The Ways and Means of Adapting and Mitigating Climate Change Vulnerability of Northwest Bangladesh

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Executive Summary

Bangladesh is recognized worldwide as one of the most vulnerable countries to the impacts of climate change. The location, dominance of floodplains and low elevation from the sea, high population density, high levels of poverty, and overwhelming dependence on nature, its resources and services makes the country ecologically vulnerable due to climate change. The country has a history of extreme climatic events claiming millions of lives and destroying past development gains. People's vulnerability to climate change is frequently a reflection of marginalization within their own communities. Climate change incidents will affects the entire Northwest region and people will be affected at large scale. It is already mentioned that the region is characterized by high temperature and low rainfall compare to average condition of Bangladesh. Entire area is prone to flood, flash flood, river bank erosion, drought, cold wave pattern which is likely to become more frequent and intense along with horizontal expansion due to climate change. It is also important to note that changes in timing of this natural phenomenon which is influenced by the micro and macro level climatic condition is really alarming resulting from erratic behavior and distribution of rainfall and temperature rise. The major impacts would be on agriculture, fisheries, availability of water resources for agriculture and domestic use, wet lands, food security, education, gender, human health and working capacity, assets and assets developments, social security and on many more.

The review of literature indicated that many studies attempted to deal with the climate change incidents in the recent some. But unfortunately no one enlighten the adaptation and mitigation measures in the Northwest region in detail. It indicates the urgency of the present study is to examine the evidence of climate change and measure the impact of recent climate change phenomenon in Northwest region of Bangladesh. It will help to gather information on vulnerability and adaptation capacity considering both present and future. It identifies best ways and means for adaptation and mitigation of climate change impacts in Northwest region in different sector. As a whole some degree of enlightened the important livelihood resources/indigenous knowledge and skill may be viewed and explore for cope up with climate change by facilitate dialogue between communities and local institutions on climate change vulnerability for community based adaptation in Northwest region considering river bank erosion prone community, drought prone community, cold wave prone community and flood prone community for survival of the local people and their livelihood in this region.

The principle objective of the current study is identifying the means and ways of adaptation and mitigation of climate change in the north-west region of Bangladesh. The specific objectives research are, (1) to gather information on vulnerability and adaptation capacity in Northwest region considering both present and future, (2) to find out the climate change impacts and best ways and means for adaptation and mitigation of those in northwest region in different sector ((i.e. agriculture, Fisheries, wetlands, water, food security, education, gender, climate forecasts etc.) and (3) to facilitate dialogue between communities and local institutions on climate change vulnerability for community based adaptation in Northwest region in three different level- Household level, Local government level and National level.

Study applying Climate Vulnerability and Capacity Analysis (CVCA) method. It helps to understand the implications of climate change for the lives and livelihoods of the people in Northwest region. By combining local knowledge with scientific data, the process builds people's understanding about climate risks and adaptation strategies. It provides a framework for dialogue within communities, as well as between communities and other stakeholders. The results provide a solid foundation for the identification of practical strategies to facilitate community-based adaptation and mitigation to climate change. The CVCA prioritizes local knowledge on climate risks and adaptation strategies in the data gathering and analysis process.

Participatory Research Assessment (PRA) and secondary research exercises (prior to PRAs) were considered for both quantitative and qualitative data collection. It focused on communities (considering river bank erosion prone community, drought prone community, cold wave prone community and flood

prone community). Research approach recognizes the role of local and national institutions and policies in creating enabling environment for community-based adaptation and mitigation by analytical framework comprised of guiding questions, emphasis on process for learning and dialogue and links community knowledge to scientific climate change data. Primary data were collected through FGD (Focus Group Discussion), KII (Key Information Interview) and Case Study. For limitation of time a large-scale qualitative survey is not planned but several sets of Focus Group Discussion (FGD) was undertaken incorporating cross section of people and organizations (both GO and NGOs) in the Northwest region. Beside this, qualitative information was collected using participatory tools such as in-depth interview. It was considered four groups,(1) local partners (Government), (2) local partners (NGOs, considering project managers and field staff on livelihoods projects and community-based adaptation projects), (3) vulnerable communities, (4) household and (5) individual for primary data collection.

Four districts of northwest Bangladesh are considered (Kurigram, Nilphamari, Panchagarh and Gaibandha) .These are delimited on the basis of available information and the degree of vulnerability from the climate change incidents from the secondary sources and literature review. Kurigram, Nilphamari, Panchagarh and Gaibandha district were measured for riverbank erosion, drought, cold wave and flood respectively. But of these at least three upazilas from four districts is selected for the present study according to the purposive sampling procedure.

The collected information will be processed qualitatively as well as quantitatively. Qualitative modes of analysis will be concerned with textual analysis of FGD and case studies processed through computer with the help of EXCEL and WORD software for identifying best means and ways of adaptation and mitigation. The quantitative data will be processed through computer with the help of EXCEL livelihood and vulnerability ranking by descriptive statistics. Some of the secondary data is concern for mapping of assessing general physical and socio-economic condition of the Northwest region. The special software ArcView-3.3 and ArcGIS-0.9 will be used for cartographic presentation. The statistical method (Standard Deviation) was applied to show the spatial distribution pattern of some of the key indicators to examine the physical and social-economic condition of the Northwest region at national level covering 64 districts of Bangladesh.

As part of the study, it reviewed the theoretical construct of the climate change scenario in overall Bangladesh mainly from the secondary sources. From the review it was indicated that the country will be highly susceptible to: (a) increased flooding, both in terms of extent and frequency; (b) increased moisture stress during dry periods leading to increased drought susceptibility in terms of both intensity and frequency; and (c) increased salinity intrusion during the low flow conditions. The impacts have been observed that summers are becoming hotter, monsoon irregular, untimely rainfall, heavy rainfall over short period causing water logging and landslides, very little rainfall in dry period, increased river flow and inundation during monsoon, increased frequency, intensity and recurrence of floods, crop damage due to flash floods and monsoon floods, crop failure due to drought, prolonged cold spell, salinity intrusion along the coast leading to scarcity of potable water and redundancy of prevailing crop practices, coastal erosion, riverbank erosion, deaths due to extreme heat and extreme cold, increasing mortality, morbidity, prevalence and outbreak of dengue, malaria, cholera and diarrhea, etc. The climate change in Bangladesh creates insecurities for food, water, life, property, settlement, livelihood assets and others. Climatic impacts reduce securities directly and indirectly. Beside this, present study describes general environmental conditions of Northwest region with two terms: (i) physical conditions, and (ii) socio-economic conditions. These provide a generalized picture having bearing on human habitat and economy of the study area in Northwest Bangladesh. Physical condition is considering physiography, river system, climate, Soil, land and land use pattern, agro-ecology, environment and natural disaster (i.e. Flood, river bank erosion, drought, and cold wave). The socio-economic condition covers population, age structure, labor force and occupation, dependency ratio, rural and urban differentials, poverty, calorie intake, land ownership status in the selected study areas of Northwest region. It will help to understand the correlation of physical and socio-economic condition of the study area with climate change incidents. The empirical studies on the study area meaningfully indicated both physical and social condition of the study area is vulnerable for the community and climate change

events will increase such vulnerability more. Apart from this information it will also help to identify the local capacity of the study are to combat climate change in near future.

The result of the present study has shown that vulnerability to climate change varies not only within communities but also in households. The pattern and types of climate change vulnerability is significantly different and that is why the ways and means of climate change adaptation is also varies among the community. Such ways and means of adaptation and mitigation of climate change in Northwest region of Bangladesh is identified by the local community. Before analyzing the ways of adaptation they discuss climate change impacts in different sectors (i.e. agriculture, fisheries, wetlands, water, food security, education, gender, human health and working capacity, assets, climate change forecast). They predict the impact of climate change in future in their locality also. Local people explore important livelihood resources, its types, availability and access for their coping strategies in their locality.

The evidence of climate change in four different community (river bank erosion prone, drought prone, cold wave prone and flood prone) in Northwest region is significantly clear, such as, increase temperature, changing the duration of season, absence of six seasons, late rainy season, high temperature, decreasing the water flow in rivers, originating more char lands in the river, irregular rainfall, water table declined, short duration of winter, prolong flood, late flood, stormy wind and occurring storm, decreasing the rate of rainfall, increasing the intensity of cold wave and remaining it for long time, increasing the rate of riverbank erosion, decrease of crop production, remaining fog for long time, occurring untimed rainfall etc.

The local people observed the recent climate change events by using their local indigenous knowledge and locally inherited perception. They detected the rainy season differences which makes a huge impact on agriculture, livestock and fisheries. Crop production is decreasing but comparatively insecticide and fertilizer using more because people want to produce more crops. It causes losing of soil fertility. Natural irrigation system has been interrupted as a large scale in dry season. Rainfall pattern is very low in cultivation season but excessive rainfall in lean season is observed. All of the respondents united in one point that they observed lack of rainfall when needed.

For agricultural sector using indigenous knowledge to combat climate change is one of the best ways to predict climatic change phenomenon. Enhance irrigation facilities is immediately desired. Government should give more emphasis on flexibility of irrigation in both dry and wet season, ensure proper power supply for irrigation when needed and even using electric pump if necessary. Digging more cannel to use river water for irrigation purpose is another way to minimize irrigation problem in the dry season. Local community will be ensured by the local government that irrigation would be continued for them and they will give more intention to 'Rabi seasons' crop while more water in needed for cultivation. GO/NGO will trained local farmer about advance irrigation technology. Agricultural diversification is also needed. It will be start by the local community by changing cropping pattern, for example promote fruit like water melon and rock melon cultivation in sandy soil in the char areas of Northwest region. Government will take initiative to invent such kind of crop variety, disaster resilient crop, modified high yielding variety and short duration variety of rice and other crops. Agricultural information is mandatory for the local farmer and such information will be given by the local government to them. They want that government will introduce especial insurance scheme for the poor farmers due to crop failure / production losses for climate change incidents. Both GO and NGO will monitor the soil condition and maintain a database of local soil for every year that they can detect the change it will also help to preserve soil condition and fertility.

A proper planning of fishing is needed in entire Northwest region. Fishing should be banned at breeding season and small fish should not be caught. Local ponds and other wetlands should be ready for the whole year for fishing. Community people will have the access to use pond and such kinds of wetlands. Initiative should be come from the government but need assessment will be done by the local community with the help of government and NGO to introduce new fish variety and disaster resilient fish species. Emphasis should be given on the quick growing fish species. Local people will practice the new variety but they must maintain the distinction of local species with the new one. Introduce commercial

fishing by digging more new ponds in the locality will be another option. It is urgent to build awareness among the community for optimum use of insecticide, pesticides to protect water pollution. High technology for fishing will be promote by the GO/NGO to the local community to preserve water in the wetlands even in extreme dry season, such as possible option for fishing in the pond by the plastic coating and casing fishing in flooding time.

Both GO/NGO and local community will maintain local wet lands considering erratic rainfall and temperature pattern in Northwest region. Wetland should be protected from sand due to flood. It will be insured by the local people that wetlands are properly utilized by them. Emphasis should be given on irrigation for proper utilization of the wet land when needed in extreme climate change events in dry season.

Urgently need international co-operation (i.e. India vs. Bangladesh) for proper water managements. Advancement of the political influence and more agreements on water treaty and related things is required to ensure proper river and cannel as well as water management in Northwest region. Government should implement especial policy for management the river for continuous flow of water for whole year. Improvement of the rainwater harvesting concept in needed. Implement planning for monitoring such option and promote technology for storing rainwater that could be used for domestic and agriculture purpose. More research is needed to justify the possibilities of rainwater harvesting at regional basis of Northwest region. Set more deep tube well for ensure drinking water and local people will be accountable for pure and safe drinking water. Sometimes GO will give purification devices and safe drinking water to the community when needed in emergency period.

Agricultural production should be maximum cost effective and alternative cropping could minimize the food security problem in such areas. In-depth research is needed to assess the possibilities of alternative crops and proper land utilization especially for agriculture in Northwest region. Local people can practice the option of homestead gardening. Need absolute co-operation between GO/NGO for implement various planning on food and food security. Government should monitor the total system of food production, distribution and marketing. Spread diversified employment option with a minimum wage of rate all over the Northwest region for landless and extreme poor that they can buy food in lean season. Thinking of alternative option such as seasonal/ permanent migration, giving micro-credit or taking loan from GO/NGO and the possibilities of '*Dhan*' bank to ensure food security in Northwest region. Government should take initiative to take census on poverty, food security and any other related issue as a regional basis taking into account on Northwest region.

Include climate change topics in education in necessary. Government will take initiative to include climate change topic in national curriculum by modifying syllabus at secondary and primary level. This will be also helpful to build up awareness on climate change adaptation and mitigation issues at early stage. Promote education considering climate change in essential. Establish more primary and secondary school in this region and char/remote lands. Set up new school by thinking of the distance that children can easily go by foot and giving warm cloths to the poor children that they can go to their school at early morning when needed. Road must be higher than flood line and distance must be consider that little children can go to their school even in the extreme climatic condition or any disaster events.

