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Risks, Vulnerability and Adaptation in Bangladesh

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Background Paper on

Risks, Vulnerability and Adaptation in Bangladesh

by

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Acronyms and Abbreviations

BADC	Bangladesh Agricultural Development Cooperation
BARC	Bangladesh Agricultural Research Council
BCAS	Bangladesh Centre for Advanced Studies
BELA	Bangladesh Environmental Lawyers Association
BIADP	Barind Integrated Area Development Project
BIDS	Bangladesh Institute of Development Studies
BINA	Bangladesh Institute of Nuclear Agriculture
BMDA	Barind Multipurpose Development Authority
BRRI	Bangladesh Rice Research Institute
BUET	Bangladesh University of Engineering and Technology
BUP	Bangladesh Unnayan Parishad
BWDB	Bangladesh Water Development Board
CANSA	Climate Action Network—South Asia
CBA	Community Based Adaptation
CBDPP	Community Based Disaster Preparedness Programme
CBO	Community Based Organisation
CCCM	Canadian Climate Change Model
CDM	Clean Development Mechanism
CDMP	Comprehensive Disaster Management Programme
CEGIS	Center for Geographic Information System
CIDA	Canadian International Development Agency
CLACC	Capacity Strengthening of LDCs for Adaptation to Climate Change
CNRS	Centre for Natural Resource Studies
COP	Conference of the Parties
CRA	Community Risk Assessment
DAE	Department of Agriculture Extension
DEFRA	Department for Environment, Food and Rural Affairs
DFID	UK Department for International Development
DoE	Department of Environment
DMB	Disaster Management Bureau
DMC	Disaster Management Committee
DNA	Designated National Authority
DPHE	Department of Public Health Engineering
DTW	Deep Tube-wells
ENSO	El Niño - Southern Oscillation

FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GFDL	Geophysical Fluid Dynamic Laboratory
GHG	Greenhouse Gas
HYV	High Yield Variety
HRCPA	High Risk Cyclone Prone Area
ICZMP	Integrated Coastal Zone Management Plan
IIED	International Institute for Environment and Development
IMDMCC	Inter-Ministerial Disaster Management Coordination Committee
IPCC	Intergovernmental Panel on Climate Change
ITDG	Intermediate Technology Development Group
IUCN	International Union for the Conservation of Nature
LACC	Livelihood Adaptation to Climate Change
LDC	Least Developed Country
LEG	LDC Expert Group
MDG	Millennium Development Goal
MOEF	Ministry of Environment and Forest
MOFDM	Ministry of Food and Disaster Management
MOHFW	Ministry of Health and Family Welfare
NAPA	National Adaptation Programme of Action
NDMC	National Disaster Management Council
NGO	Non-Government Organisation
NRM	Natural Resource Management
PRSP	Poverty Reduction Strategy Plan
RA	Resource AnalysisS
RRAP	Risk Reduction Action Plan
RVCC	Reducing Vulnerability to Climate Change
SAARC	South Asian Association for Regional Cooperation
SIDA	Swedish International Development Agency
SMRC	SAARC Meteorological Research Centre
SOD	Standing Orders for Disaster
SSN	SouthSouthNorth
SSNAPP	SouthSouthNorth Adaptation Project Protocol
SST	Sea Surface Temperature
STW	Shallow Tube-wells
SWG	Sectoral Working Group

UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
VDPC	Village Disaster Preparedness Committee
WARPO	Water Resources Planning Organisation

1 Introduction

1.1 The Shifting Paradigm:

1.1.1 Climate Change Impacts Affects Development

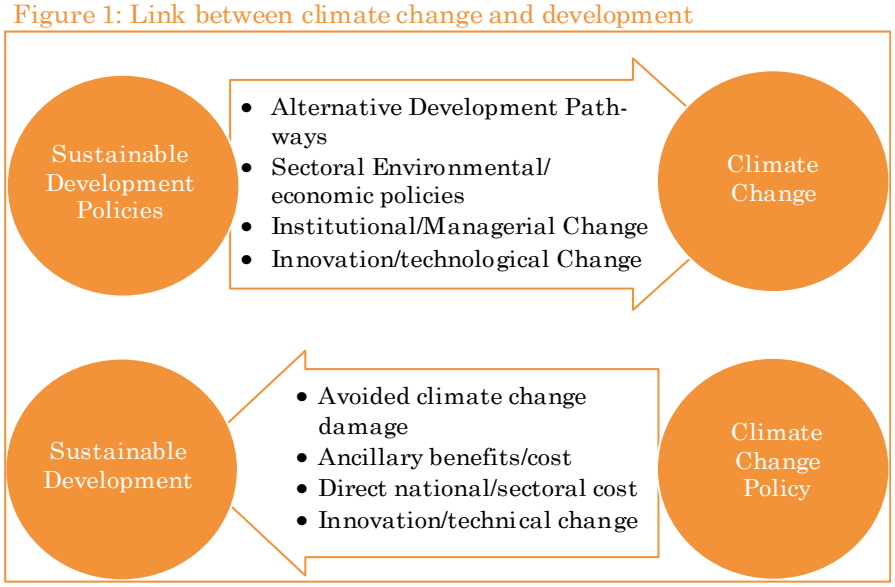
Climate change is one of the greatest threats to mankind in the twenty first century. Climate change is a complex, multifaceted, multidimensional, long-term, slow onset phenomenon with enormous impacts that touches many aspects of human society including most of its production-consumption processes. Further the impacts of climate change are likely to enhance the vulnerability of many of the societies and communities, particularly those are already vulnerable to climate variability as well as lack of development. Climate change is likely to threaten many development investments and efforts.

Besides, the risks of climate variability are likely to be accentuated manifolds by the ensuing and extended climate change. For example, food security, water security and energy security are key elements of development. These combined with health and social securities and increments in freedoms contribute to the development of individuals and communities. The impacts of climate change are likely to impede the process of achieving those securities in many affected communities.

1.1.2 Climate: Not Constant Anymore

In most development processes there is a tacit assumption that during the lifetime of a plan, a programme or a project climate will remain constant. This is hardly ever made explicit in any plan, programme or project documents. Human experiences of at least last two centuries have confined to work on the basis of this assumption. Climate change will severely challenge this status-quo and consequently change one of the deepest rooted assumptions in development planning. This will require far reaching intellectual, institutional and governance transformation in many aspects of development.

Figure 1: Link between climate change and development



(Source:Swart et al.,2003

The planning paradigms will have to shift from a static climate to dynamic (climate change) paradigms. A simplistic representation of the links between climate and development and their respective policies is depicted in Figure-1. Table 1.1 is a representation of the simple and complex climate extremes with representative examples of projected impacts.

Table 1.1 Examples of impacts from projected changes in extreme climatic events

Projected Change in extreme Phenomena during the 21st Century	**Representative examples of projected impacts**
Simple Extremes Higher maximum temperatures, more hot days, and heat waves over nearly all land areas	• Increased incidence of death and serious illness in older people and urban poor • Increased heat stress in livestock and wildlife • Increased risk of damage to several crops
Higher (increasing) minimum temperatures: fewer cold days, frost days and cold waves over nearly all land areas	• Decreased cold-related human morbidity and mortality • Decreased risk of damage to several crops • Extended range and activity of some disease vectors
More Intense precipitation events	• Increased flood, landslide • Increased soil erosion • Increased flood runoff
Complex Extreme	
Increased summer drying over mid-latitude continental interiors and associated risk of drought	• Decreased crop yields • Decreased water resource quantity and quality • Increased risk of forest fire
Increased tropical cyclone peak wind intensities, mean and peak precipitation intensities	• Increased risk to human life, risk of infectious disease epidemics • Increased coastal erosion • Increased damage to coastal ecosystems and coral reefs
Intensified droughts and floods associated with El Niño events in many different regions	• Decreased agriculture and range-land productivity in drought-prone and flood-prone regions
Increased Asian summer monsoon precipitation variability	• Increased flood and drought magnitude and damages in temperate and tropical Asia

Source: Intergovernmental Panel on Climate Change (IPCC), Third Assessment Report, 2001

1.2 Bangladesh Perspectives: One of the most Vulnerable Countries to Climate Change Impacts

1.2.1 Climate Change is a Reality

Climate change is now a reality. The recent finding of the Fourth Assessment Report of the world scientific community, represented by the Intergovernmental Panel on Climate Change (IPCC), demonstrates that human activities are responsible for global warming and global climate change. Climate change impacts have been already visible across the world in various forms. This is demonstrated through various recent extreme climatic events around the world such as prolonged floods and severe drought in South Asia and Africa, heat waves in Europe, devastating cyclones and tidal surges (Katrina and Rita) in Atlantic coasts. The 1990s was the warmest decade and the year 1998 was the warmest on record. The current century is expected to see warming quicker than at any time in the past 10,000 years due to many anthropogenic activities. It seems that we cannot prevent climate change and it will affect the basic elements of human life including food, water, health, fodders and fuel. Climate change will have adverse impacts on human, social and natural systems and sub-systems in different degrees. The developing and poor countries including Bangladesh are one of

the most vulnerable to the adversities of climate change due to their poor socio-economic development and lack of capacity to address the impacts.

This has been adequately illustrated in the recently published newspaper supplement (Daily Star, Dhaka, 28 February 2007 of the Second International Workshop on Community Based Adaptation to Climate Change, Dhaka, February 2007, Bangladesh).

1.2.2 Climate Change Impacts on Bangladesh

Bangladesh will face many of the impacts of climate change due to its geophysical location, hydrological influence by monsoon rainfall and regional water flow patterns. The country faces too much water in monsoon causing floods and too little water in dry season. This situation will be aggravated in the warmer climate resulting in severe droughts and increasing floods. The maps show the current and projected areas under drought and additional likelihood of floods.

It is projected that the possible sea level rise will affect the country by inundating coastal areas of Bangladesh. These will dislocate millions of people from their homes, occupations and livelihoods. Salinity has already increased in the coastal zones. This is contributed by low flow of fresh water from the Ganges and ingress of salt water from Bay of Bengal. It is predicted that for 45cm of sea level rise about 10 percent of the country will be inundated. Further for a 1m sea level rise 21% of the country will go under salt water (IPCC, 2005). This has affected the agriculture, mangroves including the Sunderbans and coastal ecosystem. The climate change and the possible sea level rise is likely to inundate the coastal wetlands, lowlands, accentuate coastal erosion, increase frequent and severe floods, create drainage and irrigation problems. The poor and marginal groups would be critically affected by the possible sea level rise and salinity intrusion in Bangladesh coastal zone. Sea level rise from the south and enhanced Himalayan snow and glacial melt from the north will inundate additional large parts of Bangladesh over today's flood affected areas.

1.2.3 Threats to Increase Poverty

Climate change and its associated events will affect the natural resources and common property resources such as fisheries, mangroves and forests, which provide livelihood supports for the common people and the poor. This will contribute to increase poverty. Climate change will affect the sectoral as well as regional developments and current disaster preparedness. Climate change impacts may affect achieving the MDGs, particularly the goal –one i.e., eradicating poverty and hunger. Because, climate change is likely to directly impact the poor's livelihoods in many ways, their assets and resources base including their employment, income, access to water and natural resources and health. The poor in Bangladesh will face more food insecurity, water stress and health problems in the rapidly changing climate. The effort to reduce poverty under Poverty Reduction Strategy Plan (PRSP) will be significantly undermined by the impacts of climate changes in Bangladesh.

1.2.4 Addressing Climate Change: Mitigation and Adaptation

There are two main approaches to address climate change and its impacts. These are mitigation (reduction of GHG emission) for halting dangerous climate change and adaptation to address the impacts of climate change. Mitigation is the main response measure to prevent future impacts of climate change and consists of acts such as switching from using coal to petroleum to natural gas (the least polluting fossil fuel) or better still switching gradually with evolving technologies from fossil fuels to renewable energy (such as solar or wind), as well as generally reducing energy use and increasing energy efficiency. The development processes need to be significantly de-carbonized.

Adaptation entails efforts to deal (or cope) with the unavoidable impacts of climate change (due to the failure of mitigation efforts). In recent years, adaptation has gained in prominence as an important response measure (especially for poor and vulnerable countries) since it became clear that some impacts are now unavoidable in the short to medium term.

1.2.5 Mitigation Must, Adaptation Too

Mitigation is the best form of adaptation. Adaptation is certainly no substitute for mitigation. Any delay in reducing emissions will only increase the need and cost of adaptation, and increase the risk of runaway global climate change. Significant carbon reduction must be achieved in the short opportunity presented in this and the next decade.

Adaptation and mitigation can complement each other. Adaptation to climate change may build capacity of the vulnerable groups of people to better cope with adverse impact of possible climate change or extreme climatic events while mitigation, as a response strategy would reduce GHG emission and thus help to stable rapid climate change. Adaptation deals with adverse effects of climate change through a process, practices and structure while mitigation deals with reduction of greenhouse gases through different mechanisms. There are synergies between mitigation and adaptation. Adaptation to climate change should be long term responses to deal with anticipated long-term effects of climate change on lives and livelihoods people as well as social and natural systems of a country or a region. The adaptation to climate change is to be integrated with the relevant national policies and strategies as well as in the socio-economic development process, natural resources management and livelihoods promotion efforts.

1.2.6 The Communities are Adapting to the Changes

Communities and peoples in Bangladesh are already actively adapting to climate variability. It is however the poor communities are in the front lines of this climate battle. Bangladeshis are not sitting idle, they are building dams, changing agricultural practices and irrigating their soils to avoid drought. But despite their dynamic approach, the climate challenge is too vast. Much remains to be done. Bangladesh needs to continue developing its adaptation techniques, share their knowledge with other vulnerable countries and plan for future weather changes. It also needs to develop using clean energy, where possible, and continue to put forth a strong negotiation team and efforts for international negotiations, in order to bring more attention to the plight of developing countries in relation to climate change and adaptation. The government and NGOs are working together and setting a good example. But much more needs to be done. The challenges are multi-sectoral, multi-dimensional, long term and the causes are global in nature.

1.2.7 Freedom from Climate Injustice

Climate change is an issue of consumption, production and environmental justice. Civil society plays a key role in influencing governments and other stakeholders to make decisions in favour of the planet, above small groups' on individual country's narrow interests. It is the right of poor countries to meet their development needs and achieve their dignity. Freedom from hunger, injustice, terror and political repression will be threatened by climate change all over the world. No part of the planet is free from this danger. Climate security is a global affair. Climate change is an issue of global justice and must be addressed now.

1.3 Key Hazards, Vulnerabilities and Risks

1.3.1 Introduction

These three interlinking concept have been discussed later in detail. This section highlights the most important on key elements which impacts life, livelihood, development investment of private sector, donors and all the actors (government, NGOs, community) on the sectors (e.g. agriculture, water, energy) and different ecosystems and communities.

Bangladesh is one of the poorest countries of the world and is a member of the Least Developed Countries (LDC) Group. It has a population of 139.2 million (UNDP 2006) making it one of the most densely populated countries and the present population growth rate is 1.7 in the year 2004. Though growth rate has decreased significantly, the high base population makes the need for development efforts that such more challenging.

Though the Government policies have been quite progressive, their implementation is poor in most sectors in Bangladesh. The NGO community in Bangladesh in particularly thriving and playing a key role in the development process, the challenges of poverty reduction, meeting the basic needs of food security (adequate calorie and protein for all with access by all), water security (availability and access to safe drinking water and sanitation) energy security (adequate and accessible energy for food preparation, making water safe, minimum adequate lighting and electricity for all families) remain on a daunting challenge. But there have been development gains. These gains are likely to be significantly undermined by the impacts of climate change.

Climate change comes as an additional and huge burden on an already stressed economy and ecosystem. This additionality may be the proverbial “straw that broke the camel’s back”. Bangladesh geological and spatial location makes its highly populous and extended coastal lands and islands extremely flat, dynamic and vulnerable.

The key risks of exposure of the Bangladesh communities and ecosystems are summarized here. More detailed description and specific elaboration is given in later chapters.

1.3.2 Sea level rise

It is predicted that around 10% of Bangladesh area will be inundated for 45 cm and over 21 percent of the country areas confined in the coast Bangladesh will be inundated for 1 metre sea level rise (IPCC, 2005). This will reduction in the change in agricultural productivity, livelihood option and risking food security and climate induced marine migration. Simplistically put, 30 years of development investment will be wiped out for 30 cm sea level rise.

1.3.3 Salt Water Intrusion

The seawater is saline and ingress of salt water will intrude to fresh water or increase the level of salinity. This will result is reduction of fresh water crops such a rice. The recent history shows decrease in crop productivity, biodiversity, livestock and peoples’ livelihoods opportunities due to ingress of the saline prism. This type of detrimental impacts will be accentuated.

1.3.4 Increasing Cyclones and Storm Surges

One of the predictions of the climate change is the intensification of the extreme weather events such as cyclones and associated storm surges. Bangladesh coast is vulnerable to recurrent cyclones. The enhancement in intensities of wind velocity is expected to incur greater losses to vulnerable

communities and ecosystems. Further increase in sea level rise will bring the water line further inwards. Consequently the affect of storm surge will penetrate deeper into the landmass.

As population increases both numbers of affected people and investment in infrastructure will incur greater losses.

1.3.5 Increasing Floods in the flood prone areas and river bank erosion

The enhanced snow melt from the Himalayan permafrost, due to increase in temperature will force more water to flow through the Ganges, Meghna, Brahmaputra river systems and their river networks. This will create additional flooding extending over the central flood plain of Bangladesh.

Further the additional flow will bring with it sediments which will make the shallow riverbed even shallower. This will result in a lower capacity of riverbed to flow out water rapidly, thus increasing the probability of enhanced flooding and erosion of riverbanks.

1.3.6 Increased Drought

The northwestern drought prone areas of Bangladesh are projected to be greatly affected by decreasing rainfall. These has been major investment over the last two decades in the Barind area and succeeded in raising agricultural productivity. But most of these efforts will be challenged by predicted increasing drought in the northwest Bangladesh.

1.3.7 Temperature Increase

Climate change related increase in temperature is likely result in increased demands for cooling in urban centres, housing and transports.

Further Bangladesh's major crop is rice, which is vulnerable to increased temperature. At the high ranges of temperature the rice crops drops its yield. In some areas, particularly north western parts the crops yield is likely to be reduced contributing to overall food insecurity. Replacement or rice by wheat or maize will need farmers' change of perception and practices which is a long term phenomenon.

1.3.8 Erratic Weather Patterns

This is likely to disturb and even disrupt part of the crop calendar. The rate at which climate change may affect these erratic shifts may be faster than the rate of technology shift as well as farming communities' capacity to change and adapt to new and modified practices.

1.3.9 Impact on Mangrove Ecosystem

Sunderbans in the coastal Southern Bangladesh will be exposed to several of the above risks, particularly sea level rise, saline intrusion and intensive extreme weather events. Given enough time the mangrove under threat and rapid change is expect to readjust and recolonize if space and time would permit. But the demographic pressures in areas north of the Sunderban would not permit the requisite space. The rate at which climate change related sea level rise and saline intrusion is likely to take place is going to be much faster than the rate at which the mangrove ecosystem will be able to readjust. This will result in reduction in species and biodiversity as well as decrease in the areas of the mangrove forest with all its concomitant consequences.

1.3.10 Combination of Impacts

In several geographical areas multiple impacts will reinforce the overlapping impacts and the consequences will be compounded. For example, in the coastal areas livelihoods of communities will be impacted by sea level rise and water inundation, intrusion of salt water, increase in water surges as well as consequent loss of biodiversity, communication and livelihood options.

Similarly the drought prone areas will suffer from water scarcity, temperature increase, increase in dust content in the air etc. leading to economic deprivation and increased respiratory diseases.

2 Challenges of Climate Change and Development Linkages

2.1 Problems and Achievements

Bangladesh is making efforts to achieve its development goals despite very difficult circumstances. Rampant poverty, increasing landlessness, poor infrastructure, mal-governance, poor political leadership and political instability-have all contributed to its development challenges. Despite all these obstacles and challenges Bangladesh has made significant strides. But climate change is likely to offer tremendous and extended new challenges and dampen the momentum of development and undermine many of its present and near future development efforts.

Bangladesh has increased its literacy rate (49.1% in 2003 from 45.3% in 2001), decreased girl students enrolment in schools, decreased population growth rate (1.43% in 2003 from 2.10 in 1991), created a thriving readymade garments and textile industry, generated 3 millions jobs mostly for women, NGOs and government has accessed millions people, mostly women with micro credit, managed to generate over 5% increase in GDP for over last ten years and over 6% over last three years, virtually eliminated large famines, developed a disaster management strategy (Standing Order for Disaster, 2005) reducing mortality from major disasters such as cyclones and floods (BBS 2005). The objective of the Standing Order for Disaster was to ensure that the concerned persons understand their duties and responsibilities regarding disaster management at all levels, and accomplish them. All Ministries, Divisions/Departments and Agencies are responsible for preparing their own Action Plans in respect of their responsibilities under the Standing Orders for efficient implementation. The National Disaster Management Council (NDMC) and Inter-Ministerial Disaster Management Coordination Committee (IMDMCC) ensure coordination of disaster related activities at the National level. Coordination at district, Thana and union levels will be done by the respective District, Thana and Union Disaster Management Committees. The Disaster Management Bureau renders assistance to them by facilitating the process. Most of the poor, particularly women have been covered by micro-credit support of NGOs and government and much of the country has been covered by forming development support groups by NGOs and government agencies. Huge numbers of labourers, mostly unskilled are working abroad, sending back significant remittance. These are no mean achievements given the low economic base and high demographic pressure.

2.2 Understanding the Challenges

2.2.1 Poverty Reduction: The Central Focus of Planning

All political opinions, civil society prioritization, bureaucratic efforts have a legitimate central focus of poverty reduction. The international development partners and financial institutions also focus on poverty reduction and the millennium development goal (MDGs) as desired targets. So focus of the planning process in last two years is the Poverty Reduction Strategy Paper. This document is mostly an economic and econometric analysis and environmental considerations had to be incorporated in the later stages of its modification. Climate change, though mentioned is an after thought.

2.2.2 Climate Change: For Understanding and Lack of Integration in Planning

The planning horizon in Bangladesh is annual to five yearly. A small group of researchers and private organisations have been working on climate change and its adaptation issues. Some of the government and non-government organisations working on climate change are the Department of Environment (DoE), Bangladesh Rice Research Institute (BRRI), Bangladesh Institute of Nuclear Agriculture (BINA), Bangladesh Institute of Development Studies (BIDS), Department of Forests, Bangladesh Water Development Board (BWDB), Department of Public Health Engineering (DPHE), Bangladesh Centre for Advanced Studies (BCAS), IUCN, Centre for Environmental and Geographic Information

Services (CEGIS), Bangladesh Unnayan Parishad (BUP), etc. The understanding of climate change is limited to this small community of scientists, activists and planners. There is a serious lack of understanding of the issues and implications of climate change. Given the threats of sea level rise there is a sense of helplessness as little can be done in the face of this massive threat. Further, if all the people of Bangladesh even stop breathing and ceases all economic activities, it will have little impact on the reduction of global greenhouse gas emission as per capita emission of Bangladesh is miniscule.

So the general lack of understanding the planners and policy makers is compounded by a sense of despair and fatalism. Despite these a systematic albeit small beginning of progress is being made in terms of mainstreaming climate change into development.

2.3 Lack of Experience and Awareness

The experiences of farmers, fishers, small businesses and communities have been confined to wide ranging climate variability. So their exposure to the variability has equipped them somewhat into coping strategies for the variability and extremes. But climate change will result in irreversible shift in the baseline at least over several decades. This will result in the shift of cropping patterns, some infrastructural changes and shift in settlements due to sea level rise induced inundation.

This experience of climate change has not been a part of the literature or the folklore and is new to the communities. Hence there is need for scientific clarity, increasing awareness and an acceptance to change practices. When asked to several village elders in coastal areas in focused group discussions, they concur that there has been continuous shift in climatic patterns, timing of the onset of monsoon or the highest level of tidal levels. But their experiences have not yet taken a shape which can be integrated into the development process. Thus efforts are needed to assess, understand the nature and threat of climate change and then mainstream these experiences into the development process. Then use these substantive experiences into general awareness, education and planning domains.

2.4 Priority Challenges

2.4.1 Poverty Reduction Focus and Centralized Planning

For all concerned in development the central priority is poverty reduction and employment generation though sustainable livelihood enhancement is likely offer great opportunities for poverty reduction of the bottom and half of the population who are mostly landless. But the planning process being often centralized in the government ministries, usually led by urban elite not involving local government representatives and bureaucrats who mostly focus and employment and food production. The central issue of distribution and access is left to the market, supplemented by safety nets in crisis and vulnerable feeding programmes. Local level governance is weak and has had several false starts. Hence many decisions remain centralized and resource allocation is mainly in the hands of economic and infrastructure related ministries.

