a simple 'U' shaped tub made of several concreted round rings with one feet width each, cemented one above the other, the bottom being placed on a concrete platform and the top being covered with another concrete slab is filled with rain water leading it to the tank through appropriate pipes fitted in the network. The size depends on the size and number of the rings employed in the construction of the tank. So making the ring diameter large, a sizable large tank can be raised.

A single family size plant is constructed with 7 round rings of 1 ft width each one above the other and then fitted with other accessories and can contain 2200 liters of water. Quality of water stored will remain good if chance of contamination can be avoided. Purification in the ad interim can be done by bleaching or mixing alum so that the bacteria or germs that are supposed to be born may be killed. One pound of bleaching materials or a kg of alum may be enough to use for purification of water for the whole year. This may cost at best taka 100. It is learned that a single family size plant costs taka 7510 and the family had to pay taka 2000 each for each plant and the remaining amount is subsidized by the some local level NGOs. But in case of community plant, depending on the size, the cost of construction increases proportionately. However, people can share this installation cost of the community plant. DUring the time of this fieldwork, the standard user payment was taka 2000. There are several likely positive and negative impacts of rain water harvesting as described below:

| Likely Positive Impacts | Likely Negative Impacts |
|---|---|
| o The community people report that it ensures safe drinking water.<br>o It is health and environment friendly.<br>o It reduces the sufferings of people and saves time of women. Before establishing the RWHP, women used to collect drinking water from a deep tube well, which are located sometimes as far as 4–5 km.<br>o The communities reported that the raw materials were easily available and construction, running and maintenance are simple. Usually the women take care of the plants.<br>o It is dependent on rainfall and hence runs well in the rainy season. | o It is costly for the poor community.<br>o The capacity of holding rainwater is very limited. The stored water can run 6 months and after that, again they are in the same problem of collecting water from distant places.<br>o<br>o The stagnant water in a confined dark tank may at times be polluted.<br>o Rainwater with contamination, such as acid rain, can be another threat. |

## Aquaculture and Commercial Farming

**Crab Cultivation:** The practice of commercial crab aquaculture is very much common to the inhabitants of Assasuni, Shayamnagar, Kaliganj, and Debhata upazilas of Satkhira district; Koyra, Paikgacha, Dacope, Batiaghata and Dumuria upazilas of Khulna district; Mongla, Rampal, Morelganj, Sharonkhola, Kachua and Sadar upazilas of Bagerhat district. Crab cultivation is an important alternative source of livelihood which is also a very viable adaptive measure under changing climatic conditions. Crab feeds are collected from natural water bodies of the surrounding region. There are provisions in NAPA and BCCSAP to scale up the crab cultivation as an adaptation options across the coastal areas. After collection of crabs from the pond, they survive maximum 7 days in air. Crabs are such animals as cannot be eaten after death, as it becomes decomposed as soon as it dies and gives out bad smell. Therefore, this factor is very important and needs to be taken into consideration during harvesting, processing, transporting and marketing in the international market. The middlemen buy the crabs from the owners of the besiegement according to their weight gradings and sell the stock to the exporters.

**Shrimp Cultivation:** Existing shrimp cultivation needs to be remodeled. All the existing enclosures should be channelized with the intersecting networks of canals so that water can circulate in every shrimp farms. Classical examples are third and fourth fisheries in Paikgacha in Khulna district. However, there are several likely positive and negative impacts of crab and shrimp cultivation as described below:

| Likely Positive Impacts | Likely Negative Impacts |
|---|---|
| o The local farmers reported that cultivation of crabs is a non–traditional export oriented enterprise and so they have adopted this enterprise as an alternative livelihood source.<br>o It is a profitable venture compared to other traditional agric products in a same piece of saline land.<br>o Crabs are cultivated in a small plot of saline pond with materials available in their environment.<br>o It does not need much capital and labor. It can be done by house–wives and with minimum capital.<br>o The local people think this crab culture is friendly with changing environmental condition, as they are affected by salinity.<br>o Crab cultivation earns foreign currency by exporting. | o The farmers stated that the collection of crab calves were not available easily. This creates problems at times.<br>o Crab cultivation does not allow any other integrated farming; once a farmer cultivates crab in a piece of land, he cannot go back to other crops and hence he is to depend on crab cultivation always.<br>o To allow entry of saline water to the besiegement area, the adjoining lands also become saline and hence become useless for cultivation of other crops.<br>o Salinity leaches through the pores of soil, contaminating soil & groundwater. |

## Land Use Zoning

The present study identifies several issues related to present land use patterns and the degradation of land resources. Firstly, in the salinity prone areas, valuable agriculture land has been decreasing rapidly due to unplanned development of fisheries projects (especially shrimp ghers), housing and settlements, markets, industries, roads and for different other development infrastructures. Secondly, most of the old canals are closed due to unplanned human interventions like construction of houses, markets and other infrastructures, which are obstructing natural flow of water and thus ultimately creating drainage congestion. Thirdly, loss of biodiversity and degradation of eco–system due to unplanned human interventions and hazards like cyclone, storm surges, land erosion, drainage congestion, salinity increase etc. are damaging human lives and livelihoods. Finally, like many other areas, unplanned uses of land and other natural resources, in the salinity prone regions, have direct bearing upon the eroding livelihood base of the marginal groups. However, efficient utilization of land resources would protect agricultural land degradation and would help mitigating the challenges of global warming and climate change in the salinity prone region.

## Multicriteria Assessment of Adaptation Options

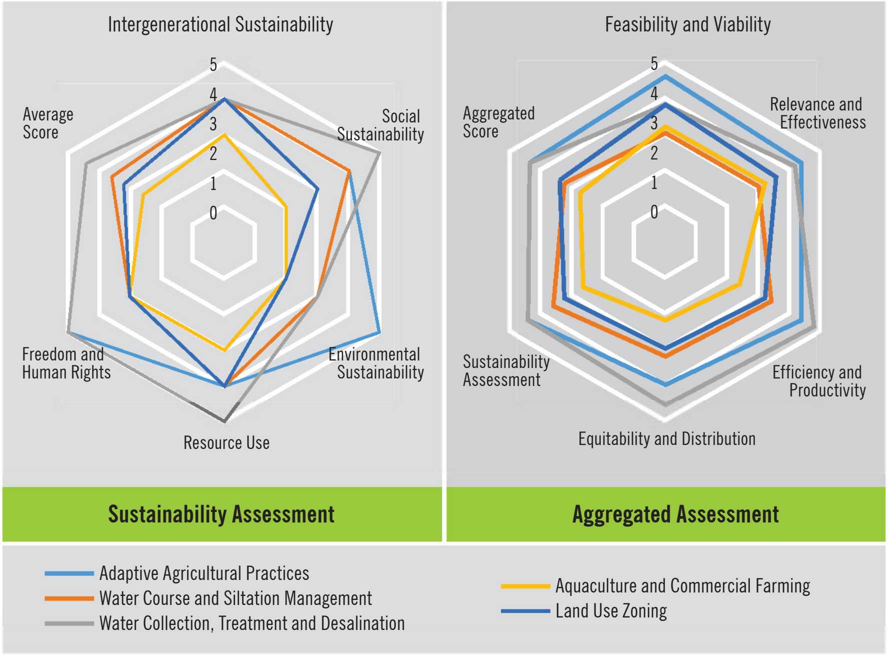
**Feasibility and Viability:** This diagram compares the multicriteria assessment of adaptation options based on subjective evaluation by various stakeholders. The stakeholders were asked to rate five types of intervention options (adaptive agricultural practices, watercourse and siltation management, water treatment and desalination, aquaculture and commercial farming, and land use zoning) in five categories for five assessment criteria on a scale of 0 to 5. For assessment criteria feasibility and viability this diagram shows that adaptive agricultural practices has high administrative, social and intervention feasibilities, while land use zoning has high scale of intervention feasibility. Water collection, treatment and desalination have medium scale feasibilities in all categories, while Watercourse and siltation management and aquaculture and commercial farming have medium to low score for social, administrative, intervention, dynamic climate and structural feasibilities. However, from all the five intervention options for feasibility and viability the average scoring ranges from high to medium scale.

