Empowered lives.
Resilient nations.

COUNTRY REPORT
CLIMATE RISK MANAGEMENT IN BANGLADESH: FOCUS ON THE AGRICULTURE SECTOR

By Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES)

January, 2013

United Nations Development Programme

CRISIS PREVENTION AND RECOVERY

Supported by
United Nations Development Programme (UNDP)
Bureau for Crisis Prevention & Recovery (BCPR)-Bureau for Development Policy (BDP)
Under the
Climate Risk Management - Technical Assistance Support Project (CRM-TASP)

This report was commissioned by the United Nations Development Programme's Bureau for Crisis Prevention and Recovery (BCPR) under the Climate Risk Management – Technical Assistance Support Project (CRM-TASP)

This CRM-TASP report is authored by:

Arjunapermal Subbiah
Ramraj Narasimhan
J. Shanmugasundaram
Carlyne Yu
of Regional Multi-hazard Early warning System (RIMES) through a contract administered by Asian Disaster Preparedness Center.

Cite as: United Nations Development Programme (UNDP), Bureau for Crisis Prevention and Recovery (BCPR). 2013. *Climate Risk Management for Agriculture Sector in Bangladesh*. New York, NY: UNDP BCPR

Published by:
United Nations Development Programme (UNDP), Bureau for Crisis Prevention and Recovery (BCPR), One UN Plaza, New York-10017

UNDP partners with people at all levels of society to help build nations that can withstand crisis, and drive and sustain the kind of growth that improves the quality of life for everyone. On the ground in 177 countries and territories, we offer global perspective and local insight to help empower lives and build resilient nations. www.undp.org

CONTENTS

LIST OF ABBREVIATIONS AND ACRONYMS

BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agriculture Research Institute
BBS	Bangladesh Bureau of Statistics
BCCRF	Bangladesh Climate Change Resilience Fund
BCCSAP	Bangladesh Climate Change Strategy and Action Plan
BCPR	Bureau for Crisis Prevention and Recovery
BDP/EEG	Bureau for Development Policy Energy and Environment Group
BDT	Bangladesh Taka
BINA	Bangladesh Institute of Nuclear Agriculture
BJRI	Bangladesh Jute Research Institute
BMD	Bangladesh Meteorological Department
BRRI	Bangladesh Rice Research Institute
BSRI	Bangladesh Sugarcane Research Institute
CCA	Climate Change Adaptation
CCCM	Canadian Climate Change Model
CDB	Cotton Development Board
CDMP	Comprehensive Disaster Management Programme
CFAB	Climate Forecast Applications for Bangladesh
CRM	Climate Risk Management
CPP	Cyclone Preparedness Programme
CPPIB	Cyclone Preparedness Programme Implementation Board
CRM TASP	Climate Risk Management Technical Assistance Support Project
DAE	Department of Agriculture Extension
DMB	Disaster Management Bureau
DMC	Disaster Management Committees
DMTPATF	Disaster Management Training and Public Awareness Building Task Force
DRR	Disaster Risk Reduction
DSSAT	Decision Support System for Agro technology Transfer
ECNEC	National Economic Council (NEC) and its Executive Committee
EWS	Early Warning System
FFWC	Flood Forecasting and Warning Centre
GDP	Gross Domestic Product
GFDL	Geophysical Fluid Dynamics Laboratory
GOB	Government of Bangladesh
HYV	High Yield Variety
IMDMCC	Inter-Ministerial Disaster Management Coordination Committee
IRRI	International Rice Research Institute
JDNLA	Joint Damage, Loss, and Needs Assessment

MDG	Millennium Development Goals
MoA	Ministry of Agriculture
MOEF	Ministry of Environment and Forestry
MOFDM	Ministry of Food and Disaster Management
NAPA	National Adaptation Programme of Action
NARS	National Agricultural Research System
NDMAC	National Disaster Management Advisory Committee
NDMC	National Disaster Management Council
NDRCG	National Disaster Response Coordination Group
NGO	Non-Government Organization
NOAA	National Oceanic and Atmospheric Administration
NPDM	National Plan on Disaster Management
NPDRR	National Platform for Disaster Risk Reduction
NWP	Numerical Weather Prediction
OPP	Outline Perspective Plan
RIMES	Regional Integrated Multi-hazard Early Warning System for Africa and Asia
SAARC	South Asian Association For Regional Cooperation
SCA	Seed Certification Agency
SLR	Sea Level Rise
SOD	Standing Orders on Disaster
SPARRSO	Space Research and Remote Sensing Organization
SRDI	Soil Resources Development Institute
SYFP	Sixth Five Year Plan
UNDP CO	United Nations Development Programme Country Office
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
USD	United States Dollar
WASA	Water Supply & Sewerage Authority
WATSAN	Water and Sanitation

FOREWORD

Climate change has the potential to exacerbate conflict, cause humanitarian crises, displace people, destroy livelihoods and set-back development and the fight against poverty for millions of people across the globe.

For example, it is estimated that over 20 million people in the Mekong Delta and 20 million in Bangladesh could be forced to move as their homes are affected by saltwater incursion from rising sea levels. Entire populations of some low lying island states, such as Nauru or the Maldives may have to be relocated. In countries like Honduras, where more than half the population relies on agriculture, climate induced risks, such as hurricane Mitch in 1998, which caused over USD 2 billion in agricultural losses, will continue to pose a staggering potential for damage. Similarly, climate risk assessments in Nicaragua show that changes in rainfall patterns, floods and drought could put human health at risk by increasing the prevalence of respiratory and water borne diseases and malnutrition.

Long-term incremental changes will mean that people everywhere must learn to adapt to weather or rainfall patterns changing, or to shifts in ecosystems that humans depend upon for food. Perhaps more worrying however, is that climate variability and change will also bring unpredictable weather patterns that will in turn result in more extreme weather events. Heat waves, droughts, floods, and violent storms could be much more common in the decades to come. Climate change is "loading the dice" and making extreme weather events more likely. These disasters will undermine the sustainability of development and render some practices, such as certain types of agriculture, unsustainable; some places uninhabitable; and some lives unliveable.

As climate change creates new risks, better analysis is needed to understand a new level of uncertainty. In order to plan for disasters, we need to understand how climate change will impact on economies, livelihoods and development. We need to understand how likely changes in temperature, precipitation, as well as the frequency and magnitude of future extreme weather will affect any sector, including agriculture, water-use, human and animal health and the biodiversity of wetlands.

This report is a product of the *Climate Risk Management – Technical Assistance Support Project*, which is supported by UNDP's Bureau for Crisis Prevention and Recovery, and Bureau for Development Policy. This is one in a series of reports that examine high-risk countries and focus on a specific socio-economic sector in each country. The series illustrates how people in different communities and across a range of socio-economic sectors may have to make adaptations to the way they generate income and cultivate livelihoods in the face of a changing climate. These reports present an evidence base for understanding how climatic risks are likely to unfold. They will help governments, development agencies and even the communities themselves to identify underlying risks, including inappropriately designed policies and plans and crucial capacity gaps.

This series is part of a growing body of climate change adaptation resources being developed by UNDP. The Climate Risk Management – Technical Assistance Support Project has formulated a range of climate risk management assessments and strategies that bring together disaster risk reduction and climate change adaptation practices. The project is designing a common framework to assist countries in developing the necessary capacity to manage climate-induced risks to respond to this emerging threat. The climate risk assessments discussed in this report and others in the series will feed into a set of country-level projects and regional initiatives that will inform the practice of climate risk management for decades to come.

Addressing climate change is one of UNDP's strategic priorities. There is strong demand for more information. People at all levels, including small communities want to understand the potential impact of climate change and learn how they can develop strategies to reduce their own vulnerability. UNDP is addressing this demand and enabling communities and nations to devise informed risk management solutions. UNDP recognises that climate change is a crucial challenge to sustainable development and the goal of building resilient nations.

As the full effect of climate change becomes apparent, it is assessments such as these that will become the lynchpin of national responses and adaptation strategies for many years to come. Like the threat from many disasters, there is still time to prepare for the worst impacts of climate change in developing countries if we expand our understanding now.

This knowledge must be combined with real preparedness and action at all levels. Only then will we be able to stave off the worst impacts of climate change in the most vulnerable and high risk countries of our world.

Jordan Ryan
Assistant Administrator and Director
Bureau for Crisis Prevention and Recovery
United Nations Development Programme

Olav Kjorven
Assistant Administrator and Director
Bureau for Development Policy
United Nations Development Programme

ACKNOWLEDGEMENTS

The Report *Climate Risk Management for Agriculture Sector in Bangladesh* was commissioned under the Climate Risk Management – Technical Assistance Support Project (CRM-TASP), a joint initiative by the Bureau for Crisis Prevention and Recovery (BCPR) and the Bureau for Development Policy (BDP), UNDP and implemented by Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES) through a contract administered by Asian Disaster Preparedness Center.