2.4.2 Poor, Extreme Poor, Ultra Poor: Lack of Access

High density of population, low resources base, poor economy, lack of good governance and high incidence of natural disasters etc., characterize Bangladesh. All those factors have adverse implications on economic growth, poverty situation, food insecurity and hunger. The country has experienced some progress in poverty reduction in 1980s and 1990s (Table 2.1). Though, the country has achieved some limited progress in reduction of poverty in the recent years, but the absolute number of the poor has increased in the last decades. Currently, Bangladesh has over 140 million people and over 44% of them live under poverty line (BBS, 2002). However, different sources say that about 20% of the population (28 million) are ultra poor those who do not have adequate income

and wealth and they suffer from continuous food insecurity, hunger and serious malnutrition. They take food having calorie value less than 1600 kcal.

Table 2.1. Percentage Distribution of Poor People in Bangladesh by Decades

Type of Poverty		**1983-84**	**1991-92**	**2000**
Extreme Poor*	Rural	36.7	28.3	18.7
	Urban	37.4	26.3	25.0
	National	36.8	28.0	20.0
Poor**	Rural	61.9	47.6	42.3
	Urban	67.7	46.7	52.5
	All:	62.6	47.5	44.3

* Extreme Poor: Per capita daily calorie intake less than 1805 kcal

** Poor: Per capita daily calorie intake less than 2122 kcal

Source: BBS, 2001 and MoF, Bangladesh Economic Survey, 2002

Given the above, food security or access is central to all planning. Further the areas to safe drinking water which was ensured over the last four decades by hand pumping ground water to over 90 percent of the population has reduced to 74% due to the ground water contamination by arsenic.

2.4.3 Fire Fighting Against the Odds

So food, energy and water security remains central which urban rich and poor get their first preference in planning. Given the resource constraints much of the delivery of services and goods are on a short-term seal or even on a fire-fighting mode. Hence climate change impacts though very frightening does not seem to get the attention of policy makers.

Further the response strategies to the challenges on climate change on food security or potential climate migration is limited because the options are limited and mostly long term. Even the need to develop salt tolerant variety of rice for the coastal area threatened by sea level rise may seem urgent and possible, the degradation of agricultural research institution make even these initiatives slower.

The garments and textile industries has created jobs while exporting of mostly unskilled workers bring in remittances of huge hard currencies. Hence these become priorities over long term efforts to increase awareness, building rural capabilities for adapting to climate change impacts. These are mostly left to the rural communities without much support. Even the knowledge of the linkages between climate change and health is very limited worldwide and even less in Bangladesh.

2.4.4 Climate Change Efforts: Important but Limited

Compared to many other developing or least developed countries Bangladesh is doing a lot more in climate change. This is mostly undertaken at a small, isolated and dedicated group of people and institutes in the NGO and government sectors. The national activities are confined at pilot scale by NGOs and private research organizations. Example of one adaptation activity taken at the community level in flood prone areas is ‘floating bed agriculture’ where crops and vegetables are grown on floating platforms during inundation of land. Interesting, early results and methodologies are emerging but challenge of integrating these to mainstream development is enormous. Number of worlds leading experiments has been initiated in Bangladesh, but mainstreaming climate change or adaptation to development is still a far way. Another challenge to these limited resource persons is that there is very little skilled capacity development on climate change science, policy analysis and technology transfer in developing countries. Consequently there is a high demand from negotiations, networking, science and policy analysis on the few highly qualified individuals with international experience and capability. Much of their time is needed to address the global and urgent need for

analytical work; as well as supporting governments and international organizations. There is a need to develop larger number of qualified capable people to dedicate to the complex tasks of climate change related activities.

2.5 Integration Amongst Institution, Sectors and Decision Levels in Natural Resource Management

2.5.1 Decision Making Levels: Possible Actors and Their Respective Domains

Climate change is an area where a global action or actions of individuals through the global atmospheric processes affect communities and individuals in distance place of with devastating impacts. Someone emitting GHG in a northern city may contribute to inundate someone else at a different distant shore or coastal area. Intentions are not motivated but consequences are real.

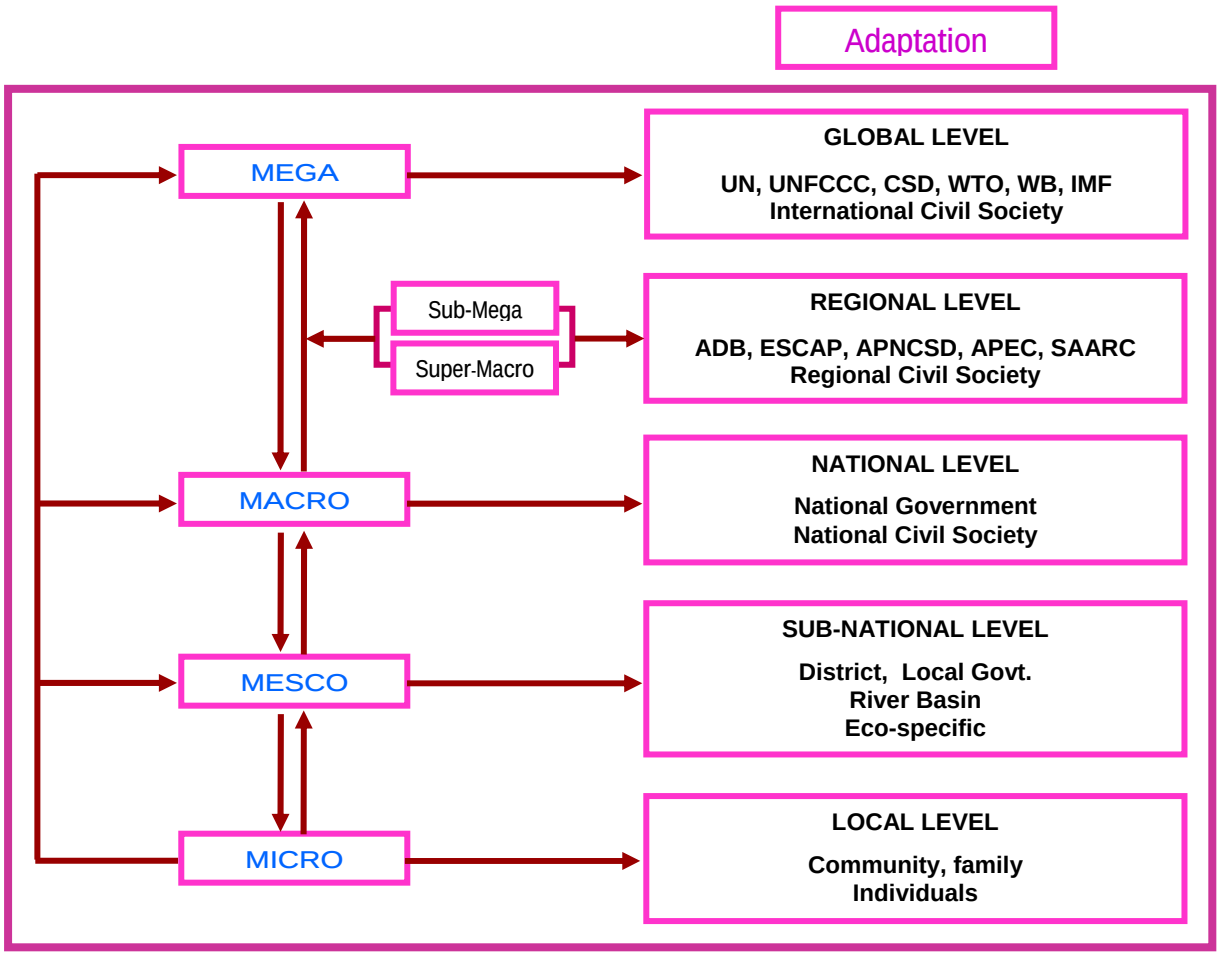
The actors or the key players in managing adaptation for an impacted community and/or the respective government would take adaptation measures depending on the locations specific impacts. The anticipated impacts, however, would take place at different levels. Occurrence of climate change induced increased ice melt and volume of water in the oceanic system is an example of change at *mega* (global) *level.* Some changes are anticipated within a particular region, sub-region or country. For example, increased ice melt and rainfall in the Himalayas would affect surface and groundwater hydrology of the rivers and floodplains of China, India, Nepal, Bangladesh, Bhutan and Pakistan. Each of the co-riparian countries would experience somewhat similar impact, especially during monsoon. Such a change and its impacts would be observed at *macro* (country/regional) *level.*

Within a country, however, different communities would experience different types of impacts depending on geomorphology and physiographic characteristics of the area. Adaptation measures to reduce such location specific impacts would have to be considered at *meso* (community) *level.*

The ultimate impacts would be observed at the bottommost level, known as the *micro level,* where small family units and individuals would experience changes in the physical system and consider adaptation options. The impacts at the micro level would always be observed irrespective of the origin of the processes.

Since the impacts would be observed at four different levels, mentioned above, the management aspects of adaptation would depend on actions taken/considered at all those levels. Figure-2 shows the interactive management of adaptation at different levels.

Different levels of interactive Management and Decision Maker



2.5.2 Resource Base

Bangladesh's natural resource base is very rich, including fertile land and water, their products and attributes such as fisheries, forestry, crop, fuel, fodder, biodiversity, etc. This is the basis for livelihoods of the vast majority of the poor who are mostly underemployed or unemployed.

Trends in agricultural productivity over the past few decades have often been at the cost of those most dependent on these resources for survival and livelihood. In recent years, the natural resource base in Bangladesh is increasingly stressed with increases in population, demands for food security, expanded application of inputs in agriculture, gradual expansion of industry and infrastructure such as roads, bridges and embankments.

2.5.3 Lack of Integration

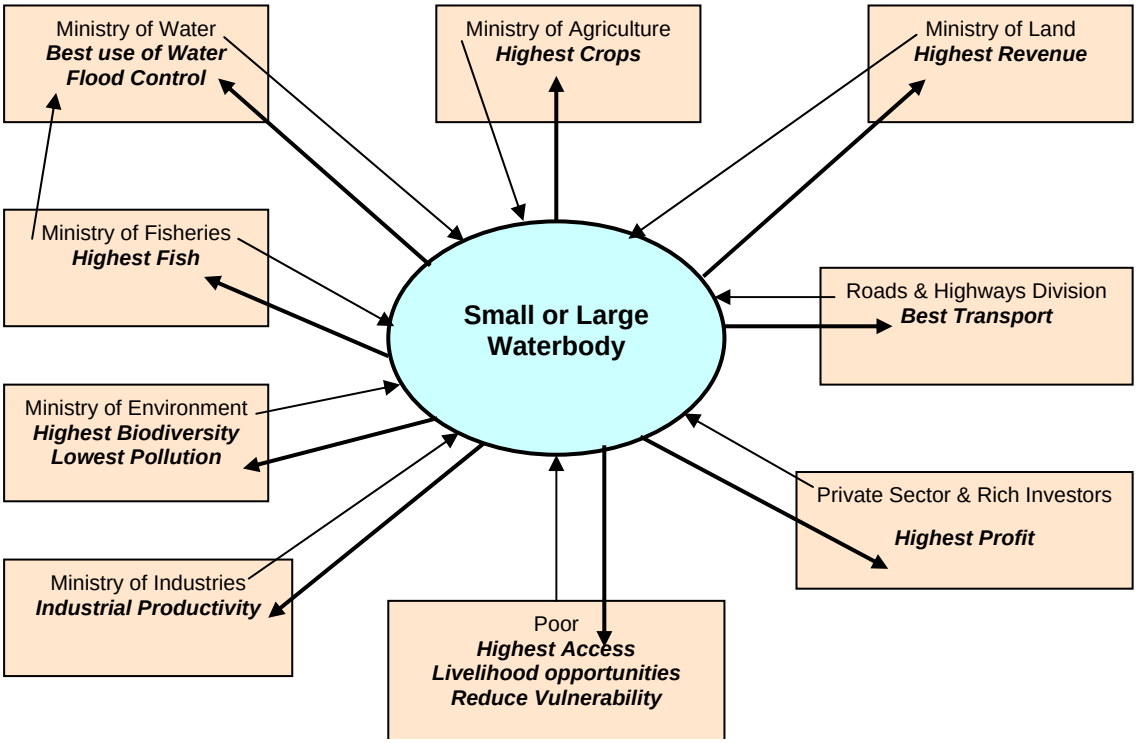
The country lacks a coordinated and integrated institutional framework for sustainable natural resource management, resulting in fragmented and ineffective approaches to resource management.

Each isolated system and its components, whether a small or large water body or landmass is under tremendous pressure to provide different services and benefit depending on the users and managers. The figure in the next page schematically represents the conflicting nature of these demands for different services from different quarters or agencies.

To optimize productivity and attain sustainable development objectives it is essential to enhance integration, reduce conflicting tensions and provide services for the poor with sustainable livelihood opportunities.

2.5.4 Involving Key Actors

In most development, natural resource management and sustainable livelihood discourses the need for



Multiple & conflicting demands on natural resource & management goals

integration at different levels are recognized and emphasized. These levels are spatial, sectoral, community stakeholders, actors and facilitating intermediaries, policy decision makers including government, donors, researchers, NGOs, private sector, local elites and projects.

But little has been done to formally pull together all these demands into actionable programmes and projects. Hence, there is a clear need to pull together a selected group of key players to address these issues based on some background work and a pubic discussion and analysis. The need is to address these issues and concerns for mainstreaming integrated natural resource management as a way to support the poor and enhance sustainable livelihood opportunities.

2.5.5 Sustainable Natural Resource Management

Development needs puts enormous pressure on scarce land and water bodies. Poverty alleviation remains the central focus of all planning and development efforts in Bangladesh. Employment

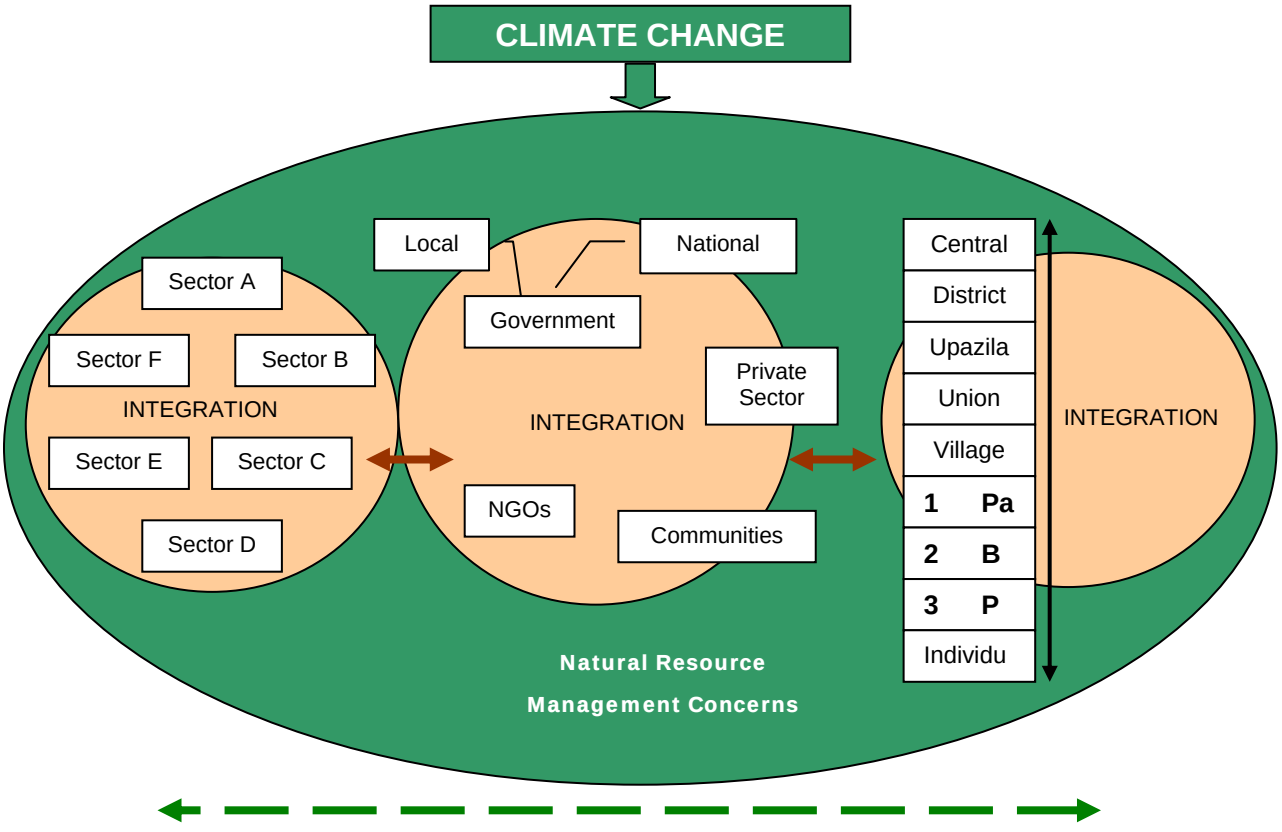
generation is the surest way of alleviating poverty. But given the fluctuations and constraints to create employment, most of the poor remain in managing their livelihood portfolios depending on natural resources. Hence, integrated and sustainable natural resource management becomes a central concern for livelihoods of the vast majority of the rural poor and much of the urban poor.

The major concern in this regard lies in identifying opportunities and potential for a new paradigm toward NRM planning and implementation, as well as limitations and threats that goes with such a fundamental shift, including issues of governance and decentralization.

Further, opinions and responses necessary to continue further dialogue, debates, activism and implementation towards an integrated institutional arrangement for NRM is essential but absent. Participation by the resource users, local communities, marginal and poor sections of the society in the NRM integration is vital but limited at present. Adequate livelihood support from natural resources uses are yet to be secured. Building consensus and developing a better understanding of the conflicts and potential for better NRM also deserve attention.

For Bangladesh, it is a dire necessity to address issues of sustainable natural resource management. Until now, the process of rural economy diversification has relied on agricultural growth, namely productivity of natural resources. Impact of poor natural resource management could well be a reduction in the rate of expansion within the rural economy. Increasing population pressures and demand for natural resources may lead to increased conflict over access, control and management of resources. The poorest are likely to suffer most as productivity including those of khas land and common property that traditionally provides them with safety nets erode further. With a general decline in the capacity of natural resource, vulnerability, food insecurity and poverty will subsequently increase.

An integration framework for Natural Resource Management is represented below:



2.5.6 Climate Change Demands Greater Integration

In a climate change world such integration efforts will be needed even more as the whole sector-actor-decision level systems in different ecosystem will be destabilized or challenged by instability. The governance system of natural resource or urban management in already under stress demanding integration climate instability will put further demands to accommodate the climatic instability.

2.5.7 Data Projection and Uncertainty

The planning horizon which is in annual of five yearly increasing will need good data bases. There have been some studies undertaken. But pragmatic and ecosystems based databases to reflect and incorporate the realities of climate change impacts are missing. There is no acknowledgement of climate change yet by the planning commission responsible for planning or for that matter any other ministries.

Thus the uncertainties resulting on the existing databases by the impacts of climate change offer another major challenge.

2.5.8 Adaptation Efforts and Autonomous Adaptation: Distinguishing Climate Change Adaptation Projects

As is being increasingly recognized adaptation efforts would be needed to reduce some of the risks associated with climate change impacts. There are only a few attempts at adaptation projects which are pilot in nature and being undertaken by leading NGOs (key BCAS and Caritas). These are also trying a develop methodologies in the absence of methodologies for projects which distinguishes climate change based adaptation projects from other development projects. This is important particularly in terms of financing need from any of the Adaptation funds of financial mechanisms. An initiative titled South South North (SSN) works in 6 countries for poverty reduction through building capacity and delivering community based mitigation and adaptation projects. SSN has developed a methodology known as SSNAPP (SSN Adaptation Project Planning) through which they address climate change adaptation projects and poverty reduction.

Beside these communities and agencies will not wait for the worst affects of climate change to undermine their capacities. Communities will make use of their sense of resilience and undertake independent actions which may be termed as autonomous adaptation. More of these activities are better. Many efforts will be a combination of the climate induced adaptation and autonomous adaptation. There will be a need to distinguish these to be able to make any claims to global adaptation finances.

2.6 Mainstreaming Climate Change

2.6.1 Wide Ranging Integration

The discussion above shows that there will be a need to develop a better understanding of the specifics of the climate change. The actions will be needed in (a) adaptation (b) mitigation (c) policies (d) institutionalization (e) implementation, (f) resource mobilization and (g) Research.

Though it is fortunate that the research and environmental developmental NGOs has given a lead and some early institutional initiatives have been taken by the government. But this is mostly confined to the Ministry of Environment and Forests (MOEF) and the Department of Environment (DoE), which

are small, weak and often do not have the convening power of taking major decisions. Activities of the MOEF and DoE are constrained by lack of funds, expertise and man-power. Even major service delivery based development NGOs have not yet taken climate change into consideration and their uptake will be slow. A network of Environment and Development NGOs (for instance Climate Change Network and Climate Change Development Forum) has been formed recently but it will take a longer time for key NGOs to integrate climate change into their programmes. According to the NGOs, for implementation of climate change into programmes in the long-run, specific training is required. Already BCAS has initiated a few climate change training programmes in partnership with Christian Aid, Gono Unnayan Kendra and Practical Action in the Gaibandha district of Bangladesh.

In the government agencies any integration on mainstream will be slower. For example, the Ministry of Energy is developing a number of Clean Development Management (CDM) projects in isolation from the Ministry of Environment and Forest which is the seat of the Designated National Authority (DNA) for authorization of the CDM projects. Though common NGOs are assisting both the ministries on some of the above initiative, inter-ministerial integration is yet to materialize.

2.6.2 Development Supportive Climate Action

The National Adaptation Plan of Action (NAPA) is a more integrated efforts between Government agencies, research NGO and the private sector community. In general, for the private sector climate change is very new and yet to penetrate into their thinking for serious considerations.

In the final analysis it is only those climate change efforts that are directly complementing to general development priorities and actions will be acceptable to the communities and agencies. Hence mainstreaming climate change initiative into development will be the most useful and cost effective way of addressing climate change.

2.7 Enhancing Adaptive Capacity

2.7.1 The Relation

The simplified relationship between the overall impacts of an event to the event and the impacted system can be represented as follows

Disaster Management
Impact-Adaptation Relationship

$$\text{Impact of Event} = \sum\int \text{Intensity of Event} \times \int \text{Baseline Conditions} \times \int \text{Adaptive Capacity}$$

The impact of an event is a function of the (a) Intensity of the event (b) the Baseline conditions and (c) the Adaptive capacity of the system.

In the case of climate change the intensity of the event is beyond the control of Bangladesh Government or people. The Bangladesh's contribution to GHG is minuscule and per capita contribution is one of the lowest is the world. Its capacity to affect the contribution of other countries' GHG is also rather limited.

Hence the intensity of the event is virtually independent of a country such as Bangladesh, it being the victim of severe impacts. The baseline represents the socio-economic infrastructural, situation and entitlements. In Bangladesh it represents lack of developments dominating poverty, low level of institutional capacity and local government and poor infrastructure.

The catastrophic cyclone of 1991 which killed around 134,000 people of the Bangladesh coastal area, most of the poor died because of lack of infrastructure, good housing and absence institutional and local level organizations. A similar cyclone that hit the Florida coast of the USA, only 29 people died but in the subsequent period the insurance industry was almost devastated as the human system was well protected, so the economic systems paid the price.

In the subsequent decades the Bangladesh government and NGOs organized themselves and the local communities under a comprehensive disaster management plan and actions reducing the human loss by one to two orders of magnitude.

Dr. Mohammed Yunus, the Grameen Bank Managing Director in his commentary on the BCAS Book "Cyclone 91" (Dhaka 1991) wrote "Cyclone is not the only disaster, poverty is the main disaster".

2.7.2 Investing in Adaptive Capacity – The Priority

Thus the baseline condition is difficult to shift rapidly and is ingrained in the overall pace of development. Given the low development base, the most cost effective investment is to focus and build and enhance the adaptive capacity. This would involve focused and directed activities to reduce the impacts by mobilizing the community and enhance specific adaptation actions. Thus community based adaptation offers one of the earliest possible and most cost effective actions to address climate change impacts. But actions which helps food security, water security, energy scarcity, public health and institutional and community capacity building have the greatest potential of success.