**Relevance and Effectiveness:** Adaptive agricultural practices, water collection, treatment and desalination, and land use zoning have the high policy relevance, adaptive agricultural practices is highly cost effective, adaptive agricultural practices, water collection, treatment and desalination, and land use zoning have medium outcome effectiveness, and climate relevance and management effectiveness are medium to low for all the intervention options. Overall, all five–intervention options have medium to high relevance and effectiveness.

**Efficiency and Productivity:** For efficiency and productivity, water collection, treatment and desalination have the highest productive, technical, social and allocative efficiencies, while adaptive agricultural practices have

**Figure- 8.3a: MCA of Adaptation Options in Saline and Brackish Water Ecosystem**

**Figure- 8.3b: MCA of Adaptation Options in Saline and Brackish Water Ecosystem**




high technical and eco–efficiencies. However, watercourse and siltation management, aquaculture and commercial farming, and land use zoning have medium to low scoring for efficiency and productivity. Overall, for all five–intervention options efficiency and productivity remains in the high to medium scale areas.

**Equitability and Distribution:** Risk creation, gendered equity of benefits and distributive equity are high for water collection, treatment and desalination, while distributive equity is high for adaptive agricultural practices. However, watercourse and siltation management, aquaculture and commercial farming, and land use zoning have medium scoring for relevance and effectiveness. Overall, all the five intervention options remain in the high to medium average scale of the relevance and effectiveness assessment in this study.

**Sustainability:** This diagram compares the multicriteria assessment of adaptation options in saline and brackish water ecosystem based on subjective evaluation by various stakeholders. The stakeholders were asked to rate five types of intervention options (adaptive agricultural practices, watercourse and siltation management, water treatment and desalination, aquaculture and commercial farming, and land use zoning) in five categories for five assessment criteria on a scale of 0 to 5. Social sustainability, freedom, and human rights, and resource use are high for water collection, treatment and desalination, while environmental sustainability and freedom and human rights are high for adaptive agricultural practices. However, for all five–intervention options resource use, social sustainability, intergenerational sustainability, and environmental sustainability have greater priorities with medium to low scaling.

**Aggregated Assessment:** The aggregated assessment for all five–intervention options shows different scenario. Adaptive agricultural practices and water collection, treatment and desalination are highly prioritized in terms of feasibility and viability, relevance and effectiveness, efficiency and productivity, equitability and distribution, and sustainability. For all these adaptation options, watercourse and siltation management, aquaculture and commercial farming, and land use zoning have medium score and showing medium range priority. Overall, the aggregated score shows the trend from high to medium for adaptive agricultural practices to watercourse and siltation management, water treatment and desalination, aquaculture and commercial farming, and land use zoning.

## Perspective of Local Stakeholders

Different stakeholders were asked to assess feasibility of five types of intervention options (adaptive agricultural practices, watercourse and siltation management, water treatment and desalination, aquaculture and commercial farming, and land use zoning) on a scale of highly positive to highly negative. For farmers, marginal farmers and sharecroppers all these intervention options are highly positive. Fishermen have identified all the interventions as beneficial while they regarded aquaculture and commercial farming as detrimental interventions for them. Landless agricultural laborer and non-agricultural laborer have considered aquaculture and commercial farming as highly detrimental and moderately detrimental interventions respectively. Both landless agricultural laborer and non–agricultural laborer have considered water treatment and desalination highly positive, while the other intervention options are not so crucial for them. Ethnic, indigenous or religious minority, female–headed households, excluded communities, dependent people, female of all ages, and people with disability have considered water treatment and desalination, and land use zoning highly positive intervention options. However, in most of the cases watercourse and siltation management and aquaculture and commercial farming have received less priority from most of the stakeholders. Adaptive agricultural practices get relatively less attention from landless agricultural laborer, ethnic, indigenous or religious minority, female-headed households, excluded communities, and female of all ages whilst non-agricultural laborer and PWD think it having neutral significance for them.

**Table– 8.7: Perspective of Local Stakeholders**

| Stakeholder Categories | Option– 01 Adaptive Agricultural Practices | Option– 02 Water Course and Siltation Management | Option– 03 Water Treatment and Desalination | Option– 04 Aquaculture and Commercial Farming | Option– 05 Land Use Zoning |
|---|---|---|---|---|---|
| Farmer | ++ | ++ | ++ | ++ | ++ |
| Fishermen | ++ | + | ++ | – | ++ |
| Marginal farmer and Share Cropper | ++ | ++ | ++ | – | ++ |
| Landless Agri-laborer | + | + | ++ | –– | + |
| Non-Agri-laborer | 0 | 0 | ++ | – | + |
| Ethnic, Indigenous or Religious Minority | + | + | ++ | 0 | ++ |
| Female Headed HH | + | + | ++ | 0 | ++ |
| Excluded Communities | + | 0 | ++ | 0 | ++ |
| Dependent Population | + | 0 | ++ | 0 | ++ |
| Female of all Ages | + | 0 | ++ | 0 | ++ |
| People with Disability | 0 | 0 | ++ | 0 | ++ |

*Note: Eudaimonic Well-Being (EWB) Scale*

| Highly Beneficial | Beneficial | Neutral | Detrimental | Highly Detrimental |
|---|---|---|---|---|
| ++ | + | 0 | – | –– |

## ADAPTATION TO DROUGHT AND ARIDITY

### Proposed Adaptation Interventions

In this study, five packages of adaptation intervention options have been proposed for drought and aridity prone region and these are: (1) Option–01: Adaptive Agricultural Practices, (2) Option– 02: Water Storage and Irrigation, (3) Option– 03: Water Course Management, (4) Option– 04: Horticultural Practices, and (5) Option– 05: Land Use Zoning. These are already in place in varying degrees, but the proposal is to upscale them, based on lessons learnt. The proposed options and sub–options are described in the table below:

**Table– 8.8: Adaptation to Drought and Aridity**

| Intervention Option | Intervention Types | Project Types |
|---|---|---|
| Option – 01 | Adaptive Agricultural Practices | Agricultural Intensification |

| Intervention Option | Intervention Types | Project Types |
|---|---|---|
| | | Drought Tolerant Crop Selection and Diversification |
| | | Diversification of Livestock and Fisheries |
| | | Crop Cycle Management |
| | | Large Scale Plantation to Reduce Evaporation |
| Option – 02 | Water Storage and Irrigation | Excavation of Water Reservoir |
| | | Impounded reservoirs |
| | | Barrage and Sluice Construction |
| | | Extraction of Ground or Surface Water for Irrigation |
| Option – 03 | Water Course Management | Excavation or Restoration of Dead Channel and Rivers |
| | | Hydromodification and Channelization |
| Option – 04 | Horticultural Practices | Mango Cultivation |
| | | Apelkul Cultivation |
| Option – 05 | Land Use Zoning | Planning and Changing Land Use Pattern |

## Adaptive Agricultural Practices

The drought and water crisis scenario in Porsha upazila have several consequences in farming, raising livestock and maintaining household activities by the farmers, resulting in the disruption of local livelihood system. Farmers have been practicing different adaptation options and adopted different water management practices to deal with the growing water crisis in Porsha upazila. For instance, the farmers are now cultivating drought tolerant rice varieties BRRI dhan– 42, BRRI dhan– 43 during kharif season. These adaptive measures are taken to mitigate the losses in agricultural productivity. Possible agricultural adaptations include different practice for agricultural intensification, switch to crop varieties that are better adapted to the changing weather patterns, amend planting schedules, managing crop cycle, change the choice of crops grown and large scale plantation to reduce evaporation.

## Water Storage and Irrigation

Water is the main limiting conditions for human adaptation in Porsha upazila, which is located at the high Barind Tracts region. Most of the ponds in Porsha Upazila dry out at the onset of dry season, due to the combined effect of evaporation and seepage. The main purposes of excavated and impounded reservoir is to increase the water storage capacity of natural ponds to extend their period of utilization, and to create new surface water reservoirs in order to better manage the surface water resources. Pumping up of ground or surface water for irrigation is another common measure against drought. However, there are several challenges to this adaptation measure (Gallagher 2003): (1) in arid and semi–arid regions, the runoff coefficient and the size of the basin are inversely correlated i.e. the runoff coefficient becomes lower as the catchment basin size gets bigger and therefore, much quantities of water cannot be harvested by intercepting the runoff; (2) the high evaporation rate in the Barind region suggest that the ponds dry out even after deepening; (3) seepage also causes loss of water in the surface reservoirs, while techniques of lining (plastic or rubber sheets) to reduce seepage are too costly to afford in local context; (4) barrage and sluice construction can retain water for irrigation purposes but these measures may create further risk by resulting in water shortage in the downstream; and (5) excavation of permanent surface reservoirs under hot climatic conditions may cause health risk of parasitic diseases.

## Water Course Management

Watercourse or waterways management involve excavating stream-beds and banks. Such works include stabilizing stream-beds, protecting and stabilizing stream banks, diverting streams, creating channels to drain land and alleviate floods, deepening stream-beds, extracting sand and gravel, and works associated with developing water infrastructure, such as bridges, sluice, regulators and pipelines. Excavating can severely degrade or destroy ecosystems in and around waterways and wetlands. However, devoid of appropriate precautionary principle, excavating the bed and banks should not be undertaken as it is likely to cause significant environmental harm.

Stream restoration or river restoration, sometimes–called river reclamation, describes a set of activities that help rejuvenating the environmental health of a river or stream. These activities has the potentials to restore the natural state and functioning of the river system in support of biodiversity, recreation, flood management and landscape development. Silted up channels or water–bodies can be excavated and banks protected because with deeper and wider channels these water bodies would contain more water. That water could be used for irrigation but it will also recharge the ground water sources. Therefore, the possibility of drought in the locality can be reduced as a result of hydromodification and channelization. Trees will be planted as a part of stabilization and protection of the banks that will have a positive impact against drought as well, because trees help to retain moisture in the environment.

There are some key principles to enhance effectiveness of restoration. Firstly, any restoration project should focus on improving the overall ecosystem integrity and biodiversity, rather than focusing on the status of single species. Secondly, the project should understand the wider connections between natural processes upstream and downstream as well as consider the broad riparian areas, floodplains and the wider catchment areas. Thirdly, the project should use the minimal possible intervention to reinstate natural processes so that rivers can recover by themselves (Addy, et al. 2016).

## Horticultural Practices

Drought and aridity, and scarcity of irrigation facility have resulted in reduced economic return for paddy cultivation in Porsha upazila. Encountering such environmental changes, people are transitioning to horticultural (orchard) practices to increase their economic productivity of land. The horticultural practice include demanding fruit crops like mango and *apel kul* cultivation. These practices have enhanced cropping intensity with maximum economic profitability and sometimes even by bringing fellow land under horticultural cultivation. Almost all the farmers used to plant seasonal fruit trees around their houses but cultivation of mango and *apel kul* on a commercial basis or planting such fruits instead of paddy is what could be considered as the changing trend and adaptive response in the Barind region. Around fifteen years ago, the farmers first initiated mango cultivation in Radhanagar of Nawabganj. Some of the farmers brought good quality seedlings of mango and got a good production while they planted those around their houses. The initial success in maximizing economic profitability has encouraged them to adopt these fruits cultivation on a commercial basis. The goal of mango and apelkul cultivation is to reduce the vulnerability of community people to natural hazards, especially to drought and aridity. The mango cultivation initiative aims at increasing their land productivity and cropping intensity with maximum prospects for economic profitability. However, these fruits cultivation practice have reduced the employment opportunities of the daily wage laborers compared to that of the laborer requirements in the organization of paddy cultivation.

## Land Use Zoning

Land zoning can identify the drought prone areas and help to plan appropriate adaptive measures. If the drought prone areas are marked, it will be easy to select crop, livestock and fishery practice for that area. It will also help to plan irrigation projects.

| Likely Positive Impacts | Likely Negative Impacts |
|---|---|
| ○ Would enhance adaptive capacity and help mitigating the challenges of global warming and climate change at the local level.<br>○ Ensure optimum economic uses of land and water resources with environmental sustainability. | ○ Some of the property owners may resist relinquishing their individual property freedoms. |

| Likely Positive Impacts | Likely Negative Impacts |
|---|---|
| ○ Optimum and efficient utilization of land resources based on physical and chemical characteristics would ensure the economic return to land use.<br>○ Would support to diversification of agricultural crops and thereby ensuring food security of the local people.<br>○ Protection of agricultural land degradation, conversion of both agricultural and wetlands.<br>○ Unplanned farming of land will be protected in all cases.<br>○ Ensure socio–economic development of local people through generation of more income related activities, expansion of local job facilities and increase of crop production. | ○ It may limit, to certain extents, the development potential of previously existing land uses and structures that do not conform to the zoning's standards.<br>○ It can discourage some development in some locations.<br>○ People may become skeptical about land zoning.<br>○ Zoning will have impact on price and land value in a community. |