Protect gender violence due to climate change is an urgent issue. Raise awareness and give counseling among local people to protected early marriage, dowry and other social crisis. Policy implication is prerequisite for emergency health condition in disaster time especially for the women. More emphasis should be given on maternity health in disaster time. Emphasis should be given also for the left behind women, children, and elderly people. Implement the concept of 'Community Clinic' or 'Mobile Medical' center in the remote area is required. Special support from GO/NGO in emergency period is needed for women such as diversified employment opportunity, develop cottage industry , give priority to female in case of appointing schools in village etc.

Policy implication for better health condition at Upazila level is obligatory. Need more doctors, nurses and medicine facilities at government hospitals. Common medicine should be distributed among poor people in remote areas and in any emergency time. Rising consciousness about climate change related diseases seasonal diseases and any crisis of health issues. Both GO and NGO will be responsible for emergency health service. Infrastructure development is needed that medical center should be available for the local people up to upazila level.

Emphasis should be given on women for income generation and asset development. Build up awareness to involve various economic activities by both GO/NGO. Proper land distribution is required and Government will take initiative to distribute '*khas*' land among the local poor and landless people. Proper use of the land and embankment will be ensured by the local people. Generate opportunities for asset development such as develop assets by creating employment opportunities and such opportunities should be permanent, industrialization, develop small and large business and industrial activities in the Northwest region, create others employment opportunities etc. Common shelter is needed in disaster period. Tree plantation (i.e. local fruit tree plantation-lotkon, betel nut, mango and papaw etc.) will be another option of household level asset development.

At present there is no forecast of climate change occurrences in Northwest region. People claim there is no meteorology center in their area. Some of them have no idea about climate change forecast. But they realize that climate forecast is required for early warning that will be effective to protect their assets and livelihood. Local people argued for monitoring present forecasting system. Government should take initiative at local level to inform about climate change events, temperature and rainfall to local administrative office that they can provide the information to the local farmer when needed. Government will implement policy for regional basis climate change information up to upazila level. Need information center in village from where they can get information about climate change incidents. It is mandatory to disseminate climate change information among the community. Local representative from both GO/NGO will pass the climatic information. There is many other option such as announcement by the mike at local level, local radio station can inform about the climatic information, climate forecasting through bill board in the open common places where local people are usually gathered, climate forecast should be spread through various organizations (i.e. the concept of federation by the RDRS will be more effective), climate forecasting through union porishad networking, school/ college teacher, local imam by the local mosque, mobile messaging etc. Massive use of indigenous knowledge is required, Experienced and elderly people can use their common intelligence, commonly practices prophecy to understand about the local climatic condition and discuss with others local farmer.

Lastly, a framework for three different level (i.e. Household/individual, local government/community level, national level) is depicts by local people for climate change adaptation by using their indigenous/ local level knowledge, skill, locally available resources and possible expectations. The outcome of the present study indicated that local people are typically depending on their local level indigenous knowledge to combat with the recent climate change phenomenon. It gives possible recommendation for four different climate change incident prone community in their locality as well as a general recommendation for the Northwest region to combat with climate change. It is not always necessary to have everything laid out or monitor by the Government or NGO or any other organizations. If local people are made aware and motivated to use the locally available resources, knowledge and innovative technologies then the climate change vulnerability can be reduced to a greater extent.

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LOCAL TERMS

Adivasis - Smaller ethnic population groups.
Agrahayan - Bangla month (mid-November to mid-December).
Amon - A variety of rice.
Ashwin - Bangla month (mid-September to mid-October).
Aus - A variety of rice.
Baishakh - Bangla month (mid- April to mid-May).
Bazar - Market.
Bhumi - Land
Beel - Inland water bodies/wetlands.
Char - Shoal/sandbar or Mid-river island (also some of alluvial deposits along the banks).
Dhan - Unhusked paddy.
Haat - Rural markets/collecting centers of agricultural products.
Kharif - Crop season, generally covering summer and monsoon seasons.
Khas (land) - Without individual ownership/newly emergent land generally held by the government.
Rabi - Crop season, generally covering winter period.
Union - A fourth-level administrative unit usually consisting of 12 to 15 villages and/or several *Mouzas*.
Upazila - A third level administrative unit consisting of several unions with an average population of around 20,000. A number of *Upazilas* forms a *Zila* or District, the second-level administrative unit. A number of Zilas form a *Division*, the first-level administrative unit. Bangladesh has composed of seven administrative divisions

ABBREVIATIONS

AEZ	Agro-Ecological Zone
ASB	Bangladesh Asiatic Society.
BARC	Bangladesh Agriculture Research Center.
BBS	Bangladesh Bureau of Statistics.
BIDS	Bangladesh Institute of Development Studies.
BRAC	Bangladesh Agricultural Research Council.
BUP	Bangladesh Unnayan Parishad
CBA	Community-Based Adaptation
CBO	Community-Based Organization
CCC	Climate Change Cell
CDMP	Comprehensive Disaster Management Programe
CVCA	Climate Vulnerability and Capacity Analysis
DC	Developed Country.
DoE	Department of Environment
EWS	Early Warning System
FAO	Food and Agriculture Organization of the United Nations
FG	Focus Group
FGD	Focus Group Discussion
GCM	General Circulation Model
GDP	Gross Domestic Product.
GIS	Geographic Information System
GoB	Government of Bangladesh.
GUK	Gana Unnayan Kendra
IPCC	Intergovernmental Panel on Climate Change
IRRI	International Rice Research Institution.
IUCN	International Union for the Conservation of Nature
IWM	Institute of Water Modeling
KII	Key Information Interview
LDC	Less Developed Country.
MoEF	Ministry of Environment and Forest
NAP	National Action Programme
NAPA	National Adaptation Programme of Action
NGO	Non- Governmental Organization.
RBA	Rights-Based Approaches
RDRS	Rangpur Dinajpur Rural Service
SLR	Sea Level Rise
SMRC	SAARC Meteorological Research Center
SPARRSO	Space Research and Remote Sensing Organization.
SRDI	Soil Resources Development Institute
UN	United Nations
UNDP	United Nation Development Project.
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Fund for Population Activities.
UNISDR	United Nations International Strategy for Disaster Reduction
UNO	United Nations Organization
USAID	United States Agency for International Development
VCA	Vulnerability and Capacity Assessment
VGD	Vulnerable Group Development
WARPO	Water Resources Planning Organization
WFP	World Food Program
WRI	World Resources Institute

Chapter 1

INTRODUCTION

Introduction

Bangladesh is situated in the South Asia and bounded by India, Myanmar and the Bay of Bengal. Except for the hilly region to the east and the high land to the north, the country is primarily a low, flat and fertile land. The land area of Bangladesh is 147,570 square kilometers with a population of 130.0 million (BBS, 2001). Bangladesh, a developing country in South Asia, is primarily deltaic flood plains, and elevations in most of the country do not exceed 10m. The country has a humid tropical climate. Average rainfalls in drier and wetter regions are 1500mm and 5000mm per year respectively. In winter, the average minimum and maximum daily temperatures are about 9.7 and 26.6°C respectively. In the summer, the average maximum temperature is about 32.2°C (BARC, 1991). Bangladesh is frequently cited as one of the most vulnerable countries to climate change (Huq, 2001, Rahman and Alam, 2003, UNDP, 2007 and Huq and Ayers, 2007) because of its disadvantageous geographic location; flat and low-lying topography; high population density; high levels of poverty; reliance of many livelihoods on climate sensitive sectors, particularly agriculture and fisheries; and inefficient institutional aspects (CCC, 2006). Many of the anticipated adverse effects of climate change, such as sea level rise, higher temperatures, enhanced monsoon precipitation, and an increase in cyclone intensity, will aggravate the existing stresses that already impede development in Bangladesh, particularly by reducing water and food security and damaging essential infrastructure (MoEFa, 2005). These impacts could be extremely detrimental to the economy, the environment, national development, and the people of Bangladesh (Reid and Sims, 2007). Bangladesh has developed some capacity for dealing with the impacts of climate change at the national level, and policy response options have been mobilized that deal with vulnerability reduction to environmental variability in general, and more recently, to climate change in particular. In addition, Bangladesh has for some time been recognized as a particularly vulnerable country by the international community and has received disaster management and adaptation support in several sectors.

A climate change scenario is defined as a physically consistent set of changes in meteorological variables, based on generally accepted projections of concentrations of carbon dioxide (CO2 thought to be the likely cause of future climate change). Scenarios of climate change were developed in order to estimate their effects on crop yields which may be severe in coming days as per the speculations going on throughout the world. The set of scenarios used is intended to capture a range of possible effects and set limits on the associated uncertainty. The scenarios were created by changing observed daily data from the current daily-observed historical climate data (1975-1995). The scenarios are the combination of a range of temperature (-2°C, 0°C and +2°C) and precipitation (+/-25%). For simplicity, solar radiation, vapor pressure and wind speed were assumed to remain unchanged for all scenarios although some changes associated with temperature and precipitation changes is to be expected (Ahmed and Shibasaki, 2000).

The balance of scientific evidence now suggests that over the last century humans have begun to have a discernible influence on the earth's climate, causing it to warm (IPCC, 1996, 1998). Since the beginning of the industrial age, the concentration of CO2 in the atmosphere has increased from 280 to 350 parts per million (Bazzaz and Fajer, 1992). The increase of CO2 in the atmosphere has been more rapid in recent years. The major reason for this increase may be attributable to the extensive use of fossil fuels, such as oil, coal and gas. The destruction of carbon sink by excessive land use and deforestation might be another important cause for the atmospheric CO2 increase over the last 100 years (Houghton et. al., 1990). It has been projected from the historical data and simulation models that the CO2 level in the atmosphere will reach 600 ppm in the last half of this century (Strain, 1987). The increase of CO2 and several other green house gases such as methane, nitrous oxide, chlorofluorocarbons (CFCs) could cause an increase global temperature of about 4.2°C and possibly a change in precipitation patterns and amounts in some regions (Kimball et. al., 1993). Global warming due to increasing concentrations of green house gases poses a threat to human society by changing the living and working environment to which society has adapted over many generations (Jodha, 1989). Agricultural impacts of climate change could have profound effect in poor and developing countries.

The country depends on the South Asian summer monsoon for most of its rainfall. A multi-model study for South Asia projected “a significant increase in mean monsoon of 8% and a possible extension of the monsoon period” with an intensification of both extremely heavy and extremely deficient monsoons (Kripalani *et al.* 2007). Climate scientists are also concerned about the stability of monsoon and the potential for it to undergo a nonlinear phase shift to a drier regime (Lenton *et al.* 2008). A recent fine-scale study noted the potential for

climate change to weaken monsoon overall across the sub-continent, an average decline in summer rainfall, a delay in the onset of monsoon and more monsoon break periods, but also potentially increased rainfall in Bangladesh, which would lead to more flooding (Ashfaq *et al.* 2009). Bangladesh faces an additional hydrological challenge in that the Ganges and Brahmaputra rivers both rise in the Himalaya-Tibetan Plateau region, where glaciers are melting rapidly. Glacial meltwater provides as much as 70% of the summer flow in the Ganges and 50-60% for other major rivers in the region (Barnett *et al.* 2005). But temperatures on the Tibetan Plateau have risen three times faster than the global average for the last 50 years (Qiu, 2008). The Intergovernmental Panel on Climate Change (IPCC) concluded that rapid melting is expected to increase river flows until around the late-2030s, by which time the glaciers are expected to have shrunk from their 1995 extent of 500,000 sq-km to an expected 100,000 sq-km (Cruz *et al.* 2007). After the 2030s, river flows could drop dramatically, turning the great glacier-fed rivers of Asia into seasonal monsoon-fed rivers. The IPCC concluded that as a result, water shortages in Asia could affect more than a billion people by the 2050s. Over the same period, crop yields are expected to decline by up to 30% in South Asia due to a combination of drought and crop heat stress (IPCC, 2007a and IPCC, 2007b). It seems then that Bangladesh could experience a phase shift in future climatic conditions: An initial period of more frequent and intense flooding as the Himalayan glaciers melt and monsoon rainfall increases, followed after the 2030s by a more uncertain period when glacier melt waters decline dramatically, monsoons become more uncertain and variable, crop losses increase from heat and drought, and humanitarian and security concerns start to dominate as the entire region experiences major water and food shortages. Bangladesh is therefore likely to face substantial challenges in the coming decades.