3 Nature of Climatic Variability and Risk

The pattern and behavior of climate, including variability and extreme events, play a significant role in freshwater availability; agriculture and its productivity; function of natural ecosystems and biodiversity; human health; and livelihoods of the people those depend on natural resource base in Bangladesh. These characteristics of climate either create favorable condition for a system to function better or put risk on a system and increase vulnerability. Therefore, economic growth and performance of a nation and society relay heavily on the behavior of climate.

The climate of Bangladesh is influenced by monsoon climate and characterized by high temperature, heavy rainfall, often-excessive humidity and marked seasonal variations. Although more than half the area is north of the Tropics, the effect of the Himalayan mountain chain is such as to make the climate more or less tropical throughout the year. The climate is controlled primarily by summer and winter winds, and partly by pre-monsoon (March to May) and post-monsoon (late October to November) circulation. The Southwest Monsoon originates over the Indian Ocean, and carries warm, moist and unstable air. The easterly Trade Winds are also warm, but relatively drier. The Northeast Monsoon comes from the Siberian Desert, retaining most of its pristine cold, and blows over the country, usually in gusts, during dry winter months.

Climatic Variability: *Variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may result from natural internal processes within the climate system (internal variability) or to variations in natural or anthropogenic external forcing (external variability) (Burton and Huq et al., 2004)*

Risk: *The result of the interaction of physically defined hazards with the properties of the exposed system i.e. their sensitivity or vulnerability. Risk can also be considered as the combination of an event, its likelihood, and its consequences i.e. risk equals the probability of climate hazard multiplied by a given system's vulnerability (Burton and Huq et al., 2004).*

Vulnerability: *The degree to which a system is susceptible to or unable to cope with adverse effects of hazard. In other word, vulnerability is a function of the character, magnitude, and rate of event to which a system is exposed to, its sensitivity, and its adaptive capacity. According to IPCC sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. Climate-related stimuli encompass all the elements of climate change, including mean climate characteristics, climate variability, and the frequency and magnitude of extremes. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise).*

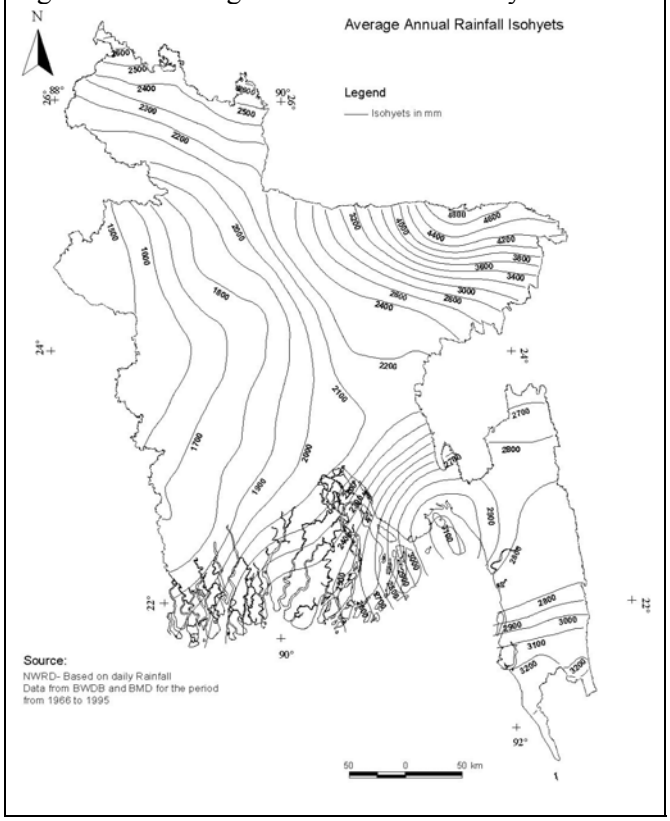
3.1 General Characteristics of Climate

The country has an almost uniformly humid, warm, tropical climate. There are four prominent seasons, namely winter (December to February), Pre-monsoon (March to May), Monsoon (June to early-October), Post-monsoon (late-October to November). The mean annual rainfall varies widely within the country according to geographical location, ranging from 1,200 mm to 5,800 mm.

- Winter is relatively cool and dry, with the average temperature ranging from a minimum of 7.2 to 12.8°C to a maximum of 23.9 to 28.9°C. The minimum temperature occasionally falls below 5°C in the north though frost is extremely rare. There is a south to north thermal gradient in winter mean temperature: generally the southern districts are 5°C warmer than the northern districts. The western depression of winter rains, mainly from 20th January to 25th February, when it rains from 10mm to 40mm.

- Pre-monsoon is hot with an average maximum of 36.7°C, very high rate of evaporation and erratic but occasional heavy rainfall from March to June. In some places the temperature occasionally rises up to 40.6°C or more. The peak of the maximum temperatures is observed in April, the beginning of pre-monsoon season. In the pre-monsoon season the mean temperature gradient is oriented in southwest to northeast direction with the warmer zone in the southwest and the cooler zone in the northeast. The *pre-monsoon thunderstorms,* known as the Nor'westers (North-westerlies), begin about the 10th of March.

Figure 3.1 Average Annual Rainfall Isohyets



- Monsoon is both hot and humid, brings heavy torrential rainfall throughout the season. About four-fifths of the mean annual rainfall occurring during monsoon. The total rainfall in these months varies in different parts of the country. The mean monsoon temperatures are higher in the western districts compared to that for the eastern districts. Warm conditions generally prevail throughout the season, although cooler days are also observed during and following heavy downpours. Monsoon rains start from the end of May and continue till mid October.

- Post-monsoon is a short-living season characterized by withdrawal of rainfall and gradual lowering of night-time minimum temperature.

3.2 Observed Changes in Climate and Extreme Events

3.2.1 Temperature

The observed climatic data from 1971 to 2002 indicates that the temperature is generally increasing in the monsoon season (June, July and August). The average monsoon maximum and minimum temperatures show an increasing trend annually at 0.05°C and 0.03°C, respectively. Average winter season (December, January and February) maximum and minimum temperature show respectively a decreasing and an increasing trend annually at 0.001°C and 0.016°C (Rahman Alam: 2003). It is also revealed that 1998 was the warmest year in the last 30 years.

SAARC Meteorological Research Centre (SMRC) has studied surface climatological data on monthly and annual mean maximum and minimum temperature, and monthly and annual rainfall for the period of 1961-90. The study showed an increasing trend of mean maximum and minimum temperature in some seasons and decreasing trend in some others. Overall the trend of the annual mean maximum temperature has shown a significant increase over the period of 1961-90. Regional variations have been observed around the average trend (SMRC, 2003).

Bogra and Rangpur are two among other meteorological stations in the northwest region of Bangladesh. Observed data of the Bogra Station from 1971 to 2002 indicates that overall annual maximum and minimum temperature is generally increasing annually at the rate of 0.008°C and 0.003°C, respectively. However, rate of change in the monsoon season is higher than annual rate of change. In monsoon season (June, July and August), average maximum and minimum temperature shows an increasing trend annually at the rate of 0.033°C and 0.014°C, respectively which means monsoon season is becoming warmer. On the other hand average maximum temperature in winter season (December, January and February) shows almost no change while minimum temperature shows an increasing trend annually at the rate of 0.035°C which means winter is also becoming warmer.

Observed data of the Rangpur Station from 1978 to 2002 indicates that overall annual maximum and minimum temperature is generally increasing annually at the rate of 0.035°C and 0.027°C, respectively. However, rate of change of maximum temperature in the monsoon season is slightly lower than annual rate of change. In monsoon season (June, July and August), average maximum temperature shows an increasing trend annually at the rate of 0.02°C while changes in minimum temperature in the monsoon season is insignificant. On the other hand average maximum temperature in winter season (December, January and February) shows an increasing trend annually at the rate of 0.041°C while minimum temperature shows an increasing trend annually at the rate of 0.026°C which mean winter is also becoming warmer.

3.2.2 Rainfall

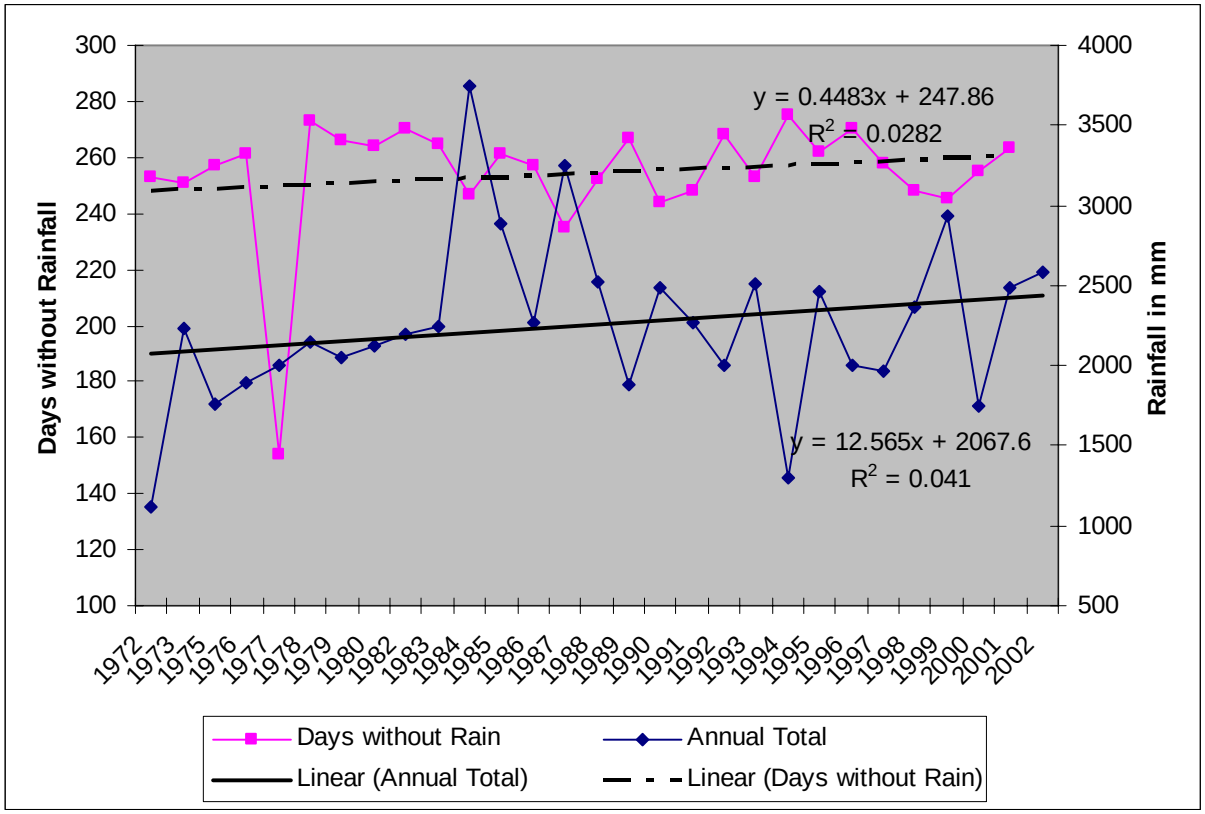
The mean annual rainfall of the country is about 2300mm, but there exists a wide spatial and temporal distribution. Annual rainfall ranges from 1200mm in the extreme west to over 5000mm in the east and north-east (MPO, 1991). It is 1220 mm in the northwestern part, 1490mm in the central part, 3380mm in the coastal areas, and over 5000mm in the northeastern part - across the borders from Cherapunji and Mawsyriem, two of the rainiest places in the world (Rashid, 1991). Possible connections with El Nino have only now begun to attract attention as a major possible influence on climatic patterns in the Sub-continent.

It was observed that the last monsoon (2006) there was lower rainfall resulted in reduction of *Aman* crop production of about 25-30% (Karim, 2006). The most remarkable change of rainfall is the change in duration of rainy season. Bangladesh NAPA states that the duration of rainy season has been decreased but the total annual rainfall remains more or less same. It means that heavy rainfall is occurred within short period. This behavior of rainfall mostly affects agriculture sector and other livelihood systems.

It is found from rainfall data in Bogra that the annual average rainfall is 1834 mm of which 1024 mm rain occurs during the month of June, July and August. On the other hand annual average rainfall for Rangpur is 2270 mm of which 1294 mm occurs during the month of June, July and August.

It is found from the analysis that number of days without rainfall in Bogra station is showing an increasing trend while total annual rainfall is showing decreasing trend. It is also to be noted that the change is not significant and relationship is not very strong. It is found from the analysis that both number of days without rainfall and annual total rainfall in Rangpur is increasing, which means more rain is occurring in short duration. It also reflects erratic behavior of rainfall. It is also to be noted that the change is not significant and relationship is not very strong. Figure 3.2 shows changes in annual rainfall and days without rainfall with their trend in Rangpur Station.

Figure 3.2. Change in Trend of Annual Rainfall and Days-without Rain (Rangpur Station)



3.2.3 Extreme Events

The geographical setting of Bangladesh makes the country vulnerable to natural disasters. Every year one or more natural calamities upset people's lives in some parts of the country. The major natural hazards include flood, cyclone and storm surge, flash flood, drought, tornado, earthquake, riverbank erosion and landslide. Floods and cyclonic storm surges are major killers as well as cause of most direct and indirect impediment to economic development. Agriculture probably suffered more than non-agricultural sectors.

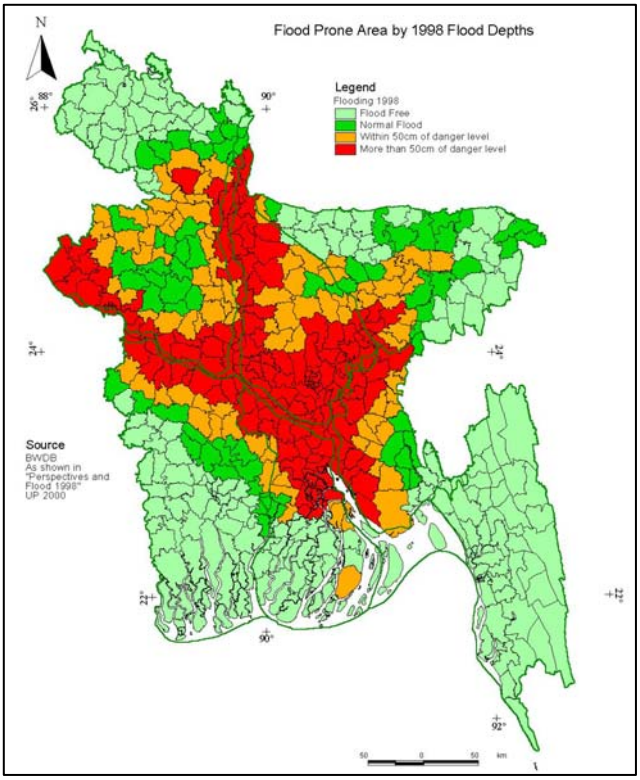
Floods

Flood in Bangladesh is a normal phenomenon. Floods affect about 80% of land in Bangladesh. In a normal year, 20-25% of the country is inundated which term as normal flood by river spills and drainage congestions. Coverage of inundated area varies overtime and by its return period. Approximately 37%, 43%, 52% and 60% of the country is inundated with floods water of return periods of 10, 20, 50 and 100 years, respectively (MPO, 1986). Four types of flooding occur in Bangladesh.

- Flash floods caused by overflowing of hilly rivers in eastern and northern Bangladesh (in April-May and in September-November).
- Rain floods caused by drainage congestion and heavy rains.
- Monsoon floods in the flood plains of major rivers (during June-September).
- Coastal floods due to storm surges.

Devastating floods of 1987, 1988 and 1998 inundated more than 60% of the country. The 1998 flood alone caused 1,100 deaths, inundated nearly 100,000 sq-km, rendered 30 million people homeless, damaged 500,000 homes and caused heavy losses to infrastructure. In 2004, floods inundated 38% of the country. Figure 3.3 shows flood prone area of Bangladesh and Table 3.1 indicates broad adverse impacts of major floods during the last 50 years.

Figure 3.3. Flood Prone Area of Bangladesh



But in last 10 years the country is experiencing early or late or prolonged floods. NAPA-Bangladesh has also identified the erratic behavior of major disasters including flood. About 1.32 m ha cropland is highly flood-prone[1]. Besides, crops, perennial trees and livestock are damaged by flood every year. In two severe flood years of 1974 and 1987 the shortfall in production from trend were about 0.8 and 1.0 Mmt of rice, respectively. During 1984, flood affected both Aus and Aman rice crop and the shortfall was about 0.4 Mmt. The following table shows major floods and its impacts:

Table 3.1. Broad Adverse Impacts of Major Floods during the last 50 years

Event	Impact
1954 floods	Affected 55% of country
1974 flood	Moderately severe, over 2,000 deaths, affected 58% of country, followed by famine with over 30,000 deaths
1984 flood	Inundated 52,520 sq-km, cost estimated at US$378 million
1987 floods	Inundated over 50,000 sq-km, estimated damage US$ 1.0 billion, 2055 deaths
1988 floods	Inundated 61% of country, estimated damage US$ 1.2 billion, more than 45 million homeless, between 2,000-6,500 deaths
1998 floods	1,100 deaths, inundated nearly 100,000 sq-km, rendered 30 million people homeless, damaged 500,000 homes, heavy loss to infrastructure, estimated damage US$ 2.8 billion
2004 floods	Inundation 38%, damage US$ 6.6 billion, deaths 700, affected people nearly 3.8 million

Source: MoEF, 2005

Drought

Drought is primarily an agricultural phenomenon that refers to conditions where plants are responsive to a certain level of moisture stress that affects both the vegetative growth and yield of crops. The

[1] Depth of seasonal and permanent flood water level is more than 180 centimeters, defined as F3 and F4 land.

farmers concern on drought is when crop production gets hampered due to lack of rain and soil moisture. The north-western part of the country is originally less vegetative and soil moisture is less. According to the local people of the drought-affected areas, intensity and longevity of drought is increasing over time. The western part of the country receives less rainfall averaging some 1400mm as against the national average of about 2150 mm. As a consequence, susceptibility and severity of drought in the western districts are much higher than elsewhere. Based on the characteristics of moisture retention capacity, infiltration etc., high prevalence of drought is observed in the western districts of Rajshahi, Chapai Nawabgonj, Bogra, Pabna, Dinajpur, Rangpur and Kustia. Drought of different intensities in Kharif, Rabi and Pre-kharif seasons cause damage to 2.32 m ha of T. Aman and 1.20 m ha of Rabi crops annually. Yield reductions due to drought vary from 45-60% in T. aman and 50-70% in Rabi crops in very severe drought situation. In the severe drought year of 1979 the shortfall was about 0.7 million tons. During 1981 and 1982, drought affected the production of monsoon crop (Aman) and the shortfalls from the trend were 0.5 and 0.3 Mmt, respectively. Drought affected the northwest part of the country last year (2006) and crop production was reduced by 25-30%. The table 3.2 presents drought prone areas by cropping seasons.

Table 3.2. Showing drought prone area by cropping seasons

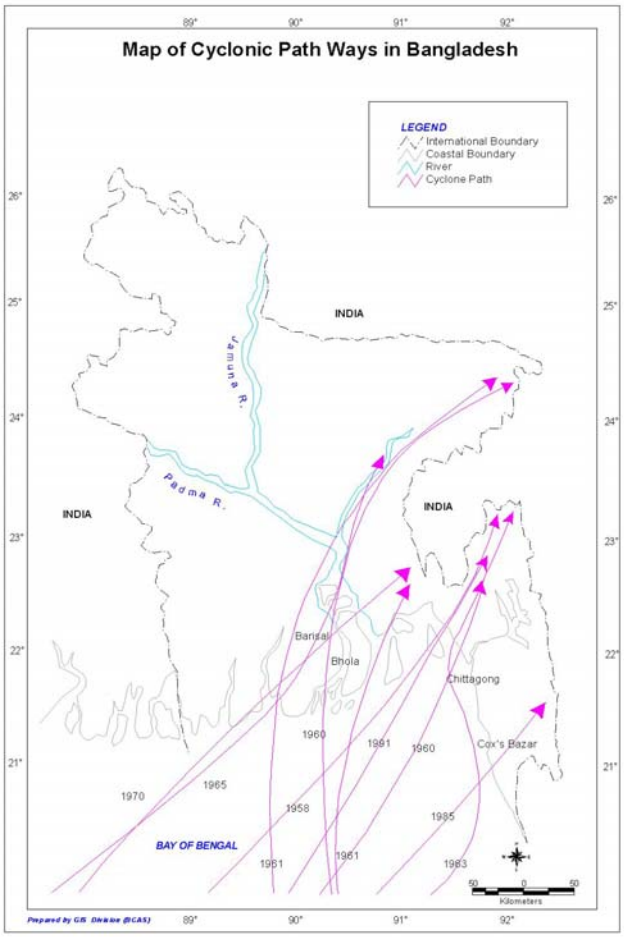
Crop season	Area under various drought severity class[2] (in million ha)					
	Very severe	Severe	Moderate	Slight	Unaffected	Non-T. Aman
Pre-Kharif	0.403	1.15	4.76	4.09	2.09	-
Kharif (T. Aman only)	0.344	0.74	3.17	2.90	0.68	4.71
Rabi	0.446	1.71	2.95	4.21	3.71	-

Source: Iqbal and Ali, 2001

Cyclone

Bay of Bengal is an ideal breeding ground for tropical cyclones and depressions. Funnel shaped configuration of the coastline of Bangladesh produces the catastrophic ravages of cyclones and storm surges. During pre-monsoon and post-monsoon periods, disastrous tropical cyclones form in the Bay of Bengal. An average of 1.5 severe cyclonic storms hit the country each year and associated storm surges as much as six meters higher than normal, can reach as far as two hundred km inland along the water ways (Murty et al., 1986). In Bangladesh alone, about 40% of the total number of global storm surges are recorded (Murty, 1984). Figure 3.4. shows some common cyclone paths in the Bangladesh coast.

Figure 3.4. Some Common Cyclone Paths in the Bangladesh Coast



[2] Classified based on precipitation, evapotranspiration, and soil moisture (BARC, 1990)

Over last 30 years different scales of cyclones have been affecting the country with loss of valuable lives and property (Table-3.3). It was estimated in 1996 that about five million people currently live in 'High Risk Areas'[3] (HRAs) along the western, central and south-eastern coasts of Bangladesh. Of these, 4 million live in 'Very High Risk Areas'. However, only 10 % of the actual population in the HRAs could be accommodated in existing safe havens (excluding Sub-district headquarters buildings and cyclone shelters built outside these HRAs). Approximately 9 million more shelter places were needed in the three cyclone-prone zones by the year 2001 and 12.5 million by 2021 as a result (EU: 1998). The attached figure shows the areas affected by the 1970, 1985 and 1990 cyclones plus the designated High Risk Areas. Table 3.3 shows that cyclones usually struck this country in the months of April, May and October, November and December.

Table 3.3. Cyclone affecting Bangladesh since 1960

Date	Year	Max. wind speed in Kms/hr	Storm surges height (in ft)	Deaths
09 Oct	1960	162	10	3,000
30 Oct	1960	210	15-20	5,149
09 May	1961	146	8-10	11,466
30 May	1961	146	20-29	-
28 May	1963	203	14-17	11,520
11 April	1964	-	-	196
11 May	1965	162	12	19,279
31 May	1965	-	20-25	-
14 Dec	1965	210	15-20	873
01 Oct	1966	146	15-30	850
11 Oct	1967	-	6-28	-
24 Oct	1967	-	5-25	-
10 May	1968	-	9-15	-
17 April	1969	-	-	75
10 Oct	1969	-	8-24	-
07 May	1970	-	10-16	-
23 Oct	1970	-	-	300
12 Nov	1970	223	20-30	5,00,000
08 May	1971	-	8-14	-
30 Sep	1971	-	8-14	-
06 Nov	1971	-	8-18	-
18 Nov	1973	-	8-13	-
09 Dec	1973	122	5-15	183
15 Aug	1974	97	5-22	-
28 Nov	1974	162	7-16	A few
21 Oct	1976	105	8-18	-
13 May	1977	122	-	-
10 Dec	1981	97	6	02
15 Oct	1983	97	-	-
09 Nov	1983	122	-	-
03 June	1984	89	-	-
25 May	1985	154	10-15	11,069
29 Nov	1988	162	5-10	2,000
29 April	1991	225	20-25	1,38,000
02 June	1991	100	6	-

[3] Areas exposed to Bay of Bengal and cyclone and storm surges first hits these areas.