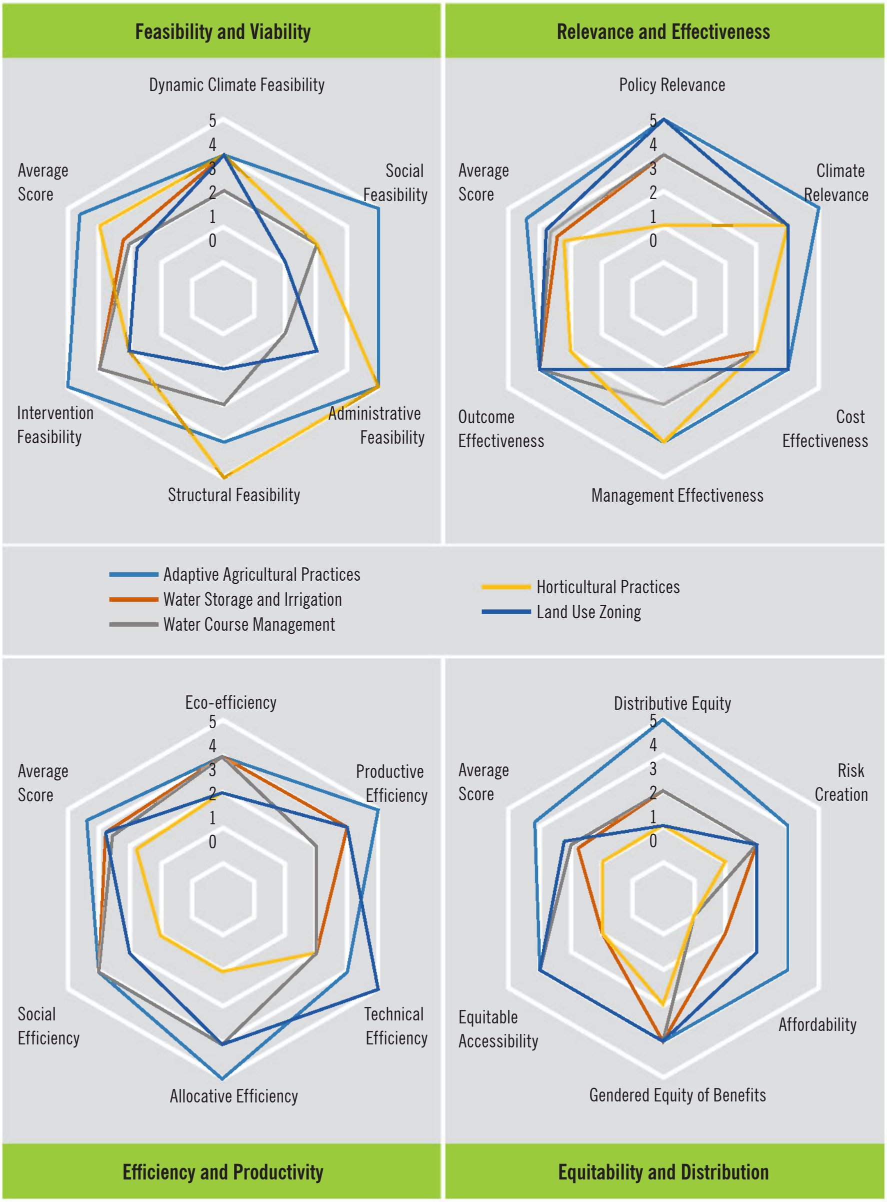
## Multicriteria Assessment of Adaptation Options

**Feasibility and Viability:** This diagram compares the multicriteria assessment of adaptation options to drought based on subjective evaluation by various stakeholders. The stakeholders were asked to rate five types of intervention options (adaptive agricultural practices, water storage and irrigation, watercourse management, horticultural practices, and land use zoning) in five categories for five assessment criteria on a scale of 0 to 5. For assessment criteria feasibility and viability this diagram shows that adaptive agricultural practices has high administrative, social and intervention feasibilities, while horticultural practices has high scale of administrative and structural feasibilities. However, water storage and irrigation, watercourse management, and land use zoning have medium scale feasibilities in all categories. Overall, from all the five intervention options for feasibility and viability the average scoring ranges from high to medium scale.

**Relevance and Effectiveness:** Adaptive agricultural practices have the highest policy and climate relevance, while land use zoning has the highest policy relevance with lowest management effectiveness. Adaptive agricultural and horticultural practices have received medium to high management effectiveness, while water storage and irrigation and watercourse management have got medium priority in the relevance and effectiveness of feasibility viability. Overall, all five–intervention options have medium to high relevance and effectiveness.

**Efficiency and Productivity:** For efficiency and productivity, adaptive agricultural practices have the highest productive and allocative efficiencies, while land use zoning has the highest technical efficiency. However, water storage and irrigation, and watercourse management, have medium to high productive, technical, social, allocative and eco–efficiencies, while horticultural practices have the lowest efficiency and productivity. Overall, for all five–intervention options efficiency and productivity remains in the medium to low scale areas.

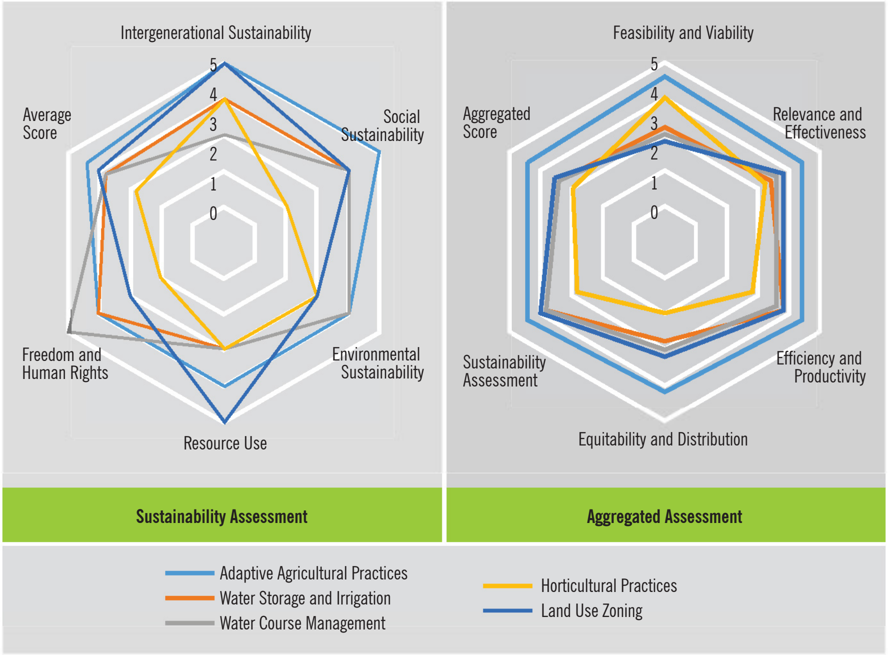
**Figure- 8.4a: MCA of Selected Adaptation Options to Drought and Aridity**



**Equitability and Distribution:** Distributive equity is high for adaptive agricultural practices with medium scoring for risk creation, gendered equity of benefits, affordability, and equitable accessibility. However, water storage and irrigation, watercourse management, horticultural practices, and land use zoning have medium to low scoring for relevance and effectiveness of efficiency and productivity. Overall, all the five intervention options remain in the medium to low average scale of the relevance and effectiveness assessment.