The Project, its methodology and analytical framework was conceptualized by Maxx Dilley, Disaster Partnerships Advisor and Alain Lambert, Policy Advisor, Disaster Risk Reduction and Recovery Team (DRRT), BCPR with key inputs from Kamal Kishore, Programme Advisor, DRRT, BCPR and Ms. Bo Lim, Special CC Advisor, Environment and Energy Group (EEG), BDP.

Within BCPR, the Project implementation process has been supervised by Alain Lambert and Rajeev Issar who provided regular inputs to ensure in-depth climate risk assessments and identification of tangible risk reduction and adaptation options. From BDP, Ms. Mihoko Kumamoto and Ms. Jennifer Baumwoll provided their inputs and comments to refine the assessment and recommendations. The climate risk assessment has also benefitted immensely from the strategic guidance provided by Jo Scheuer, Global Coordinator, DRRT, BCPR and by Ms. Veerle Vandeweerd, Director, EEG, BDP.

The Project team would like to acknowledge and give special thanks to the main authors of the Report from RIMES.

For their valuable contribution to the project implementation and climate risk assessment process, the Project team and lead authors would like to gratefully acknowledge the unstinted support provided by colleagues from UNDP Country Office who provided regular inputs and anchored the process at the country level, officers from the national/sub-national nodal department/ agency and other stakeholders who actively participated in the deliberations.

The climate risk assessments under the CRM-TASP project have been undertaken with the funding support of the Government of Sweden.

EXECUTIVE SUMMARY

Bangladesh is a high climate risk prone country with a population of over 150 million people (BBS, 2012). Due to the reforms initiated in early 1990s, the country has witnessed an impressive annual economic growth at the rate of 6.3 percent GDP in the last decade (World Bank, 2012). Population below the poverty line has been reduced from 50 percent in 1996 to 31.5 percent in 2010 (World Bank, 2012). Food grain, particularly rice crop production has increased over two folds from 17 million tons in 1970 to 48 million tons in 2009 (IRRI, 2012). The share of agricultural sector GDP however has come down from 70 percent (in 1950) to 18 percent (in 2011) and the contribution of industry and service sector is around 82 percent (World Bank, 2011). A gradual shift in rice production from high risk pre-monsoon and monsoon seasons to low risk post- monsoon seasons has largely insulated rice production from recurrent floods.

Despite an impressive economic growth during the last decade, key development concerns persist. Although the agriculture sector's contribution to the GDP has gradually reduced, agriculture still supports 65 percent livelihoods (source and date).The rural economy constitutes a significant component of the national GDP, with agriculture (including crops, livestock, fisheries and forestry) accounting for 21 percent and the non-farm sector, which is also driven primarily by agriculture, for another 33 percent (World Bank, 2012).Rural poverty is very high at 47 percent of the rural population and population increases have prevented Bangladesh from meeting its basic nutritional needs. The country still depends on food aid of around 300,000 tonnes of food grains every year. Bangladesh's geographical location also makes it one of the most vulnerable countries to climate change and natural calamities like cyclones and floods. Sixty percent of the worldwide deaths caused by cyclones in the last 20 years occurred in Bangladesh (World Bank, 2012).

The agriculture growth since the early 1980s largely focused on increasing rice production during the dry season (Nov-Jun). 80 percent of rice production increase came from dry season rice crop; with exploitation of groundwater and high consumptions of fertilisers and pesticides. This approach has reached its limits due to unsustainable use of ground water beyond recharge capacities and degradation of soil. The over reliance on dry season rice production has also marginalized the production of oil seeds and pulses. It costs the government one-fifth of foreign exchange earnings every year to import these commodities.

Taking note of these development concerns, the Government of Bangladesh (GoB) developed a Vision Document-2021 to achieve a balanced economic growth, significantly reduce poverty and enhance sustainable food security for a large section of the population.

The Vision Document-2021, proposes to shift a large number of rural work-force to industrial and high productivity service sectors using a skill development approach. However, considering the geophysical location of Bangladesh, the industrial facilities and production processes could be exposed to risks of recurring floods and tropical storms. Moreover the risks faced by the agriculture sector could have a cascading impact on the industrial and service sector, since agriculture indirectly supports these sectors by providing raw materials and markets to manufactured goods. However, there has been no systematic evaluation of such risks on future development trajectories. It also proposes to increase agriculture productivity to ensure national food security.

Considering the limitations of current crop production patterns, the Sixth Five Year Plan (2011-2015) in consonance with Vision Document-2021 recommends an ecologically favourable option of reserving the winter season (Nov-Feb) for the production of non-rice crops and March-Oct for rice crops. However, pre-monsoon and monsoon season production of rice exposes it to high levels of climate risk. Past experience suggests that the monsoon floods could destroy around 1-3 million tonnes of rice crop depending on severity of floods (as in the case of the 1998 and 2007 floods). A cyclonic storm at the time of harvest could destroy around 1 million tonnes of rice crop (as in the case of Cyclone Sidr in 2007). Prolonged dry spells during monsoon season and soil moisture deficiencies in the post monsoon season could reduce crop by 1-3 million tonnes (as in the case of the 1979 and 2006 droughts).

The current Sixth Five Year Plan (2011-2015), also proposes to restructure crop systems with drought and submergence tolerance rice variety. This strategy needs extensive resources for research and extension efforts including development, testing and introduction of new risk resistant varieties. The SFYP however has only allocated 0.01 percent of the annual development budget (US$ 200 million) in the next five years for crop production, which is not adequate for restructuring of the cropping pattern and could take a long time.

In the above context, several efforts have been made to understand the nature of past and emerging climate risks in Bangladesh. Within the sector of agriculture, there is growing interest within the Ministry of Agriculture (MoA), Ministry of Environment and Forestry (MoEF), the Ministry of Food and Disaster Management (MOFDM) and their respective agencies to reduce these risks. However, they are limited by resources, capacities and coordination processes to conduct climate risk assessments, develop CRM options in response to emerging risks and operationalize them at the local level.

In light of the above limitations, this assessment report recommends the following areas of priority work for climate risk reduction and resilience in Bangladesh in general and in the sector of agriculture in particular:

1. **Strengthen climate risk assessment** by capacity mapping, leveraging and developing capacities of key government stakeholders. Additionally, expand the scope of the assessment to include potential impact of not only existing, but emerging climate risks and, understanding the impact of climate risk on the national economy and social welfare in the short and long term. Further, map capacities of both government and non-government actors who are invested in reducing climate risks;

2. **Prioritization of climate risk options** by including new generation forecast technologies including the 5 to 10 day flood and weather forecast and farmer-need-based agro advisories system; crop restructuring; crop diversification; crop insurance; ground water management and enhancing in-land fisheries habitat by controlling low-land boro rice cultivation. The new generation flood forecasting technology can be used to reduce risk in agriculture and other climate sensitive sector, production facilities and processes;

3. **Information Management for CRM** by building a dedicated and use-friendly climate information system for agriculture management within the MoA. A conservative estimate of the value of weather information to minimise climate risk and maximize potential agricultural management gains in Bangladesh is estimated to be 2.3 billion USD per annum. Such a system should provide tailor-made climate information as per user needs; characterize and package uncertainties associated with climate information of different timescales; interpret and translate climate information and inherent risk in climate information and; demonstrate the economic benefits in using climate information and adopting the CRM framework;

4. **Capacity development for effective and sustainable climate risk reduction and resilience.** This includes building of institutional, financial and technical capacities of the key government stakeholders including Bangladesh Meteorological Department's (BMD), Department of Agriculture Extension (DAE), Flood Forecasting and Warning Centre (FFWC), Disaster Management Bureau (DMB) and relevant agencies and authorities under the Ministry of Agriculture (MoA) with mandates and roles in CRM. These efforts should be aligned with the existing plans of the GoB and MoFDM to strengthen CRM, for example to upgrade the entire early warning system for all natural hazards, considering that investment of 1 US$ in EWS could bring benefit of 40 US$.

Although this study's focus was on assessing the CRM capcities and gaps of the government in Bangladesh, there is need to take stock of the capacities and needs of the non-government sector, which is a critical player in development, climate change adaptation and disaster risk management in the country.

INTRODUCTION

BACKGROUND

Climate risk management (CRM) is an inter-disciplinary, multi-stakeholder process that involves analysis of climate-related risks leading to consensus-based identification and prioritization of risk management actions to anticipate and manage both extant and emerging climate risks.