The resilient Bangladeshi people have always coped with the effects of extreme weather patterns and environmental conditions not related to climate change. Arsenic-contaminated groundwater, for example, is a serious problem that is exacerbated by climate change. Bangladesh's proximity to sea level is another natural condition that increases its vulnerability to the effects of global warming. The frequency and severity of these natural disasters, however, are rapidly escalating because of climate change. Because Bangladesh is both low-lying and densely populated, the impacts of climate change on the country will be particularly intense. Minor environmental changes will have major consequences. A recent World Bank report lists Bangladesh as one of the 12 countries most at risk for climate-related problems. It is seriously at risk for all of the five main climate threats: drought, floods, storms, sea-level rise, and agricultural crop loss. A one-meter rise in sea level as the result of the melting of the Himalayan glaciers and Greenland ice sheet could flood one-third of the country and displace as many as 40 million people. In other areas of Bangladesh, climate change may contribute to

salinity intrusion and increase the likelihood of winter drought. In both of these scenarios, a shortfall in crop production would ensue, threatening the food security of a society that is highly dependent on agriculture. The repercussions of global warming on Bangladesh are diverse and wide-reaching. The environmental changes that are occurring directly affect all aspects of society. Human health, food security, industry and energy security, infrastructure, and economic development are all threatened by climate change. According to the World Bank, 40 percent of foreign aid to Bangladesh is vulnerable to climate-related factors. In a country as densely populated as Bangladesh, even small-scale shifts in ecological systems have a profound humanitarian impact. As the effects of climate change continue to intensify, the potential for social, economic, and humanitarian disaster is rapidly increasing. One of the most serious impacts of climate change is on human migration. As sea levels rise and a vast proportion of Bangladesh becomes inundated, many will have no choice but to flee their homes. Bangladeshi "land squatters" have for decades settled on vulnerable islands of silt known as chars. already vulnerable during monsoons, this rootless population is sure to increase. With higher sea levels and stronger storms, the chars are quickly eroding under their inhabitants' feet. Farmers who can no longer cultivate their land, inhabitants of coastal areas that have been submerged in sea water, and other impoverished Bangladeshis who are forced to leave their homes to escape from climate change will become environmental refugees (Matthews, 2009).

Agricultural crop of Bangladesh is influenced by seasonal characteristics and different variables of climate such as temperature, rainfall, humidity, day-length etc. It is also often constrained by different disasters such as floods, droughts, soil and water salinity, cyclone and storm surges. Several studies indicated that climate is changing and becoming more unpredictable every year in Bangladesh. Its variability extreme weather events are being experienced more frequently than ever before. Hazards like floods, droughts, cyclones and salinity intrusion are likely to be aggravated by climate change and sea level rise. Flood and water logging in the central region, flash-flood in the northeast region, drought in the northwest and southwest region, and salinity intrusion and coastal inundation in the coastal regional would be a more acute problem in future. All of these will have an extra bearing on the agriculture sector. Extreme temperature due to climate change would affect livestock. High temperature would affects livestock in a number of ways: causes great discomfort as in the case of human, decreases feed intake and alters nutrient metabolism leading to high loss of energy and thirdly the combined effects of discomfort and nutrient metabolism reduces their productivity, resulting in financial loss of the farmers. Apart from extreme temperature, natural disasters such as cyclone and tidal surge as mentioned above, cause immense loss and sufferings to livestock through destruction of forage crops as well as housing.

Northwest Bangladesh, the northernmost area of the country, known as greater Rangpur Dinajpur in Rajshahi Division, districts namely Dinajpur, Thakurgaon, Panchagarh, Nilphamari, Kurigram & Lalmonirhat in the greater Rangpur-Dinajpur region in the northwest part of Bangladesh. Presently this includes 307 Unions – the lowest tier of local government and extends into the riverine belt to include the islands and sandbars in the River Brahmaputra. The area is generally very low-lying, and crisscrossed by river systems. The northwest Bangladesh is historically more neglected and poor. The soil tends to be sandy and water tables deeper than in other regions. The area is vulnerable to frequent natural disasters. People face catastrophe like cyclones during summer, floods and river-bank erosion in the rainy season, drought in summer, spring and cold wave in winter. Lacking any significant industrial development agriculture is the mainstay of the economy and main source of employment. The spread of irrigation has reduced the extent of the lean season but remains problematic (RDRS, 2001)

The northwest region is characterized by high temperature and low rainfall compare to average condition of Bangladesh. The region is primarily prone to drought which is likely to become more frequent and intense along with horizontal expansion due to climate change. It is also important to note that changes in timing of drought will be other phenomenon, resulting from erratic behavior and distribution of rainfall, and temperature rise. The major impacts would be on agriculture and availability of water resources for agriculture and domestic use particularly in the dry season. There is a strong possibility that moisture content of the topsoil would decrease substantially resulting from decrease in winter precipitation and higher evapo-transpiration. Late Kharif II drought in December would adversely affect Aman crop at the ripening stage, while an early Rabi drought would more severely affect wheat and Boro crops at both germination and vegetative growth stages (Karim et al 1998). Furthermore, increasing moisture stress in early Kharif I would significantly affect Aus production. In Boro Rice, it is revealed that up to 30 percent moisture stress will result 1 to 4 percent yield reduction while reduction will be 10 to 33 percent at 60 percent moisture stress condition.

In order to adequately understand the complex, dynamic, spatial and nonlinear challenges facing Bangladesh, an integrated and appropriately adaptation and mitigation ways and means is required to combat climate change in near future. Present study describing the characteristics of Northwest region of Bangladesh that make it particularly vulnerable to climate change, before outlining the main climate change impacts that are of concern to Bangladesh. These impacts will then be discussed in relation to their adverse effects on

different sectors in this region. Finally, the local level responses to manage these effects will be outlined, including actions that mitigate the impacts of climate variability in general and find out the best adaptive means and ways.

Statement of the problem

The northern part of Bangladesh is situated in the Tista-Jumuna basin and contains many tributaries to these rivers. Topography and micro-climate make northern Bangladesh ecologically vulnerable to destabilizing variations of natural livelihood that is affected by floods, river erosion, drought spells and often cold waves, all of which occur more frequently and intensely than in other region of Bangladesh (www.icg.bangladesh.org). Climate change incidents will affects the entire region and people will be affected at large scale. It is already mentioned that the region is characterized by high temperature and low rainfall compare to average condition of Bangladesh. It is prone to flood, flash flood, river bank erosion, drought, cold wave pattern which is likely to become more frequent and intense along with horizontal expansion due to climate change. It is also important to note that changes in timing of this natural phenomenon which is influenced by the micro and macro level climatic condition is really alarming resulting from erratic behavior and distribution of rainfall and temperature rise. The major impacts would be on agriculture, fisheries, availability of water resources for agriculture and domestic use, wet lands, food security, education, gender, human health and working capacity, assets and assets developments, social security and on many more.

Review of Literature

Bangladesh ranks currently as one of the world's foremost climate change impacts prone countries. Till now, some studies have attempted to deal with climate change in Bangladesh but not as such on the ways and means of adaptation and mitigation on a particular region of Bangladesh. Many physical and social sciences that subject of climate change is an underlying factor which needs to be appreciated in underlying how these disciplines fit into the wider picture. To combine with general background Burroughs (2001) provides a balanced view to give the right weight to the impact of climate change on various disciplines. This will involve assessing how the climate can vary on its own accord and then adding in the question of how human activities may lead to further change. He gave a balanced coverage of the physical principle of the global climate, its behavior on all the time scale, and the evidence for and consequences of past change. Shapley (1953) depicts climate change, its evidence, causes and effects. Lamb (1982) explores the basics about climate, reconstructed the past

record of climate. Wigley et.al (1981) describes the past climate and their impact on man.. Themsan and Peray (1997) emphasize the effects of climate on the physical, biological and cultural environments and include both present day and future relationships.

In order to adequately understand the complex, dynamic, spatial and nonlinear challenges facing Bangladesh, an integrated model of the system is required. An agent-based model (ABM) permits the dynamic interactions of the economic, social, political, geographic, environmental and epidemiological dimensions of climate change impacts and adaptation policies to be integrated via a modular approach. Integrating these dimensions, including nonlinear threshold events such as mass migrations, or the outbreak of conflicts or epidemics, is possible to a far greater degree with an ABM than with most other approaches. Angus et.at (2009) developing a prototype ABM, implemented in Netlogo, to examine the dynamic impacts on poverty, migration, mortality and conflict from climate change in Bangladesh from 2001 to 2100. The model employs GIS and sub-district level census and economic data and a coarse-graining methodology to allow model statistics to be generated on a national scale from local dynamic interactions. This approach allows a more realistic treatment of distributed spatial events and heterogeneity across the country. The aim is not to generate precise predictions of Bangladesh's evolution, but to develop a framework that can be used for integrated scenario exploration. So far the prototype model has demonstrated the desirability and feasibility of integrating the different dimensions of the complex adaptive system and, once completed, is intended to be used as the basis for a more detailed policy-oriented model.

Agrawala, et.al (2003) structured around a three-tiered framework. First, recent climate trends and climate change scenarios for Bangladesh are assessed and key sectoral impacts are identified and ranked along multiple indicators to establish priorities for adaptation. Second, donor portfolios in Bangladesh are analyzed to examine the proportion of development assistance activities affected by climate risks. A desk analysis of donor strategies and project documents as well as national plans is conducted to assess the degree of attention to climate change concerns in development planning and assistance. Third, an in-depth analysis is conducted for coastal zones, particularly the coastal mangroves – the Sundarbans – which have been identified as particularly vulnerable to climate change. Huq and Ayers (2008) analyzed the sectoral impacts (i.e. agriculture and fisheries, water resources and hydrology, coastal areas, forestry /biodiversity, human health, urban areas and particularly vulnerable groups) of climate change at present and future.

Major works in Bangladesh on local level change of temperature and rainfall elements of climate has been undertaken by Climate Change Cell (CCC 2009a). They used a model called PRECIS (Providing Regional Climates for Impact Studies). Develop by hardly center UK. The model used data from 31 weather stations of Bangladesh and regression analysis is performed. The model outputs are provided in a 50 km × 50 km grid format. The model was used to project rainfall and temperature in 2030, 2031, 2050, 2051, 2070 and 2071 in Bangladesh using ECHAM4 SRES A2 emission scenario as model output. The months December, January, February was considered as winter and March, April and May as summer season. The model obtain 6.93, 6.88, 6.84, 7.16, 7.17, 7.33 mm/d in those respective years, where the baseline period (1961-1990) rainfall is 6., the 78 mm/d. However the major findings of PRECIS model are-(1) Rainfall differentiate according to the monsoon and in years (2) Rainfall will increase, (3) Monthly average maximum temperature will change, (4) Monthly minimum temperature will increase, (5) variation of rainfall and temperature will fluctuate on basis of location and (6) Bogra in North West region will have the maximum temperature in 2030.Another major works was also conducted by the CCC (2009b), where they attempted to characterize changes of Bangladesh climate in the context of agriculture and irrigation. Here they also considered summer and winter season. The research showed that annual and seasonal mean temperatures are found to have a general increasing trend in Bangladesh. The magnitude of the trends is dependent on the period of analysis of the available data. The overall trend in mean annual temperature is found to be +0.10 and +0.21 °C per decade for years 1948-2007 and 1980 to 2007 respectively. It concludes that warming has been more rapid in recent decades. In addition Rahman et.al. (1997) found evidence of changes in monsoon rainfall pattern.

All of these works mainly provide future changing scenarios of climatic elements (i.e. temperature and rainfall) of Bangladesh based on the available historic data and had limited focus on the retrospective kind of analysis to capture the real (not predicted), subtle nature of climatic variables. It gave an overall changing trend applicable for all the regions of the country, which may not provide the local level scale insights useful for relating that change to different sectors like agriculture, fisheries of that area.

One of the pioneering works in Bangladesh to address climate change problems was carried by Warrick et.al (1996). In seven briefing documents, they mainly tried to present the scenarios of green house effects and climate change within the physical, social, and legal frame works of the country. They put little emphasis on community resilience build up

process. World Bank (2001a) also identifies climate change induced problems in coastal resources, fresh water resources, agriculture, human health, ecosystem and bio-diversity.

Islam and Neelim (2010) tried to established local scale climate change that happen during the last fifty years since when digital data on climate variables (especially temperature and rainfall) are available with Bangladesh Meteorological Departments. The results of changes were then overlaid on top of Bangladesh Agro Ecological Zones so that likely impacts of any change on cropping pattern and on other sectors could be established. Mirza.et.al (1998) also analyzed long term annual precipitation records of metrological sub divisions of the Ganges, Brahmaputra and Meghna river basins are found no general significance change, with slight exceptions in a few meteorological subdivisions.

Coping with climatic events like drought, cyclones and flooding are not new to Bangladesh. There has been an important reduction in the number of deaths from cyclones due to the establishment of efficient early warning systems and the construction of cyclone shelters. The impacts of climate change are anticipated to exacerbate these existing stresses and constitute a serious impediment to poverty reduction and economic development. Given that Bangladesh has relatively low emissions of green house gases, the major effort will focus on adaptation measures to cope with increased flooding, salinity intrusion and falling agricultural yields. Hasan et.al (2007) attempted to study temperature rise and its probable impacts on socio-economic development of Bangladesh. Many socio-economic activities highly depend on weather and climate. A number of studies on the impact of climate change in Bangladesh exist. Notable among them are those of Mahtab (1989), BUP (1994), Ali (1999). Rise in temperature, as well as climate change of Bangladesh have been studied by different authors like Chowdhury and Dedsharma (1992), Karmaker and Nessa (1997), Karmaker and Shrestha (2000). They found that the annual mean temperature over Bangladesh has a slight increasing trend during the period of 1961-1990.