**Sustainability:** This diagram compares the multicriteria assessment of adaptation options to drought based on subjective evaluation by various stakeholders. The stakeholders were asked to rate five types of intervention options (adaptive agricultural practices, water storage and irrigation, watercourse management, horticultural practices, and land use zoning) in five categories for five assessment criteria on a scale of 0 to 5. Social and intergenerational sustainability are high for adaptive agricultural practices, while intergenerational sustainability and resource use is high for land use zoning and freedom and human rights are high for watercourse management. However, for all five–intervention options resource use, social sustainability, intergenerational sustainability, freedom and human rights, and resource use have greater priorities with high to medium scaling.

**Figure- 8.4b: MCA of Selected Adaptation Options to Drought and Aridity**



**Aggregated Assessment:** The aggregated assessment for all five–intervention options shows different scenario. Adaptive agricultural practices are highly prioritized in terms of feasibility and viability, relevance and effectiveness, efficiency and productivity, equitability and distribution, and sustainability. For all these adaptation options, water storage and irrigation, watercourse management, horticultural practices, and land use zoning have medium score and showing medium range priority. Overall, the aggregated score shows the trend from high to medium for adaptive agricultural practices to water storage and irrigation, watercourse management, horticultural practices, and land use zoning.

## Perspective of Local Stakeholders

Different stakeholders were asked to assess feasibility of five types of intervention options (adaptive agricultural practices, water storage and irrigation, watercourse management, horticultural practices, and land use zoning) on a scale of highly positive to highly negative. For farmers all these intervention options are highly positive. Fishermen, and marginal farmers and sharecroppers have prioritized adaptive agricultural practices and land use zoning, while landless agricultural laborer and non–agricultural laborer have considered land use zoning as priority. Ethnic, indigenous or religious minority, female–headed households, excluded communities, dependent people, female of all ages, and people with disability have considered land use zoning and horticultural practices highly positive intervention options. However, in most of the cases water storage and irrigation, watercourse management, and horticultural practices have received less priority from most of the stakeholders.

**Table– 8.9: Perspective of Local Stakeholders**

| Stakeholder Categories | Option– 01 | Option– 02 | Option– 03 | Option– 04 | Option– 05 |
|---|---|---|---|---|---|
| | Adaptive Agricultural Practices | Water Storage and Irrigation | Water Course Management | Horticulture Practices | Land Use Zoning |
| Farmer | ++ | ++ | ++ | + | ++ |
| Fishermen | ++ | + | – | + | ++ |
| Marginal Farmer and Share Cropper | ++ | ++ | + | 0 | ++ |
| Landless Agri-laborer | + | + | 0 | – | + |
| Non-Agri-laborer | 0 | 0 | + | 0 | + |
| Ethnic, Indigenous or Religious Minority | + | + | + | 0 | ++ |

| Stakeholder Categories | Option– 01 Adaptive Agricultural Practices | Option– 02 Water Storage and Irrigation | Option– 03 Water Course Management | Option– 04 Horticulture Practices | Option– 05 Land Use Zoning |
|---|---|---|---|---|---|
| Female Headed HH | + | + | + | 0 | ++ |
| Excluded Communities | + | 0 | 0 | 0 | ++ |
| Dependent Population | + | 0 | + | 0 | ++ |
| Female of all Ages | + | 0 | + | ++ | ++ |
| People with Disability | 0 | 0 | + | ++ | ++ |

*Note: Eudaimonic Well–Being (EWB) Scale*

| Highly Beneficial | Beneficial | Neutral | Detrimental | Highly Detrimental |
|---|---|---|---|---|
| ++ | + | 0 | – | –– |

*Image– 22 (above left): Destruction of Shundarban during Sidr on 15 November 2007 (Photograph by Bryan Katz); Image– 23 (above right): Collecting Water from Distant Places in Assasuni (Photograph by Md. Borhan Uddin); Image– 24 (below left): Riverbank Erosion (Photograph by Hasan Shafie); and Image– 25 (below right): Sandy Riverbank (Photograph by Mohosin Kabir).*



*Image–26: Reconstructing Embankments in Cyclone Aila Affected Area (Photograph by Hasan Shafie)*

Chapter Nine

# A Climate Resilient Future

## OVERVIEW OF FINDINGS

At the beginning of the book, we defined the scope as to be a strategic assessment of adaptation options under changing climatic conditions in Bangladesh. However, in the conclusion, we will try to summarize the discussion and evidences presented above and recommend different sets of adaptation options to address different climatic hazards in Bangladesh. The preceding discussion suggests that Bangladesh's vulnerability to climate change is significantly an outcome of a complex interrelationship among biophysical, social, economic and technological factors. The economic development of the country has been significantly eroded by the adverse impacts of climate change including sea level rise, higher temperature, enhanced monsoon precipitation and run–off, potentially reduced dry season precipitation. The projected scenario of these impacts and the anticipated future directions are significantly alarming for our country. Furthermore, the high degree of base vulnerabilities would in fact aggravate many of the existing stresses at an accelerated pace. All these factors would have complex and compound aftermath on socio–economic conditions and overall development of Bangladesh.

The magnitude and intensity of climate change will determine the severity of the stresses to which Bangladesh will be exposed. The present evidences and trends of changing climate suggest that these features are gradually amplifying the hazards. Climatic variability and extreme climatic events disrupt production of food and supplies of water, reduce incomes, damage homes and property, impact health and even take lives. The natural and social processes of climate change have gained momentums, which will continue for decades and well beyond. Nevertheless, assessing the given scenario of climate change impacts and the upcoming threats, we cannot afford inaction or be late in responding to these challenges because in this case we risk much more severe consequences. Rather, how we respond to these challenges will shape our future in significant ways. Both mitigating and adapting to climate change are necessary to enable our present and future generations to better cope with and adapt to the climatic hazards and reduce the damages.

The challenges are substantial for the developing world, particularly for Bangladesh. Bangladesh has a high dependence on climate–sensitive natural resource sectors for livelihoods and incomes, and the changes in climate that are projected for the tropics and sub–tropics, where most developing countries are found, are generally adverse for agriculture (IPCC, 2001 and 2007a). Moreover, the means and capacities for adapting to changing climate in these countries like Bangladesh are scarce or low owing to low levels of human and economic development and high incidence of poverty. These conditions multiply each other to create a state of high vulnerability to climate change impacts in Bangladesh.

Given this backdrop, `climate–proofing' of our development activities are of prime concerns for Bangladesh. Although it is evident in our preceding discussion that the national policies, strategies as well as sectoral policies and plans are yet to install climate change sensitive lenses into their respective development programs and adopt the `climate proofing' of these development interventions. Widespread and rapid environmental degradation nationwide evidently implies that the existing policy measures, as well as their translations into practices e.g. existing EIA practice, are not functioning adequately to address environmental concerns. Moreover, the international climate change negotiations initiatives have not yet yielded into any concrete commitments for mitigating climate change through reducing GHG emissions by the major polluters. All these factors suggest that countries like Bangladesh should explore the possibilities of large–scale investments on various adaptation plans and programs to address climate change–induced hazards.