Climate Change can further alter the observed climate mean or cause changes in nature of extremes (severity, frequency, spread, duration and timing) as well as possible surprises. The resultant climate risks could resemble current climate variability patterns, but with higher amplitude variations. Hence, CRM suggests that pattern of risks could be anticipated and the experiences of present systems in dealing with these risks could be drawn upon towards building resilience to long-term climate change. For climate "surprises," while past climate patterns may not provide any clue as to how they would unfold and manifest, human experiences in dealing with extreme climate events may provide guidance for dealing with uncertainties associated with climate change-related risks. Thus from a policy point of view, building the capacities of institutions and systems around managing current climate extremes and thereby a resilient development, could also assist to take care of climate "surprises."

The climate risk management framework has been developed by the United Nations Development Programme (UNDP), through its Bureau for Crisis Prevention and Recovery (BCPR), responsible for assisting countries to develop capacity to better manage disaster risks, and Bureau for Development Policy's Energy and Environment Group (BDP/EEG), responsible to assist countries to develop capacity to adapt to climate change. The framework aims to assist countries to develop capacities to manage risks associated with climate variability and change. The Climate Risk Management Technical Assistance Support Project (CRM TASP) aims to facilitate the operationalization of CRM frameworks by integrating CCA and disaster risk reduction (DRR). As a first step it involved assessment of risk management priorities and capacity needs in six countries in Asia, including Bangladesh. The Regional Integrated Multi-hazard Early Warning System for Africa and Asia (RIMES) in collaboration with Asian Disaster Preparedness Center (ADPC) were tasked with facilitating this assessment in partnership with national stakeholders in Bangladesh.

APPROACH AND METHODS

The CRM TASP was initiated through a regional inception meeting organized for the UNDP focal points and key government representatives from the six countries at Pondicherry, India in July 2010. In Bangladesh the project involved the Bangladesh Meteorological Department (BMD), the United Nations Development Programme (UNDP) and the Ministry of Food and Disaster Management. It also involved extensive consultations with Flood Forecasting and Warning Centre (FFWC), Disaster Management Bureau (DMB), Department of Agriculture Extension (DAE) among others. Based on stakeholder consultations, the projects dual focus was on one, the agriculture sector, considering its contribution to the economy in general and the livelihoods and food security of Bangladeshis in particular, and two, on strengthening early warning capacities for addressing climate risk through a review seeking to assess the capacities and gaps of national and local government stakeholders. Table 1.1 outlines the implementation process and the approach adopted for undertaking the climate risk assessment.

TABLE 1.1 PROJECT STEPS AND METHODS

PROJECT STEP & PURPOSE		SPECIFIC STEPS APPLIED IN BANGLADESH
1. Initiation	• Introduce CRM TASP • Country engagement in Bangladesh facilitated by UNDP Country Office (UNDP CO)	• Inception Meeting and discussions with key stakeholders • Discussions with UNDP CO and the national stakeholders resulted in identification of agriculture sector as priority sector, and agriculture risk management as entry point for CRM. Also determined focus on climate risk information applications for decision-making, especially around early warning systems for climate events.
2. Needs Assessment	• Participatory risk assessment involving stakeholders • Identify stakeholder needs to integrate CRM into sectoral planning and practices • Community Risk Profiling and Assessment to identify community level climate risks and perceptions	• Established a National CRM forum with participation of climate information providers and users. It provided a platform for generating, interpretation, application and integration of different time scale oriented climate risk information products at the national and local level. It strengthened the multi-hazard early warning system through a regular and sustained multi-stakeholder dialogue that identified key gaps and priorities for each sector. • Established Monsoon Forums to identified climate risk patterns and potential use of information for risk reduction and capacity enhancement for generation and application of CRM information. • Designed a community focussed consultation process. • Profiled two pilot sites to assess community perceptions on climate risks, climate change and integration of information for managing current and future risks.
3. Integration of CRM in government systems	• Integrate CRM process into development planning processes and institutions.	• Proposal developed for upgrading the current EWS using state-of-the-art know-how and information. Developed by the Ministry of Food and Disaster Management (MOFDM) with involvement of all stakeholder departments and assistance from RIMES. It focusses on building community resilience to climate event; improving accuracy of forecasting for extreme weather events and strengthening disaster management institutions for end-to-end warning, including capacities and products for decision-makers for all time-scales. • The GOB has agreed to allocate resources for the project under its Climate Resilient Program
4. Documentation and Report writing	• Documentation and finalisation of CRM TASP report	• Synthesis of the process used to develop the CRM Bangladesh Country Report, which was shared with UNDP CO

REPORT STRUCTURE

This report documents the analyses and outcomes of a capacity and gap analysis for CRM in Bangladesh. Chapter 1 captures the process steps and methods used during the analysis. Chapter 2 focuses on the development context and trends in Bangladesh, and the rationale for prioritization of climate sensitive issues. Chapter 3 focuses on geo-physical environment and climate risk features of Bangladesh. Assessment of climate threats in the context of past climate risks and anticipated climate change projections are covered in Chapter 4. Current Climate Risk Management processes, policy and institutional systems to address the threats are discussed in Chapter 5, and Chapter 6 focuses on ownership of CRM within the government, assessment of capacity needs, and recommendations for future actions.

DEVELOPMENT PROFILE

This chapter provides a brief analysis of the development context in Bangladesh as relevant to climate sensitivity and risk management. It covers key development conditions, trends observed over the past decades, and their projected future as envisioned in the national planning documents.

CURRENT DEVELOPMENT CONDITIONS, TRENDS AND CHALLENGES

Bangladesh is spread over close to 148,000 square km, much of it being exceedingly flat, low lying, fertile alluvial plains in the deltaic regions of two major rivers- Ganges and Brahmaputra and over 230 rivulets. Bangladesh has a coastline of over 710 km along the Bay of Bengal to which its rivers empty forming a biodiversity rich deltaic mangrove area called the *Sundarbans*. The coast also opens up Bangladesh to frequent tropical cyclonic storms and depressions that result in damage from heavy rainfall, winds, and storm surges that inundate hundreds of kilometres of the low-lying coastal belt.

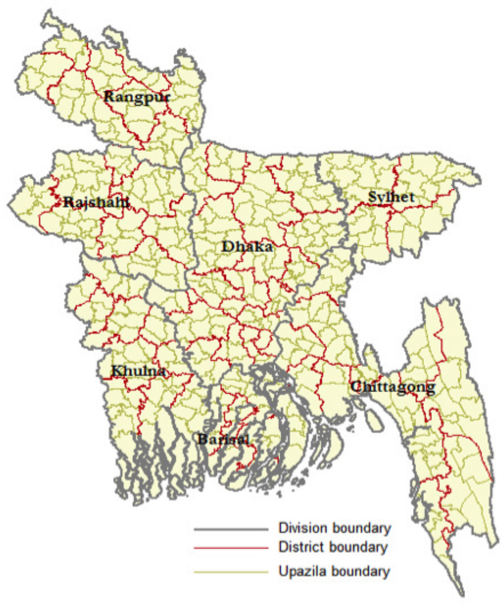


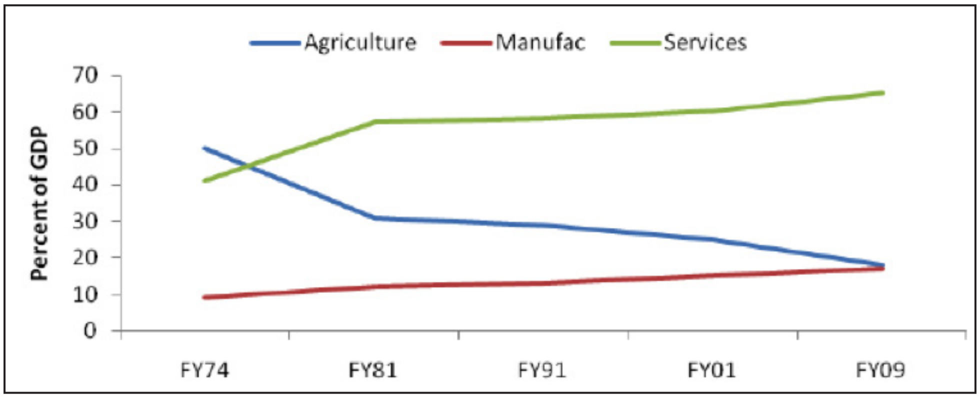
Figure 2.1. Divisions of Bangladesh

The country is divided into seven administrative divisions- named after their headquarters or largest cities located therein- Dhaka, Sylhet, Chittagong, Barisal, Khulna, Rajshahi and Rangpur. Dhaka, its capital city is also the largest city and largest region. These divisions are made of 64 districts (*zila*) which are further sub-divided into sub-districts (*upazila*), which are comprised of *Unions*, which comprise several villages. Over 150 million people live in Bangladesh, resulting in a density of over 1000 persons per sq. km, making it one of the most densely populated countries in the world. Over two-thirds of its population reside in rural areas. Dhaka metropolitan area is home to over 13 million people.