The NGOs of Bangladesh have been trying to play an important role in reducing climate change induced problems. They have been trying to assist people with different kind s of programmes with the consideration that these interventions may provide backup support to community level adaptive initiatives to cope with climate change uncertainties. Some of the external interventions focus on livelihood protection; some are aimed at infrastructure building, rehabilitation, and protection while some of the projects are deployed in reducing psychological shocks and trauma. RDRS (2009) designed to short term project to expand the capacity of rural poor communities in North-West Bangladesh to cope with natural calamities named ‘Community Coping Mechanism for Climate Change’. In this case drought considered

due to irregular rainfall –by using alternative access to food and income. Undertaken with the other NGO's to implement and monitor the activities. This indicated that how people with limited resources would be able to respond in future to rapid shifts in their environments brought about by climate change. GUK (2009) arranged an exceptional 'Climate poverty Hearing' program at Gaibandha district. The program was help on the open stage, making a dummy court with the community people to established global climate justice. There were panel members, complainers and guests on the stage. The claimers from the different districts from North West region expressed their present vulnerable situation caused by different disasters. Many of the local people of North-West region claimed that the rich countries of the world responsible for their present situation as they are now aware of climate change. They also implemented various programmes and projects on 'Reduction of Disaster Risk and Sustainable Environmental Management Programme'.

Some of these above mentioned materials may be of help in explaining the impact of climate change on various sectors considering both national and international context. Reviewing the above mentioned materials it also helps to determine various issues to understand climate change, its impact and vulnerabilities and find out possible options for adaptation and mitigation.

Rationale of the Study

Bangladesh is one of the most climate vulnerable countries in the world and will become even more so as a result of climate change. Floods, tropical cyclones, storm surges and droughts are likely to become more frequent and severe in the coming years. Many would say that the signs of the future changes have already begun to become apparent. These changes will threaten the significance achievements Bangladesh has made over the last 20 years in increasing incomes and reducing poverty, and will make it more difficult for sustainable development. It is essential that Bangladesh prepares now to adapt to climate change and safeguard the future well-being of its citizen. The rationale of the present study is to examine the evidence of climate change and measure the impact of recent climate change phenomenon in North West region of Bangladesh. It will help to gather information on vulnerability and adaptation capacity considering both present and future. Though many works have been done on climate in different areas of Bangladesh, but particularly empirical studies on Northwest region did cover in a broad sense. It will identify best ways and means for adaptation and mitigation of climate change impacts in northwest region in different sector. As a whole some degree of enlightened the important livelihood resources/indigenous knowledge and skill may be viewed and explore for cope up with climate change by facilitate dialogue between

communities and local institutions on climate change vulnerability for community based adaptation in northwest region considering river bank erosion prone community, drought prone community, cold wave prone community and flood prone community for survival of the local people and their livelihood in this region.

Events of Climate Change in Northwest Region

According to the secondary information the following phenomenon are considered as an impact of climate change in northwest region-

- Flood/flash flood/ seasonal flood
- Drought
- Riverbank erosion
- Temperature fall/rise
- Cold wave
- Excessive rain/ uneven rainfall pattern
- Water logging
- Losing soil fertility
- Loss of biodiversity
- Pests and weeds
- Strom/thunder storm

Objectives

According to the above conceptual framework, the following specific questions are addressed in the proposed research identifying the means and ways of adaptation and mitigation of climate change in the north-west region of Bangladesh. The specific objectives of the research are:

1. To gather information on vulnerability and adaptation capacity in Northwest region considering both present and future.
2. To find out the climate change impacts and best ways and means for adaptation and mitigation of those in northwest region in different sector ((i.e. agriculture, Fisheries, wetlands, water, food security, education, gender, climate forecasts etc.)..
3. To facilitate dialogue between communities and local institutions on climate change vulnerability for community based adaptation in Northwest region in three different level- Household level, Local government level and National level.

Research Methods and Approaches

Research Method

Climate change is expected to hit developing countries the hardest. Its effects—higher temperatures, changes in precipitation patterns, rising sea levels, and more frequent weather-related disasters—pose risks for agriculture, food, and water supplies. At stake are recent gains in the fight against poverty, hunger and disease, and the lives and livelihoods of billions of people in developing countries. Tackling this immense challenge must involve both mitigation—to avoid the unmanageable—and adaptation—to manage the unavoidable—all while maintaining a focus on its social dimensions (World Bank, 2001)

Effective adaptation is based on a solid understanding of vulnerability to climate change. The impacts of climate change affect people differently based on their capacity to respond. What this means is that many of the factors which shape vulnerability to climate change have nothing to do with the climate. Issues of power, access to information and services and control over resources are important in determining people's capacity to adapt to climate change. Therefore, it is needed to understand the socio-economic dimensions of vulnerability, and in particular those factors that make women and other marginalized groups particularly vulnerable (CARE, 2001).

The Climate Vulnerability and Capacity Analysis (CVCA) methodology helps to understand the implications of climate change for the lives and livelihoods of the people all over the world. By combining local knowledge with scientific data, the process builds people's understanding about climate risks and adaptation strategies. It provides a framework for dialogue within communities, as well as between communities and other stakeholders. The results provide a solid foundation for the identification of practical strategies to facilitate community-based adaptation and mitigation to climate change.

The CVCA (Climate Vulnerability and Capacity Analysis) methodology, developed by CARE International, provides a framework for analyzing climate change vulnerability and adaptive capacity at the community level. Recognizing that local actors must have the opportunity to drive their own future, the CVCA places local knowledge on climate risks and adaptation strategies at the forefront of the data gathering and analysis process. The main objectives of the CVCA are, (1) analyze vulnerability to climate change and adaptive capacity at the community level. It provides guidance and tools for participatory research and learning,

and a guiding framework of questions for analyzing the information. It also takes into account the role of local and national institutions and policies in facilitating adaptation, (2) combine community knowledge and scientific data to yield greater understanding about local climate change impacts.

The analytical framework of the CVCA is based on CARE's Community Based Adaptation (CBA) Framework. It examines resilience factors at multiple levels (national, local government/community, and household/individual levels). Field guides are provided for conducting participatory analysis with different groups within communities. It is designed to be used in conjunction with other resources, tools, and analytical frameworks, and links to complementary resources. CARE believes that the most effective way to do this is through a participatory analysis process which engages all stakeholders in understanding climate-related challenges, identifying adaptation solutions and taking steps to act on those solutions. To facilitate this, CARE has developed the Climate Vulnerability and Capacity Analysis (CVCA) process to help the communities to better understand the implications of climate change for the lives and livelihoods of the people (CARE, 2001). The methods considering the following ten pillars-

1. Participatory Research Assessments exercises (prior to PRAs):Semi-structured interview
2. Resource mapping
3. Historical timeline
4. Seasonal calendar
5. Community hazard mapping
6. Livelihoods strategy ranking
7. Cash flow diagrams
8. Venn diagram
9. Vulnerability ranking
10. Gender/vulnerable group analysis

The present study is not considering all those because of the time constrain. It only combining local knowledge with scientific climate information, the process builds people's understanding about climate risks and adaptation strategies by Participatory Research Assessments exercises (prior to PRAs):Semi-structured interview. It uses the framework for dialogue within communities, as well as between communities and other stakeholders. Most important, it helps to identify those people within communities and households who may be particularly vulnerable, and to better understand the challenges they face. It examines the important livelihood resources by livelihoods strategy ranking and lastly, analysis gender/vulnerable

group. The results of the analysis provide a solid foundation for the identification of practical strategies to facilitate community-based adaptation to climate change. The knowledge can also be used to integrate find out the best ways and means of adaptation and mitigation considering livelihoods and natural resource management programs according to various sectors, and to provide practical evidence for advocating pro-poor climate change policies. The following research approach and target group is considered for in-depth interview, FGD (Focus Group Discussion), KII (Key Information Interview) and Case Study.

Research Approach

- Participatory Research Assessment (PRA) and secondary research exercises (prior to PRAs)
- Focused on communities (considering river bank erosion prone community, drought prone community, cold wave prone community and flood prone community).
- Recognizes the role of local and national institutions and policies in creating enabling environment for community-based adaptation and mitigation
- Analytical framework comprised of guiding questions
- Emphasis on process for learning and dialogue
- Links community knowledge to scientific climate data.

Target Group

- Local partners (Government).
- Local partners (NGOs, considering project managers and field staff on livelihoods projects and community-based adaptation projects)
- Communities
- Household
- Individual

The CVCA methodology provides a framework for analyzing vulnerability and capacity to adapt to climate change at the community level. Recognizing that local actors must drive their own future, the CVCA prioritizes local knowledge on climate risks and adaptation strategies in the data gathering and analysis process. The main objectives of the CVCA are to:

Analyze vulnerability to climate change and adaptive capacity at the community level

The CVCA is a methodology for gathering, organizing and analyzing information on the vulnerability and adaptive capacity of communities, households and individuals (photo 2.1). It provides guidance and tools for participatory research, analysis and learning. It also takes into account the role of local and national institutions and policies in facilitating adaptation.

Combine community knowledge and scientific data to yield greater understanding about local impacts of climate change

One of the challenges of working at the local level on climate change adaptation is the lack of scaled-down information on impacts. This is coupled with inadequate data and information on weather and climate predictions. The process of gathering and analyzing information with communities serves to build local knowledge on climate issues and appropriate strategies to adapt. The participatory exercises and associated discussions provide opportunities to link community knowledge to available scientific information on climate change. This will help local stakeholders to understand the implications of climate change for their livelihoods, so that they are better able to analyze risks and plan for adaptation.

The CVCA methodology is based on a framework of "enabling factors" for Community-Based Adaptation (CBA). It presents a set of guiding questions for analysis of information at national, local and household/individual levels. It provides guidance on facilitating a participatory process for multi-stakeholder analysis and collaborative learning.

The CVCA methodology provides a starting point for engaging stakeholders, assessing current vulnerability and understanding future climate risks. Its results provide an excellent foundation for designing, implementing and evaluating adaptation strategies through a participatory learning and planning process (photo 2.3). The following sections describe the analytical framework and the steps in the CVCA process.

A Framework for Community-Based Adaptation

Climate change is only one of many challenges facing poor people. In order to effectively reduce vulnerability, climate change adaptation must form part of a holistic response which aims to build resilience of communities to withstand the range of shocks and stresses that they are exposed to.

From CARE's perspective, CBA requires an integrated approach which combines traditional knowledge with innovative strategies to address current vulnerability while building adaptive

capacity to face new and dynamic challenges (CARE, 2009). The process of CBA involves four inter-related strategies:

- Promotion of climate-resilient livelihoods strategies in combination with income diversification and capacity building for planning and improved risk management;
- Disaster risk reduction strategies to reduce the impact of hazards, particularly on vulnerable households and individuals;
- Capacity development for local civil society and governmental institutions so that they can provide better support to communities, households and individuals in their adaptation efforts; and
- Advocacy and social mobilization to address the underlying causes of vulnerability, such as poor governance, lack of control over resources, or limited access to basic services

Data collection

Initially an extensive library search was undertaken in order to collect relevant materials. This was involve collection and study of relevant books, journals, research reports, seminar reports, unpublished documents and also reviewing reports and editorials of major or national newspapers. To conduct a research based on the objective the present study were used both qualitative and quantitative methods. An interview (semi structured) was done to collect quantitative data, using face to face interview method. Besides, qualitative information will be collected using participatory tools such as in-depth interview, FGD (Focus Group Discussion), KII (Key Information Interview) and Case Study. For limitation of time a large-scale qualitative survey was not planned but several sets of Focus Group Discussion (FGD) will be undertaken incorporating cross section of people and organizations (both GO and NGOs) in the Northwest region. The details of the respondents are given in appendix 2. The fig 1.1 indicates the number of respondents covering the target group of four different climate change prone communities. It is clear from the graph that different community cover different number of target group . Highest number of information is collected from the individual category, then household category is in second position. The other three categories (i.e. Local partner, GO and NGOs and communities) show differenciation among the different climate change incidents. This flactuation was happening due to availability of the respondents during the survey period in the study area. Case study was also be made from the study areas, documentation through digital recording i.e., still pictures were also be taken from the field. As a whole a keen observation was done to gather information on household and life style of

the study area. Some cartographic presentation of different zone of the study area is giving a clear picture of various indicators and spatial differences.