The SEA approach to address adaptation concerns in decision–making is of relatively recent origin both globally and nationally. The SEA approach has gained wide acceptance across nations, regions and sectors. The present study on SEA of selected adaptation options has been a real learning experience for the study team and the Department of Anthropology. During the courses of its completion, the study team and the BCCT representatives closely interacted and tried to internalize the collective wisdom in this pioneering exercise of conducting SEA in Bangladesh. The present SEA study has yielded significant lessons about adaptation to climate change in Bangladesh. The lessons, formulated as recommendations, are briefly outlined below, followed by a more detailed empirical assessment of their policy implications in the context of Bangladesh.

## GENERAL RECOMMENDATIONS

### Enabling and Conducive Conditions for Adaptation

Climatic extremes and variabilities is causing substantial damage to households, communities, natural resources and economies in the study areas. Immediate response to repair damage and withhold the processes of such impacts can avoid the necessity to do much more later on. People in the study sites are sustaining gradual damages suggesting an adaptation deficit and the shortfall of present interventions compared to existing possibilities. We have found adaptation deficit in all the field sites and, therefore, immediate action is essential which would not only yield immediate benefits but also would initiate longer–term processes of adapting to a changing climate in Bangladesh.

The adaptation deficits in the study areas can be explained in terms of numerous obstacles that impede adaptation. Common obstacles include demands on scarce resources, poverty that limits capacity to adapt, lack of knowledge, weak institutions, degraded natural resources, inadequate infrastructure, insufficient financial resources and poor governance. These structural constrains within the broader socio–economic environment severely limit people's capability and functionings. These structural barriers need to be addressed by government initiatives to create enabling environmental conditions and appropriate motivations for people to find adaptation solutions and take protective actions against climate change impacts. Therefore, transcending the structural obstacles and creating enabling environment are important preconditions of successful adaptation interventions and the Government can take such initiatives.

### Functioning of Institutions

Local, national and international institutions play important roles in creating enabling and conducive conditions for adaptation. Local level and traditional institutions, including community organizations, trade associations, local government institutions, informal local associations, kinship networks and other traditional institutions, serve important functions in reducing and mitigating risks at the community level. The functioning of local and traditional institutions provides the foundations for climate risk management by developing adaptive social protection; sharing knowledge, human and animal labor, equipment and food reserves; mobilizing local resources for public works; and extending credit and other services. Apart from local institutions, the national and international institutions also provide public services, extension services, training, improved technologies, infrastructure, credit, financial assistance, disaster relief, weather forecasts, and other goods and services. Findings from this study suggest that weak functioning of many of such institutions are significantly impeding the management of risk environment. The present study therefore recommends the strengthening of these institutions (traditional, local, national and international) to perform strategic functions in support of adaptation and to facilitate the management of climate risks.

### Inclusion of At-Risk People

Capturing the voice of the front-line people and involving the people at–risk in the process of adaptation planning and implementation would increase the effectiveness of adaptation to climate change in Bangladesh. The present study involved at–risk groups in assessment of adaptation activities. Lessons learnt from this study demonstrate the potential of participatory approaches to adaptation for focusing attention on people's initiatives in managing their risks environment based on their local knowledge, expertise and resources. Participatory approach and inclusion of at–risk people help understanding climate risks into the wider framework of their other problems and finding solutions that aim at attaining multiple objectives.

### Inclusion of Socially Excluded and Most Vulnerable Groups

Gender, as the men–women relationship in a given socio–cultural context, needs to be considered as a perspective, which implies equal respect for women and men as well as for the contribution of each gender group. Knowledge, experience, risk, vulnerabilities and activities of women and men should always be given equal importance. A gendered response to the needs of women cannot be separated from different sectoral needs, rather we should have an integrated approach to address gender differentiated needs. The socio–economic factors that obstruct women's active participation must be addressed. It is also important to develop understanding of gender perspective in the organizational level of the stakeholders.

In order to build a culture of resilience, participation of all social categories in all actions is essential. It is also important to respect all community members regardless of age, gender and socio–economic status– respecting and recognizing all community members without distinction of gender, age and socio–economic status, makes each and every of them feel part of the solution. Encouragement means without imposing roles– when preparing invitations for activities, roles should never be imposed on participants to enable them to contribute with spontaneity. This helps them feel confident about their contributions. It also helps them appreciate the importance of their contributions.

### Management of Natural Resources

The study finds that over exploitation of natural resources and climatic variability are causing pressures on and degradation of natural resource base. Degraded state of natural resources further increases the vulnerability of people and make them highly susceptible to climate change impacts. Replenishment and protection of natural resources, and conservation of biodiversity are essential for enhancing adaptive capacities and devising successful adaptive strategies in climate sensitive regions. Protecting natural resources and biodiversity requires initiatives in institutional, legal and regulatory arrangements at the national level and more effective enforcement of regulations.

### Integrated Approach to Adaptation and Development

Adaptation and development projects are quite similar in nature. Climate change impacts and projected risks tend to erode the development achievements. Adaptation has the potential to influence development outcome and thereby reduce climate risks (Adejuwon, et al. 2012). At the same time, development interventions has the prospect of leveraging climate change adaptation. Climate change adaptation needs to address other aspects of vulnerability including marginalization process, land tenure system, access to social protection programs and poverty reduction programs. The important need is to mainstream adaptation issues into general development interventions in different sectors including livelihood, education, food security, nutrition and water–sanitation etc. A comprehensive and integrated approach to adaptation and development planning and actions can make the effective use of resources and lead towards building a resilient and sustainable future for Bangladesh.

## POLICY RECOMMENDATIONS

### Policy Coordination and Cross–Referencing

Policy analysis in the present study reveals evidences of a substantial gap in level of integration between different policies and cross–referencing between national and sectoral policies and plans. Coordination between BCCSAP and other national and sectoral policies appears to have weakened the implementation of the BCCSAP. However, the present study suggests a need of balanced influence and integration between sectoral policies and climate change policy in order to achieve an optimal level of performance.

### Technical Coordination and Institutional Mechanism

Coordination mechanisms between different government institutions and the interfaces between each mechanism take on crucial and central importance in the successful implementation of adaptation programs. The climate response in Bangladesh at this stage relates to adaptation strategies ranging from infrastructure to social protection programs as well as has a strong link to DRR. Currently, the main responsibility to foster adaptation lies with the lead institution, Ministry of Environment and Forest (MoEF). Apart from MoEF, different Ministries including Local Government, Social Welfare, Agriculture, Water Resources, Disaster Management and Relief have climate change components and mandates. All these Government institutions receive funds to implement programs through the Annual Development Plan (ADP) and non–development budgets. There remains a tension among the Ministries over climate change related issues owing to the tension that exists between the development of policy and the differences in budget between institutions (CPEIR 2012). The institutional mandates in respect of co–ordination should be clarified and steps taken to strengthen these and the interfaces between them. This should involve specific cross–institution actions involving Planning Commission, Finance Division, MoEF, MoDMR and other significant institutional partners within government that make a significant contribution to the government's climate change response. However, the study recommends that the MoEF should have a clear legal mandate, adequate human resource, and specific Rules of Business from the Cabinet Division to lead all the activities centered on climate change in the country and the other Government institutions should have clarified and specialized institutional mandates for budget allocation and management of adaptation programs.