Despite the significant development strides made by Bangladesh, 31.5 percent of its population is poor (2010), of whom more live in rural areas (35.2 percent) compared to urban areas (21.3 percent). The improvement in poverty rates, from 56.6 percent in 1992 to 31.5 percent in 2010, is largely attributed to the economic growth in the 90s resulting from the revenue generated by readymade garments manufacturing and remittances from overseas Bangladeshis (SFYP, 2010). Poverty is also unevenly distributed across the country. A high proportion of poor live in the coastal region of Barisal and their poverty is largely attributed to the large number of disasters impacting this area (SFYP, 2010).

The current structure of the Bangladeshi economy is very different when compared to the past few decades (*Refer to Figure 2.2*). There has been a decline in contribution of the agriculture sector (from close to 50 percent in 1970s to less than 20 percent in 2012), concurrent with the steadily increasing contribution of manufacturing sector (from 10 percent to about 20 percent) and the more rapidly increasing services sector (from 40 percent to over 60 percent) of the Gross Domestic Product. (GDP).

Development practice has contributed to environmental issues like ground water depletion (due to increasing rice cultivation during Boro season), arsenic contamination of ground water (exposing almost 20 million people), and inundation of the low-lying coastal areas due to sea level rise and during storms.



Source: Bangladesh Bureau of Statistics

Figure 2.2: Structure of Bangladesh Economy, FY74-FY09

NATIONAL DEVELOPMENT VISION, OBJECTIVES AND PRIORITIES

The key document guiding current development in Bangladesh is the Sixth Five Year Plan 2011- 2015 (SFYP). It has been formulated in accordance with the development vision articulated in the Outline Perspective Plan (2010-2021), which in turn is based on 'Vision 2021', of the current government.

Vision 2021 aims to make Bangladesh a middle-income country by 2021. It aims to reduce poverty significantly (by two-thirds compared to 2008) by strengthening agriculture, improving social safety nets for the poorest and, generating employment opportunities to halve unemployment. Some of the priorities and strategies in agriculture and rural development in Vision 2021 are:

1. Food self-sufficiency in Bangladesh, including crops, fish, milk, egg, livestock etc. Increased agricultural subsidies, enhanced and simplified lending, agricultural storage facilities and fair prices for agricultural production;

2. Commercial agriculture, use of genetic engineering methods and development of non-agricultural sector in rural areas. Increased agriculture production through modernization of agriculture, technological innovations, and improved research in agriculture;

3. Reclamation of coastal lands, and improved land database to allocate land to landless farmers.

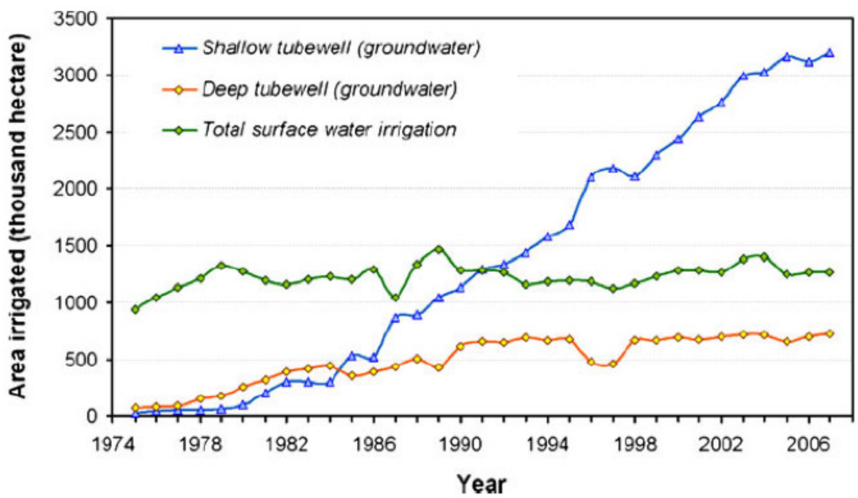
While, the Vision 2021 and OPP notes the declining contribution of agriculture and allied sectors to the GDP, it recognizes their vital importance in providing employment to 48 percent of the total population. The Vision 2021 aims to bring down the proportion of population dependent on agriculture for employment to 30 percent by transferring some of them through to the industrial and service sectors by 25 percent and 45 percent (from corresponding figures of 16 percent and 36 percent in 2008) respectively. It also aims to strengthen agriculture as a key sector for food security and poverty reduction. Noting the decreasing availability of land due to competing demands on scarce land resources, the plan focuses on increasing agricultural productivity and diversification in both crop and non-crop subsectors to increase incomes from agriculture.

The SFYP has also set targets for development programmes to operationalise the vision laid out in OPP and Vision 2021 including an annual average growth of 7.3 percent, poverty headcount reduction by 10 percent and increased employment in the industrial sector.

CONDITIONS, TRENDS AND PRIORITIES IN THE AGRICULTURE SECTOR

Agriculture, despite its decreasing contribution to GDP, from over half in 1970s to less than one-fifth now, is a critical sector, providing employment to around half of the work force in Bangladesh. It is growing steadily at a rate of over 4 percent per annum, largely due to adoption of better and high yielding varieties- especially rice, and introduction of new cropping resulting in crop intensity of 180 percent.

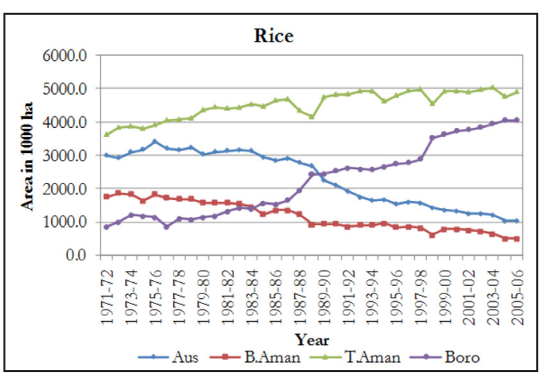
The total cultivable area in Bangladesh is about 8 million hectares of which over 7.53 million hectares are already cultivated, leaving less than 0.47 million ha fallow. There are over 14 million farm holdings with a very large percentage small and marginal holdings practising mainly subsistence based farming. Only 171,000 farms were more than 3 ha in 2005. Despite abundance of water resources just over 56 percent of the total agricultural lands are irrigated. Ground water irrigation accounts for a surprisingly large percentage of close to 80 percent with surface water sources contributing to only 21 percent. Much of the ground water is extracted through the shallow tube wells. (Refer to Figure 2.3)

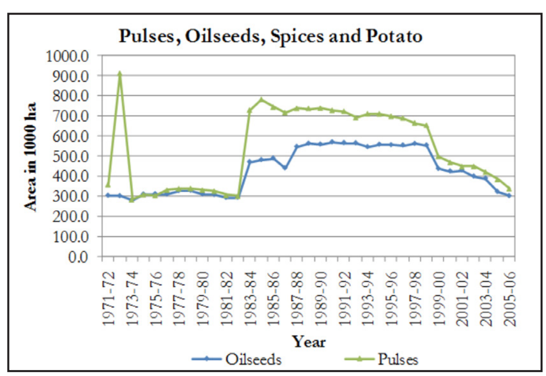


Source: Shamsudduha et al., 2011

Fig. 2.3 Trends in annual records of the area irrigated by shallow tubewells, deep tubewells, and surface water in Bangladesh from 1975 to 2007

Total rice produced in 2010-11 was 33.5 million tons of which over 55 percent was Boro rice, 38 percent Aman and just over 6 percent was Aus . This is a significant improvement compared to production of 15.4 million tons 25 years before (1986-87). Major reason for the increased production is the three-fold expansion in Boro cultivation (from 4 mi ha to 11.7 mi ha) resulting in over a four-fold production increase (from 4 mi tons to 18.6 mi tons), and use of improved (high-yielding) varieties. Boro rice has replaced the monsoon dependent (and affected) low-yielding Aus crop. This increase is also a result of increased area brought under irrigation- mostly sourced from ground water. Changes in cropped areas of rice, cereals, pulses, fruits and vegetables from 1971 to 2006 are presented in Figure 2.4.





Source: Ministry of Agriculture Data

Figure 2.4: Changes in cropped areas: Rice and Pulses, Oilseeds

Analysis reveals that over 18 policies guide the agriculture sector (*GoB, 2006*; Annex 2 lists the important policies and their key thrust areas). The most recent and important being the National Agriculture Policy, revised in 2010. The National Agricultural Policy notes that climate and environmental factors such as risks from floods, droughts, storms, salinity, river erosion, pests and climate change associated risks are the major threats for agriculture sector. The Policy aims to develop and harness improved technologies through research and training, increase productivity, income and employment by transferring appropriate technologies and managing inputs; promote competitiveness through commercialization of agriculture; and establish a self-reliant and sustainable agriculture adaptive to climate change and responsive to farmer's needs.