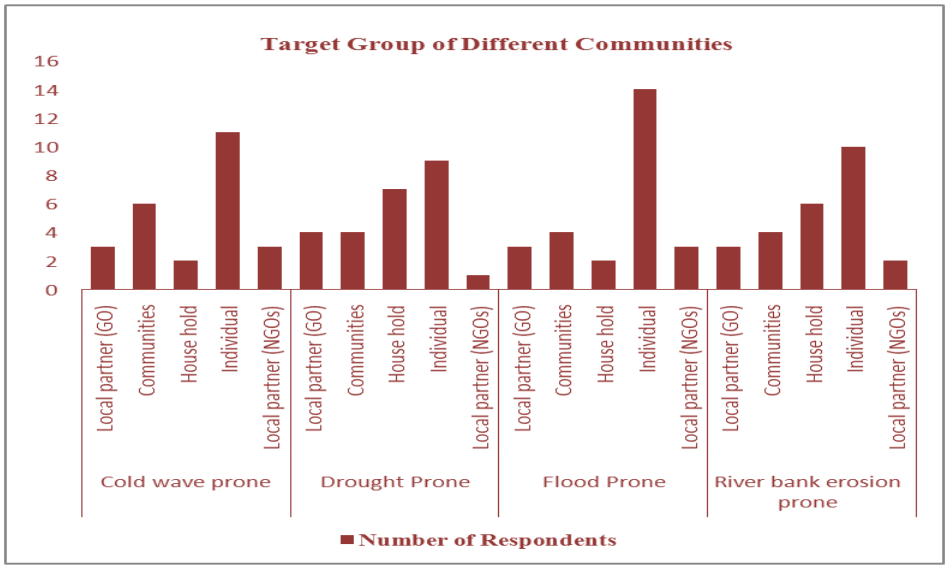
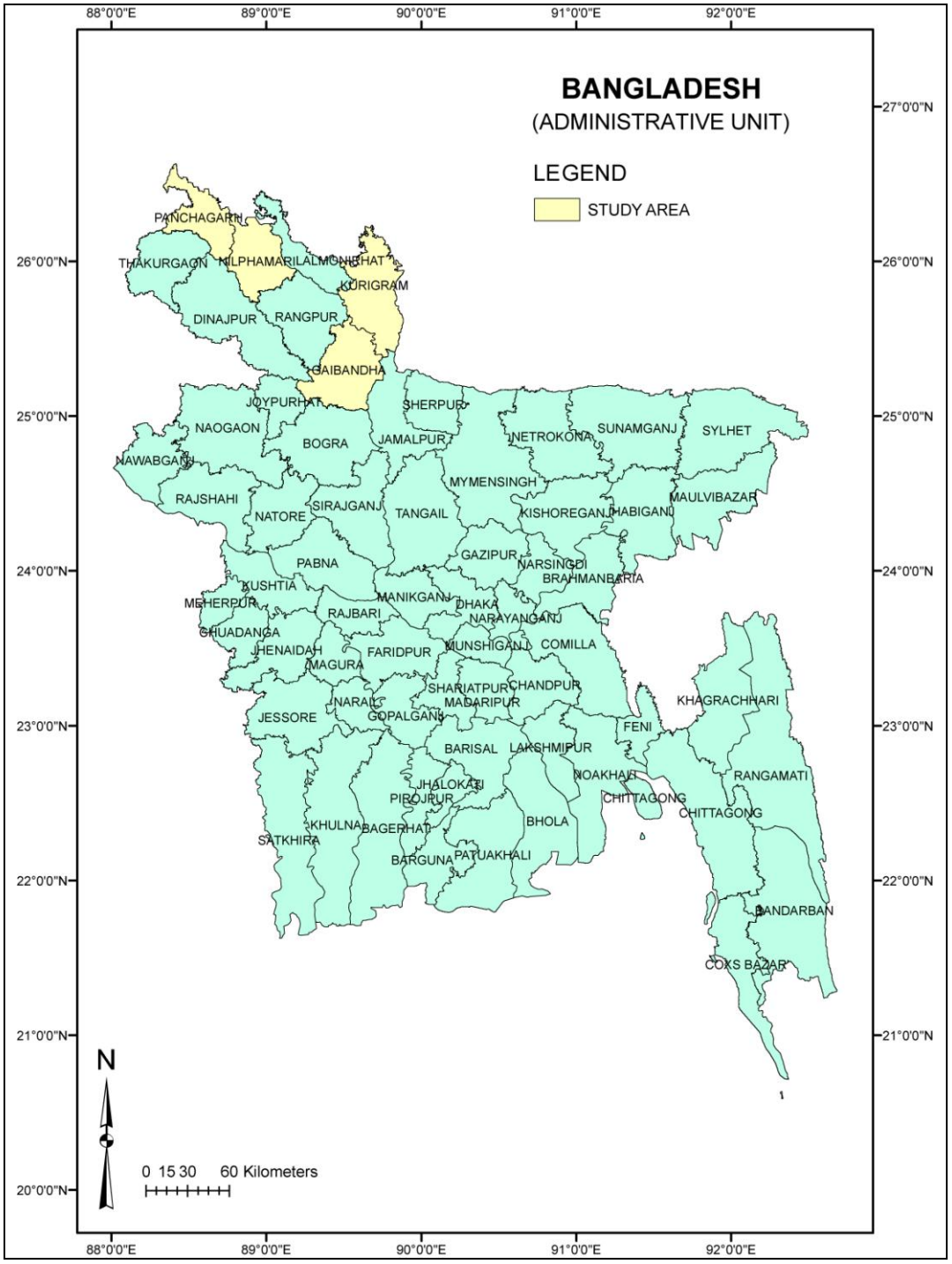


Fig 1.1 Number of respondents covering the target group of four different communities.

Study Area

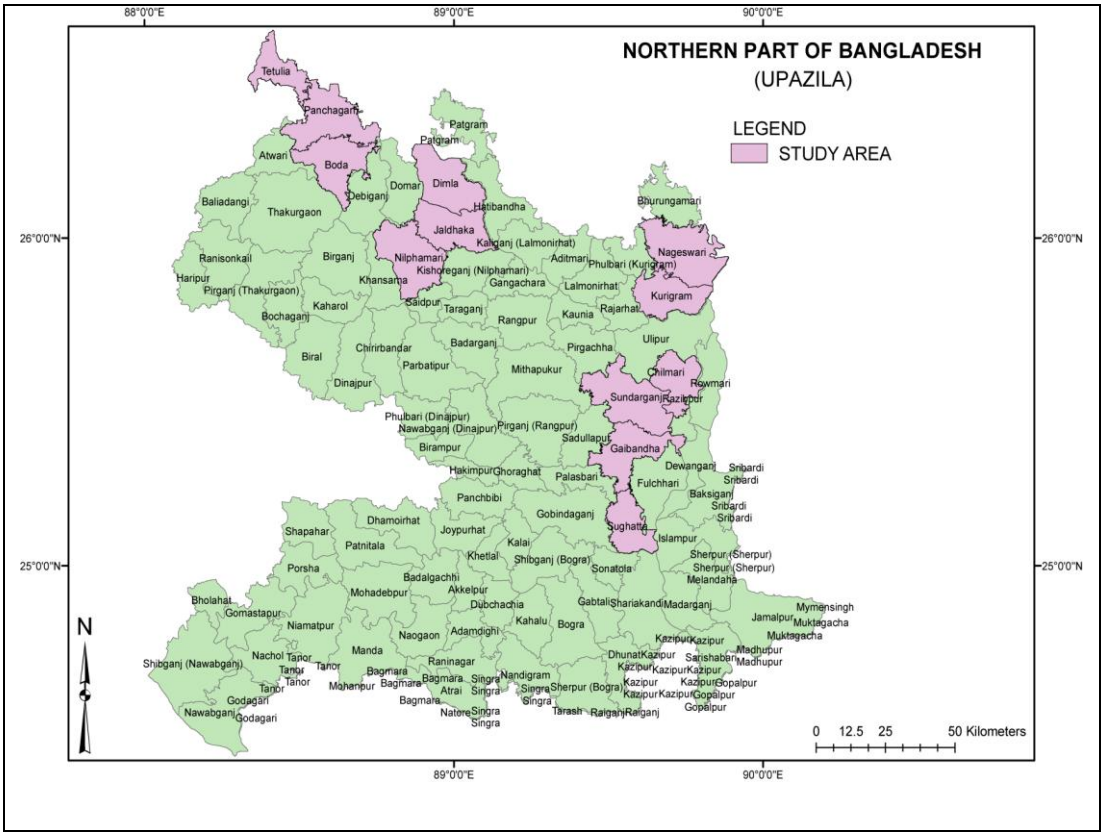
Initially study covered the whole Bangladesh (Fig 1.2a and 1.2b) for measuring the evidence of climate change, to assess their impacts and vulnerability mainly from reviewing the secondary information. Later it went through the regional setting to the Northwest region (Table 1.1). The profile of the study area is given in Chapter 2 in details. The following procedure is taken into consideration to demarcate the study area-

Sampling frame for present study, four districts of northwest Bangladesh are considered (Kurigram, Nilphamari, Panchagarh and Gaibandha) (Fig 1.3). These were delimited on the basis of available information and the degree of vulnerability from the climate change incidents from the secondary sources and literature review.



Source: Made by Author, 2010

Fig 1.2a Bangladesh (Administrative Unit with study area, districts)



Source: Made by Author, 2010

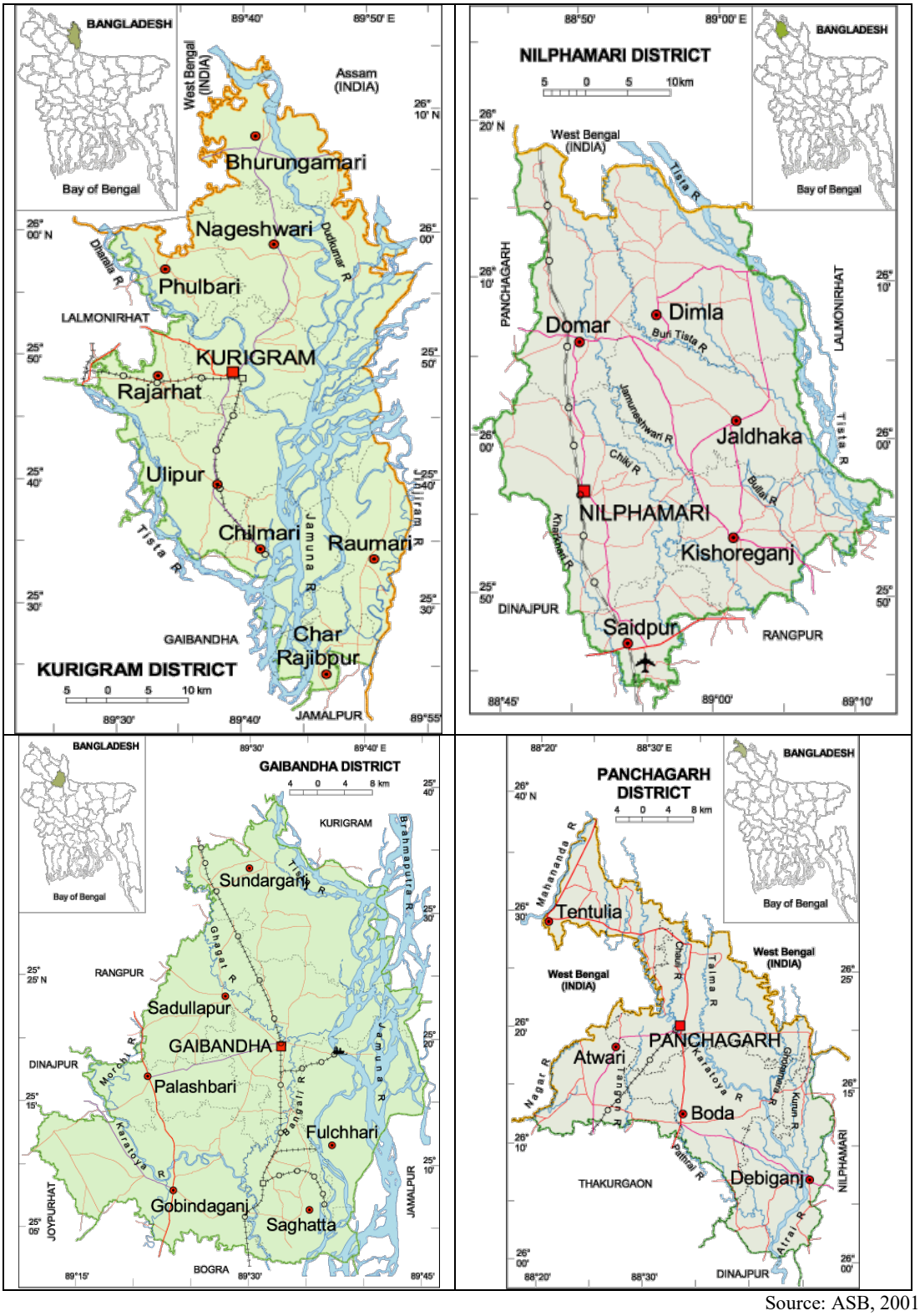
Fig 1.2b North West region of Bangladesh (study area, upazila)

Table 1.1 Sampling frame in relation to climate change incidents

Districts	Climate Change Incidents
Kurigram	River bank erosion
Nilphamari	Drought
Panchagarh	Cold wave
Gaibandha	Flood prone

Sampling procedure

Purposive sampling was done during the research time. The national newspapers focusing on the climate change incident in a broad sense offer a great deal of insight into the problem as the reports were dispatched by the local journalists at Upazilas and Union levels. A sequential survey was made on these reports to examine the spatial context of the climate change events in Northwest region Bangladesh from 1995 to 2010.