### Adaptation Finance Architecture and Performance Coordination

The magnitude of financial needs for adaptation is much greater than the current level of finance. There is a dire need to enhance financial supports over and above regular development allocations. The front-line people at risk obtain finance through community and informal networks to recover from losses and invest in risk reduction. However, vulnerable areas require greater financial assistance at the regional level from Government and international sources to create conducive conditions for adaptation.

Innovative ideas are needed to mobilize financial resources from different sources including private sector investment in adaptation.

A coordination mechanism needs to be in place to improve the flow of funds and to ensure that BCCSAP concerns are properly addressed at the level of implementation. A diverse range of Government institutions is implementing projects having climate sensitivity. The role of Finance Division is highly significant in the coordination of funding and resource allocation following policy priorities. The optimization of climate funding requires a different financial architecture including governance, coordination and performance management mechanism given the cross–cutting, cross–institutional and cross–sectoral nature of adaptation programs. In addition to decentralized financial mechanism, appropriate accountability and monitoring mechanism needs to be in place for climate change program in Bangladesh. A National Parliamentary Standing Committee (can be the existing committee on Environment) can be empowered as body to oversee and guide various activities related to climate change, including involvement in international negotiations for adaptation.

### Climate Proofing of Development Interventions

The Government needs to adopt appropriate policies in the area of climate proofing of the ongoing and upcoming development interventions. An appropriate guideline can be prepared based on the policy framework and can be disseminated across different ministries and agencies, NGOs, private sector as well as donors for installing climate sensitive lens and climate proofing other their respective interventions.

## RECOMMENDATIONS ON PROGRAM ENTRY POINTS

### Scalable Adaptation Options

The discussion in preceding chapters explores the prospects and possibilities of replicating and associated knowledge sharing on scalable adaptation options. There are some intrinsic limitations in relation to context, capacity and cultural resistance, while there are some other challenges in the complexity of broader adaptation related institutional and governance processes. Scaling of adaptation options can be both vertical and horizontal in nature depending on the variety of processes (Rossing, et al. 2014). `Scaling up' or vertical scale-up of adaptation refers to micro-macro continuum i.e. from the local or community level to regional, national or global levels of decision making. Upscaling of adaptation options has been addressed through mainstreaming climate change adaptation into development, environment and supportive sectoral policies in Bangladesh, which is, by and large, carried out as a top-down strategy at the national level. This top-down process has been lacking in the availability of locally relevant down-scaled climate data to inform local-level adaptation strategies (Birkman, et al. 2009), which may partially be transcended by relying on local knowledge and experience from local change processes to inform decision-making at policy levels. In addition, upscaling of adaptation needs to be mainstreamed into the wider development processes of Bangladesh. The outscaling of adaptation constitute the second process whereby adaptation options can be expanded over a larger geographical area through horizontal scale-up process (Rossing, et al. 2014). A small-scale adaptation intervention or initiative can be horizontally scaled-up through broadening of the spatial scope and undertaking larger-scale replication endeavors (Snapp and Heong 2003). However, scalability of adaptation interventions, across different contexts or with larger outreach (horizontal and/or vertical), needs to be context appropriate and coordinated with wider policy, legislative, planning and budgeting frameworks (Rossing, et al. 2014).

## Promoting Research and Knowledge Management

There is a dire need of conducting series of research works in understanding the impacts of climate change in different regions and across different livelihood sectors. Real–time monitoring and surveillance systems need to be in place to better understand the present and future directions of climate change and associated impacts in the context of Bangladesh. The present study finds that knowledge as a critical constraint on adaptation and identifies the need to communicate knowledge as a high adaptation priority. We have particularly investigated the climate change related knowledge and awareness of the youth and indigenous population in the study areas. However, it has been revealed that people have inadequate or lack of access to information about climate history, projections of future climate change and potential impacts, estimates of climate risks, causes of vulnerability, and measures for managing climate risks. Therefore, we need to have programs to help advance, communicate, interpret and apply knowledge for managing climate risks. In this regard, it is recommended that academic and research bodies and universities should be engaged in conducting research and facilitating generation of information and effective management of knowledge for reducing climate risks.

## Promoting the Application of SEA

Lessons learnt from this study recognize the significance and effectiveness of SEA approach in addressing environmental concerns and sensitivity of development interventions in Bangladesh. Therefore, it is recommended that the SEA methodology can be adopted and institutionalized by the government to screen out public and private interventions for environmental issues. BCCT can initiate the drafting of a Guideline for SEA for application in the context of Bangladesh.

### GO–NGO Coordination in Adaptation Programs

The NGOs have been playing significant roles in addressing the concerns raised in BCCSAP. Some of the NGOs are engaged in massive public awareness campaign including preparedness training on climate change and sea–level rise and their impacts. Nevertheless, these NGOs and CSOs operate outside the Joint Country Strategy (JCS) framework, which leaves scopes for potential overlap and duplication of efforts with the development programs of the government. Besides, the study finding suggests capacity deficits of local bodies to plan and manage climate related projects. Moreover, weak co–ordination between national, regional and local governments institutions is evident impeding the achievements of the project outcomes under the guidance of BCCSAP.

The present study recommends the development of appropriate mechanism for ensuring coordination between government and nongovernment organizations working in promoting adaptation programs. All involved stakeholders in CCA, including GO, NGOs and private sector, must have a proper coordination of plans and activities. Each stakeholder must have a common understanding of CCA, at the same time, everyone's duties and responsibilities should be clearly stated and executed. Moreover, it is also important that the private sector and civil society organizations create partnerships that are more inclusive so that all their efforts are coherent and have greater impact on reducing climate vulnerability.

### Capacity Building of Local Level Institutions

The study finding suggest that the local government institutions (LGI) have remained at the focus of many DRR and CCA capacity–building projects. Now we have to work together with civil society organizations (Journalist Association, Teachers Association), local institutions (school, hospitals, training institutions, etc.), community based organizations (youth club, market committee, credit groups, fishermen associations, farmers clubs, water management groups, etc.) and engage these local institutions in the local governance of climate change adaptation and mitigation actions. Therefore, increase in public investment is recommended on capacity building of local level institutions and service providers at the frontline.

### Development Plan of Union and Upazila Parishad

The Union Parishad (UP) and Upazila Parishad (UzP) are conducting risk reduction action plan (RRAP) at the local level and it is important to implement the action plan to reduce the risk of local communities by addressing the concerns of respective RRAPs. The present study recommends to facilitate proper initiatives in mainstreaming of RRAPs in the respective ADPs of Union Parishad and Upazila Parisahd. This will motivate community to own both the DRR and CCA programs.