The policies emphasises research and development, agriculture extension, provision of quality seeds and planting materials and fertilisers, sustainable irrigation practices, mechanization of agriculture and better marketing facilities and linkages. However, many of them are based on notional ideas and not backed by rigorous and thorough analysis of data both due to lack of their availability and lack of capacities to undertake such analysis (*ibid*).

SFYP also considers agriculture a key component of development in Bangladesh. Noting that food import accounts for over one-fifth of the export earnings, SFYP proposes crop diversification to reduce imports of non-cereal food items such as pulses, oils etc. Some of the major objectives of the SFYP relating to the agriculture sector are:

a. To attain self-sufficiency in food grain production and increase production of nutritional crops;

b. To increase productivity and real income of farming families in rural areas on a sustainable basis;

c. To promote adoption of modern agricultural practices in drought, submergence and saline prone areas;

d. To encourage research on adaptation to climate change and proper use of genetically modified technology in agriculture;

e. To gradually shift the main HYV, irrigation-fed Boro rice production to the Southern areas; utilize salinity, submergence, and other stress tolerant varieties, and utilize surface water for irrigation;

f. To utilize the irrigated north-eastern uplands to grow more high value cash crops like wheat, maize, corn etc. and horticulture products;

g. To increase production of jute, by improving jute variety and systems to obtain quality fibres;

h. To include oil crops and spices for increased production;

i. To encourage research and extension for the promotion of pulse crop, and;

j. To bring coastal and hilly areas under intensive cultivation.

Some of the key strategies proposed in the SFYP to achieve these objectives are food inter-cropping, diversification, crop intensification (especially in Sylhet and Char areas), use of winter season (November to February) for non-rice crops and improved research and development capacities to develop stress tolerant varieties (salt-tolerance, submergence tolerance, and drought tolerance for rice, and heat tolerance for wheat). Building an enabling environment is also proposed through land reform initiatives, use of technology including information and communication technology and remote sensing to systematically collect accurate data, and increase storage facilities.

KEY MESSAGES (DEVELOPMENT PROFILE)

- Bangladesh is a least-developed country with a population of 150 million people with a poverty level of 31.5 percent. (2010).

- Its economy has been transformed in recent decades from agriculture sector-led to manufacturing and service sector-led.

- Despite increased economic growth in the recent decades, 47 million people live below the poverty line and food security is very delicately balanced with production just equalling demand.

- The environment is overstretched to support dry season Boro crop in terms of over-exploitation of ground water and degradation of soil health. There is a need to balance both the needs of crop production with environmental sustainability.

- Increasing Boro crop production has come at the cost of other rice crops like Aus and B.Aman and; jute, oil seeds and pulses crops.

- Development Vision 2021 and related policy and planning instruments propose to address these trends and bring a balanced, sustainable economic growth by reducing poverty to less than 15 percent, ensuring food security to all, strengthening the agriculture sector and transferring livelihoods from agriculture to the manufacturing and service sectors.

CLIMATE PROFILE OF BANGLADESH

This Chapter provides baseline information on current and future climate and related trends in Bangladesh.

NATIONAL WEATHER AND CLIMATE CONTEXT

Bangladesh extends from 88°E to 92°35′ longitude and 21°N to 26°40′ N latitude. The country has a tropical monsoon climate characterized by wide seasonal variations in rainfall, high temperatures, and high humidity. Regional climatic differences in this flat country are minor. Three seasons are generally recognized: summer from March to May; monsoon season from June to November; and winter from December to February. Monthly rainfall and temperature climatology are presented in Figures 3.1a and b.

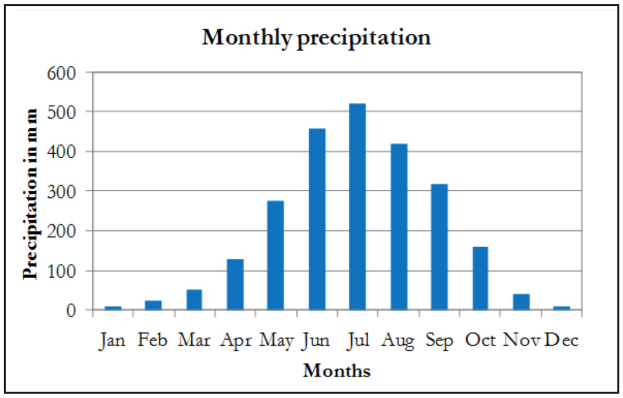


Figure-3.1a Rainfall Climatology of Bangladesh

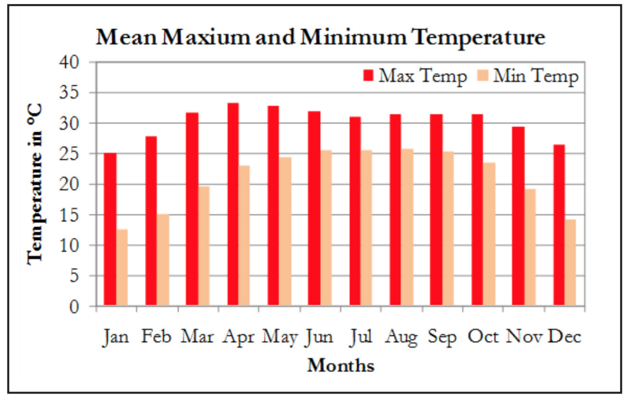


Figure-3.1b Temperature Climatology of Bangladesh

Rainfall

Annual average rainfall is 2,427.7mm. The monsoon season (June-Nov) has significant rainfall (Figure 3.1 a and b), with the north eastern region and south eastern coastal zones receiving heavier rainfall than other parts of the country. The north western part of Bangladesh receives very low rainfall compared to the country, for example, Rajshahi, has an annual rainfall of about 1,600 mm (63.0 in). Monsoon season accounts for about 80 percent of the rainfall. The month of July registers the highest rains because of south west monsoon. Bangladesh also has significant spatial rainfall variability as per Figure 3.2.

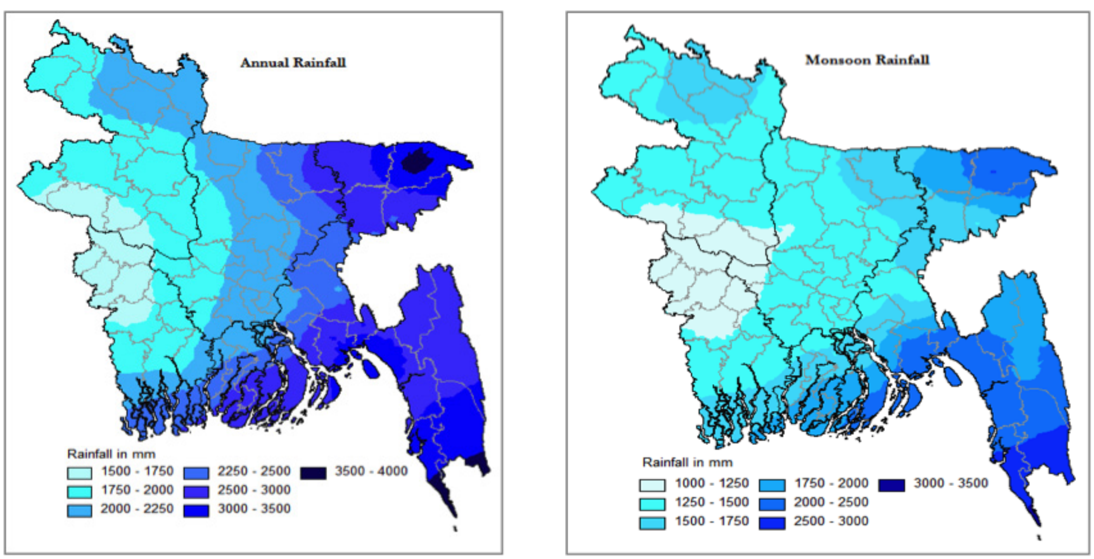
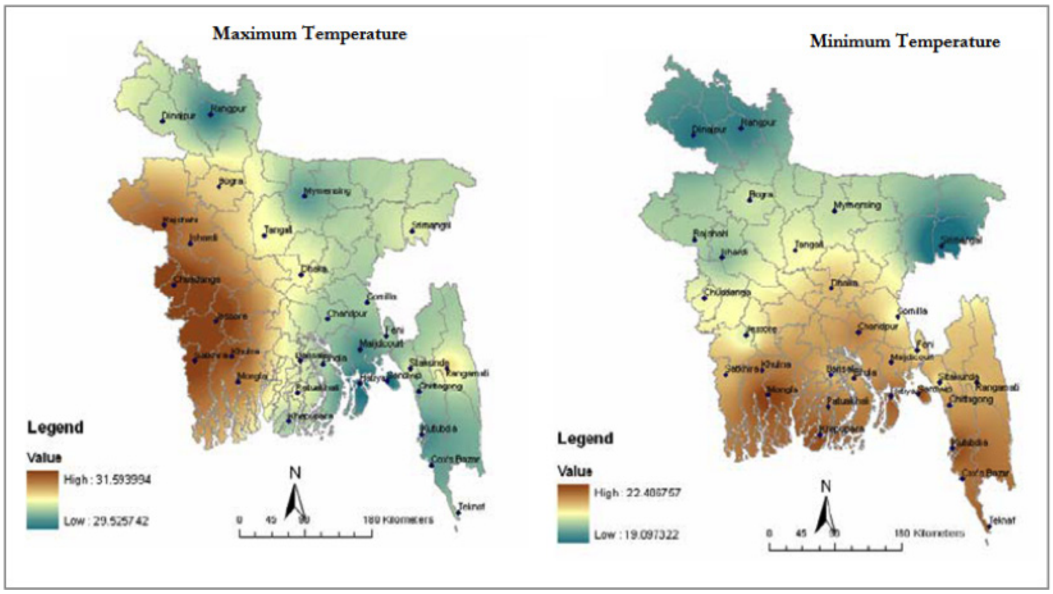