02 May	1994	200	-	170
25 Nov	1995	100	-	6
19 May	1997	225	15	126
26 May	1997	150	10	70

Source: Cyclone Shelter Preparatory Study, 1996

In the 1991 'super cyclone' (which was a storm of exceptional intensity with wind velocities up to 225 km/hr) a large number of deaths occurred mainly in three coastal districts in the Eastern Zone: Chitagong (79,697 dead and 2600 injured) Cox's Bazar (51.147 dead and 133,000 injured) and Noakhali (8,878 dead and 995 injured). Half a million cases of diarrhoeal (MoHFW: 1992) disease were also reported from the affected areas. In sum, the cyclone wreaked enormous social and economic havoc on these exceptionally vulnerable communities from which they have not yet recovered. The economic losses alone from the cyclone are estimated at US$ 2.4 billion. The loss of life was, however, substantially less than the 1.2 million people killed by the 1970 cyclone. The loss of human life further declined due to large investment and awareness raising activities after 1991 cyclone. About 36 thousand volunteers of red-cross and red-crescent along with government and non-government organizations are being provided support for cyclone preparedness, recovery and rehabilitation which brought significant positive result to save human life.

3.2.4 Sea Level Rise

The SAARC Meteorological Research Council (SMRC) carried out a study on recent relative sea level rise in the Bangladesh coast. The study has used 22 years historical tidal data of the three coastal stations. The study revealed that the rate of sea level rise during the last 22 years is many fold higher than the mean rate of global sea level rise over 100 years, which shown the important effect of the regional tectonic subsidence. Variation among the stations was also found. Table 3.4 represents the trend of tidal level in three costal stations.

Table 3.4. Trend of tidal in three coastal stations

Tidal Station	Region	Latitude (N)	Longitude (E)	Datum (m)	Trend (mm/year)
Hiron Point	Western	$21^{O}48'$	$89^{O}28'$	3.784	4.0
Char Changa	Central	$22^{O}08'$	$91^{O}06'$	4.996	6.0
Cox's Bazar	Eastern	$21^{O}26'$	$91^{O}59'$	4.836	7.8

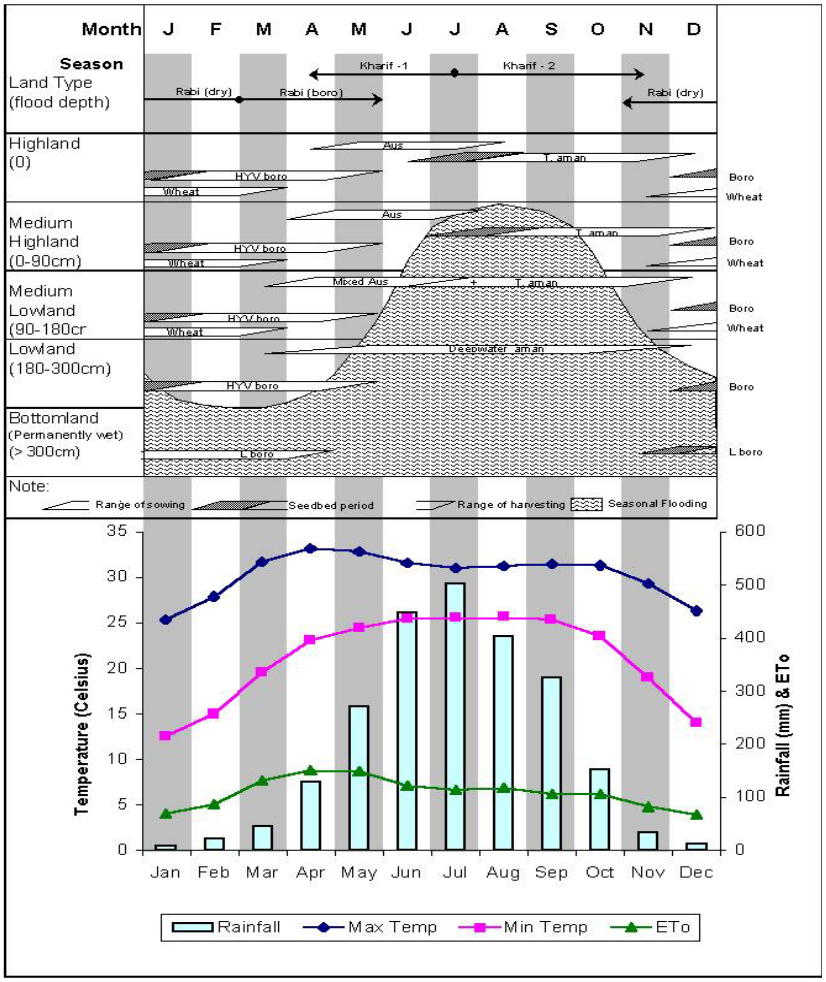
Source: SMRC, No. 3

3.3 People's Perceptions

Recent studies and the regional stakeholder consultation workshops carried out under Bangladesh NAPA revealed that the erratic nature of rainfall and temperature has indeed increased (MoEF, 2005). Adverse effects of erratic nature of rainfall and temperature on agricultural productivity and availability of freshwater is already quite evident in many areas of Bangladesh. Erratic behavior of weather includes fog in places where were never heard of during summer time, drought, salinity far from the sea, floods including flash flood and cyclone and storm surges as major problems they are facing in different parts of the country. Problems related to flood include water logging and drainage congestion, early and intimely floods, localized inundation and flash floods. Salinity intrusion due to reduction of fresh water flow from upstream, salinization of groundwater and fluctuation of soil salinity are major concern. Continuous and prolonged drought, extreme temperature and delayed rainfall are major problems that agriculture sector is facing. Storms, cyclones and tidal surges appear to have increased in the coastal areas. The local people did not necessarily relate any of these observed changes to future climate change. However they did notice trends and changes in patterns

that had already occurred or are occurring. Other local level studies also suggested that the heat wave and cold wave have become the regular phenomena in the last few years (BCAS and BELA, 2006).

Figure 3.5. Seasonal variation climatic parameters and relationship with production system



3.4 *Inter-relation of Climate Change, Variability and Extreme*

Relation among climatic system, natural resource based and production system is very close and complex. The complexity varies across spatial and temporal scale. The complex relationship of the climatic system, natural resource base and production system particularly agriculture is given in figure 3.5. Table 3.5 depicts scale of relationship between climate change and variability, and physical vulnerability context.

Table 3.5. Relationship of Climate Change and Variability with Physical Vulnerability Context

Climate Change					Climate Variability			
Increase average temperature	Increase average rainfall	Decrease average rainfall	Sea level rise	Erratic temperature (extreme heat or cold)	Erratic rainfall (excessive rainfall and lack of timely rainfall, untimely rainfall)	Erratic tidal Wave	Cyclone and storm surges	**Physical Vulnerability Context**
+	++		++		+	+	+	Inundation
+		++			+			Low Flow
			++			++	++	Salt Water Intrusion
	++				++			Flash Flood
++		+++		++	+			Drought
	+		++			++		River Morphology

Note: +++ refers to high, ++ refers to moderate, and + refers to low level of relationship

4 Future Climate Change and Impacts

4.1 Climate Change Scenario

Future changes of temperature and rainfall are estimated for Bangladesh using two general approaches i.e. (a) projection based on observed data, and (b) using available climate model. It is to be noted that projection based on observed data had no scope to incorporate future concentration of CO_2 in the atmosphere under different emission scenario. Vulnerability and adaptation assessment studies carried out on Bangladesh have used both older and newer versions of General Circulation Models. National Adaptation Programme of Action for Bangladesh has complied future impacts, vulnerability and adaptation based on existing model outputs. It considered future changes in the climate as given in Table 4.1.

Table 4.1. Climate Change Scenario Used in Bangladesh NAPA

Year	Temperature change (°C) Mean (standard deviation)			Precipitation change (%) Mean (standard deviation)			Sea Level Rise (cm)
	Annual	DJF	JJA	Annual	DJF	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

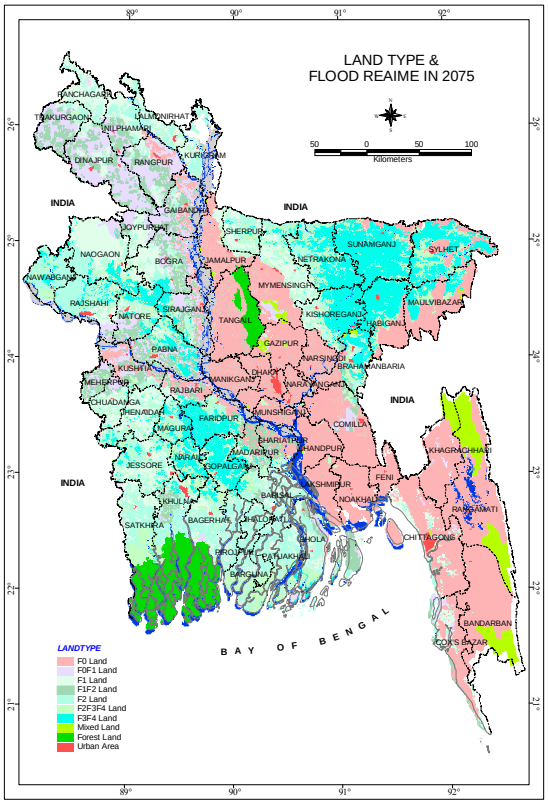
4.2 Water Resources

Changes in water resource due to climate change and sea level rise are likely to be some of the most critical issues for Bangladesh, especially in relation to coastal and riverine flooding, but also in relation to the enhanced possibility of winter (dry season) drought in certain areas. The effects of increased flooding resulting from climate change will be the greatest problem faced by Bangladesh as both coastal (from sea and river water), and inland flooding (river/rain water) are expected to increase. In addition, changes of the riverbed level due to sedimentation and changes in morphological processes due to seasonal variation of water level and flow are also critical for Bangladesh.

4.2.1 Sedimentation and River Bed Rise

The process of sedimentation may rise as water level gradients change due to higher downstream water levels at sea resulting in lower flow velocities. The morphologically highly dynamic rivers in Bangladesh are expected to adapt to such changes in water levels over a period of time for several decades. The changes in bed levels in turn will cause additional changes in river levels, which

Figure 4.1 Land Type and Flood Regime in 2059



effect will propagate the impact of sea level rise in upstream direction. The first assessments of this effect in the study for the Jamuna Bridge showed the importance of this feed back mechanism (Rendel et al., 1990).

Forecasts show that at the bifurcations of the Jamuna river with its distributaries Dhaleswari river and Old Brahmaputra river, the bed level will rise 0.08, 0.12 and 0.41 m at the mouth of the Dhaleswari river and 0.05, 0.08 and 0.27 m at the mouth of the Old Brahmaputra river for the years 2015, 2025 and 2095 respectively (BCAS/RA/Approtech, 1994). This will probably result in a considerable increase in the discharges in the distributaries and a small decrease of the discharges in the Jamuna and Padma rivers. The discharge distribution at the tributaries of the Ganges and the Padma rivers (Gorai and Arial Khan rivers) will change also due to the considered sedimentation. These changes might be of important consequences for the course of the main river channels in Bangladesh.

4.2.2 Change of Land Type and Flood Regime

Bangladesh Climate Change Country Study (1997) assessed vulnerability of water resources considering changes in flooding conditions due to a combination of increased discharge of river water during monsoon period and sea level rise for the two projection years, 2030 and 2075. Figure 5 depicts spatial distribution of land type[4] for 2075.

From the analysis it was found that much of the impact would be for F0 land followed by F1 land in the year 2075, where embankment played an important role in restricting the extent of flood affected areas. Again, it is the F0 land followed by F1 land in 2030 which would experience much of the changes in the north-central region in 2030. A combination of development and climate change scenarios revealed that the Lower Ganges and the Surma floodplain would become more vulnerable compared to the rest of the study area. On the other hand, the north-central region would become flood free due to embanking of the major rivers (Alam, et al., 1999). Table 4.2 and 4.3 show changes in land type in 2030 and 2075 due to climate change and sea level rise.

Table 4.2. Changes in Land Type in 2030

Land Type	Study Area	Transformed in 2030			
		F0	F1	F2	F3F4
F0 (0-30 cm)	43,060	**23,415**	16,033	3,442	170
F0 + F1[1]	1,184	592	592		
F1 (30-90 cm)	31,986	4,399	**9,519**	17,672	396
F1 + F2[2]	260		130	130	
F2 (90-180 cm)	15,572	2,440	162	**7,903**	5,067
F2 + F3 + F4[3]	362			127	235
F3F4 (> 180 cm)	14,076	2,080	9	155	**11,836**
Urban area[4]	757	757			
River bank/sand bar etc.	1,539				
Forest	5,546				
Mixed land	178				
No data	647				
Total	**115,167**	**33,683**	**26,445**	**29,429**	**17,700**

Source: Alam et al, 1999

[4] Classified based on season depth of inundation

Table 4.3. Changes in Land Type in 2075

Land Type	Study Area	Transformed in 2075			
		F0	F1	F2	F3F4
F0 (0-30 cm)	43,060	**19,588**	16,203	6,730	537
F0 + F1[1]	1,184	592	592		
F1 (30-90 cm)	31,986	7,884	**4,160**	17,589	2,354
F1 + F2[2]	260		130	130	
F2 (90-180 cm)	15,572	4,735	429	**3,552**	6,857
F2 + F3 + F4[3]	362			127	235
F3F4 (> 180 cm)	14,076	3,088	-	46	**10,946**
Urban area[4]	757	757			
River bank/sand bar etc.	1,539				
Forest	5,546				
Mixed land	178				
No data	647				
Total	**115,167**	**36,644**	**21,510**	**28,174**	**20,929**

Source: Alam et al, 1999

4.3 Future Drought Situation

Bangladesh Agricultural Research Council (BARC) has delineated different area of the country under several categories of drought for two periods: Kharif (roughly May - October) and Rabi/pre-Kharif (roughly December - March) (BARC, 1990).

During the Kharif season precipitation exceeds evapotranspiration. Droughts in this season refer mainly to shortage of rainfall in the late growing period of T. Aman rice, which causes serious yield reduction and shifts in harvesting time which affects the Rabi cultivation after T. Aman. During Rabi period, evaporation exceeds rainfall and soil moisture depends heavily on the remaining water after the Kharif season. Water stress is felt frequently after mid Rabi season. During the pre-Kharif period, drought conditions depend on the rainfall pattern, which tend to be erratic during this period.

Future drought conditions were studied under two different sets of scenarios. It is found that the intensity of droughts will increase in both the scenarios. About 12,220 km² will be transformed to very severe class against the existing 3,639 km² (more than 3 fold) under severe changes in climatic system during Rabi season. During Kharif four times more area will be changed to very severe class from the severe and moderate areas. The worst affected region would be north-west, north-central and south-west where both irrigated and rainfed crops would be affected. Spatial distribution of present and future drought prone area in Rabi & Pre-kharif, and Kharif seasons are given in Figure 4.2 and 4.3 respectively.

Figure 4.2. Spatial distribution of drought prone area in Rabi & Pre-Kharif season under different climate change scenarios

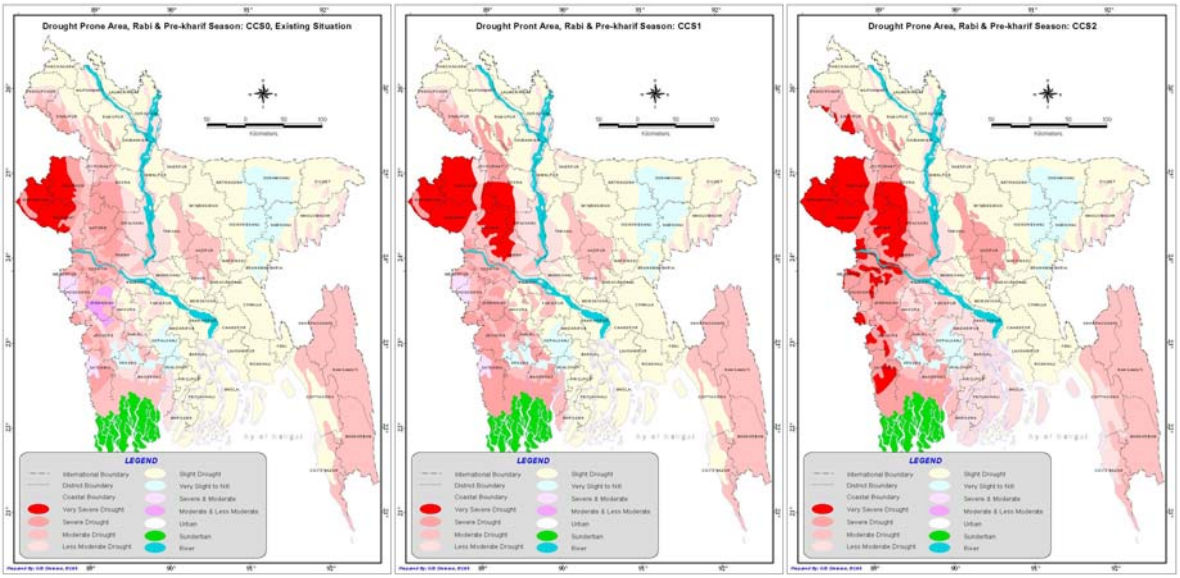
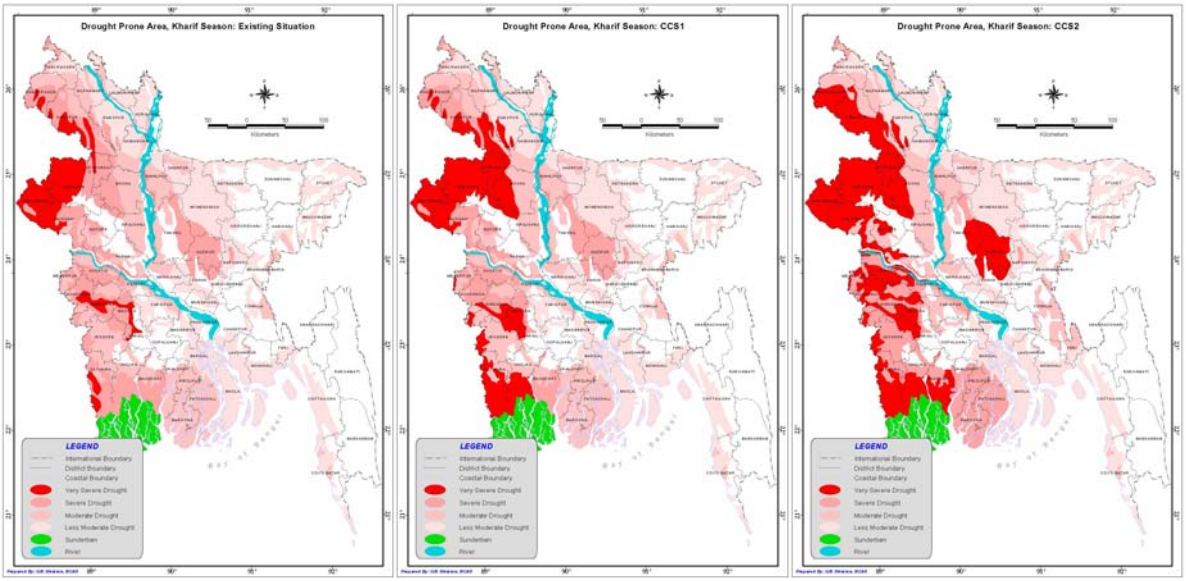


Figure 4.3. Spatial distribution of drought prone area in Kharif season under different climate change scenarios



4.4 Future Salinity Situation

Changes in surface water salinity due to 30 cm and 1 m rise of sea level were prepared by considering the topography and contours of the area and present stream flow patterns. A linear projection was used in which the stream flow pattern was kept similar to the present condition. Topographic and geomorphic information used for the present analysis were taken from the Topographic Maps prepared by Survey of Bangladesh, Bangladesh in Maps prepared by Dhaka University, Aerial Photos and Landsat Imagery.

Changes in the surface water salinity pattern due to 30 cm rise of sea level revealed that the present dry season saline front (2 dS/m) is expected to move 30 km to 50 km North, affecting most of Khulna, Jessore, Barisal, Patuakhali and Noakhali (greater) districts and parts of Faridpur and Comilla districts.

With 1 m rise of sea level, the saline water front will move far North on the Northeastern side of Bangladesh. Most of Jessore, Faridpur, Comilla and part of Dhaka (greater) districts will be affected by saline surface water intrusion. Most of Barisal, Patuakhali, Sundarbans, Bhola, Hatia and Sandwip will be directly inundated by saline / brackish water or will have serious saline waterlogging problem. Salt water intrusion along the Meghna river valley may reach up to Mymensingh and Sylhet districts. The surface water salinity of Karnaphuli and Matamuhuri network in greater Chittagong district may also be affected. Drinking water supply of major cities like Dhaka, Chittagong and Khulna will be affected by salinity. On the Western side of Bangladesh, the saline water front will move close to Kushtia and Pabna districts.

With one meter rise of sea level, it may be expected that cyclonic surges will penetrate further North into the country. This may have serious consequences for the low lying areas of Faridpur, Mymensingh and Sylhet districts, where large amounts of salt water may be dumped by cyclones and inland waterbodies (beels) may be affected by salinity. This will start to change the ecology of the area. Salinity may build up in groundwater aquifers and soils as well as in some of the beels and ponds.

4.5 Increased intensity of extreme events

The coastal area of Bangladesh and the Bay of Bengal are located at the tip of northern Indian Ocean, which has the shape of an inverted funnel. The area is frequently hit by severe cyclonic storms, generating long wave tidal surges which are aggravated because the Bay itself is quite shallow. Cyclones and storm urges are expected to become more intense with climate change. Though the country is relatively well equipped particularly in managing the aftermath of cyclones, the increased intensity of such disasters implies major constraints to the country's social and economic development. Unless proper adaptive measures are undertaken, private sector investment in the coastal zone is likely to be discouraged by the increased risks of cyclones and flooding.

4.6 Impacts and Vulnerabilities

The geographical location and socio-demographic features of Bangladesh make it one of the most vulnerable countries to climate change, variability and extreme events. Its long coast line, vast low-lying landmass, high population density and nature-dependant traditional agricultural practices would be impacted upon due to climate change. It is likely that vulnerability of the disadvantaged and poor community would be worse than the non-poor and better-off strata of the society. The issue of climate change in relation to vulnerability and adaptation for Bangladesh has been assessed through several studies.

4.6.1 Crop Agriculture and Food Security

Various studies indicate that a temperature rise of 1 to 2^0C in combination with lower solar radiation causes sterility in rice spikelets. High temperature was found to reduce yields of HYVs of *aus, aman* and *boro* rice in all study locations and in all seasons. The effect was particularly evident at a rise of temperature by 4^0C. Climate changes, especially in temperature, humidity and radiation, have great effects on the incidence of insect pests, diseases and microorganisms. A change of 1^0C changes the virulence of some races of rust infecting wheat.

The production of crop in Bangladesh is constrained by too much water during the wet season and too little during the dry season. Presently total irrigated area is 4.4 million ha which is more than 50 % of the potentially irrigable area of 7.12 million ha cultivated area. This area is being irrigated through surface and ground water resource. Irrigation coverage through Shallow tubewells (STWs) during the dry period has grown very fast following a policy of privatization and deregulation. As a result, the groundwater table in Bangladesh is declining at a rapid rate causing STWs to become non-operational in many parts of the country during dry period. Lack of surface water during the dry season limits the function of Low Lift Pumps.

The GFDL model predicted about 17 % decline in overall rice production and as high as 61 per cent decline in wheat production compared to the baseline situation of 1990 under 4 degree changes in temperature. The highest impact would be on wheat followed by rice (*aus* variety). This translates to a reduction of 4.5 million tons of rice at the present level (2002) of production. Of the three varieties of rice grown in Bangladesh, the *aus* rice (grown during the summer, monsoon period under rain-fed conditions) seems to be the most vulnerable. The other model, Canadian Climate Change Model (CCCM) predicted a significant fall in food-grain production. It should be noted, however, that this scenario was based on projecting existing cropping patterns into the future-which is not necessarily what will happen, as there are signs of significant changes in cropping patterns already occurring.