Source: ASB, 2001

Fig 1.3 Map of Sampling frame (Districts)

Cartographically the spatial context was identified. For this GIS (Geographic Information System) software will be used to find out the most climate change vulnerable Upazilas. This was finalized after a field level verification.

Units of observation and sampling size

As per existing information, the districts of Northwest region was considered, but of these at least three Upazilas from four districts was selected for the present study according to the above mentioned sampling procedure (Table 1.2). The detail of the investigating areas is given in appendix-1.

Table 1.2 Unit of observation and sample size (Districts and Upazilas)

Unit of Observation (District)	Unit of Observation (Upazila)
Kurigram	Kurigram Sadar
	Nageshwari
	Chilmari
Nilphamari	Nilphamari Sadar
	Dimla
	Jaldhaka
Panchagarh	Panchagarh sadar
	Tentulia
	Boda
Gaibandha	Gaibandha sadar
	Saghatta
	Sundarganj

Data processing

The collected information was processed qualitatively as well as quantitatively. Qualitative modes of analysis will be concerned with textual analysis of FGD and case studies. The quantitative and qualitative data was processed through computer with the help of EXCEL and WORD software respectively for livelihood and vulnerability ranking and to find out the best means and ways of adaptation and mitigation of climate change in Northwest region. Some of the secondary data was concern for mapping of assessing general physical and socio-economic condition of the Northwest region. The special software ArcView-3.3 and ArcGIS-0.9 used for cartographic presentation. The statistical method (Standard Deviation) was applied to show the spatial distribution pattern of some of the key indicators to examine the social economic condition of the Northwest region at national level covering 64 districts of Bangladesh.

Scope of the Study

It has already been mentioned that there has been little studies on climate change in Northwest region considering adaptation and mitigation of climate change impacts. Many studies has attempted to deal with the climate change incidents at national level but of them very less is concentrated on regional context. That is why the present studies deserve

importance and by opening up scope for research. It identified the evidence and impacts of climate change on regional basis. The scope of the study empirically explore, in some details, the strategies they employ over time as they strive to cope and eventually adopted by poor communities as climate change impacts on their highly complex livelihood systems. This was also provided insights into the impacts of present and future exposure on the resilience and traditional coping strategies and livelihood of the local communities resulting the means and ways of adaptation and mitigation for the poor people. The research also however, shed light on assessing the response of the three level household/individual, local level/community and national level- utilizing their thinking, knowledge, skill to counteract the aftermath of climate change impacts of North West region.

Further Research Option

Participatory research is valuable for gathering information and understanding a range of perceptions at a local level and for designing local level interventions that may help hundreds of people. However, it is time-consuming, and can't easily be generalized to other locations. Participatory research alone is seldom sufficient to influence national policies or convince decision-makers to change things that can affect millions of people; the results can be seen as "just stories" or anecdotes.

In order to broaden the understanding of different situations, and to strengthen the ability to influence policies and programs more widely, participatory research can form the basis for design of large-scale, survey-based studies. Information and perceptions gained by using the guiding questions and tools outlined above can help for thinking, and to identify more specific questions that can be used in surveys covering many people in a large number of locations. This can improve the understanding of the various ways in which climate change may affect different parts of a country. Such broader perspectives can be valuable as the basis for influencing a range of national policies and practices impacting millions of people, such as agricultural research and development priorities, standards for surface water utilization, or development of infrastructure for densely populated areas.

Limitations

There are some limitations of the CVCA method when it applied at field level. They are as follows:

a. The CVCA assumes an established relationship with the communities that will engage with in the process. Without an existing relationship, the process of developing trust in order to undertake the participatory analysis can be time-consuming.

b. The analysis has been carried out by only one person, whereas it is designed to be by a team. It has been cross-checked with the project staff however.

c. The assessment was not able to use all the suggested Participatory Research Assessment tools.

d. The PRAs were carried out with mixed groups of women and men, whereas a gender segregated process is encouraged. However due to the possibility of only conducting one set of sessions, both genders were included.

Summary and Conclusion

Climate change is a major threat to sustainable growth and development in Bangladesh, and the achievement of the Millennium Development Goals. Although Bangladesh is the country least responsible for climate change, it is particularly vulnerable to the effects, including reduced agricultural production, worsening food security, the increased incidence of both flooding and drought, spreading disease and an increased risk of conflict over scarce land and water resources. The CVCA method when it applied for the present study it is found that it was one of the best method to find out the climate vulnerability and the ways of adaptation and mitigation of the climate change risk at region context considering the North West region of Bangladesh. The frame work of this method is really very applicable to gather information from the target group. On the other hand, the method is easily understood to continue the process to collect and analyze the data. Community people easily participate with this process. But before going field level verification the method indicated to make a strong background of the study area mainly from the secondary sources. According this it is a well-balanced method to combine both primary and secondary information. The following chapter assesses the general physical and socio-economic condition of the community of study area on the basis of secondary information. Thus it will help to understand past, present and future scenario of the climate change and people's perception about it as well as their knowledge and skill to find out the means and ways of climate change adaptation and mitigation.

Chapter 2

ASSESSING THE GENERAL ISSUES OF CLIMATE CHANGE IN BANGLADESH AND PHYSICAL/SOCIO-ECONOMIC SIGN OF THE NORTHWEST REGION

Introduction

Bangladesh is recognized worldwide as one of the most vulnerable countries to the impacts of global warming and climate change. This is due to its unique geographic location, dominance of floodplains and low elevation from the sea, high population density, high levels of poverty, and overwhelming dependence on nature, its resources and services. The country has a history of extreme climatic events claiming millions of lives and destroying past development gains. Variability in rainfall pattern, combined with increased snow melt from the Himalayas, and temperature extremes are resulting in crop damage and failure, preventing farmers and those dependent from meaningful earning opportunities. In a changing climate the pattern of impacts are eroding assets, investment and future. This stands for families, communities and the state. Global warming and climate change threatens settlements and the number of people displaced from their land due to riverbank erosion, permanent inundation and sea level rise which are increasing rapidly every year. Resources and efforts of government and people are quickly drained addressing the impact of one event when another hazard strikes. Impacts of global warming and climate change have the potential to challenge country's development efforts, human security and the future.

During the 20th century the average temperature has risen by 0.8°C over land and 0.5°C at sea. It is widely agreed by the scientific community that human activities are altering our climate system and that the temperature will continue to rise. The United Nations Intergovernmental Panel on Climate Change (IPCC) forecasts the following impacts due to climate change:

- Extreme weather events such as droughts, storms and floods are likely to increase both in frequency and magnitude

-Increased level of flooding, accelerated erosion, loss of wetland and mangroves and seawater intrusion in freshwater reserves in many coastal areas

-the number of people living in areas that are water stressed is projected to increase to several billions by 2050.

Impacts of climate change will affect developing nations most and climate change is a serious threat to poverty eradication (ADB, 2003). This is explained by geographical and climatic conditions in many developing countries but also on their higher dependence on natural resources and limited capacity to adapt to the changes. Human induced climate change is mainly caused by use of fossil fuels (oil, natural gas and coal), deforestation and emissions of methane from livestock, agriculture and waste dumps.

Three dimensional (Fig 2.1) model of the region clearly indicates that Bay of Bengal and Indian Ocean in the south and major uplands in remaining three areas have strong influence on the rainfall occurrence, water discharge and sediments flow through the river systems of Bangladesh. The Himalayan mountain range builds 7 to 8 kilometers high wall in the immediate Northern parts of Bangladesh, which influence the thermodynamic properties of monsoon clouds and result in bounce back parts of monsoon winds causing downward gliding of clouds. As a result condensation of water vapor happens and resulted in the occurrence of rainfall in the region. Thus the rainfall occurs over about 1.72 million square kilometers of Ganges-Brahmaputra-Meghna (GBM) catchments (12 times larger than the area of Bangladesh) (Islam and Neelim, 2010).

Source: Islam and Neelim, 2010

Fig 2.1 Physical model (not to the scale) of Asian sub-continent depicts that the physical landscape of the region has a profound impact on the physical and climatic processes of Bangladesh.

Bangladesh in a Changing Climate

Assessment of average temperature and precipitation over Bangladesh has been done using a new version of MAGICC/SCENGEN based upon over a dozen recent GCMs. The results obtained by Agrawala et al. (2003) for changes in temperature have been adopted by The National Adaptation Programme for Action (NAPA) (Table 2.1) for Bangladesh. But the results of Agrawala et al. regarding changes in precipitation were modified. Identified changes are as follows-

Table 2.1 Scenarios provided in NAPA document

Year	Temperature change (°C) mean			Rainfall change (%) mean			Sea Level Rise (cm)
	Annual	DJF	JJA	Annual	DJF	JJA	JJA
2030	1.0	1.1	0.8	5	-2	6	14
2050	1.4	1.6	1.1	6	-5	8	32
2100	2.4	2.7	1.9	10	-10	12	88

Source: NAPA, 2005.

A scenario of sea-level rise has also been presented in The NAPA document. However there were no evidences presented in the document in support of the data. Eventually the upper values of the IPCC SLR Scenario was adopted for developing the scenarios for 2050 and 2100, while the curve was extrapolated for developing the 2030 SLR scenario (NAPA, 2005).

Using a number of GCMs including Canadian Climate Centre Model (CCCM), Geophysical Fluid Dynamics Laboratory equilibrium model (GFDL), and 1% transient model of GFDL (i.e., GF01) (Table 2.2) a model-driven climate change scenario was generated:

Table 2.2 Outputs of GCM exercise using GFD 01 transient model

Year	Average Temperature			Temperature increase			Average Precipitation			Precipitation Increase		
	W	M	Ave	W	M	Ave	W	M	Ave	W	M	Ave
	(oC)			(oC)			Mm/month			Mm/Month		
1990	19.9	28.7	25.7	0.0	0.0	0.0	12	418	179	0	0	0
2030	21.4	29.4	27.0	1.3	0.7	1.3	18	465	189	+6	47	10
2075	22.0	30.4	28.3	2.1	1.7	2.6	00	530	207	-12	112	28

Source: Ahmed, 2000.

Another model-driven climate change scenario was generated based on ensemble technique which is applicable for Bangladesh. Projected temperature rise according to the Bangladesh Country Study for the U.S. Country Studies Program was 1.3°C by 2030 (over mid-20th century levels) and 2.6°C by 2070. However, this projection was made using an older version of the Geographical Fluid Dynamics Laboratory (GFDL) transient model (Mahtab, 1991).

This is slightly higher than the projection made in Table 2.3 and may reflect lower climate sensitivity in more recent climate models. Nonetheless, the central findings are coherent with the analysis presented above: the report estimated that winter warming would be greater than summer warming. Also according to the estimation in the study, there would be little change in winter precipitation and enhancement in precipitation during the monsoon (Ahmed and Alam, 1989).

Table 2.3 GCM projections for changes in temperature and precipitation for Bangladesh

Year	Temperature change (°C) mean (standard deviation)			Rainfall change (%) mean (standard deviation)		
	Annual	DJF	JJA	Annual	DJF	JJA
Baseline average 2030	1.0 (0.11)	1.1 (0.18)	0.8 (0.16)	3.8 (2.30)	-1.2 (12.56)	+4.7 (3.17)
2050	1.4 (0.16)	1.6 (0.26)	1.1 (0.23)	+5.6 (3.33)	-1.7 (18.15)	+6.8 (4.58)
2100	2.4 (0.28)	2.7 (0.46)	1.9 (0.40)	+9.7 (5.8)	-3.0 (31.6)	+11.8 (7.97)

Source: Ahmed, 2000

The above projections of climate parameters may be concluded that the country will be highly susceptible to: (a) increased flooding, both in terms of extent and frequency; (b) increased moisture stress during dry periods leading to increased drought susceptibility in terms of both intensity and frequency; and (c) increased salinity intrusion during the low flow conditions.

These changes in the physical system of the country will directly affect a number of major productive systems that include (a) crop agriculture, (b) livestock production, (c) aquaculture and fish production, (d) coastal shrimp production, and (e) forest and vegetation and (f) livelihoods of poor and marginal households. Due to changes in temperature and humidity, human health will also be affected. The high susceptibility to water-based natural hazards will affect settlement of the population and also physical immobile infrastructure. Based on secondary sources, the following sub-sections and table 2.4 provide brief understanding on anticipated impacts of climate change on bio-physical aspects of the country. The following are key likely impacts due to climate change extracted from different impact predictions for Bangladesh.

- Heat stress will increase and summer duration would be longer. Huge pressures on basic facilities and existing support services (water, sanitation and health).