Figure 3.2: Annual and monsoon rainfall distribution in Bangladesh [Source: Islam[2]]

Temperature

Average maximum temperature in the country fluctuates between 25.2°C to 33.2°C and average minimum temperature fluctuates between 12.5°C to 25.7°C. The maximum of mean maximum temperature occurs in the month of April (Chuadanga recorded 36.3°C), and March to May are relative hot season for Bangladesh. The minimum temperature is generally recorded in the month of January. Maximum and minimum temperature intra annual variation is presented in Figure-3.1b. Figure 3.3 shows the spatial distribution of temperature in Bangladesh, which highlights the western zone as having higher temperature than the eastern zones and north Bangladesh with the lowest minimum temperature in the country.



Source: Islam, undated[2]

Figure 3.3: Rainfall monsoon in Bangladesh (1971 to 2005)

CURRENT CLIMATE DRIVERS AND HAZARDS

Climate drivers

Bangladesh is located in the humid tropics, with the Himalayas on the north and the funnel-shaped coast touching the Bay of Bengal on the south. This peculiar geography brings not only the life-giving monsoons but also catastrophic cyclones, tornadoes and floods. The Bay of Bengal provides an ideal breeding ground for tropical cyclones. Rainfall in Bangladesh mostly occurs during the monsoon season, caused by weak tropical depressions that are brought from the Bay of Bengal. Higher rainfall in the northeast is caused by the additional uplifting effect of the Meghalaya plateau. (Shahid, 2010[3])

Climate hazards

Bangladesh is exposed to climate hazards such as flood, flash flood, cyclone, drought, storm surge and heavy rainfall. According to the Asia Pacific Disaster Report 2010, Bangladesh leads the Top 10 countries in the Asia-Pacific region based on absolute physical exposure to floods; is 5th for storms; and 8th for earthquakes (RIMES, 2011). According to the World Bank (2012) Bangladesh's geographical location makes it one of the most vulnerable countries to climate change and natural calamities like cyclones and floods. Sixty percent of the worldwide deaths caused by cyclones in the last 20 years occurred in Bangladesh.

Flood

Climate variability in Bangladesh will likely have the most adverse effect on water related hazards– primarily coastal flooding (from sea and river water), and inland flooding (river and rain water) are expected to increase. Flooding is a regular feature in Bangladesh and has contributed to loss of life through drowning, increased prevalence of disease, and destruction of property.

Much of Bangladesh is located on a floodplain with three major rivers and their numerous tributaries. One-fifth of the country is flooded every year, and in extreme years, two-thirds of the country can be inundated. This vulnerability to flooding is exacerbated by its location in a low-lying delta exposed to storm surges from the Bay of Bengal. (Figure 3.4)

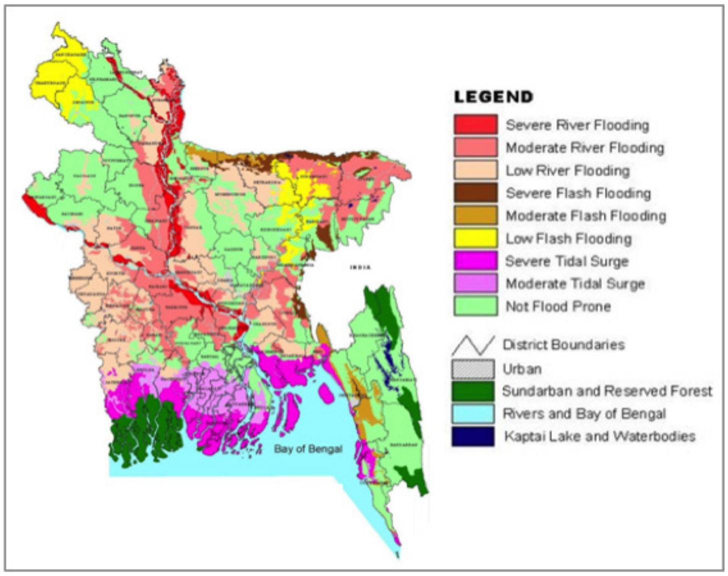


Figure 3.4 Flood hazard map of Bangladesh

Source: BARC, 2000[4]

Tropical storms and cyclones

Cyclones in Bangladesh and its adjoining areas are common and destructive. Cyclones hit Bangladesh in April-May and September-December. On an average, five severe cyclonic storms hit the country every year and the accompanying surge can reach as far as 200 km inland. Storm surges are one of the most destructive elements of the cyclone, and they hit Bangladesh as high as 3m to 9m. Astronomical tides in combination with cyclonic surges lead to higher water levels and hence severe flooding.

From 1981 to 1985, 174 severe cyclones were formed in the Bay of Bengal. Because of the funnel shaped coast of the Bay of Bengal, Bangladesh very often becomes the landing ground for these cyclones. The Bay cyclones also move towards the eastern coast of India, towards Myanmar and occasionally into Sri Lanka. But they cause the maximum damage in Bangladesh and the states of West Bengal and Orissa in India. This is because of the low flat terrain, high density of population and poorly built houses.

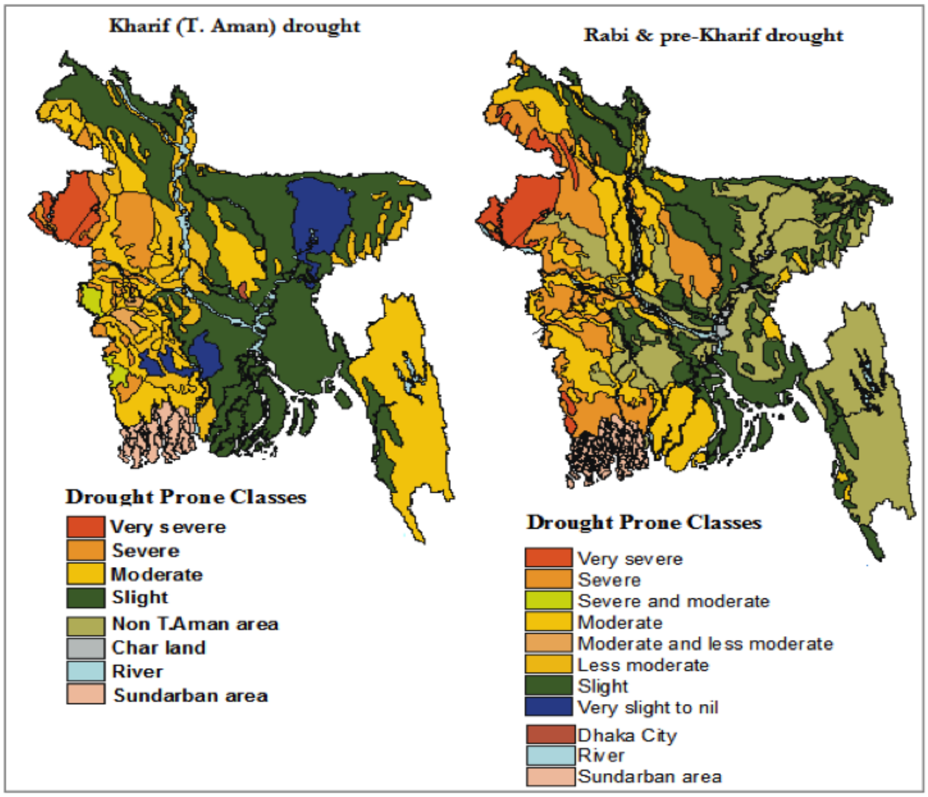
Cyclone warning and preparedness measures have improved in Bangladesh in recent years (RIMES, 2011).. Bangladesh's Comprehensive Cyclone Preparedness Programme (CPP) jointly operated by the Bangladesh Red Crescent Society and the Ministry of Disaster Management and Relief has aided this process. Nevertheless, the frequency and severity of cyclones appears to have increased.