It was noticed that temperature increase of 4^oC would have severe impact on food-grain production, especially for wheat production. On the other hand, carbon-dioxide fertilization would facilitate food-grain production. A rise in temperature would cause significant decrease in production of 28 % and 68 % for rice and wheat respectively. Moreover, doubling of atmospheric concentration of CO_2 in combination with a similar rise in temperature would result into an overall 20 % rise in rice production and 31 % decline in wheat production. It was found that *boro* rice would enjoy good harvest under severe climate change scenario with doubling of atmospheric concentration of CO_2 (Karim et al., 1999).

The apparent increase in yield of boro (dry season rice crop generally grown under irrigated conditions and includes high yielding varieties) and other crops might be constrained by moisture stress. A 60 % moisture stress on top of other effects might cause as high as 32 % decline in boro yield, instead of having an overall 20 % net increase. It is feared that moisture stress would be more intense during the dry season, which might force the Bangladeshi farmers to reduce the area for boro cultivation. Shortfall in foodgrain production would severely threaten food security of the poverty-ridden country.

Under a severe (4^oC temperature rise) climate change scenario the potential shortfall in rice production could exceed 30 % from the trend, while that for wheat and potato could be as high as 50 % and 70 % respectively (Karim, 1996). Under a moderate climate change scenario the crop loss due to salinity intrusion could be about 0.2 Mt (Habibullah et al., 1998). The loss of production due to such effects may be relatively higher compared to that under floods. However, the loss incurred in other sectors could be much higher in case of floods than the direct climatic changes. The effect of

low-flow on agricultural vulnerability is considered to be much less intense compared to other effects. The ultimate impacts of loss of food grain production would increase import of food which will require spending hard currency.

4.6.2 Coastal Zone

Several studies indicate that the coastal zone vulnerability would be acute due to the combined effects of climate change, sea level rise, subsidence, and changes of upstream river discharge, cyclone and coastal embankments (BCAS/RA/Approtech, 1994, WB, 2000). Four key types of primary physical effects i.e. saline water intrusion; drainage congestion; extreme events; and changes in coastal morphology have been identified as key vulnerabilities in the coastal area of Bangladesh (WB, 2000).

- The effect of saline water intrusion in the estuaries and into the groundwater would be enhanced by low river flow, sea level rise and subsidence. Pressure of the growing population and rising demand due to economic development will further reduce relative availability of fresh water supply in future. The adverse effects of saline water intrusion will be significant on coastal agriculture and the availability of freshwater for public and industrial sectors will fall.

- The combined effect of higher sea water levels, subsidence, siltation of estuary branches, higher riverbed levels and reduced sedimentation in flood-protected areas will impede drainage and gradually increase water logging problems. This effect will be particularly strong in the coastal zone. The problem will be aggravated by the continuous development of infrastructure (e.g. roads) reducing further the limited natural drainage capacity in the delta. Increased periods of inundation may hamper agricultural productivity, and will also threaten human health by increasing the potential for water borne disease.

- Disturbance of coastal morphological processes would become a significant problem under warmer climate change regime. Bangladeshs' coastal morphological processes are extremely dynamic, partly because of the tidal and seasonal variations in river flows and run off. Climate change is expected to increase these variations, with two main (related) processes involved:

    - Increased bank erosion and bed level changes of coastal rivers and estuaries. There will be a substantial increase of morphological activity with increased river flow, implying that riverbank erosion might substantially increase in the future.

    - Disturbance of the balance between river sediment transport and deposition in rivers, flood plains and coastal areas. Disturbance of the sedimentation balance will result in higher bed levels of rivers and coastal areas, which in turn will lead to higher water levels.

4.6.3 Forestry and biodiversity

Bangladesh has a number of natural forest ecosystems including inland Sal forest (Shorea Robusta), dipterocarp forest, savanna, bamboo bushes in the hilly regions and freshwater swamp forests. It also has littoral mangrove ecosystems and swamp forests. In addition to the forests the country also has a very rich aquatic biodiversity (with over 400 species) and bird and plant life. The biodiversity (including both in the forested areas as well as elsewhere) is undergoing threats due to human interventions, fragmenting of habitats, etc. Climate change impacts will add an extra dimension to these ongoing stresses.

Bangladesh Climate Change Country Study has made an attempt to qualitatively analyze the impact of climate change on forest resources of Bangladesh. It was found that increased rainfall during the

monsoon would cause increased runoff in forest floor instead of infiltration into the soil. As a result there would be enhanced soil erosion from the forest floor. The erosion problem would be more pronounced in poorly dense hill forest areas. Prolonged floods would severely affect growth of many timber species, while it would cause high incidence of mortality for Artocarpus species. In contrast, enhanced evapotranspiration in winter would cause increased moisture stress, especially in the Barind and Madhupur Tract areas, affecting the Sal forest ecosystem. The tea plantations in the north-east would also suffer due to moisture stress. It was found that the Sundarbans mangrove forest would be the most severely affected by climate change. Due to a combination of high evapotranspiration and low-flow in winter, the salinity of the soil would increase. As a result the growth of freshwater loving species would be severely affected. Eventually the species offering dense canopy cover would be replaced by non-woody shrubs and bushes, while the overall forest productivity would decline significantly. The degradation of forest quality might cause a gradual depletion of rich diversity of the forest flora and fauna of the Sundarbans ecosystem (Ahmad et al., 1999).

4.6.4 Human health

High summer temperatures could result in enhanced deaths due to heat stress, but the extent of such impacts has not been quantitatively assessed yet. However, the combination of higher temperatures and potential increases in summer precipitation could create favorable conditions for greater intensity or spread of many infectious diseases. Still the perceived risk to human health is low relative to those in other sectors (such as water resources) mainly because of the higher uncertainty about many of the possible health outcomes. Increased risk to human health from increased flooding and cyclones seems most likely. Changes in infectious disease are less certain as the causes of outbreaks of infectious disease are quite complex and often do not have a simple relationship with increasing temperature or change in precipitation. It is not clear if the magnitude of the change in health risks resulting from climate change will be significant compared to current risks. It is also not clear if increased health risk will be apparent in the next few decades. However, in general climate change is expected to present increased risks to human health in Bangladesh, especially in light of the poor state of the country's public health infrastructure. Life expectancy is only 61 years, and 61% of children are malnourished (World Bank, 2002). Perhaps more illustrative of this point, though, is the low expenditure of US$12 per person per year that the Bangladeshi government makes on health, well below the US$21 spent in low income countries in general (World Bank, 2002). Another factor to consider is that access to adequate health care is already difficult for the poorest and most vulnerable-who are also likely to be the group most adversely impacted by any adversial change in human health.

4.6.5 Impacts on Livelihoods

Whatever happens to climate and subsequently to various other sectors, all these are important for the main reason that these affect the lives and livelihood of the people. The NAPA exercise tried to figure out these likely changes as a second round impacts of climate change. Climate change is expected to have major physical impacts on agriculture, industry, infrastructure, disaster, health and energy and consequently on people's livelihood in terms of employment, income and consumption (including food security). Various groups in society will experience the impacts in various degrees depending upon their initial economic conditions (poor or non-poor), location (coastal or non-coastal, rural or urban) and gender. Furthermore some of the impacts and consequent adaptation may be observed at the macroeconomic level such as trade to close the future food gap.

The impacts on livelihood due to climate change depend on the nature and severity of the physical impacts relating to agriculture, water availability and quality, disaster-proneness, hospitability of the physical environment due to rising temperature and changing water regimes to pathogenic activity and coastal inundation. Given these physical changes including sea level rise, the livelihood impacts may

be felt in several ways, not necessarily in any given sequence although the final outcome is always a diminution in employment or employability, income and consumption, although the impacts may be felt in different degrees by different socio-economic groups These mean a poorer Bangladesh compared to a situation without climate change and lower level of development. Climate change impacts on livelihood thus become a challenge of development under most adversarial changes in dynamics of nature.

On a more specific plane, in absence of climate change, the projected requirements for food grains by 2030 will be 42.5 mn mt. The best that Bangladesh can produce by 2030 is 37.8 mn mt requiring an annual import of 4.7 mn mt around that time. Of the total import, 0.8 mn mt or nearly 16% is expected to be the result of additional shortfall due to climate change.

Part of the vulnerability will be due to water shortages for agriculture. But there are other areas where water-related vulnerability may increase. Some of this would be related to health and disaster. On the other hand, extensive water-logging that is being experienced now may exacerbate, creating major problems of livelihood for a poor person all of whose land may be submerged permanently.

Both flooding and drought may increase in frequency. Particularly floods may be more devastating creating major problems of livelihood and macroeconomic dislocations, slowing growth and pushing people down to the poverty line. Also if cyclones and storm surges increase in frequency and intensity, the potential losses to life and livelihood would be most severe. The following table provides link and relationship of different types of disaster and livelihoods.

Type of Disasters	Livelihood Vulnerability
Flood	Reduce livelihood options due to loss of agriculture, illness, restriction of movement
Drought	Lack of job opportunity due to lack of agricultural activities, illness due to extreme heat etc.
Cyclone and storm surges	Limits fishing time in the Bay, loss of life, and illness

The health problems due to climatic factors such as temperature rise, increased SST, ENSO and degrading water quality as well shortage will increase likelihood of cholera, diarrhea, dysentery, malaria and typhoid and also involuntary fetus abortion in the coastal areas due to rising salinity leading to hypertension. Increased food insecurity will exacerbate the problems further by causing more widespread malnutrition. Unfortunately these are little calibrated or not enough to be superimposed on to socio-economic trends to refine the livelihood impacts. Yet, one can safely assume that the poor will suffer much more disproportionately than the non-poor and more so in the coastal and rural areas than elsewhere.

Taking a livelihoods analysis approach to potential impacts of climate change it is clear that the most vulnerable groups within each community are the poorest amongst them and even within the poor groups the most vulnerable are the women, children, elderly and the sick. It is therefore quite likely that the adverse impacts from climate change will fall disproportionately on these most vulnerable groups within the country as a whole as well as within each vulnerable region of the country.

Therefore any attempt to adapt to or cope with the adverse impacts of climate change will need to have special emphasis on protecting and helping these most vulnerable groups.

4.6.5.1 Vulnerability of Small Farmers in the coastal zone

Recent study on coastal area vulnerability and livelihood relationship revealed that physical or natural vulnerabilities are strong in regard to small farmer's livelihoods all over the coastal zone. Particularly cyclone/tidal bore, water logging/ drainage congestion, various types of flooding, sand deposition and soil salinity became the major physical hindrance to farming and production. These are also found as the major causes of sudden crop damage to small farmers. Seasonal attack by rats/ insects was another important vulnerability which led to massive crop damage in many districts.

Physical vulnerability varies across the coastal region. For example: Khulna region: water logging, soil salinity, lack of cultivable land and are significant; in Barisal region tidal flooding, cyclone/ tidal bore, salinity, siltation, rat/insect; in Noakhali region cyclone/ tidal bores, river erosion, and drainage congestion are found as the most adverse physical or natural vulnerabilities; and in Chittagong region cyclone/tidal bore, different types of flood, deterioration of soil fertility due to salinity are found major physical vulnerabilities.

4.6.5.2 Wage Labor in the coastal zone

Rural wage labourers are more vulnerable to economic and social factors. Lack of employment opportunities and low wage rate seem to be the major vulnerability factors among the rural wage labourers. Physical vulnerabilities such as lack of cultivable land, climate change stress etc that has an effect on agriculture ultimately converts into lack of employment opportunities for the wage labourers. The wage labourers depend on the proper functioning of the natural environment of which climate change and agriculture is a major part.

4.6.6 Summary of the Key Impacts

From the above findings, the impacts of climate change and variability on biophysical system and consequences on different sectors are evident. It is also found that coastal zone, north-western zone, central region and piedmont plain are most susceptible to existing climate variability and anticipated future climate change. A summary of causes of impacts, vulnerable areas and impacted sectors are given table 4.3. Intensity of impacts on different sectors due to changes of vulnerability context are given in table 4.4.

Table 4.3. Causes of Impacts, vulnerable areas and impacted sectors

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

Climate and Related Elements	Critical Vulnerable Areas	Most Impacted Sectors
		▪ Health ▪ Disaster ▪ Energy
Cyclone and Storm Surge[1]	▪ Coastal and Marine Zone	▪ Marine Fishing ▪ Infrastructure ▪ Human settlement ▪ Life and property
Drainage congestion	▪ Coastal Area ▪ Urban ▪ South West	▪ Water (Navigation) ▪ Agriculture (crop)

Source: NAPA Bangladesh, Draft Document

[1] *Frequency of formation cyclone in the Bay resulted frequent return of fisherman from the deep sea*

Table 4.4. Intensity of impacts on different sectors due to Climate Change

Physical Vulnerability Context								
Extreme Temperature	Sea Level Rise		Drought	Flood		Cyclone and Storm Surges	Erosion and Accretion	**Sectoral Vulnerability Context**
	Coastal Inundation	Salinity Intrusion		River Flood	Flash Flood			
+++	++	+++	+++	+	++	+++	-	Crop Agriculture
++	+	+	++	++	+	+	-	Fisheries
++	++	+++	-	-	+	+++	-	Livestock
+	++		-	++	+	+	+++	Infrastructure
++	+++	++	-	++	+	+	-	Industries
++	+++	+++	-	++	-	+	-	Biodiversity
+++	+	+++	-	++	-	++	-	Health
-	-	-	-	-	-	+++	+++	Human Settlement
++	+	-	-	+	-	+	-	Energy

Source: MoEF, 2005

5 National Responses and Adaptation

Article 4 under the frameworks convention on climate change has stated a number of commitments both for Annex-I and Non-annex I country parties. Article 6 under the Convention also allows parties to implement activities on education, awareness raising and training. The Kyoto Protocol created opportunity to participate in Clean Development Mechanism projects. Subsequent decisions under the Convention and Kyoto Protocol also brought Government of Bangladesh under several obligations in mandatory and voluntary nature. The key commitments and obligations under the Convention and Protocol are given below.

5.1 Submission of National Communication

The Government of Bangladesh has prepared and submitted the Initial National Communication (INC) in October 2002 to the United Nations Framework Convention on Climate (UNFCCC) to comply with the commitments. It has also carried out a number of studies on climate change and has been involved with a number of research organizations in carrying out climate change related studies. The National Communication includes national circumstances, a GHG inventory, and chapters on vulnerability and adaptation to climate change, mitigation and a climate change response strategy. The Second National Communication is under preparation process.

5.2 Submission of National Adaptation Programme of Action

National Adaptation Programme of Action (NAPA) for Bangladesh has been prepared by the Ministry of Environment and Forest (MOEF), as a response to the decision of the Seventh Session of the Conference of the Parties (CoP7) of the United Nations Framework Convention on Climate Change (UNFCCC). The preparation process has followed the generic guiding principles outlined in the annotated guideline prepared by LDC Expert Group (LEG). Involvement of different stakeholders was an integral part of the preparation process for assessing impacts, vulnerabilities, adaptation measures keeping urgency and immediacy principle of the NAPA. Policy makers of Government, local representatives of the Government (Union Parishad Chairman and Members), scientific community members of the various research institutes, researchers, academicians, teachers (ranging from primary to tertiary levels), lawyers, doctors, ethnic groups, media, NGO and CBO representatives and indigenous women contributed to the development of the NAPA for Bangladesh.

The six Sectoral Working Groups (SWG) are a) Agriculture, Fisheries and Livestock coordinated by Bangladesh Agricultural Research Council (BARC), b) Forestry, Biodiversity and Land-use coordinated by IUCN, Bangladesh, c) Water, Coastal Zone, Natural Disaster and Health coordinated by Water Resources Planning organization (WARPO), d) Livelihood, Gender, Local Governance and Food Security coordinated by Bangladesh Institute of Development Studies (BIDS), e) Industry and Infrastructure coordinated by Department of Environment (DoE), and f) Policies and Institutes coordinated by Bangladesh Centre for Advanced Studies (BCAS). It is anticipated that participation of key stakeholder in the preparation process will help in mainstreaming adaptation to climate change into national and sectoral development policies and plans as well as implementation of adaptation projects in future. Members of the project steering committee, sectoral working group and experts attended the inception workshop, regional stakeholder consultation workshops, and national stakeholder consultation workshop.

NAPA includes immediate and urgent needs for Bangladesh to address adaptation to climate change. It has identified 15 priority activities including general awareness raising, technical capacity building and implementation of projects in different vulnerable areas.

The total financial requirement estimated for implementing these projects is more than 70 million while the total available fund for all 48 Least Developed Countries (LDCs) is about 115 million. Therefore, a limited number of projects are expected to be implemented though these are identified as immediate and urgent need to address adaptation for Bangladesh. It was also expected that involvement of the key agencies from different sectors such as water and agriculture would help in taking own initiatives for mainstreaming adaptation to climate change into their sectoral programme and plans. However, it is far from expectation. This slow progress at sectoral level may be due to other priority within sector to address.

5.3 National Level Studies and Adaptation Options

Over the last decade a number of studies have been carried out on impacts, vulnerability and adaptation assessment for Bangladesh to climate change and sea level rise. Major climate change impacts and vulnerability assessment studies are (a) Assessment of Vulnerability Bangladesh to Climate Change and Sea Level Rise, 1994 carried out by Bangladesh Centre for Advanced Studies (BCAS) in association with Resource Analysis (RA), the Netherlands, and Approtech Ltd, Bangladesh; (b) Climate Change Country Study Bangladesh under U. S. Climate Change Study Programme, 1997 carried out by Bangladesh Centre for Advanced Studies (BCAS) in association with Bangladesh Institute for Development Studies (BIDS), Bangladesh Unnayan Parishad (BUP) and Bangladesh University of Engineering and Technology (BUET) for the Government of Bangladesh; (c) Climate Change and Adaptation Study for Achieving Sustainable Development in Bangladesh, 2000, by the World Bank; (d) Country Study on Bangladesh under Regional Study of Global Environmental Issues Project of Asian Development Bank (ADB, 1994) by Bangladesh Institute of Development Studies (BIDS); and (e) Synthesis Report on Dialogue on Water and Climate Change, 2004 by IUCN Bangladesh in association with other research organizations.

Most of the studies have assessed impacts of, and vulnerability and adaptation to climate change and sea level rise by sectors and geographic areas such as water, coastal zone, agriculture, infrastructure, forestry and health. It has been observed that the vulnerability of the country to climate change is the result of a complex interrelationship among biophysical, social, economic and technological characteristics of the country. It is revealed that many anticipated adverse impacts of climate change including sea level rise, higher temperatures, enhanced monsoon precipitation and run-off, potentially reduced dry season precipitation, and an increase in cyclone intensity would in fact aggravate many of the existing stresses that already pose a serious impediment to the process economic development of Bangladesh. The climate change policy, particularly adaptation thus becomes a part and parcel of the development policies of the country.

The adverse effects of climate change including variability and the extreme events on the overall development of Bangladesh are significant and in many cases related to possible changes to be experienced in the water sector. Most damaging effects of climate change are floods, salinity intrusion, and droughts that are found to drastically affect crop productivity almost every year. Climate change induced challenges are: (a) scarcity of fresh water due to less rain and higher evapo-transpiration in the dry season (b) drainage congestion due to higher water levels in the confluence with the rise of sea level, (c) river bank erosion, (d) frequent floods and prolonged and widespread drought, (e) wider salinity in the surface, ground and soil in the coastal zone (WB, 2000).

Low level of economic development and corresponding low investment capacity, inadequate infrastructure, low level of social development, lack of institutional capacity, and a high dependency on the natural resource base make the country highly vulnerable to climate change (including both variability as well as extreme events). It was found that the population living in the coastal area are more vulnerable than the population in other areas (Alam and Laurel, 2005). The agricultural sector

will face significant yield reduction. Thus food-grain self sufficiency will be at risk in future (BCAS/RA/Approtec, 1994, and Alam, 2004).

The ultimate key impacts of climate change and variability will be on livelihoods of the people depending on natural resource base and services of other sectors including infrastructure and industries. For example, the changes in agriculture may lead to a fall in domestic production of food, fodder and fiber. What all of these mean is falling output, employment and incomes of the people may fall lowering their consumption that will lead to a rise in malnutrition and income poverty.

Several studies have identified adaptation measures to reduce adverse impacts of climate stimuli including variability and extreme events (World Bank, 2000, (BCAS/RA/Approtech, 1994, Agrawal *et al.*, 2003). Key adaptation measures identified for the above key three sectors have been grouped under three broad categories of adaptation measures.

5.3.1 Physical Measures

The physical adaptation measures include engineering projects to reduce vulnerability, particularly to reduce flood impacts and to improve drainage conditions for addressing adverse impacts related to floods, salinity and drought. These are typically more expensive measures that address a specific problem but they can also produce multiple uses and benefits. The World Bank study focused on the identified major physical impacts: freshwater flow, drainage congestion; salt water intrusion; morphologic dynamics; and natural disasters. The identified physical measures are as follows.

Flooding: Full flood protection and controlled flooding have been identified to address the flooding problem in Bangladesh. Full flood protection is widely practised in Bangladesh. Effectiveness and feasibility is high but sustainability is low because of operation and maintenance requirements and long term accumulating effects of flood storage reduction and prevention of sedimentation in the floodplain. Controlled flooding in combination with compartmentalization is one form of adaptation which has been practiced under the Flood Action Plan project. The advantage of this option is less exposure to erosion while the sedimentation in the floodplain enhanced. The major disadvantage is the limited land use allowed in the floodplain and the advanced arrangements needed for proper management.

Increasing surface water availability: Increasing surface water flow has been identified to address drought and salinity problems in the dry season. Augmentation of river water by increasing local storage capacity of surface or groundwater for irrigation and addressing salinity problem for Sundarbans is necessary. Desalinization plants and equipment for addressing the drinking water problem related to salinity has also been identified. The Gorai River Restoration Project is an example of increasing surface water flows through deviating water from the Ganges River towards the southwest. Effectiveness of such measures is high, but feasibility is low because of high costs. The possibilities for increased local storage of surface and groundwater in the area itself are low as well. Desalinization plants and equipment are too expensive as possible adaptation measure.

Reduce Drainage Congestion: Reduction of drainage congestion requires mainly two steps: (i) bringing water from the land into the main drainage system; and (ii) draining water to the sea. At present, step (i) is done under gravity, mostly through regulators which open during low water flow in the river and low tides in the coastal area. Increasing the drainage capacity of existing infrastructure seems a feasible and effective way to reduce drainage congestion where culverts, bridges, regulators etc hamper drainage. When higher water levels impede this process, pumping remains the ultimate solution. Step (ii) requires a well-maintained drainage network. Continuous dredging is an option, which can be reduced by the construction of regulators and/or tidal basins. Tidal basins stand out as a

preferred option from an environmental and maintenance perspective (since tidal basins would substantially reduce the maintenance dredging and bring sediments to the *beel* areas). The tidal basin experience in Khulna-Jessore Drainage Rehabilitation Project proves that this is a feasible approach.

Construction of new infrastructure: New infrastructure includes cyclone shelters and /or coastal embankments and landfills, modification of existing infrastructure. Construction of coastal embankments and landfills should focus on special areas such as urban centers and concentrations of industrial activities. Design of new high value infrastructure (roads, sluices and embankments) could be altered with consideration of climate change. New and existing mangrove belts (as mentioned earlier) appear to be effective in protecting against coastal storms, and in facilitating sedimentation (Haider, 1992). Such activities in Bangladesh needs to be streamlined by ensuring peoples' participation in maintaining and benefit sharing.

Mangrove and Cross Dams: Adaptation measures were identified to address morphological dynamics include mangrove greenbelts, cross dams and/or river training works. Mangrove greenbelts in the foreshore areas and along the coastal embankments, and cross dams at the same time enhance accretion. River training works, e.g., through bank protection or strong holds are confined to the estuarine river branches. All these measures are effective. The main challenges for cross dams and river training works are not feasible because it requires long-term maintenance. The high effectiveness and feasibility of mangrove greenbelts are well acknowledged.

5.3.2 Soft Measures

Effective Early Warning System: An early warning system for cyclonic disasters and floods in Bangladesh is a viable adaptation strategy for reducing damage. The present early warning system and responses for cyclone disasters is effective while the warning system and responses to floods needs improvement. Continuous monitoring of the formation of cyclones in the Bay of Bengal involving satellite-based technology; monitoring of the gradual development and track of imminent cyclone; issuance of cyclone warning well ahead of time for the people to take precautionary measures; evacuation from homesteads and relocation in multi-purpose cyclone shelters and concrete buildings ─ all may be considered as highly useful and proven adaptation strategies. Already such measures have allowed thousands of coastal people to successfully avoid loss of lives during two high intensity cyclonic events: one occurring in 1994 and the other in 1997.