- Inadequate water supply and health facilities for the poor within the hotspots. Decrease ground water supply, deteriorate water quality, reduce recharge of ground water, and reduce water availability for rain fed-agriculture.
- Rainfall erratic and untimely.
- Increase social and mental health stress, food security, safe drinking water problem, insecure shelters, and unsafe health condition.
- Loss of forestation and degradation of ecosystems and loss of biodiversity. The composition of geographic distribution of ecosystems will change as individual species respond to new conditions due to climate change.
- Sea level rise and salinity intrusion in the coastal zone. Small islands are extremely vulnerable. Thousands of people are displacing from coastal and islands community. Possible more sea level rise will dislocate millions from their livelihoods and displace them from settlements.
- Huge damages of livelihood resources, livestock and live support systems by climatic extremes (Floods, erosion, cyclones etc.) enhance mass migration.
- Damages of infrastructures and poor housing and phenomenal growth in human settlements and communication.
- Over 35 million will be climate refugees in Bangladesh by 2050. This will induce internal and external migration. Drought prone areas in Bangladesh in Rajshahi region. It facing many challenges in agriculture, commerce and forestry sector.
- Cyclone and Salinity affected Coastal Zones of Bangladesh Flood affected People Poor/Climate Refugees are on move to main Cities in Bangladesh from different Climate Hotspots.
- Disaster Risk Reduction (DRR) would be unsuccessful within the hotspots and economic and all development process will face various obstacles and GDP is not being achieved.
- Increase some infectious vectors disease such as malaria and Schistosomiasis and nuisance attack.
- Forced migration and social conflicts increasing gradually from hotspots to safer zones.
- Unplanned urbanization and growing slums in the big cities rapidly

Table 2.4 Critical vulnerable areas and most impacted sectors due to climate change in Bangladesh

Climate and Related Elements	Critical Vulnerable Areas	Most Impacted Sectors
Temperature rise and drought	• North-west	• Agriculture (crop, livestock, fisheries) • Water • Energy • Health
Sea Level Rise and Salinity Intrusion	• Coastal Area • Island	• Agriculture (crop, fisheries, livestock) • Water (water logging, drinking water, urban) • Human settlement • Energy • Health
Floods	• Central Region • North East Region • Char land	• Agriculture (crop, fisheries, livestock) • Water (urban, industry) • Infrastructure • Human settlement • Health • Disaster • Energy
Cyclone and Storm Surge1	• Coastal Zone • Marine Zone	• Marine Fishing • Infrastructure • Human settlement • Life and property
Drainage congestion	• Coastal Area • Urban • South West	• Water (Navigation) • Agriculture (crop)

Source: NAPA, 2005.

Climate Change and Security Issues in Bangladesh

The climate change in Bangladesh creates insecurities for food, water, life, property, settlement, livelihood assets, livelihoods and others. Climatic impacts reduce securities directly and indirectly. Environmental degradation, degradation of land resources ultimately reduces food securities, health securities etc. and at the same time increases conflicts over resources and livelihood persuasions. Following are limited elaborations of insecure domains;

Frequency of formation of cyclone in the Bay resulted in frequent return of fishermen from the deep sea.

Food security: Loss of crop due to flood, storm surge, cyclone, and drought are increasing every year. Salinity and permanent inundation are also limiting crop production.

Water scarcity: Reduced precipitation, prolonged dry season and drought are resulting scarcity of drinking water. Contamination of fresh water resources with saline water are reported in the coastal aquifer.

Loss of property and life: An increasing number of people are suffering damage or loss to their property and sometime life. Increased cyclone, storm surges, floods, river bank erosion destroys and damage peoples properties including land, house, cattle, and other livelihood assets and living essentials. Frequent disasters increases damage and loss by many folds.

Land degradation and loss: Following the climate change, the river bank and coastal erosion are increasing at alarming rate. According to IPCC findings a 45 cm sea-level rise will inundate almost 10.9% of our territory and will displace 5.5 million populations of our coastal regions. Salinity intrusion into the country side reached 100km and degrades land resources. Land use for farming, shrimp and other uses in the declining context generates conflicts.

Loss of livelihoods: Land loss and degradation, scarcity of water, floods, and other hazards reduces livelihood opportunities. The rough sea limits fishing opportunities. Health hazards, malnutrition, access to services prior, during and after disasters reduce working days and opportunities.

Insecurity of women: Women and disadvantaged groups are suffering more during disasters as they don't receive warning in time and women has to take care of their children, elderly and disabled.

Displacement: People compelled to move from their land to other places raises conflicts for resources where they move. Most migrants end up in urban slums, particularly in Dhaka (capital), and there is some evidence that this constant influx of people is contributing to rising crime and insecurity in these areas.

Climate Change Hotspots and Adaptation in Bangladesh

In Bangladesh there are some places which are in more dangerous condition due to the impacts of climate change. These are called climate change hotspots. It examines the potential caring penalty of climate change within the next 20 to 30 years. Climate change is taking place at a rapid rate outstripping many worst case predictions. Climate-related disaster events

are having an impact on more communities around the globe. Humanitarian organizations have realized that climate change does not mean 'business as usual'. The extent, nature and patterns of natural hazards and disasters are changing and very likely will continue to do so.

Climate change hotspots in Bangladesh are determined based on the following considerations: hazard exposures, impact on biodiversity and conservation of marine and coastal resources, impact on life, livelihood and wellbeing of inhabitants of the areas. The degree of vulnerability of human health, water, agriculture and commercial forestry sector is also considered in identifying hotspots. The major climate change hotspots in Bangladesh are as follows:

- Cyclone-risk hotspots start from Bay of Bengal and damage crop, vegetation and lead to floods and storm surges. It includes the Coastal districts located in the southern area of the country. Cyclones and tidal surges attacked Bangladesh in 1991, 1998, 2000, 2004 and 2007.
- Flood-risk hotspots were identified in Middle and Northern-Eastern part of Bangladesh. Recent severe floods: 1988, 1998, 2004 and 2007. Floods in Bangladesh in 2007 occur two times prolonged causing 40% crop loss, outbreak of diarrhea diseases and severe food insecurity.
- Drought-risk hotspots in Bangladesh are mainly located in Northern-West region which includes Rajshahi, Kurigram, Nilphamari, Rangpur and Dinajpur districts. Bothe extent and severity of drought has increased and the consequences are Poverty, food insecurity and hunger.
- Salinity risk hotspots are located mainly in coastal districts which have a vast network of rivers and a large number of islands. Salinity intrusion started from the lower-upper area of coastal region to nearest upholds.

Examples of adaptive responses due to different types of Climate Change

The scenario development workshops and secondary review of literatures suggested the following adaptation options and practices in different climate change hotspots.

FLOOD PRONE REGIONS			
Adaptation option		Typology of adaptation	
		Purposefulness	Timing
Resilient Housing Structure	Flood Resilient Housing Structure	Autonomous	Anticipatory, Proactive
	Raising Plinth of the House	Spontaneous	Anticipatory, Proactive

Adapting with Food Insecurity	Flood Resilient Crop Storage	Autonomous	Anticipatory, Proactive
	Food Preservation	Spontaneous	Anticipatory, Proactive
	Homestead Gardening	Spontaneous	Proactive, Reactive
	China	Autonomous	Anticipatory
	Maize	spontaneous	Anticipatory
	Kaon	Autonomous	Anticipatory
	Felon	Autonomous	Anticipatory
	Pera	Autonomous	Anticipatory
Adapting with Water Scarcity	Protecting Fresh Drinking Water Through Raising Tubewell's Plinth	Autonomous	Proactive
Adapting with Energy Use and Efficiency	Traditional Ways of Preservation of Fuels	Spontaneous	Proactive, Re active
Optimizing Production Proviso	Seed storage	Autonomous	Proactive
	Alternative Livelihood – Mushuri Kalai	Autonomous	Anticipatory, proactive
	Organic Manure	Spontaneous	Proactive
	Duck Rearing	Spontaneous	Proactive, Reactive
	Peanut Plantation	Spontaneous	Proactive
	Sugar Cane	Autonomous	Proactive
	Banana	Spontaneous	Proactive
	Bhenda – A Medicinal Plant	Spontaneous	Proactive
	Conservation of Tall Grasses (Kashban)	Autonomous	Anticipatory
Adapting and Community Resilience	Constructions of Protection Embankment	Autonomous, Planned	Proactive

FLASH FLOOD PRONE REGIONS			
Adaptation		Adaptation typology	
		Purposefulness	Timing
Resilient Housing Structure	Protecting Homestead and Embankments in the Haor Regions	Autonomous	Proactive
	Housing pattern of Hilly Area	Spontaneous	Proactive
Optimizing Production Proviso	Adapting in Wetlands – Harvesting Plants	Spontaneous	Proactive
	Duck Rearing	Spontaneous	Proactive, Reactive
	Harvesting Firewood from Flash Floods	Spontaneous	Reactive
	Murta Cultivation and Weaving Shitol Pati	Autonomous	Proactive, Re active
	Manufacturing Cane Furniture in Shunamgonj	Autonomous	Proactive, Re active
Community Resilience	Seeds Storage	Autonomous	Proactive
	Protection Embankment	Autonomous	Proactive
	Bridge over Troubled Water	Autonomous	Reactive

WATER LOGGED REGIONS		
Adaptation option	Adaptation typology	
	Purposefulness	Timing

Adapting with food insecurity	Hazard Resilient Crop Storage	Autonomous	Proactive, Anticipatory
	Food Preservation	Autonomous	Proactive, Anticipatory
Adapting with energy use and efficiency	Traditional Ways of Preservation of Fuels	Spontaneous	Proactive, reactive
Optimizing production proviso and adapting	Floating Agriculture	Autonomous	Proactive, Anticipatory
	Organic Manure	Spontaneous	Proactive
	Fish Collection	Spontaneous	reactive
	The Kandi Method	Autonomous	Proactive, Anticipatory
	Reed Mat Weaving	Autonomous	Proactive, Anticipatory
Adapting and community resilience	Cohesion and Cooperation in Dewatering	Autonomous	reactive
	Integrating Farming	Autonomous	Proactive, Anticipatory, reactive

SALINITY PRONE REGIONS			
Adaptation option		Adaptation typology	
		purposefulness	Timing
Striving for Food Security	Kewra	Autonomous	Proactive, Anticipatory
Adapting with water scarcity	Rain Water Harvesting	Autonomous	Proactive, Anticipatory
	Preserving Fresh Drinking Water in Coastal Zones	Spontaneous	Proactive, Anticipatory, Reactive
	Sourcing and Harvesting Drinking Water – Ring Well	Autonomous	Proactive, Reactive
	Pond Water Conservation for Drinking purpose	Autonomous	Proactive, Reactive
Adapting with energy use and efficiency	Traditional Ways of Preservation of Fuels	Spontaneous	Proactive, Reactive
Optimizing production proviso and adapting	Shrimp Cultivation	Autonomous	Anticipatory
	Reed Mat Weaving	Autonomous	Reactive
	Prawn Renu	Autonomous	Reactive
	Crab Aquaculture	Autonomous	Anticipatory
	Salted lives and Silted Livelihood: Golpata	Autonomous	Anticipatory, Reactive
	Salt Cultivation	Autonomous	Anticipatory, Reactive

CYCLONE PRONE REGIONS			
Adaptation option		Adaptation Typology	
		Purposefulness	Timing
	Resilient Housing Structure and Adapting	Autonomous	Anticipatory, proactive

DROUGHT PRONE REGIONS	
Adaptation option	Adaptation Typology

		Purposefulness	Timing
Resilient Housing Structure and Adapting	The Mud House in Weather Extremities	Spontaneous	Proactive
Adapting with Food Insecurity	The Rakkha Gola	Autonomous	Proactive
	Homestead Gardening	Spontaneous	Proactive
	Maize	Spontaneous	Proactive
	Heat Tolerant Rice Cultivation	Autonomous	Proactive
Adapting with water scarcity	Dealing with Drinking in Dry Days	Spontaneous	Reactive
	Conservation of Surface Water	Autonomous	Reactive
	Mini Ponds, Many Lessons	Autonomous	Reactive
Adapting with energy use and efficiency	Traditional Ways of Preservation of Fuels	Spontaneous	Reactive, Proactive
Optimizing production proviso	Nurturing the Natural Dewdrops	Spontaneous	Reactive
	Mango Cultivation	Autonomous	Reactive
	Lakkha as Alternative Livelihood	Autonomous	Reactive
	Apel Kul Cultivation in the Drylands	Autonomous	Reactive
	Organic Manure	Spontaneous	Proactive
	Seeds Storages	Autonomous	Reactive
	Duck Rearing	Spontaneous	Proactive

Source: NAPA, 2005

Assessing the General Physical and Socio-economic Sign of Northwest Region

Bangladesh is influenced by seasonal characteristics and different variables of climate such as temperature, rainfall, humidity, day-length etc. It is also often constrained by different disasters such as floods, droughts, soil and water salinity, cyclone and storm surges. Several studies indicated that climate is changing and becoming more unpredictable every year in Bangladesh. Its variability extreme weather events are being experienced more frequently than ever before. Hazards like floods, river bank erosion, droughts, cyclones and salinity intrusion are likely to be aggravated by climate change and sea level rise. Flood and water logging in the central region, flash-flood in the northeast region, drought in the northwest and southwest region, and salinity intrusion and coastal inundation in the coastal regional would be a more acute problem in future. All of these will have an extra bearing on the agriculture, fisheries, wetlands, water, food security, education, gender, human health and asset sector. The northwest region is characterized by high temperature and low rainfall compare to average condition of Bangladesh. The region is primarily prone to drought, flood and river bank erosion which is likely to become more frequent and intense along with horizontal expansion due to climate change. It is also important to note that changes in timing of drought, flood, river bank erosion and cold wave will be extreme phenomenon, resulting from erratic behavior and distribution of rainfall and temperature rise.