Drought

In Bangladesh drought is defined as the period when moisture content of soil is less than the required amount for satisfactory crop-growth during the normal crop-growing season. Droughts are common in the north-western districts of Bangladesh, mostly affecting the pre-monsoon and post-monsoon periods.

The Barind Tract, that covers parts of the greater Dinajpur, Rangpur, Pabna, Rajshahi, Bogra, Joypurhat and Naogaon districts of Rajshahi division, receives an average rainfall of about 1,971 mm, mainly during the monsoon. Rainfall has reduced over the years from about 1,738 mm in 1981 to 798 mm in 1992. The average highest temperature of the Barind region ranges from 35°C to 25°C for the hottest season and 12°C to 15°C for the coolest season. This semi-arid, older alluvium region could also experience highs of 45°C in summer and lows of 5°C in winter, which are extremities compared to the climatic conditions in the rest of the country.

Droughts are mostly created by the cross boundary anthropogenic interventions. About 58 rivers that flow through Bangladesh come through India and Myanmar (India - 55 and Myanmar - 3). The natural flow of these rivers is interrupted by upstream withdrawal of water for economic and household uses and water management structures by the concerned countries. This obstructs the normal flow of water in rivers such as the Ganges (at Farakka), the Punarbhaba (just beyond Banglabandha) and the Tista. These structures create not only a scarcity of surface water in Bangladesh, but also negatively affect the recharge of groundwater (RIMES, 2011). Figure 3.5 shows the drought prone areas during the Kharif, Rabi and pre-Kharif seasons.



Source: BARC, 1990

Figure 3.5 Drought map of Bangladesh

Other hazards

Bangladeh's location and high density of population has resulted in devastating impacts of tropical cyclones, tornadoes, floods, storm surges and droughts. It is also impacted by landslides from heavy rainfall in the southern part and earthquake due to presence of the tectonic plate under Dhaka and Chittagong (RIMES, 2011[5]).

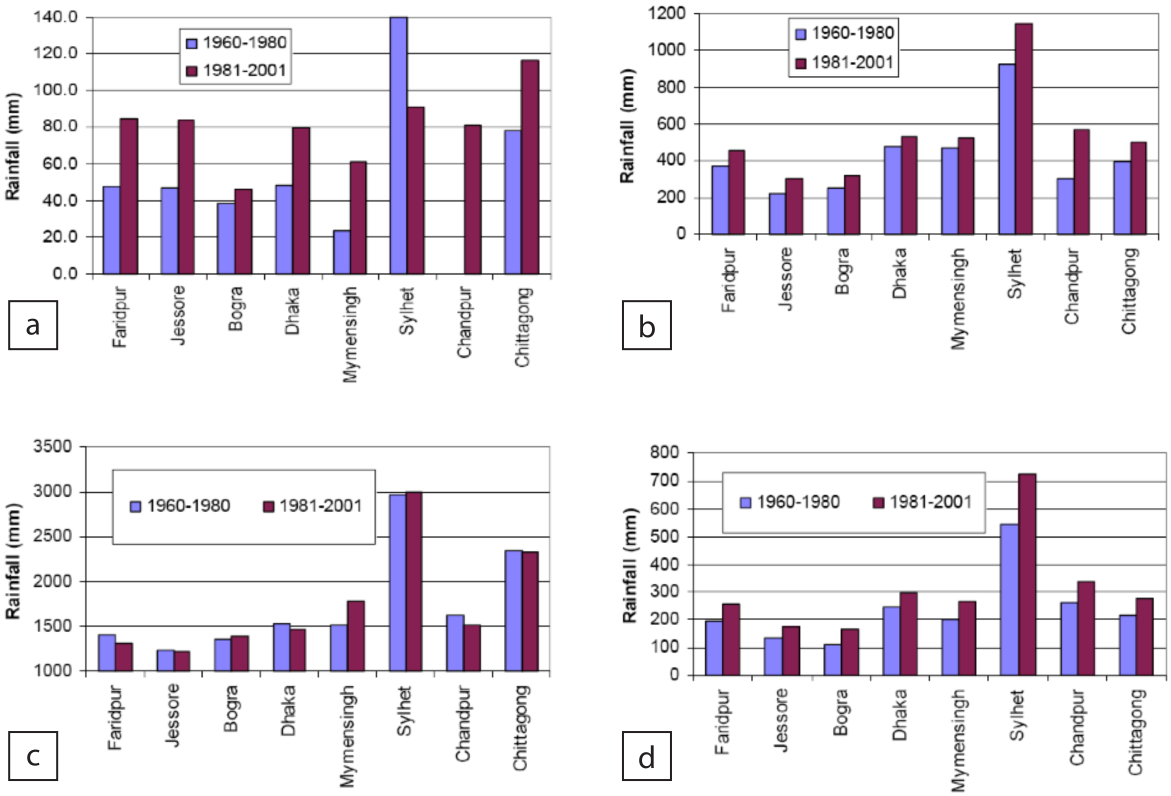
It is however increasingly facing risk from sea-level rise (SLR). It has been severely affected by storm surges in the past with damage upto 100 km inland. The accelerated sea-level rise would only exasperate and spread this impact, given Bangladeh's low topography,and wide flood plain and 21 percent of its population living in the low coastal belt.

OBSERVABLE CHANGES IN CLIMATE VARIABLES AND EXTREMES

Rainfall variability and extremes

There is much seasonal variability in rainfall in Bangladesh, with the highest rains recorded in the monsoon season. There is also significant and spatial variability in rainfall distribution ranging from – 40 percent to 25 percent. Spatial variability is highest in the north western part of the country, as much as 25 percent (Shahid, 2007).

The observable rainfall trend for two different time periods 1960-1980 and 1981-2001 for various stations in Bangladesh shows an increase in monsoon and critical period rainfall and decrease in summer and winter season rainfall. Figure 3.6. (CCC, 2009)



Source: CCC, 2009

Figure 3.6: Mean a) winter rainfall b) summer rainfall c) monsoon rainfall d) critical period rainfall at different stations of Bangladesh during 1960-1980 and 1981-2001

In general, an increasing trend in heavy precipitation days and decreasing trends in consecutive dry days are observed. There is spatial variability in extreme events indicating that coastal and eastern regions received heavier rainfall in 24 hours compared to the central and western region. Several extreme rainfall events (maximum 24hrs rainfall amount) have been recorded in Bangladesh (refer to Figure 3.7). Bangladesh will experience 5 percent to 6 percent increase of rainfall by 2030 (IPCC, 2007).

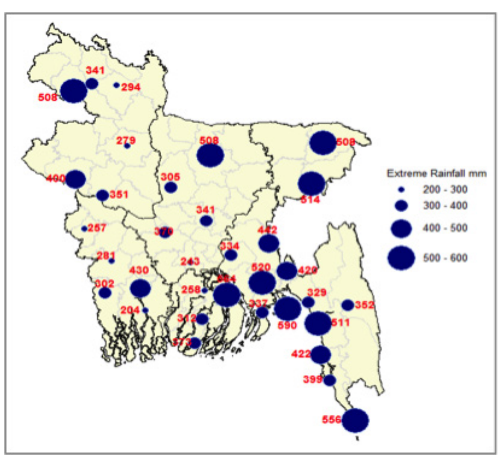
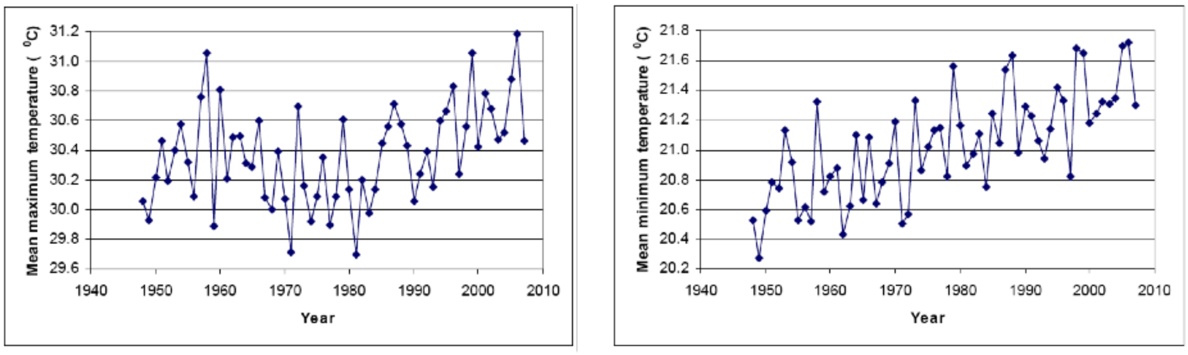


Figure 3.7 Extreme rainfall events in Bangladesh (1949 to 2010)

Temperature variability and extremes:

This inter annual variation in mean maximum and minimum temperature for Bangladesh from 1948 to 2007 suggests that maximum temperature fluctuates between 29.6 and 31.2°C and minimum temperature fluctuates between 20.2 and 21.8 °C. The year to year variability is observed to be less as per Figure 3.8.