Operation and Maintenance: Operation and maintenance of sluices and other regulators, groundwater management, land use practice, extension services, and water saving techniques are identified as win-win option to address present needs and leading to higher degree of future success. Improving maintenance and operation of sluices and other regulators to hold water in areas that are under increased stress or establishing effective groundwater management both score high on effectiveness but low on feasibility. Land use practice can be influenced by incentives to change agricultural practices so that agricultural demand for fresh water goes down.

The Bangladesh NAPA has identified immediate and urgent needs to deal with adverse impacts of climate change. It gave emphasis on coastal afforestation, development for agriculture, water resource management, increasing infrastructure resilience, community based adaptation and insurance options.

5.4 Mainstreaming and Capacity Building Initiatives in the Government

A number of climate change related projects are being implemented by both government and non-government organizations with financial support from bilateral and multilateral agencies. The noteworthy ongoing projects are a) Comprehensive Disaster Management Programme (CDMP), b)

Poverty and Climate Change c) Landuse Change, Food Security, Water and Biomass Energy in the context of Climate Change, etc. Very recently CARE Bangladesh in association with 17 partner organizations has completed Reducing Vulnerability to Climate Change (RVCC) - a community based adaptation project in Bangladesh.

Comprehensive Disaster Management Programme (CDMP) under the Ministry of Food and Disaster Management funded by DFID-Bangladesh is being implemented for disaster risk reduction in Bangladesh. Initially it started its activities in six administrative districts in Bangladesh. Assessment of knowledge of disaster management committees at different levels, community risk assessment and risk reduction action plan are key activities among others. CDMP is also supporting research through Climate Change Cell.

Ministry of Environment and Forest, Government of Bangladesh has established Climate Change Cell at the Department of Environment under the Comprehensive Disaster Management Programme (CDMP) with the objective of "Establishing an Integrated Approach to Climate Change Risk Management at National and Local Levels." The Climate Change Cell's work focuses on building the capacity to mainstream climate change issues in development activities in particular adaptation to climate change.

Climate change has bearing on the Millennium Development Goals, the objectives of the PRSP, as well as on the objectives of many development projects, for example the ICZMP. Adaptation to climate change is cutting across all sectors and needs to be embedded in the overall development process. Adaptation also needs to link to major development trends and areas.

5.5 Community Based Adaptation Activities

Reaching poor community by central government and sectoral agencies are always difficult in Bangladesh and non-government organization and international agencies are playing important role to improve livelihoods and addressing natural disasters (preparedness, recovery and rehabilitation). Livelihoods of a large number of people are dependent on quality of natural resource base and its performance. Climate change will bring addition stress to these available natural resource bases along with others. Therefore, building capacity of people living in vulnerable area is important and thus Community Based Adaptation become as one of the most effective way of reaching them and addressing their needs.

5.5.1 Reducing Vulnerability to Climate Change (RVCC)

Reducing Vulnerability to Climate Change (RVCC) was first project of its kind on Community Based Adaptation (CBA) to climate change implemented by CARE Bangladesh in the Southwestern part of Bangladesh in association with 17 partner organizations. The project was funded by Canadian International Development Agency (CIDA). The project use Participatory Vulnerability and Need Assessment to deal with climate related problems which will be aggravated in future due to climate change. The project gave emphasis on diversification livelihoods options of vulnerable communities, generated useful knowledge in how to communicate climate change (and adaptation) messages at the community level, and produced valuable knowledge and information about community-based adaptation to climate change.

The project has increased awareness among the coastal community and a number of organizations those involved are promoting and implementing similar activities with coastal community. One of the key learning of the project is that activities centered to livelihoods and disaster risk reduction help to

bring changes in their life and quality of living. Awareness raising to climate related problems is important to engage people in different activities.

5.5.2 Increase Resilience of Disaster Prone Communities in Gaibandha

Practical Action, former Intermediate Technology Development Group (ITDG) works in Gaibandha area where thousands of poor people live with the constant threat of homelessness, damage to, and loss of, their possessions and means of livelihoods, and risks of injury and death due to weather – related natural disasters – flooding, river bank erosion, storm, cyclone, drought, and cold wave. The project targeted to increase the resilience of 10,000 men, women, and children from vulnerable communities to cope with, and adapt to, the impacts of climate– induced hazards. The project also effectively brings, together issues of poverty reduction, environmental and natural resources management, disaster risk reduction and climate change.

The project has three main components:

- To strengthen the capacity of communities and government and non-government supporting institutions to prepare and respond effectively to future climate-induced emergencies

- To develop and promote practical (technology-based) interventions to strengthen people's livelihoods and natural resource assets

- To promote the engagement of vulnerable communities in decision making processes on climate-related adaptation strategies in order to influence policy change and increase self-sufficiency

5.5.3 Building Adaptation Strategy to Climate Change for Selected Drought and Flood Prone Areas of Bangladesh

Bangladesh Lawyers Association and Bangladesh Centre for Advanced Studies (BCAS) are jointly documenting different practices to deal with climate variability and extreme events in flood and drought prone areas with financial support from Oxfam NOVIB, the Netherlands. Documentation of existing coping strategies and practices in relation with natural disasters particularly flood in one of the flood prone area in the central zone of Bangladesh and drought in one of the drought prone area of northwest district is one of the key objectives. The exiting strategies and practices will be categorized based on their innovativeness, effectiveness and outcome including negative and positive in relation to environment, socio-economic development, livelihoods opportunities etc. The wider dissemination of good practices among non-government organizations in the South Asian region including NOVIB partners and members of the Climate Action Network – South Asia (CANSA) through a regional workshop.

5.5.4 Livelihood Adaptation to Climate Change (LACC) in Drought Prone Areas

The project LACC is jointly implemented by the Food and Agriculture Organization (FAO) and the Department of Agriculture Extension (DAE), under Climate Change Cell, Department of Environment. The project tried to address the needs of farmers and agricultural crops in drought prone and drought affected areas of Bangladesh with regard to risk management and adaptation in related livelihoods.

5.5.5 Adaptation Research of Climate Change Cell, Department of Environment

Climate Change Cell has undertaken the following research activities in different hot spots and relevant issues in Bangladesh with the support of some academic institutions, research organizations and NGOs;

1. Adaptive Crop Agriculture including innovative Farming Practices in the Haor Basin - Centre for Natural Resource Studies (CNRS)

2. Adaptive Crop Agriculture including innovative Farming Practices in the Coastal Zone of Bangladesh - Centre for Environment and Geographic Information Services (CEGIS)

3. Climate Change and Health Impacts - Bangladesh Centre for Advanced Studies (BCAS) and National Institute Preventive and Social Medicine.

4. Crop Insurance as a Risk Management Strategy in Bangladesh - North South University, Department of Environmental Science and Management.

5. Climate Change, Gender and vulnerable Groups in Bangladesh - BASTOB Initiative for People's Self-Development and Bangladesh Unnyan Parishad (BUP).

5.5.6 Sharing Community Based Adaptation to Climate Change

The first International Workshop on Community Based Adaptation to Climate Change was held successfully in Dhaka, Bangladesh in January 2005, jointly organized by the Bangladesh Centre for Advanced Studies (BCAS), the International Institute for Environment and Development (IIED), the RING and IUCN and co-sponsored by CIDA and DFID.

The Second International Workshop on Community-based Adaptation to Climate Change was held in Dhaka, Bangladesh, from 24-28 February 2007. This was organized jointly by the Bangladesh Center for Advanced Studies (BCAS), International Institute for Environment and Development (IIED) and RING Alliance with financial support for British High Commission, Dhaka, Commonwealth Foundation, DEFRA, DFID, UK, SIDA, Practical Action and SouthSouthNorth. The workshop consisted of two days of field trips to visit community-based adaptation initiatives followed by three days of discussions in Dhaka. The workshop aimed to share the latest developments in community-based adaptation programmes, priorities and solutions with a view to integrating the lessons into national and international development programmes. More than 110 policymakers and representatives from non-governmental organizations (NGOs), research and policy institutes, as well as development practitioners and media were in attendance.

6 Case Studies

6.1 Case Study on Improving Capacity of Vulnerable Households

"Improving Capacity of Vulnerable Households" project has implemented in flood, waterlogging and drought affected area in Gopalgonj district, a part of the Reducing Vulnerability to Climate Change (RVCC) project. Bangladesh Centre for Advanced Studies has implemented this project jointly with Care Bangladesh. Primary focus of the project was to reduce vulnerability by increasing household level income, food security and capacity building through diversification of livelihood options. The project was facilitated to identify real vulnerability, possible options and assist the beneficiary households to enhance their household level capacity to reduce vulnerability to climate change impacts.

6.1.1 Location

The Reducing Vulnerability to Climate Change project was implemented in six villages including Barompalta and Patkelbari in Muksudpur Upazila, Aruakandi and Kamarole villages in Kashiani Upazila and Baikunthapur and Tetulbari village in Kotalipara Upazila of Gopalgonj district (see location Map).

6.1.2 Ecosystem

All the villages are located in low lying areas within the Madhumoti River floodplain ecosystem. During the monsoon season (June to October) the area remains inundated with a gradient of water depth ranging from 0.0 to 300 cm. Towards early October, flood water starts receding and by December, the entire area becomes dry. There are several canals connecting the village with adjacent MBR canal, the river Kumar and floodplains. But many of the canals are silted up.

The livelihood conditions of communities settled in the project villages are overwhelmingly dependent on its natural resource base, which offer unique products due to the land-water interface characterizing freshwater alluvial floodplains. For over four months every year, almost 80 percent of the area remains inundated while in the dry season scarcity of surface water is on the rise. The variability in the seasonality and the duration of each season sets the climatic conditions for choosing livelihood strategies and options. The asset conditions of households are susceptible to such shocks, seasonalities and trends, making them vulnerable to climate impacts. Several studies reveal that vulnerability of the floodplain community, particularly the poor household, will be accentuated due to global climate change and variability.

The project study findings reveal that is 77% households on Patikelbari and Barampalta villages, 78% households of Kamarole and Aruakandi villages and 91% households of Baikanthapur and Tetulbari villages major sources of income are from agriculture or agriculture related activities. A large number of extremely poor inhabits this locality. They live mainly on subsistence agriculture, fishing, wage labour, petty businesses and by pulling rickshaws. Most of them are lower cast Hindus who have lesser voice in the society.

6.1.3 Extreme Events/Variability

The vulnerability contexts that are climate specific adversely affect the resource base, livelihood activities and livelihood security of poor and vulnerable people. Flood damage crops and disrupt economic activities, whereby people, particularly the poor and vulnerable, are unable to engage in income generating activities. Lost assets reduce the ability of the poor to cope with host of climate stresses. Vulnerability of the poor also adversely affects their health, livelihoods and undermines growth opportunities crucial for poverty reduction. Also, climate change will aggravate water stress, reduce food and income security, increase impacts from extreme weather events and displace millions.

In recent decades the community have observed shorter duration of the monsoon season from six months to four months and longer duration for the dry season than that in the past which signifies weather change in the country. Besides, the duration of the seasons, occurrences of rain in the dry season is also largely reduced. Further more, it is also evident that heavy rain occurs in a shorter duration in the monsoon season that causes rising of river water flow and results in high floods and water logging in the country. The local community also observed that the frequency of high flood has increased in the last two decades.

BCAS study findings reveal that the people of the project area have faced huge problem due to by severe floods of 1988, 1998 and the flood of 2004. Flood is creating uncountable problem in the socioeconomic lives of the people. Their livelihoods are generally dependent on normal flood that occurs by the inflow of water coming from neighboring countries (e.g., the Himalayan region) and by the local monsoon rains.

People are worried about such climate variability and high flood frequency because of disruption in livelihood, movement and communication. They face problem due to lack of food, scarcity of drinking water, problems in health & sanitation and rearing of domestic animals. People lose their crops, houses, household properties and assets.

6.1.4 Climate Change and Environment Related Problems

The area is prone to extended flooding and water logging due to both high tide of and monsoon river water the Ganges and the Jamuna. Various climate change studies have revealed that the South Central region will be more prone to enhanced flooding and water logging due to adverse effect of climate change such as heavy rainfall. Erratic behaviour of rainfall and temperature (irregular rainfall or heavy rain in short duration) are hampering crop production and livelihood activities in the area. Many villagers are already facing water logging and floodwater inundation, which affect their livelihoods, crop cultivation, employment opportunities, income, food, malnutrition and health related problems. Erratic behaviour of weather and extreme climatic events affect agriculture; homestead vegetable cultivation, fish culture, and human health adversely. Poor women and marginal sections of the community are affected the most.

Community members are currently trying to adopt single or multiple coping/adaptation strategies to reduce their vulnerable to climate. Income and food were the top two well-being indicators that were mostly affected in all vulnerable groups.

6.1.5 Activities

At the beginning, household survey, participatory vulnerability and need assessment were carried out to understand the vulnerability context by socio-economic category, household income and asset status.

Several vulnerability reduction adaptation options per vulnerability context had been identified and demonstrated under the project.

Six hundred vulnerable households were selected as the project beneficiaries, comprised of poor farmers, fisher men, day labourer and women headed households. Of the total targeted households 50% of the groups were headed by males and another 50% by female groups. At the Household-level, approaches were as follows:

- Formed beneficiaries groups (male and female different groups) and use their knowledge and experience to develop appropriate adaptation strategy and implemented the identified suitable options for implementation. This was done to diversify household livelihoods to accommodate and address the vulnerabilities.
- Assessed beneficiaries training needs on different adaptation measures
- Developed training modules on adaptation measures and climate change issues
- Conducted classroom training sessions for advanced farmers knowledge and skill
- Conducted group based training sessions facilitated by advanced farmers
- Established demonstration farms and organized cross visits individual follow-up

6.1.6 The project Adaptation Strategies were as follows:

Adaptation Strategies: Increase income through alternative livelihoods

- Duck rearing for women beneficiaries
- Poultry and goat rearing for enhancing poor household income
- Case Aquaculture during flood and water logging period
- Prawn fish poly-culture
- Drought tolerant crops cultivation in drought vulnerable area
- Tree and plant nursery activities

Adaptation Strategies: Increase food through agriculture

- Floating Garden in flood and water logging area
- Improved and portable stoves particularly when beneficiaries kitchen and cooking stove inundated by the high flood

6.1.7 Lessons Learned

Demonstration plots are a very useful way to motivate beneficiaries to adopt new adaptation measures.

Work with advanced beneficiaries to establish demonstration plots at group member farms for various adaptation measures, baira cultivation, case culture and homestead gardening. These plots have been found useful for increasing interest among other beneficiaries in implementing the measures. The plots were visited during learning sessions to provide a practical example of the measures being discussed. The plots are also visited on an informal basis by both beneficiaries and non-beneficiaries, who are able to ask questions of the farmer and observe how implementation is progressing. Observing these new crop adaptations to climate change introduced new ideas of income generating crop production. It thus increased confidence and technical skills of the beneficiaries to produce new crops.

Cross visits are a very effective means of increasing confidence of beneficiaries in new adaptation measures and motivating them to adopt these measures.

Organize cross visits for beneficiaries on adaptation measures such as vegetable cultivation on baira, duck rearing and poultry rearing. The beneficiaries visit another household where the measure is being successfully implemented, so that they can view the activity /measure and ask questions.

Through practical observation and sharing of ideas, beneficiaries learn and develop confidence to implement the activity/measure themselves. Cross visits were organized for the beneficiaries to the successful farmers and small entrepreneurs. This encouraged the project staff and the beneficiaries to observe, learn and replicate the successes of the best practices among the beneficiaries of their own area.

Poor vulnerable people of the waterlogged areas adopting low cost vegetable cultivation technology (*dhap/ baira*), have been found to improve their food and economic security.

Rural people cannot produce any crops in flooded and waterlogged areas. In such situations, they often cannot find any other employment. Sometimes they migrate to city areas to find jobs. In this vulnerable condition, vegetable gardening on floating beds (hydroponics) is a traditional agricultural practice in some parts country, was introduced in project sites. This technology involves the cultivation of traditional crops on beds floating on water rather than in soil. The floating beds used by the farmers are usually made of water hyacinth and rice paddy straw. The main crops cultivated in floating gardens include okra, cucumber, bitter gourd, kohlrabi, tomato, turmeric, and potato.

Beneficiaries group members making floating garden for vegetable cultivation, Gopalgonj

A beneficiary harvesting vegetable from her floating garden, Gopalgonj

Improved and portable stoves are appropriate for the people of flooded and waterlogged areas.

The people in flooded and waterlogged areas suffer from lack of stoves to cook their food as water destroys their kitchens along with houses. Sometimes they need to stay on boat or make a platform from bamboo to stay on until the floodwater recedes. In this situation, it is very difficult for them to cook their food.

Portable low-cost stove were provided to the flooded and waterlogging-affected people of Ujani and Kolabari Unions under the Gopalgonj district.

In order to develop an improved stove model, BCAS collected models of potentially suitable stoves. They identified the most suitable model, had it constructed locally and distributed among the beneficiaries at a cost-sharing basis. The beneficiaries found these stoves are very useful in times of flooding and waterlogging. They can easily use them on a boat, *dhap* and platform. They have noticed that the fuel cost is also low. This design may be offered to the other flood and waterlogged areas.

Cooking food using portable improve stove, Tetulbari, Gopalgonj *Learning session, Barompalta, Gopalgonj*

Group-based and locally arranged training within the locality ensured participation of more female participants.

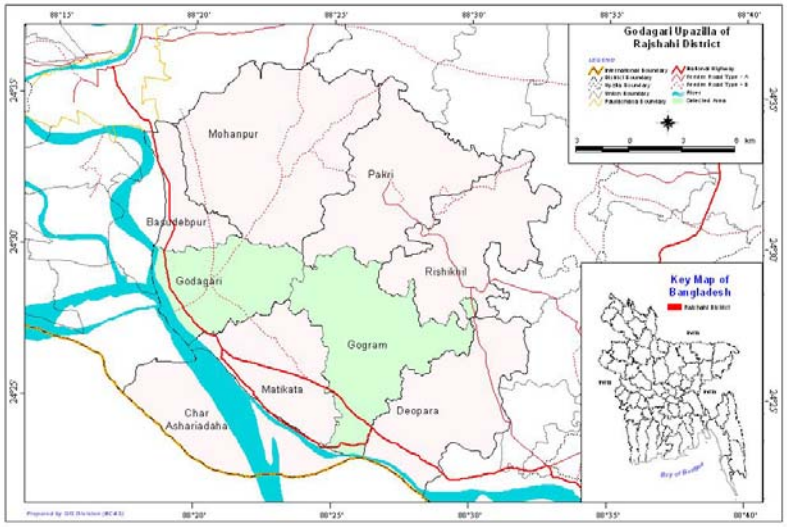
Women in the rural community are reluctant to go to distant places to participate in the training courses due to social taboos, household activities, need for childcare and insecurity. It is easy for them to attend the training courses, meeting or other activities with their group members if held in the same village area in which they reside.

6.2 Case Study on Deepwater Irrigation for Agriculture in the Barind Tracts

Farmers are using different types of supplementary irrigation in agriculture. Bangladesh Agricultural Development Cooperation (BADC) under the Ministry of Agriculture undertook the Barind Integrated Area Development Project (BIADP) in 1986 to improve livelihoods, keep environmental balance and fulfill the food-grain demand of the most backward and drought prone settlement in the north-western part of the country. It aimed to increase agricultural production by providing extensive irrigation facilities through deepwater irrigation system in fourteen Upazilas in the Barind Tract Region. The Deepwater Irrigation system has two major components i.e. installation of deep tube-well and construction of underground distribution line. The underground distribution line is an integral part of Barind Irrigation System which helps in transportation of water in the undulated terrain and to avoid evaporation loss during distribution.

6.2.1 The Project Location

The Barind Tract lies between 23028'30'' to 26038' north latitude and 88002' to 89057' east longitude (see location Map). It covers greater Rajshahi, Dinajpur, Rangpur, Bogra and Pabna districts of Bangladesh, known as north-western part and identified as a severe drought prone region in Bangladesh.



6.2.2 Socio-Economic Condition

Economic growth and development has been hampered significantly and become dissected from all types of economic activities and development efforts. Many indigenous farmers of this region migrated to the adjacent country, which caused enormous harm to the agriculture. Subsequently, new poor Muslim farmers came to this area from west India and eastern plain land and started their livelihoods. But due to lack of indigenous knowledge on climate, agriculture and land conservation system of the area, they failed to develop agriculture and started to cut down forest to meet their daily needs for survival. Besides, there were no integrated efforts for development of the Barind Tract before independence of Bangladesh.

Barind morphology looks like stairs from remote sensing visualization, which is called terrace landform. This tract is 30-40 m over mean sea level and segmented by a Pleistocene fault. About 87% to 91% soil of this region is formed with eroded greyish clay. Some tributeries of the Ganges river system such as Atri, Mohananda, Shib Pagla and Koratoa are the major rivers in the region. Unfortunately, these rivers dry up immediately after the rainy season due to low rainfall and construction of barrages in upstream by the neighbor country. Insufficient rainfall, lack of surface water, absence of forest, high temperature during summer, hard and dry radish soil, poor organic composition of soil (0.8%-5%), wavy land, uneven distribution of groundwater, very poor communication system, extreme poor residence etc. are the key characteristics of the region.

6.2.3 How the Project was Done?

Comprehensive study findings were shared with Ministry of Agriculture through BADC and the feasibility study report was followed by actual project from the BADC and the Ministry. Barind Integrated Area Development Programme (BIADP) was approved in 16 July 1986 to be implemented under BADC. BIADP phase 1 has installed 50 percent deep tube-well. Constructed of distribution system and electrification were negligible. An institutional reform occurred in 1992 and a separate authority "Barind Multipurpose Development Authority (BMDA)" was established. The Authority started with the incomplete programmes of BIADP and up to 2004 a total of 6357 Deep-tube Wells were installed and all are operating following own policy and system the authority.

This deepwater irrigation system has technology component and institutional arrangement with farmers. This irrigation system is backed by research, consultation and reality checking, pilot level intervention to check theoretical potential against actual potential, and policy advocacy.

Installation of deep tube-well

Underground Water Distribution Line

Construction of Water Distribution System

The project has targeted for 2250 water distribution plants.

Power Supply Network

Initially 2000 engines were targeted for electrification to minimize the cost of lifting water. Power Development Board was responsible for this programme. But unfortunately only 10 engines were electrified. Due to lack of integration among the Ministries, the project failed to reach the target.

6.2.4 What has been achieved?

A committee was formed integrating Ministry of Agriculture, Department of Seeds of BADC and Barind project to evaluate cropping pattern and results of the partial implemented project in the project area. The survey report of the committee reported the following achievements:

Achievements

- Total 6374 DTW were installed in the project area till June 2004
- Previously drought affected fallow lands are recently used for crop cultivation through irrigation and reducing drought affected area
- The cropping pattern has been changed tremendously. The dominance of T.aman crop has diminished while HYV boro became the most important crop. Also there has been considerable crop diversification with increase in acreage and production of wheat, potato, fruits, vegetables, spices, pulses, oil seeds etc. Area coverage and production of T aman, wheat, HYV boro, potato and maize expanded substantially while those of B. Aus, mustard, black gram and sugarcane decreased over the project areas.

Diversification of Agriculture Practices

- In the barind districts, the total production growth of food grain crops was phenomenal. Similarly, with availability of irrigation facilities the barind farmers switched from less intensive crop production to fertilizer responsive modern cultivation methods that have also raised the yielding abilities of the major crops. Boro yield increased from 3.2 to 4.24, T. Aman from 1.6 to 3.6, Aus from 2.1 to 2.4, wheat from 1.8 to 2.3 and potato from 13.3 to 18.1 tons per hectare over 1991 to 1999.
- Employment opportunity has been increased for marginal farmers and day labours. (Occupation pattern did not change much but income level increased because of increasing agricultural production, increased demand for labour and increased wage rate by eliminating poverty, income generation specially of women group)
- Wage rate of Agriculture labour in the project area was Tk. 25 to 35 for male labour in 1991 which has been increased to Tk. 50 to 80 in 1999-2000. Wage rate of female labour was as low as Tk.15 to 20 in 1991, which has been increased to Tk 40 to 60
- Environmental development has occurred by increasing cropping intensity.

- Socio-economic condition of the project areas have been improved by growing more food.

Irrigation facility in the Barind Tracts area has brought tremendous changes in the cropping pattern and production. The dominance of Transplanted Aman (T. Aman) Crop has replaced High Yielding Variety Boro (HYV Boro) Crop. There has also been considerable crop diversification with increase in acreage and production of wheat, potato, fruits, vegetables, spices, pulses, oil seeds etc. Expansion of coverage along with increase of production of T Aman, wheat, HYV Boro, potato and maize is substantial while area coverage under Broadcast Aus (B. Aus), mustard, black gram and sugarcane has decreased over the project period.