The districts of Kurigram, Nilphamari, Panchagarh and Gaibandha are regarded as the climate change incident districts due to river bank erosion, drought, and cold wave and flood

respectively. Apart from these, the incidents are more acute within the upazila level. For the present study Kurigram Sadar, Nageshwari, Chilmari considered as more river bank erosion prone upazila covering Kurigram district, Nilphamari Sadar, Dimla, Jaldhaka considered as more drought prone upazila covering Nilphamari district, Panchagarh sadar, Tentulia, Boda considered as more cold wave prone upazila covering Panchagarh district and Gaibandha sadar, Saghatta, Sundarganj considered as more flood prone upazila covering Gaibandha district . The geographical indicator of the study area is given in table 3.1.

Table 3.1 Geographical indicators of the study area (districts) 2001.

Districts	Total Area	Upazilas (Uz)	Nos. of Uz	Population (in '000)
Kurigram	2296 sq. km.	Kurigram, Bhuramgamari, Chilmari, Rajibpur, Phulbari, Rajarhat, Raumari, Ulipur and Nageshwari	9	1763
Nilphamari	1581 sq. km	Nilphamari, Dimla, Domar, Saidpur, Jaldhaka, and Kishoreganj,	6	1562
Panchagarh	1404 sq. km	Panchagarh , Boda, Debiganj, Atwari and Tentulia	5	829
Gaibandha	2179 sq. km.	Gaibandha, Phulchhari, Gobindaganj, Palashbari, Sadullapur, Saghata and Sundarganj	7	2130

Source: BBS, 2005.

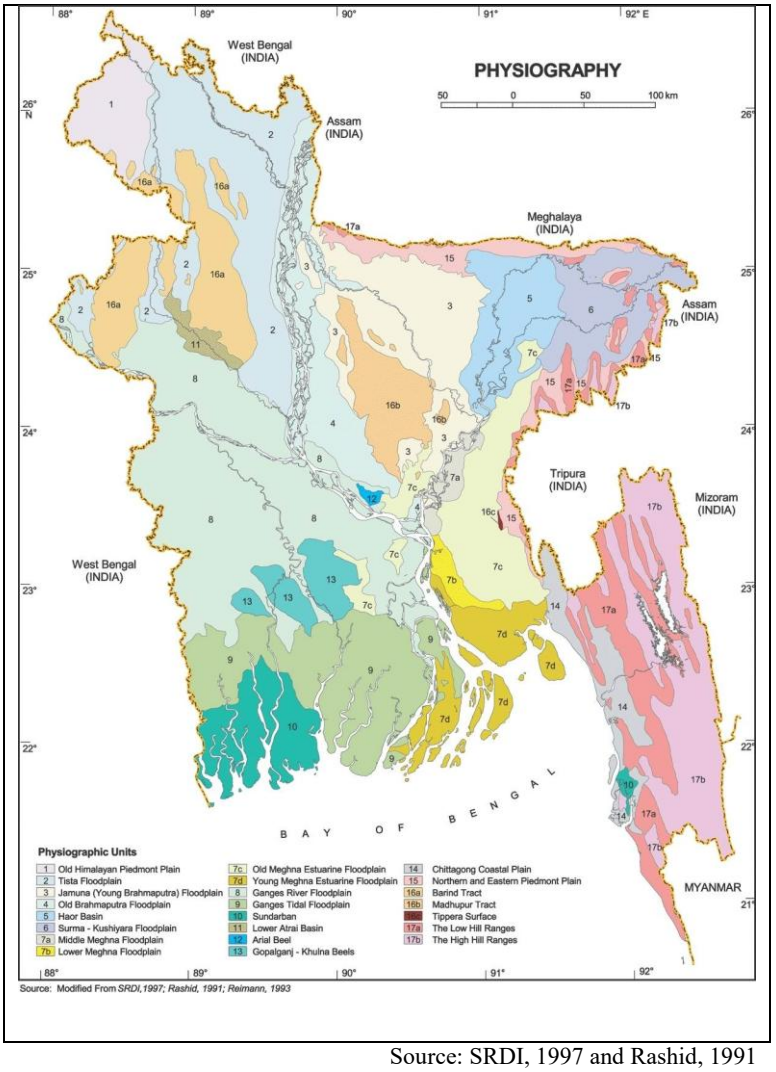
In the following section the environmental conditions of the study area (above mentioned districts) are described in two terms: (i) physical conditions, and (ii) socio-economic conditions. These provide a generalized picture having bearing on human habitat and economy of the study area in North West Bangladesh.

General Physical Conditions

Physiography. Physiographic characteristics of a region are important in relation to agricultural development. It is the key physical factor having bearing on irrigation, drainage, floodibility and soil structure. The study area belong to the physiographic units of the flood plain area of 1 and 2 as indicated in Fig 3.1, which are part of the piedmont plain and most of the Tista flood plain (Brammer, 1996). The piedmont plain comprises gently sloping land at the foot of the Himalayan hills where alluvial sediments derived from the hills have been deposited by rivers or streams. Rivers in such places shift their channels periodically, thereby forming alluvial outwash fans on which close intermixtures of sediments of different textures

occur.

Such characteristics are not suitable for soil development and/or agriculture. The soil formations often are complex, therefore, piedmont plains occur not only at the foot of the northern and eastern hills, but also at the foot of the Himalayas (in India), extending into the Dinajpur and part of Rangpur districts of Bangladesh (Fig 3.1). The physiographic



Source: SRDI, 1997 and Rashid, 1991

Fig 3.1 Physiography of Bangladesh

characteristics influence the nature and formation of soils in a marked way. The deposits are coarser sand and the relief more pronounced than in the adjoining, younger Tista flood plain. This suggests that the sediments came down either at a time of rapid snow melt at the end of the last Glacial Period and of higher rainfall during the Holocene Period (about 60,000 years ago); or following catastrophic earth movements in the Himalayas during either of these periods. A relatively younger part of the Himalayan piedmont plain occupies the northwestern part of Rangpur region (in physiographic unit-2).The deposits there are somewhat finer clastics and braided river pattern is much closer, suggesting that they belong to a distributor-channel of the Old Tista (Buri Tista) rather than to the main river course (Brammer, 2000).

River system. Tables 3.2 and 3.3 show the major of rivers of the study areas including their command areas respectively. The water flows of such rivers are very important for agriculture and normal livelihood of the people. But a number of rivers are silted up and only flow during rainy season affecting farming activities and livelihood of the local people. Some rivers in the North West region have also dried up, like, the Ghaghat, Karotoya, Bangali, Trimohini, Jamuneswari etc. On the other hand, others are so active that they lead to the possibilities of local floods (often triggered off by sheet or flash floods) and riverbank erosion**.** However, in this area, the most dynamic rivers are the Tista, Buri Tista, Ghaghat, Dharla, Jamuna-Brahmaputra, Karotoya, Dhudkumar and Trimohini, which cause frequent flood and riverbank erosion in the Monga-prone areas (Fig. 3.2).

Table 3.2 Rivers of the study areas.

Districts	Major Rivers
Gaibandha	Ghaghat, Karotoya, Bangali, Gajaria and Tista.
Kurigram	Brahmaputra, Dharla, Tista, Dudhkumar, Phulkumar, Sonabari, Jinjiram, Halhali and Jalchia.
Panchagarh	Karatoya, Atrai, Tista, Mahananda, Tangon, Dahuk, Pathraj, Bhulli, Talma, Nagar, Chawai, Kurum, Versa, Tirnoi, Chilka
Nilphamari	Buri Tista, Tista, Jamuneshwari, Manas-Alaijurhi Burhikhora-Chikli, Dhaigar and Charalkata.

Source: ASB, 2003; and Hossain, 2000.

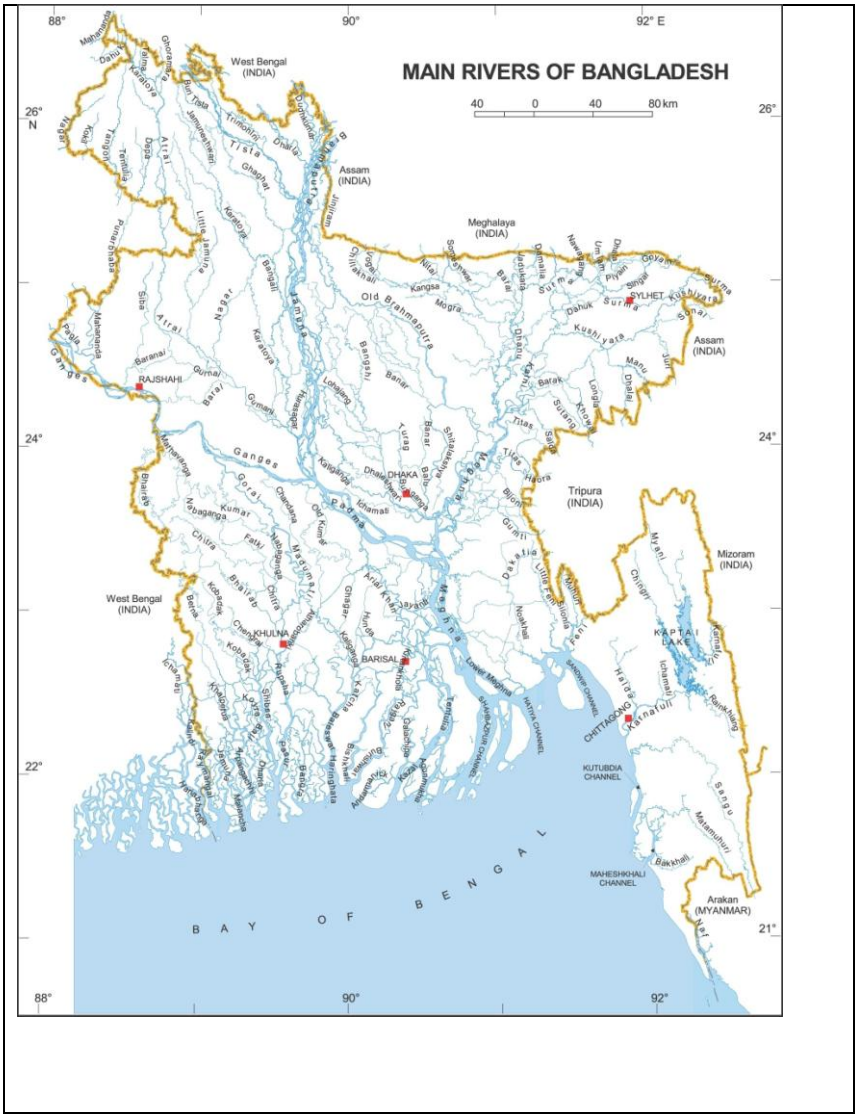
Apart from these, there are a number of small rivers, at present almost dead with sediment deposition and/or siltation. These are: Komlai, Dhum, Awliakhora, Barail, Chowra, Pangsha, Nilia, Katakhali, Sati, Bamni, Bullai, Kharuataj, Dhanjal, Katagarha, Kala, Morchi, Talai, Dara, Sonamati, Danjar, Sarbamangala, Bagdogra, Nautara, Kalamdar, Shingimari, Halhalia, Dharni, Sonabhari, Gurhgurhi, Bherbheri, Farhinga and so on (Hossain, 2000). The sandy soils (incepticols) along these rivers are almost unproductive or mostly put to mono-culture due to the coarse texture and lack of organic matter, i.e. soil nutrients.

Table 3.3 Major rivers by length and the districts covered.

River	Lengths (km.)	Area covered (former districts)
Brahmaputra-Jamuna (Jamuna: 207 km)	276	Rangpur, Pabna, Mymensingh, Tangail
Ghaghat	236	Rangpur

Karotoya-Atrai-Gur-Gumuni-Hurasagor	597	Dinajpur, Rajshahi, Pabna
Punarbhaba	160	Dinajpur, Rajshahi
Tista	115	Rangpur

Source: BBS, 2004



Source: Reinman, 1993

Fig 3.2 Main rivers of Bangladesh

Climate. Bangladesh has, in general, a tropical-humid climate with three main seasons - the hot and humid summer, the rainy season, and the mild and relatively dry winter. Spring and autumn are brief but can be distinguished by changes in vegetation as well as mean daily temperature. Mean annual temperature in Bangladesh is about 26° C and mean annual rainfall is 2540 mm (BBS, 2004). But the study area in North West Bangladesh has relatively extreme climate with mean maximum summer temperature of about 32.5° C and the mean winter temperature of approximately 10.1° C (Table 3.4).