### Media Activism, Social Media and Adaptation

Media activism should be engaged in questioning, 'power', 'participation', 'authority', 'negotiation', 'empowerment' and 'vulnerability' issues in adaptation planning and financing at all levels. Communications technology has been serving as one of the most transformative technologies in contemporary time. ICTs can be mobilized to develop and improve communication between citizens, policymakers, and researchers. Social networking sites can be mobilized to play important roles by generating positive impacts on individual's civic engagement and political participation (Gil de Zuniga, et al. 2012). Social media such as Facebook can facilitate communication with people at risk and providing services for building adaptive capacities and resilience. Social networking sites can promote enabling environment and positive attitudes towards adaptation and individuals can use these sites to keep up with news about their community.

### Promotion of Climate Risk Insurance

Exposure to climate risks causes significant financial losses for the poor households in the climate sensitive regions. Their situation is further deteriorates as they face high uncertainty about whether and when losses might happen. Given this situation, insurance mechanism for the poor can address their most pressing needs in relation to uncertainty to livelihoods, food security, crop failures, losses due to cyclones, storm surges and natural hazards. Drawing on the risk management expertise of the private sector, viable insurance products and effective distribution channels can be designed to reach the at–risk people. The Government can set incentives that facilitate insurance provision across a range of programs in the form of social protection, while development partners, NGOs and CSOs can be engaged for technical supports.

*Image–27: Drying up of Wetlands in Bangladesh (Photograph by Shuvashish Sarker).*

# APPENDICES

## Appendix – 01: Detailed Distribution of Samples

### Table 1.1: Sample of Assasuni Upazila, Satkhira District

| Name of Union | Total HH | Total Population | Cumulative HH | Selected Cluster |
|---|---|---|---|---|
| Anulia Union | 5508 | 24710 | 5508 | 01 |
| Assasuni Union | 5432 | 23624 | 10940 | 02 |
| Baradal Union | 6520 | 28037 | 17460 | 03 & 04 |
| Buddhata Union | 6903 | 29540 | 24363 | 05 |
| Durgapur Union | 4021 | 16200 | 28384 | 06 |
| Khajra Union | 5743 | 26046 | 37366 | 07 |
| Kula Union | 5957 | 24562 | 43323 | 08 & 09 |
| Pratapnagar Union | 6562 | 29250 | 49885 | 10 |
| Sobhmali Union | 6306 | 26703 | 56191 | 11 |
| Sreeula Union | 5846 | 25962 | 62037 | 12 |
| Total | 62037 | 268754 | | |

### Table 1.2.: Sample of Tarash Upazila, Sirajganj District

| Name of Union | Total HH | Total Population | Cumulative HH | Selected Cluster |
|---|---|---|---|---|
| Baruhas Union | 6421 | 26852 | 6421 | 01 & 12 |
| Deshigram Union | 5533 | 21766 | 11954 | 02 |
| Madhainagar Union | 5662 | 23141 | 17616 | 03 & 04 |
| MaguraBinod Union | 5905 | 24389 | 23521 | 05 |
| Naogaon Union | 6670 | 27553 | 30191 | 06 & 07 |
| Saguna Union | 6286 | 24234 | 36477 | 08 |
| Talam Union | 5751 | 22640 | 42228 | 09 & 10 |
| Tarash Union | 6713 | 26639 | 48941 | 11 |
| Total | 48941 | 197214 | | |

### Table 1.3.: Sample of Chokoria Upazila, Coxs Bazar District

| Name of Union | Total HH | Total Population | Cumulative HH | Selected Cluster |
|---|---|---|---|---|
| ChokoriaPouroshova | 13163 | 72669 | 13163 | 1 |
| Badarkhali | 5947 | 30964 | 19110 | 2 |
| Boroitoli | 6378 | 35585 | 27117 | 3 |
| BheolaManikchar | 3843 | 19951 | 30960 | 4 |

| Name of Union | Total HH | Total Population | Cumulative HH | Selected Cluster |
|---|---|---|---|---|
| Demusia | 2409 | 12366 | 36128 | 5 |
| Dulahazara | 7791 | 42904 | 43919 | 6 |
| Faisakhali | 4528 | 25137 | 53654 | 7 |
| Harbang | 8517 | 39638 | 62171 | 8 |
| Kakhara | 4177 | 22829 | 66348 | 9 |
| Khuntakhali | 6426 | 34088 | 76138 | 10 |
| Lakhyarchar | 1480 | 8069 | 81166 | 11 |
| Bara Bheola | 1670 | 8805 | 88391 | 12 |
| Total | 88391 | 474465 | | |

**Table 1.4.: Sample of Porsha Upazila, Naogaon District**

| Name of Union | Total HH | Total Population | Cumulative HH | Selected Cluster |
|---|---|---|---|---|
| Chhaor | 4484 | 18587 | 4484 | 01 |
| Ganguria | 3733 | 15870 | 8217 | 02 & 03 |
| Ghatnagar | 5127 | 21167 | 13344 | 04 & 05 |
| Masidpur | 5256 | 20304 | 18600 | 06 & 07 |
| Nithpur | 7073 | 33733 | 25673 | 08, 09 & 10 |
| Tentulia | 5100 | 22434 | 30773 | 11 & 12 |
| Total | 30773 | 132095 | | |

**Table 2.1a: Number of Indepth Interviews Conducted**

| | Assashuni, Satkhira | Tarash, Shirajgonj | Chakaria, Cox's Bazar | Porsha, Naogaon |
|---|---|---|---|---|
| A. Qualitative Data | | | | |
| KII with Government Officials | 14 | 14 | 11 | 12 |
| KII with Non–Government Officials | 21 | 18 | 15 | 12 |
| KII with Union Disaster Management Committee (UDMC) | 11 | 8 | 17 | 6 |
| KII with Upazila Disaster Management Committee (UzDMC) | 1 | 1 | 1 | 1 |
| KII with Disrict Disaster Management Committee (DDMC) | 1 | 1 | 1 | 1 |
| KII with Livelihood Group | 8 | 7 | 9 | 9 |

**Table 2.1b: Number of Focused Group Discussions Conducted**

| | Assashuni, Satkhira | Tarash, Shirajgonj | Chakaria, Cox's Bazar | Porsha, Naogaon |
|---|---|---|---|---|
| B. FGDs | | | | |
| FGD with Union Parishad | 11 | 8 | 10 | 6 |
| FGD with Community People | 11 | 8 | 10 | 6 |

**Table 2.2: Number of Social, Hazard and Adaptation Matrix**

| | Assashuni, Satkhira | Tarash, Shirajgonj | Chakaria, Cox's Bazar | Porsha, Naogaon |
|---|---|---|---|---|
| C. Matrix, Maps, GPS and Polygon | | | | |
| 1. Social, Hazard and Resource Map | 11 | 8 | 10 | 6 |
| 2. Hazard Calender | 11 | 8 | 10 | 6 |
| 3. Hazard Trend | 11 | 8 | 10 | 6 |
| 4. Livelihood Calender | 11 | 8 | 10 | 6 |
| 5. Livelihood Matrix | 11 | 8 | 10 | 6 |
| 6. Capacity Matrix | 11 | 8 | 10 | 6 |
| 7. Vulnerability Analysis | 11 | 8 | 10 | 6 |
| 8. Identification of Local Adaptation Strategy | 11 | 8 | 10 | 6 |
| 9.Rate/ Frequency of using Adaptation Strategy | 11 | 8 | 10 | 6 |

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## I

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