The total production and growth of food-grain is phenomenal in the Barind Tracts Area. Similarly, with availability of irrigation facilities farmers have switched from less intensive crop production to fertilizer responsive modern cultivation methods which has increased crop yield. Yield HYV *Boro* Crop has increased from 3.2 to 4.24, T. *Aman* from 1.6 to 3.6, *Aus* from 2.1 to 2.4, wheat from 1.8 to 2.3 and potato from 13.3 to 18.1 tons per hectare over 1991 to 1999.

Employment opportunity has been increased for marginal farmers and day labours. However, occupation pattern did not change much but income level increased due to increase in agricultural production, increased demand for labour and increased wage rate. Project has contributed to poverty alleviation and has improved socio-economic condition of the people living in the Barind Tracts.

6.2.5 Lessons learned

There is no doubt that use of DTW for irrigation has improved socio-economic condition

The Irrigation activities also reduced drought impact in the region and improved environmental condition tremendously

However, such a successful project was felt in threat because of Donors bindings and bureaucratic complexity

Relevant agencies and actors have to realize these situations for adaptation of the project activist to reduce adverse affect of climate change particularly drought in Barind region in Bangladesh.

6.3 Case Study on Cyclone Shelters in the Bangladesh Coastal Region

The major climatic hazards that affect Bangladesh are cyclone, floods, riverbank erosion, tornadoes and droughts. Among these cyclones are the most devastating. Generally, the hazards faced by the coastal areas are related to tide, river flows and weather conditions leading to cyclone winds. The major hazards that occur in the coastal areas are mostly due to weather conditions associated with depressions of varying severity. Tropical cyclone associated with storm surges over the Bay of Bengal greatly affected almost all parts of Bangladesh coast. This hazard vulnerability means susceptibility of coastal society to substantial damage, disruption and causalities. Severe cyclonic storms with hurricane intensity strike populated areas that have infrastructure, crops and forest.

Most of the cyclones occur during the pre-monsoon (April/May/early June) and Post–monsoon (late September/October/November) period. During the period 1877 to 1978 a total of 1050 depressions formed in the Bay of Bengal of which 254 turned into cyclones and 158 into severe cyclones. Since 1970, ten major cyclones have struck this country and caused huge damage. Around 500,000 and 138,000 lives were lost due to the devastating cyclones of 1970 and 1991 respectively. More than 8,000 square kilometers of Bangladesh coastal areas covering 44 Upazilas (235 Unions) are considered as High Risk Zones, where there could be loss of lives and resource due to storm surge inundation.

6.3.1 Location

Cyclone shelters are located in Patuakhali, Barguna, Jhalakati, Pirojpur, Bhola, Barisal, Cox's Bazar, Noakhali, Feni, Bagerhat, Satkhira, Chittagong and Khulna which have been identified as high risk cyclone prone areas (HRCPA); (see Map..).

6.3.2 Number of Cyclone Shelters

For saving human life, a total of 2033 shelters were constructed until October 2001 by different agencies (EGIS 2002). The existing cyclone shelters in 19 south and south-western districts are in a position to give temporary shelter to maximum 20 lakh people at the time of natural disaster like cyclone, tidal bore and storm. Another 30 lakh people of the HRCPA can take shelter at the educational institutions, offices and establishments during the time of emergency. The HRCPA are home to more than one crore and fifty lakh people. This means that over one crore people remain exposed to the fury of natural calamities. This numbers of cyclone shelters can provide shelter to only 20% people living in island and char areas. There is need of 3500 cyclone shelters in coastal areas of Bangladesh (The daily Independent, 17 Feb. 2000). In normal period cyclone shelters are used for multipurpose activities including school, health facilities and as community meeting centre.

Following the devastating cyclone of 1991, an institutional framework was developed by the government of Bangladesh to mitigate the loss of lives from natural disasters mainly by constructing cyclone shelters. This institutional framework comprises both national level and local level committees and bodies working under GoB institution. Since 1993, the Disaster Management Bureau (DMB) has held the responsibility of assisting the concerned ministries with necessary disaster related information. DMB also maintains liaison with and fosters cooperation between all levels of government, international and organizations and NGO communities.

Table 6.1: Shelters Constructed by different agencies

Agency	No. Constructed (1996)
PWD (CCC)	132
PWD	238
BDRCS	154
CARITAS	193
LGED	270
MoE	440
PMED	207
CCDB	44
Grammeen Bank	24
BARC	19
Save the Children	6
World Vision	12
Gano Shastha Kendra	12
PROSHIKA	6
HEED	6
Other	57
Total	1820

Source: compiled from EGIS 2000

6.3.3 The Bangladesh Red Crescent Community Based Disaster Preparedness Programme 1996-2002

After the 1991 cyclone a study by the Bangladesh Red Crescent Society and other organisations revealed that 90% of its victims were women and children and that despite the existence of some cyclone shelters, many people were not aware of their purpose or didn't feel it was safe to take refuge in them. In response to these findings the German Red Cross in 1996 initiated the Community Based Disaster Preparedness Programme (CBDPP) in Cox's Bazar District with the objective to improve the communities' self-help capacities. The programme was implemented by the Bangladesh Red Crescent together with communities living around 30 cyclone shelters along the most vulnerable points of the Bangladesh coastline. The shelters were constructed between 1986 and 1994 by various Red Cross societies and the German Bank for Reconstruction (KfW). To ensure active participation of all sectors of the community, gender specific micro groups with 15 to 25 members each were formed. Each of these groups elects one representative to be a member of the Village Disaster Preparedness Committee (VDPC), which is responsible for the use and maintenance of the cyclone shelters. The committee also conducts a range of disaster preparedness activities before, during and after the cyclone season. Each shelter also has a committee of 21 members, 11 male and 10 female. The CBDPP particularly aims to reduce the impact of cyclones on women and children and to empower them in their every day lives by paying special attention to them through group training sessions on disaster preparedness, leadership, reproductive health, nursery management techniques as well as small scale entrepreneurship such as chicken breeding. In 2002, the German Red Cross officially handed over responsibility for these activities to the Bangladesh Red Crescent Society and the local communities themselves. The recent cyclones of 1991 and 1998 have created great awareness of the need and opportunities to prepare for cyclones and to reduce vulnerability in the long-term. The prospect of climate change and sea-level rise increases the need to prepare for cyclones, whilst the development of an international climate adaptation regime increases the opportunities to do so. The urgency to prepare for climate change has led to a number of large projects in Bangladesh during the last three years.

The CLACC project (Capacity strengthening of the Least Developed Countries (LDCs) for Adaptation to Climate Change) was initiated in 2002 and aims to strengthen the capacity of civil society in LDCs to adapt to climate change, to enhance adaptive capacity among the most vulnerable groups and to integrate adaptation to climate change into the work of key non-government institutions.

The RVCC project (Reducing Vulnerability to Climate Change) is a 3-year project initiated in 2002 which works at four levels (household, community, institutional and national) to raise awareness to climate change, to adapt to environmental changes that could be exacerbated by climate change and to influence relevant policy.

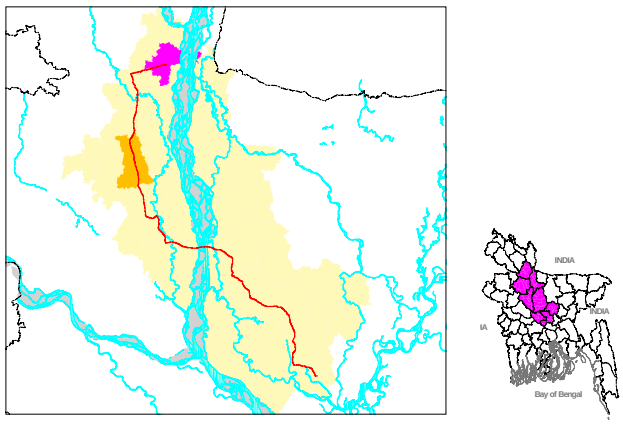
A Comprehensive Disaster Management Programme (CDMP) was created in 2003 by the GoB and UNDP. Additional funding from DFID is specifically targeted to help Bangladesh cope with shocks resulting from climate change by supporting research, developing vulnerability reduction activities, and providing assistance to strengthen communities' abilities to cope with disasters (UNDP, 2003).

The document on "Poverty and Climate Change: Reducing the Vulnerability of the Poor through Adaptation" highlighted that the climate change adaptation to be effective, empowering civil society to participate in the assessment process, including identifying and implement adaptation activities, is especially important. The document also mentioned that community based cyclone preparedness programme in Bangladesh has found that where women not involved in village level disaster preparedness committees, responsible for maintaining cyclone shelters and transmitting warning, they made up the highest proportion of cyclone victims. In Cox,s Bazaar in east Bangladesh, where women are now fully involved in disaster preparedness and support activities (education, reproductive health, self-help groups, and small and medium enterprises), there has been a huge reduction in the number of women killed or affected.

6.4 Case Study on Increasing the Resilience of Communities to Cope with Climate Change Impact, Flood and River Bank Erosion

The project increasing the resilience of communities to cope with climate change', seeks to pilot a community-based approach, enabling people to develop strategies for addressing the localised threats for addressing the localised threats of climate change.

In Gaibandha, thousands of poor people live with the constant threat of homelessness, damage to and loss of their possessions and means of livelihoods and risks of injury and death due to weather related natural disasters such as flooding, river bank erosion, storm, cyclone, drought, cold wave and desertification. This project is built on Practical Action's existing experience of working with natural disaster prone communities in Bangladesh. The project targeted to increase the resilience of 10,000 men, women, and children from vulnerable communities to cope with and adapt to the impacts of climate– induced hazards. The



project will effectively bring together issues of poverty reduction, environmental and natural resources management, disaster risk reduction and climate change.

6.4.1 Location

Gidari and Kamarjani Unions in Gaibandha Sadar Upazila (sub-district) under Gaibandha district and Sariakandi in Bogra District are located in the North-west region of Bangladesh. The Union is situated about 70 km northwest from the Bogra City and about 300 km from Dhaka (see location map).

6.4.2 Findings from metrological data

Temperature shows an increasing trend over the last 30 years with seasonal variation. Both maximum and minimum temperature in the winter season shows an increasing trend and higher than monsoon temperature. It gives an indication that winter is becoming warmer than 30 years ago.

Increasing winter temperature has negative effects on winter crop particularly potato production. The community living Holdia and Gidari Unios has also confirmed these negative impacts.

Number of days without rainfall is increasing while total annual rainfall does not vary significantly. This indicates a trend of heavy rain occurring in a short duration of time and occurrence of more droughts. Local people also confirm that scale and frequency of droughts has increased over time.

6.4.3 Climate change related problem in project area

Based on the findings of above mentioned surveys, the major climate change related problems in project area are identified as frequent flood, river bank erosion, drought, storm/cyclone and cold wave.

Vulnerabilities------- ----------living with floods and erosions

Local knowledge on climate change:

- Knowledge on climate change is not clear/incomplete.
- They could understand that due to some reason flood is occurred frequently, excess rainfall during rainy season, draught during dry season, cold wave during winter.
- Local educated people are aware about climate change
- They sometimes could predict disaster, well in advance (like flood, cold wave, and drought) by monitoring some symptoms.
- Accordingly they take preparation based on their ability by using indigenous knowledge.
- But they could not predict occurrence of tornado and hailstorm.

Indigenous knowledge of communities to monitor different weather pattern:

- According to the respondents especially the elderly people of the group, they use some local knowledge in order to predict weather/climate condition by observing some symptoms. Beside some exception, most of the cases they get accurate results from the symptoms.

Institutional knowledge on climate change:

- Respondents are aware about global warming or climate change.
- Climate change is global issue and accordingly the problem should be solved globally however, adaptation measure should be taken by the vulnerable countries like Bangladesh.
- Climate change has changed the live and livelihood of affected people (from farmer and fishermen to day laborer, small trader, rickshaw puller)
- Agriculture Department is thinking to cultivate new variety of rice crops which are flood tolerant.
- All respondents believed that due to climate change, frequent flood, storm, cyclone are occurring in this region.

The project is working with women and men from vulnerable communities in Bangladesh to increase their ability to understand, cope with, and adapt to, increase climate variability and climate-related hazards. There are four main components to the work:

- Strengthening the capacity of communities and their supporting institutions to prepare and respond effectively to future climate-induced emergencies
- Developing and promote practical (technology-based) interventions to strengthen people's livelihoods and natural resource assets
- Enabling vulnerable communities to take part in decision-making processes on climate-related adaptation strategies
- Influencing policy at different levels, through sharing the learnings from the project and demeonstration of an effective approach to community-based adaptation.

6.4.4 Community-led solutions

The starting point for the project has been people's current livelihood strategies and their local knowledge and observations of climate change and its impacts on agriculture and natural resources. Key to the project is a participatory approach, understanding the existing livelihood system and environmental assets available to the community.

6.4.5 Project Activities

Project activities have been based on the capabilities and priorities of the people. Some activities focus on protection against environmental degradation and lessening the likely impacts events of extreme weather. Other activities are focused on increasing the resilience of people's agriculture-based livelihoods to climate variability. Project Activities are the followings:

- Construction of houses on raised plinths to reduce risk of flooding
- Construction of floating vegetable gardens to provide food during flood periods
- Cages for fish culture when river flows are too fast for safe fishing
- Awareness to the communities: Mass awareness through arranged cultural program, rallies, art competition, open debate, essay writing competition for communities and school students on climate change related issues in order to create awareness among the communities
- Awareness training: Arranged training for Community Volunteers, UP members and Chairman and school teachers on climate change issues. In addition to climate change issue they also informed about their roles and responsibilities as volunteer.

Fish culture in cage

Flood proofing housing

6.4.6 Capacity building of the community and other stakeholders

- Selection of Community Volunteers (100 Male and 100 Female): They are responsible for disseminating messages and information on climate change and disaster related issues to the beneficiaries and provide support during disaster.
- Selection of Youth Volunteers: 150 Youth Volunteers were selected from the schools, among them 75 are male and 75 are female. They are responsible for disseminating messages to the school students, organize rally, art competition, debate on climate change issues.
- Selection of Early Warning Group: Among the 200 Community Volunteers, 50 Community Volunteers were selected as Early Warning Group, who are responsible for disseminating early warning messages among the beneficiaries.
- Training: Based on the identified training needs, trainings were arranged for various groups. The main objectives of the training were to raise awareness the participants about Green House Gas and Global Warming and to inform, how they could reduce Green House Gas emission as well as to reduce fuel cost by using Improved Cook Stove. The major contents of the training were food management of livestock during flood and other disasters, diseases affecting livestock and prevention of disease.

6.4.7 Policy influence and linkages

Practical Action Bangladesh is currently working with the community and other stakeholder to create awareness and strengthen their capacity to cope with vulnerability:

- Focus on the most vulnerable areas and population
- Greater awareness of climate change issues for policy-makers and the general people
- Involvement of vulnerable groups and a wide range of stakeholders in adaptation planning
- Appropriate information on climate change shared with different stakeholders

- Focus on strengthening and diversifying livelihoods to help people cope, as well as infrastructure-based projects to strengthen physical structures such as flood proof housing
- Increasing the resilience of poor communities to cope with the impact of climate change

6.4.8 Reducing the risk of climatic disaster

Dealing with the uncertainties of climate change, reducing vulnerability to today's climate variability through disaster risk reduction is an excellent method of building adaptive capacity for the future. Communities can be empowered to help themselves by undertaking the followings initiatives:

- Trained volunteers to organize evacuation to places of safety during floods or landslides
- Ready prepared emergency food and fodder packs
- Emergency community shelters and grain stores
- Prepardness for climate –induced hazards reduces the likelihood of them resulting in disasters.

Community-led activities will only have a limited effect and little sustainability unless local and regional stakeholders are able and willing to scale up and support risk reduction activities.

6.5 Early Experiences and Learning from Comprehensive Disaster Management Programme (CDMP)

The Comprehensive Disaster Management Plan (CDMP) was initiated in 2003 under the Ministry of Food and Disaster Management of the Government of Bangladesh. CDMP, a strategic institutional and programming approach project, is designed to optimise the reduction of long-term risk and to strengthen the operational capacities for responding to emergencies and disaster situations including actions to improve recovery from these events. CDMP facilitates research and implementation process into disaster management techniques and is a platform that helps to integrate all the actors and institutions in disaster management under one roof. Before the initiation of CDMP, disaster management was carried out by the Directorate of Relief and Rehabilitation (DRR) using a traditional framework. The effectiveness of CDMP lies in the fact that it takes into account not only the extreme events but also long term environmental degradation including climate change. Furthermore, CDMP carries out local level risk assessment and designs risk reduction plans which include preparedness and response to disaster. These activities were previously not carried by disaster management institutions. Local communities are trained in disaster risk management and CDMP ensures participation at the lowest level of administration.

CDMP strength lies in the fact that it combines people from the government, non-governmental sectors and community organisations to create an integrated approach towards disaster management. Key benefits associated with this approach are that:

- The resources and expertise of government, NGO, private sector and the community are deployed according to national priorities, community risk reduction programming needs and not organizational preference.
- It provides a big picture of what needs to be done and as such, a mechanism for identifying gaps, monitoring and observing achievement.
- It provides the basis upon which formal collaborating partnerships are developed and nurtured.
- It facilitates the validation of new projects against country risk reduction needs
- It serves as a management tool for donor agencies and regional organizations to guide their inputs.

CDMP is such a vast programme with numerous components that its success in disaster management is ensured. The strategies focus on ensuring a comprehensive and well coordinated approach to community risk reduction. The 5 areas of strategic focus of CDMP have 10 corresponding components. These are:

Strategic Focus	Corresponding Components
Professionalising the Disaster Management System	1. 1a—PPPDU 2. 1b—Professional Development
Partnership Development	3. 2a—Advocacy and Awareness 4. 2b—Capacity Building
Community Empowerment	5. 3a—Programme Gap Analysis 6. 3b—Risk Reduction Planning 7. 3c—Local Disaster Risk Reduction Fund
Expanding Mitigation, Preparedness and Response Across a Broader Range of Hazards	8. 4a—Urban Search and Rescue 9. 4b—Climate Change and Research
Strengthening Emergency Response Systems	10. 5a—Disaster Management Information Centre and Emergency Procedures

Of the above components, most of them have been initiated so far. CDMP is a long process and its implementation period is until 2009. CDMP is still in its implementation phase and its outcomes have not been put to the test yet. The findings and results of CDMP are not very concrete yet, but some very valuable experiences have been gathered from the studies carried out. It is still in an early stage to design solid plans of action, but the studies have given positive indication that this process will be a success. The communities have also shown appreciation for the CDMP process as it gives them a voice that is heard by the policy makers and disaster management professionals.

Three examples of studies carried out under CDMP below represent the importance of the development of Bangladesh particularly in the context of disaster management.

A. Study on Knowledge Assessment through the Baseline Study on Disaster Risk Management and Climate Change Impacts Knowledge and Understanding among CDMP Stakeholders

Introduction and Background

Bangladesh, with a population of about 144 million, is one of the poorest and most vulnerable countries in the world to disaster and climate change impacts. Different types of natural hazards including flood (e.g. river flood, urban flood and flash flood), cyclone and storm surges, drought, river bank erosion, tornadoes etc hit the country almost every year. These catastrophic events significantly hinder the economic and social development of the country through two phases-- first, damaging the resources, establishments and infrastructure and second, pulling back the on-going development, business and trade at local, national, regional and even global levels.

In 2004, the MoFDM of the GoB launched the Comprehensive Disaster Management Programme (CDMP) in partnership with the United Nations Development Programme (UNDP) and Department for International Development (DFID) to achieve a significant policy and planning reforms and to build operational frameworks to facilitate a shift in the country's disaster management programmes, from response and relief to a more balanced and comprehensive risk reduction focus.

Rationale of the study

Professionalizing the disaster management system through capacity building is one of the specific objectives of CDMP. Therefore CDMP recognizes the need of working out the level of existing knowledge, understanding and awareness of DMC members at different administrative levels of the government. The primary idea of targeting DMC members of national, district, upazilla and union levels was as they are directly or indirectly involved in policy, planning and development activities of all sectors.

Implementing Organization

Bangladesh Centre for Advanced Studies (BCAS) which has a long track record in research and participatory planning exercise on environment, climate change and disaster issues was assigned by CDMP to carryout the study. The study was conducted in 2006.

Study Locations and target populations

The study was conducted in seven districts including Lalmonirhat, Rajshahi, Sirajganj, Sunamganj, Faridpur, Satkhira, and Cox's Bazar. The DMC members at district, upazilla and union levels were the target groups for assessing knowledge and understanding on disaster risk management and climate change impacts issues. In addition, national level stakeholders were also interviewed for the same purpose.

Approach and Methodology of the Study

The methodology for conducting the study was primarily based on structured questionnaire, Focus Group Discussion, In-depth interviews and workshops. The data were collected from grass root level to national level stakeholders. However, summary of the data collection methods and respondents are given below:

Table 6.2 Summary information of the respondents/ participants covered by different methods

Level	No of DMC surveyed	Number of Respondents/ participants			
		Sample Survey	FGD	In-depth Interview	Workshop
Union	28	10x28=280	1x28=28	3x28=84	-
Upazilla	14	10x14=140	1x14=14	3x14=42	1x14=14
District	7	15x7=105	1x7=7	5x7=35	1x7=7
National	-	1x27=27	-	-	1
Total	-	552	49	161	22

Key Findings

The respondent's knowledge and awareness of the issues were based on the specific and composite indicators. According to the composite index/ indicator, appropriate knowledge and understanding on terms of hazard, risk and disaster, and disaster management ranged between 47.07 and 68.77 percent respondents (union-58.84, upazilla-47.04, district-53.66 and national-68.77). At the upazilla level it was quite low (47.02%). Even at the union and district levels the percentages were 58.84 and 53.66 respectively.

Regarding awareness on Standing Orders for Disaster (SoD) DMC members were poor at every level of administration. Interestingly, union level members were found to be more aware (35.0 %) about SoD than the stakeholders at the upazilla and district levels.

The stakeholders at the union level appear to have better knowledge about formulating short, medium and long term vulnerability reduction and capacity building action plans. The findings show that overall correct respondents at union level for all districts was 80 percent whereas it was 46.4 percent and 46.7 percent in upazilla and district level respectively.

Knowledgeable respondents about climate change and its definition was very low at the union (23.9 %) and upzilla (22.9 %) level while it was very high (90%) at the national level. Although the knowledge level on "climate change" definition was a bit poor the DMC members seem better aware on climate change impacts.

Regarding awareness on the Kyoto Protocol and Montreal Protocol the national level respondents were not very satisfactory. On the other hand, perception on CDM (Clean Development Mechanism) and DNA (Designated National Authority) issues, the stakeholders were found to have little known.

On the subject of possible impacts of climate change the appropriate response ranged from 79.3 percent at the upazilla level to 83.1 percent at the union level. It was observed that with regard to the issues of types of GHGs and effects of increasing GHGs, knowledge level was more than 70% at all study levels.

With regards to existing adaptation practices to Disaster Risk and Climate Change Impacts the respondents at every administrative level was satisfactorily positive. On the issues of preparing "community based highland" to address potential hazard especially floods, the percentage of appropriate respondents were 91.1, 90 and 89.5 at the union, upazilla and district levels respectively.

Regarding "preparedness" to adapt with possible risks the level of awareness of the respondents was also high. The highest overall appropriate response was 90.5 percent at the District level and lowest was 78.9 at the union level.

The FGDs, in-depth interviews and workshops however gave a totally different view to the perception of climate change. The survey results have shown that the stakeholders do not have a clear understanding of climate change, but during the FGDs, in-depth interviews and workshops the stakeholders gave comparatively good reflection regarding climate change and its associated events. It is clear from the FGD that even though the people do not understand the science behind climate change, they have identified shifting weather conditions and extreme events as impacts of climate change. Many of the respondents in almost all the study districts have mentioned about some changes which include-- increased temperature in summer, excessive or prolonged rainfall during rainy season or untimely rainfall, increased duration of flood, increase of fog during winter, increase of cold waves etc. In each of the qualitative data collection method (e.g. FGDs, in-depth interviews and workshops) most of the respondents mentioned the need of training on climate change and its impacts and vulnerabilities to different sectors.

The study demonstrates that the level of knowledge and understanding on three thematic issues (hazard, risk, disaster and disaster risk management; climate change and its impacts; adaptation to disaster risk and climate change impacts) of discussions were not the same. In some cases the stakeholders had adequate knowledge of the issues but in some cases their level of knowledge was quite poor. Surprisingly the stakeholders at the union level were found to have more knowledgeable than both upazilla and district level on many issues. This might be happened due to direct

involvement of both affected by extreme events and also implementation of some of the projects and programmes. This bears the messages of what needs to be done at what levels to address disaster and climate change impacts in Bangladesh.

B. Climate Change and Health Study

Introduction and Background

The health study was carried out under CDMP as a knowledge generation activity. So far the health studies done by the Government of Bangladesh and some other organisations are not very comprehensive. Furthermore the link between climate change and health was not established in earlier studies. This Climate Change and Health study is the first of its kind undertaken that looks at the impacts of climate change on health.

Many scientists already anticipated that more frequent and more intense severe weather events will result in increased deaths, injuries and disease in developed countries like Canada, but the biggest impact will be felt in low-lying, heavily populated areas such as Bangladesh, particularly when coupled with sea level rise attendant upon global warming (Canadian Association of Physicians for the Environment, 2004). According to IPCC (2001), the global warming would enhance the vector borne and water borne disease in the tropics. In addition, the heat stress and heat waves would cause more health problems and the morbidity and mortality would increase especially in the least developed countries like Bangladesh.

Over the years it has been observed that climate change has brought about changes in the incidences of diseases and other health problems. Vector borne and water borne diseases have been on the rise along with the increased shortage of fresh water supply and sanitation. Even though it has been recognised that climate change affects the health sector as much as the other sectors, climate change related health problems have been virtually ignored. Research in this area has been very limited and there has been no study to find out the extent of impact climate change has had on health related issues. Some of the health concerns that have been exacerbated by climate induced parameters are:

- Malaria and Dengue: The rise in global temperature and increased instances of water-logging due to floods has increased the population of mosquitoes especially in tropical countries. The change in temperature has also increased the prevalence of vector borne diseases significantly. According to the NAPA study note the increasing trend and variation of dengue occurrences are consistent with the corresponding trend and variation of temperature, which infers that the anticipated future warming in Bangladesh might enhance the dengue occurrence. (The following table shows the outbreak history of dengu in Bangladesh.

Period	Description
1964	First documented out break of dengue in Bangladesh
1977 – 78	Few cases of DF were found in a Clandestine Survey by IEDCR
1982 – 83	Out of 2456 blood samples taken, 278 found DEN - 1
1984 – 86	21 samples collected, 3 found positive by HI Test.
Up to 1986	Major cities were free to DHF.
1997	Cross sectional serological survey at CMCH tested 255-paired sera in which 35 were positive cases
1999	Few death cases were reported in DHF
2000	Currently an epidemic has been reported in this country
2001	Epidemic has been reported in this country.
2002	Epidemic has been reported in this country.

- Salinity intrusion in coastal regions: The rise in sea level and subsequent desertification in the northern regions of the country has caused the flow in the rivers to decrease. This results in

the intrusion of saline water inland through the rivers and channels. Also due to fluctuations in precipitation, increased groundwater withdrawal, sea surges etc, the groundwater aquifer in coastal regions have been contaminated with saline water.

- Heat Stress induced mortality: Heat stress induced mortality affects elderly people and infants the most in the summer months.
- Diarrhea and Cholera: These are water borne diseases and in summer months their incidences increase. The last few years has seen diarrhea and cholera epidemics especially in children brought on by excessive heat, floods, water-logging, lack of safe drinking water etc.
- Malnutrition and dehydration: Loss of agricultural production due to fluctuations in temperature, precipitation, salinity intrusion poses a threat to food production ultimately malnutrition. Other factors like drought, flood and increased temperature, increases dehydration in children and causes many other adverse health effects.

Implementing Organization

The study was carried out by BCAS and NIPSOM (National Institute for Preventive and Social Medicine). The study took about 6 months and was completed in January 2007.

Study Locations

The study on level of climate change induced health impacts in regard to safe drinking water and sanitation was carried out in 3 locations in Bangladesh. The locations are Naogaon, Manikganj and Satkhira. Naogaon, in the northern part of the country, suffers from severe drought; Manikganj, located in the central part of Bangladesh, is flood prone and Satkhira, in the coastal region, suffers from salinity intrusion, cyclones, and groundwater depletion. Three different regions were chosen for the study because they are affected by climate change in different ways. All these areas suffer from some form of water supply and sanitation problem brought on by climate change variables. These in turn has serious health implications for the local people.

Objectives of the Study

The overall objective of the study is to carry out more detailed research on climate change and its associated health impacts in the study sites. This study will show the possible impacts of climate change on the human health of Bangladesh.

Specific Objectives:

- Identification of the pre-existing and existing diseases or health disorders throughout the year in the study sites
- Assess seasonal variation of incidences of the human health diseases
- Status and knowledge and understanding on human health impacts due to lack of safe drinking water and sanitation services of the community people
- Perception on climate change and climate variability issues
- Perception on health impacts due to climate change

It will further help to develop capacity in the health sector, increase awareness, coordinate strategies to provide safe drinking water and sanitation, programmes and plans to reduce vulnerability of the poor to the health impacts of climate change and to bring it down to a manageable and acceptable humanitarian level.

Approaches and Methodology of the Study

The study focused on the co-relationship between climate-induced extreme events (weather variability, floods, drought and salinity) and the health problems of the community. The main focus of the study will be on the possible impacts of climate change health systems of Bangladesh, especially in the context of safe water supply and sanitation. So far the extent of prevalence and occurrence of diseases in Bangladesh and its linkage (both direct and indirect) to climate change is not known. The

rise in epidemics and various other diseases over the past few years can be attributed to climate change.

The methodology of the study includes analysis of secondary and primary data. Time series of climate factors data especially on temperature and rainfall were collected from Bangladesh Meteorological Department. Time series of disease data were collected from the Upazilla Health Complex of the study location. Pearson's correlation coefficient was used to find the association between climate factors and incidences of diseases (diarrhea, malnutrition, skin disease and kala-azar. The primary data collection tool includes household survey, Focus Group Discussion (FGD) and In-depth interview with villagers, health professionals, women in each study area. The main issues of the sample survey, FGD and In-depth interview were health disorders (present and past), perception on climate factors (temperature, rainfall, salinity, flood, drought etc), seasonal changes of climate factors etc. Statistical tables have been used for analyzing the relationship between climate change factors and health related variables.

Key Findings

The study, in addition to climate variability, has found changes of the trend of climate factors particularly yearly maximum and minimum temperature over the last three decades. Rajshahi and Manikganj were found to have an increasing trend in both maximum and minimum temperature while in Satkhira the trend was declining over the period.

The results of the study indicate that the climatic factors including temperature (maximum and minimum), rainfall (annual and seasonal) and salinity concentration are factors for causing diarrhea, skin diseases, kala-azar etc in the study areas. In addition, climate factors are associated with malnutrition problems.

The correlation coefficients between climate factors and health disorders varied among the study locations. Incidence of diarrhea was found to have positive correlation with total annual rainfall in Rajshahi and Satkhira. Monsoon's total rainfall was also found to have positively correlated with diarrhea in Rajshahi (+0.21) and Satkhira (+0.27). In contrast, dry seasonal rainfall was found to have positive correlation with Manikganj study area.

The difference between annual maximum and minimum temperatures was found to be positively correlated with the incidence of diarrhea in two study locations i.e. Rajshahi and Satkhira. However, the correlation was found negative in Manikganj.

A positive correlation implies that the incidence of diarrhea increases as the variation of temperatures also increases. A negative correlation means decrease in the incidence of diarrhea when temperature differential rises.

Skin diseases and malnutrition were also found to be positively correlated with temperature differential in both Rajshahi and Satkhira, while these were negatively correlated in Manikganj study area. The negative correlation of diarrhea, skin diseases with temperature variation in Manikganj might have happened due to non-climatic factors as well as improved health services. The survey shows that the household in Manikganj have better accessibility to safe water and sanitation and health services.

In spite of the apparent discrepancy in the correlation in the time series data among the three study locations, variation in temperatures has been identified by the survey respondents as major cause of diarrhea, skin diseases and malnutrition in all the three locations from the survey.

The study also shows that the climate factors of Satkhira are sensitive to diarrhea, skin disease and malnutrition as each of these diseases was found to have positively correlated with at least one of the

climate variables mentioned in the study. Moreover, skin disease and malnutrition are more or less highly correlated (positive) with all three climate variables (rainfall, temperature and salinity).

The study in spite of various limitations and constraints shed light on the correlations between climatic factors and human health in the context of specific locations of Bangladesh. Given the wide ranging impacts of climate change on human health and growing importance of the issues, broad-based and in-depth study should be undertaken for better understanding of the cause- effects relationship between climate change factors and human health. The findings from such study would value to policy and decision making process relating human health and sustainable development. However, the following specific activities/programmes/measures may be considered to address health impacts due to climate change:

- The study indicates that water borne diseases remain a major public health problem in Bangladesh with changes of climate factors
- To address such problems and reduce possibility of incidences of any climate sensitive diseases, some of the initiatives including policy decisions, scientific tasks and broad research to confirm earlier findings, institutional capacity building to handle consequences may need to be considered.
- The government agencies (e.g. Dg-Health) may initiate climate sensitive diseases surveillance separately or can include a separate component on this in existing national diseases surveillance programme.
- The government may develop climate sensitive diseases dataset and vector data based on geographical distribution for further research and prediction
- Health professionals may need to be trained on climate change and its impacts on human health to deal with future adversity
- The government in association with NGOs/research organizations working on climate change and health issues may initiate training programme for health professionals.
- Awareness programme on climate change impacts on human health would build resilience of the community
- Considering all relevant climate factors and non-climate factors, adaptation strategies on health to climate change can be developed. Climate Change Cell (CCC) can initiate developing this strategy in association with relevant partners GOs/NGOs.
- Improve water supply and sanitation management
- Protection of water resources
- Improve hygienic practices at individual and community level

Both GOs and NGOs can initiate programme on water supply, sanitation and hygienic practices.

C. Community Risk Assessment (CRA) and Preparation of Risk Reduction Action Plan (RRAP)

Community risk assessment is very important in disaster management since climate change impacts are location specific and CRA helps to build capacity at the local level. Some communities may face flood situations while others may be the recipient of cyclonic storms. Community level risk assessment gives a clear picture of the vulnerability of individual communities to climate change and related disasters. It involves the local community, assesses local knowledge and helps to develop a needs based planning to disaster management. The ultimate outcome of CRA is the Risk Reduction Action Plan (RRAP) which identifies the vulnerability of communities at the local level and develops appropriate risk reduction action plan.

Study Locations

Seven districts (Satkhira, Faridpur, Sunamganj, Manikgonj, Sirajgonj, Rajshahi, and Cox's Bazar) were chosen for carrying out CRA and RRAP. The CRA component is quite vast and thus the contract

to carry out the study was given to several organizations. All these organizations have been carrying out the CRA and RRAP in the seven districts independently.

Objectives

For Pre-CRA:
To achieve the knowledge for facilitation of CRA Workshop by knowing the over all condition of the area – the physical condition, demographic situation, socio-economic condition- livelihoods, sources of livelihood, natural resources, hazards, its risk by sector and sub-sectors/social elements, and affected area, etc.

For CRA:

- Identification of types of hazards/disasters (natural, manmade & technological) by focus group discussions with farmers/fishers, landless, women and disabled/old aged people in small groups
- Description of risks for affected sectors/sub-sectors by specific hazard, its extent, intensity and vulnerability for the people.
- Compilation of findings in large groups, selection of risk, prioritization of risks and management of prioritized risk considering its intensity and vulnerability.
- Preparation of RRAP.

Methodology

Different methodologies were combined to carry out CRA study in the communities.

- Transect Walk
- Social Map
- Hazard Map
- Venn Diagram for hazard
- Seasonal calendar for hazard
- Seasonal livelihood calendar
- Focus Group Discussion (FGD)
- Key Informant Interview (KII)

Learning and Challenges

The CRA and RRAP process was completed in Nagarkanda Upzila of Faridpur District which was commissioned to BCAS. The study was carried out in 18 unions of the Upzila. The learning and challenges presented here are initial findings from Nagarkanda upzila only.

CRA and RRAP activities have helped to identify disasters, risk, impacts and develop different measures for reduction of impacts. It has created a platform where the professionals from various sectors, actors of disaster management and local community together can share their experience and recommendations on improved disaster risk reduction strategies. Due to their involvement in the process the community people feel that their needs have been addressed and hence feel a sense of pride and ownership. They strongly believe that this process will bring about risk reduction and they look forward to the implementation of RRAP. The action plan of the CRA addressed issues of capacity building and awareness raising regarding disaster management and risk reduction for the local people as well as disaster management actors. This will help the community to cope with disaster in a more efficient manner. Preparedness and emergency response were also a major part of CRA and RRAP.

Furthermore it was observed that the CRA and RRAP process brought about coordination and cooperation among the different levels of stakeholders in the community. This is essential for future implementation of plans and programmes for the development of the community.

The challenges faced by CRA and RRAP were integrating the participation of the community people into this process. A Union Disaster Management Committee (UDMC) was formed with the members of the Union Parishad and local people. Implementation of this committee and its work-plan posed challenges for CRA as well. It was quite difficult to bring about cooperation and compromise among the UDMC members and local community. Moreover, there was constraint towards the acceptance of CDMP mission and its mandate among the Union Parishad members and other relevant government departments. The change was viewed with suspicion and people did not want to change their traditional mindset for the new integrated approach used by CDMP. Participation of the community in UDMC was also a new concept for the local people, but these difficulties were overcome.

7 Conclusion

7.1 A. Recommendations

7.1.1 Recognition, Acceptance and Awareness Building on Climate Change amongst all actors

There is a need for recognition and acceptance, encourages, debates and discussions about the science and impacts of climate change. This has to cover all stages of decision making from global and international community, multi-state regional agencies, national government agencies, NGOs, academic institutions and the media both print and electronic. These should include the communities and general citizens also. There is need to produce simple but accurate and attractive background materials with particular emphasis on potential impacts and what they do to mitigate and adaptation.

7.1.2 Demonstrate Linkages between Impacts and Risks to Development

There is a need to establish and demonstrate the linkages between climate impacts and risks to development investment and activities. These have to be developed holistically showing the linkages between impacts and development activities. Sectoral examples are agriculture, water, forestry, infrastructure, energy, transport etc need to be analyzed.

7.1.3 Shift Planning Paradigms to include Climate Change issues

All planning efforts should incorporate climate change issues and concerns at all levels of decision making and planning. This includes all phases of planning i.e. conceptual, project development, programmatic approaches, implementation, monitoring and evaluation.

7.1.4 Develop Communication Tools

There is a need to develop communication and awareness tools for literate and non-literate populations. These tools include leaflets, posters, videos, media advertisement including TV, Radio and Newspapers.

Materials will have to be developed for schools, colleges and universities to be included in their curriculum. Non-formal educational tools also will need to be covered.

The tools will cover areas of

- Science
- Potential Impacts and Risks.
- Actions needed in
  - Adaptation
  - Mitigation
  - Policies
  - Research
- What different communities can and need to do.

7.1.5 Climate Proofing Development Efforts and Mainstreaming Climate Actions into Development

All major development efforts will have to be screened for actions that are required to incorporate adaptation for reducing climate risks and GHG reduction enhance mitigation measures. These includes measures such as-

1. Infrastructure (roads, embankments, drainage, buildings, power supply etc).

2. Shift in agricultural practices (cropping pattern, incorporation of irrigation and tillage practices, cropping intensity etc).

3. Urbanization and habitat.

To develop zonation systems where human habitat is to be discouraged for threats of sea level rise, enhanced flooding and saline intrusion. To discourage the formation of urban centres in areas under threats of climate risks.

7.1.6 Learning from Climate Variability and Preparing for Climate Change

The societies have developed traditional as well as management practices to adapt to climate variability and extreme weather events such as floods, cyclones, droughts, salt intrusion etc. The lessons are to be learnt from these practices, built on them and modify them for climate change related events including increased temperature, flooding (extent depth and duration), cyclones (velocity and frequency), salt water intrusion (rates and coverage).

7.1.7 Develop Tools and Methodologies for Local Level Adaptation

To develop, test tools and trains local level manpower for assessments of –

- Local level risks based on predicted impacts
- Vulnerability Assessments
- Adaptation needs.

7.1.8 To develop Adaptation Projects using Common Approaches and Methodologies

Adaptation projects, particularly sector based or at community level need to be developed using common methodologies. Early trials can be made using methodologies developed by BCAS and IIED for South South North Projects (Communities in Asia, Africa and Latin America).

7.1.9 Develop National Climate Change Strategies

It is important to involve all government agencies, NGOs, research and private sector professional bodies and chambers and leading business groups to develop national

- Adaptation Plan

- Mitigation Plan

While Bangladesh has already developed its NAPA (National Adaptation Plan of Action) its premise has been to undertake “urgent and immediate action”. This was a requirement for GEF funding only. The government should develop extended and wide ranging plan for adaptation complementing its development plan.

Similarly a Mitigation Plan should be developed to produce a large number of CDM projects for carbon reduction and funding mobilization. For this capacity needs to be built in the private sector, universities and research organizations. The Designated National Authority (DNA) needs to be strengthened and assisted with trained manpower and expertise.

The initial focus on capacity building should be on existing centres and institutions of proven capabilities and build on these in the first phase. Then these should be extended to other and new organizations.

7.1.10 Prioritizing Mitigation Plus Adaptation Projects

There are a member of potential projects which can qualify both as adaptation and mitigation in different components. These can be more Mitigation and less Adaptation and vice-versa.

7.1.11 Explore Possibilities of Micro Insurance for Climate Change

Learning Lessons from micro-credit, micro insurance approaches needs investigation, demonstration and early mobilization for developing local level insurance coverage.

7.1.12 Reaching the Needy and Marginalized

The marginalized and less accessible communities such as in remote islands, coastal vulnerable areas need to be reached and their capacity built to enhance adaptation and migration as a last resort. The NGOs, civil society organization should be utilized and supported with resource, training and institutional mechanisms to reach the most vulnerable and marginalized.

7.1.13 Utilization of Existing Networks and Institutional Vehicles

Use existing networks and vehicles such as disaster management communities, research institutes and NGOs at local and national levels to incorporate in action and efforts on climate change. Appropriate training and modifications would make these as cost-effective efforts.

7.1.14 Use of Eco-Specific Participatory Management Tools

Each ecosystem has its own characteristics, adaptation potential and participatory management practices. Many indigenous practices are being undertaken by local communities, NGOs and CSOs. Eco-specific management tools and practices should be analyzed to access different types of risk prone communities. Also efforts should be made to assess different levels of risks and addressed by appropriate level of actions.

7.1.15 Develop Research Capabilities

Appropriate research capabilities need to be developed in many sectors, such as agriculture, fisheries, forestry, infrastructure, renewable energy systems, waste management techniques to reduce risk and enhance adaptive capabilities. Many of these researches may contribute to mitigation by GHG reduction and changes in consumption behavior.

7.1.16 Develop and Extend Adaptation and Mitigation Technologies for Local Needs

It is important to develop adopt appropriate adaptation and mitigation technologies for risk reduction and GHG Mitigation. Example are-

- Development of salt tolerant varieties of rice.
- Floating garden technologies.
- Water efficient agriculture, particularly in drought prone areas.
- Seed bed technologies based on different extent and timing of flooding.

- Production of biogas plants and fertilizer production using dung, vegetation and human faeces.

- Improvement of more stable efficient fluorescent bulbs and other electronic control systems.

- Manufacture and penetration of solar photovoltaic panels in areas of no- electricity.

- Improved stoves at domestic, institutional and commercial levels.

- Developing of local level decentralized electricity generation and methods of selling back electricity to the grid. Appropriate procedures need to be developed also.

- Increase of fisheries in saline areas and sustainable forest development practices need to be enhanced.

7.1.17 Assessment and technology transfer of local level Disaster Management Practices

It would be cost effective to assess, evaluate appropriateness for climate response strategies and learn from and modify existing practices in disaster management at local levels. Also transfer these good practices to other areas likely to face similar disasters and risks.

7.1.18 To develop better forecasting of seasonal variability

In a climate change world the seasonal variability is likely to be accentuated. Better seasonal forecasting capabilities need to be developed and communicated effectively. This would help better preparation and reduce severity of impacts.

7.1.19 Facilitate Voluntary Movement and skill development of climate affected populations

It is important to organize efforts, mobilize and support NGOs and local government agencies to help skill development of youth and other members of communities so that they can be organized if they choose to migrate out of severely impacted areas, such as coastal inundated regions. They should also be trained and facilitated to market their skills in urban centres or in the external international markets.

7.1.20 Government Agencies and Climate Negotiators to be trained better and faster

The Government negotiators in the climate change processing such as UNFCCC, GEF, SBI, SBSTA and COP's should develop expertise and maintain continuity of participation, skill development and policy influencing techniques both in their government and at the international levels.

Normally this has been undertaken and confined to the Ministry of Environment and Forests. Other Ministries such as Ministry of Foreign Affairs and sectoral Ministries such as Agriculture, Water, Energy and Power should be brought in to strengthen these efforts and skills.

The training offered by Climate Experts and NGOs at both the national and international levels should be enhanced to develop the negotiation skills of potential participants.

7.1.21 Accessing Adaptation and Mitigation Funds

Special groups should be developed involving skilled government and non-government negotiators and experts to facilitate the access to emerging adaptation and mitigation funds. Many of the funds are in the form of projects, whether capacity building or implementation. Sometimes it is difficult to

separate adaptation activities from mainstream development activities. Efforts should be made to undertake research and identify global opportunities for fund mobilization at different levels.

- Government (e.g. capacity building)
- Private sector (e.g. CDM)
- NGOs (e.g. Adaptation fund etc.)
- Communities (e.g. Small Grant etc.)
- Research for assessment analysis policy support and technology development.

7.1.22 Enhance Government – NGO collaboration of Climate Activities

Bangladesh has active NGOs, several world's leading experts and institutions who have developed expertise and international reputation. The Government should formalize having their input into the policy formulation, training, project mobilization and fund facilitation processes by developing formal Government – NGO collaboration systems. This mechanism can be used, affect, influence and mainstream climate into the development process. This also can develop expertise to strengthen the private sector to invest in climate related activities.

7.1.23 Learning from World Wide Community Level Experiences of climate Variability

The recently held Second International Conference in Community based Adaptation to Climate Change" held in Dhaka during 24 -28 February 2007 has shared many experiences of climate variability and community level responses. There may be lessons learnt from one part of the world appropriate for another part whether in terms of technology, social mobilization or response strategies. Building on these wide ranging practices may help in developing research and actions for climate risk reduction.

7.1.24 Developing Common Regional Positions and Global Leadership Roles

Bangladesh government can play a key role in the Least Developing Countries (LDCs) Group within the G77+ China and UNFCCC negotiations. It should pursue its role in developing adaptation policies, mobilization of global funds for LDC countries and local communities and establishing better linkages between climate change and development.

Further Government of Bangladesh should make use of South Asian Association for Regional Cooperation (SAARC) to develop common Regional Policies and Programmes for implementation. Regional modeling and response strategies can be initiated early.

Bangladesh with its South Asian Regional partners should build on the Annual Training on Climate Negotiations offered to South Asian Government negotiators by the ECBI (European Capacity Building Initiative).

Further South Asian NGOs and research institutes through CANSA (Climate Action Network-South Asia) have already been working for a decade and half. This is the most long standing and organized regional node and can be strengthened to work with the regional government initiatives and programmes.

7.1.25 South Asian Regional Programme on Private Sector Development

A regional Programme may be developed on training and stimulating private sector, both for mitigation activities. Examples are mitigation, CDM, energy efficiency, renewable energy and adaptation activities such as infrastructure developments and mainstreaming climate into

development, Business, NGOs and Governments in the South Asian Region. CANSA network can be used to stimulate and facilitate such an initiative.

7.2 Mechanisms for Implementation

- Recognition of climate change development
- Assessment of vulnerability and risks and adaptation needs. Identify and opportunities.
- Institutional capacity building
- Integration
- Mainstreaming adaptation in development
- Build on existing experiences
- Raising and mobilizing resource of addressing adaptation
- Enhancing Govt. NGO collaboration
- Bringing private sector in adaptation technologies and marketing
- Linking local farmer to formal markets chain
- For critical mass of adaptation champion and advocates
- Enhancing negotiating capacity and extending to govt. agencies and NGOs.

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