Source: CCC, 2009[6]

Figure 3.8 Annual variation of maximum and minimum temperature in Bangladesh from 1948 to 2007

Maximum and minimum temperature trends for Bangladesh show an increasing trend in daily minimum temperature in the coastal, north-western part of the country, in comparison to the other parts of the country. (Islam, undated) -- refer Figure-3.9.

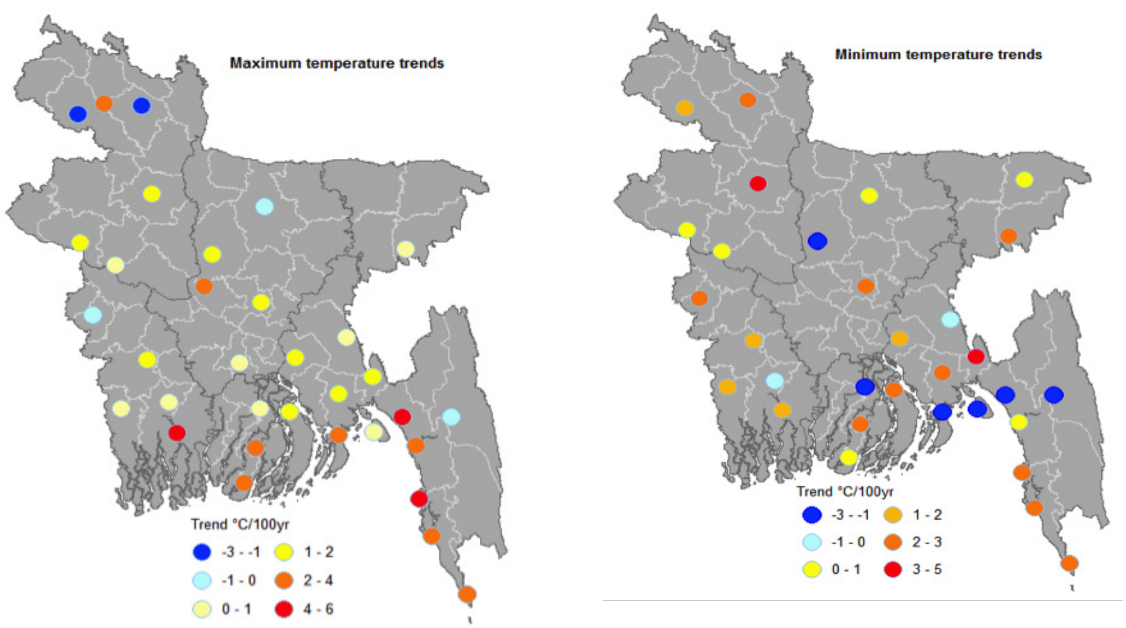


Figure 3.9 Trends (°C per 100 year) and R2 of daily maximum and minimum temperature changes for all the stations in Bangladesh

The analysis of mean temperature data from 1980 to 2007 indicates that observable changing trend (°C in 100yrs) for winter season (Nov-Feb) is 1.33°C, Summer (Mar-May) is 2.15°C, Monsoon (Jun-Oct) is 2.44°C and annual (Jan-Dec) is 2.14°C. (CCC, 2009).

Sea level rise

A SAARC Metrological Research Centre (SMRC) study at three coastal stations in Bangladesh indicate the rate of sea level rise during last 22 years as 4.0 mm/year at Hiron Point, 6.0 mm/year at Char Changa and 7.0 mm/year at Cox's Bazar. (MEF, 2005).

PROJECTED CLIMATE TRENDS

Temperatures and rainfall

The report by the US Climate Change Study team indicates that the average increase in temperature in Bangladesh will be 1.3°C for 2030 and 2.6°C for 2070. The winter precipitation would decrease to a negligible rate in 2030, and very low in 2075. At the same time the monsoon precipitation is expected to increase at a rate of 12 percent in 2030 and 27 percent in 2070. The excessive rainfall in the monsoon might cause floods and limited rain in summer and winter result in drought. (Ahmed et, al., 1999 cited in MEF, 2005). The projected changes in temperature and rainfall over three time periods for Bangladesh is presented in Table 3.1

TABLE 3.1 CLIMATE PROJECTIONS FOR BANGLADESH

YEAR	TEMPERATURE CHANGE (°C) MEAN (STANDARD DEVIATION)			PRECIPITATION CHANGE (%) MEAN (STANDARD DEVIATION)		
	ANNUAL	DJF	JJA	ANNUAL	DJF	JJA
2030	1.0	1.1	0.8	5	- 2	6
2050	1.4	1.6	1.1	6	- 5	8
2100	2.4	2.7	1.9	10	- 10	12

Note: Adopted from Agarwala et al., IPCC TAR Report cited in MEF, 2005

Extreme events

Increase in monsoon rainfall due to intense rainy days might lead to severe floods. The coastal areas of Bangladesh have always been affected by severe cyclonic storms and long wave tidal surges. Based on climate projection models, cyclones and storm surges are expected to become more intense with climate change related extreme events.

Sea level rise

Sea level is expected to rise by 14, 32 and 88 cms in the year 2030, 2050 and 2100 respectively. (MEF, NAPA, 2005). This is likely to exasperate impact of cyclones, storms and floods in low lying areas of Bangladesh, that have in the past experienced damage up to 100 km inland. IPCC (2007) also estimates that a sea-level rise of just 400 mm in the Bay of Bengal would put 11 percent of the Bangladesh's coastal land underwater, creating 7 to 10 million climate refugees.

STATUS OF CLIMATE AND HAZARD INFORMATION AT NATIONAL AND REGIONAL LEVEL

Available observed climate data and information give a picture of current and future climate hazards and trends in Bangladesh. The main driving factors and general characteristics of current climate variability are well understood in Bangladesh and the main zones of influence are known for key hazards such as droughts, cyclones and floods.

Various climate change studies have been conducted such as Bangladesh Country Study for the U.S. Country Studies Program which used an older version of the Geophysical Fluid Dynamics Laboratory (GFDL) model. Various GCM (Global Climate Model) projections have also been studied for Bangladesh under different projects. However, findings of regional climate change studies have not been used as desired. Overall, studies lack information on return periods and projections of extreme events. While, the CRM project has been able to fill certain gaps, for instance by commissioning the first calculations of return periods of extreme rainfall events, the analysis of pathways and influence zones of tropical cyclones and aridity and flood maps., nevertheless, large gaps remain. Some of these gaps could be addressed at the international level (climate models, for instance), while others, such as more and better equipped weather stations and climate experts would need to be dealt with in the country.

KEY MESSAGES (CLIMATE PROFILE)

- Majority of Bangladesh is a high rainfall area. However, there is a temporal and spatial variability in rainfall. The north western part of Bangladesh is a low rainfall region with less than 1500 mm annually and coefficient of variation is as much as -25 percent.

- Rainfall extremes are noticed from the range of 200-300 mm per 24 hours in some locations and up to 500-600 mm per 24 hours in others.

- The pre-monsoon period is prone to nor'easters, tornadoes, thunderstorms, hailstorms and highly variable rainfall. During monsoon season, severe floods with a return period of 10 years could impact lives and livelihoods. Due to heavy concentration of economic activity and population, urban flooding has become a new emerging trend. The post-monsoon months can be affected by early and late floods, cyclonic storms and early withdrawal of monsoon.

- Contrary to common perceptions, droughts pose as much loss to crop production as cyclones and floods.

- Temperature variations in winter are very high, ranging from +31 to -3 degree Celsius.

- Climate change observations reveal an increase in both temperature increases and monsoon rainfall in most cases.

- Climate projections indicate increased risk due to sea level rise, severe weather events and floods.

CLIMATE IMPACTS AND RISKS FOR AGRICULTURE

PAST CLIMATE IMPACTS

Bangladesh is a high disaster risk country. Of all the disasters affecting Bangladesh, hydro-metrological disasters, including climate related events especially cyclones, storms and flood are both high frequency and high impact (Refer to Table 4.1). They adversely affect the agricultural sector and livelihoods which in turn impacts the economy and food security of the country. Storms, floods, and drought have the highest and most widespread impacts as evident from Table 4.2.

TABLE 4.1 DISASTER LOSSES IN BANGLADESH (1971 -2006) (SOURCE: EMDAT[7])

DISASTER		EVENTS	PEOPLE KILLED	TOTAL AFFECTED	DAMAGE (000 US$)
Drought	Drought	7	1900018	25002000	-
Extreme temperature	Cold wave	18	2148	313200	-
	Extreme winter conditions	2	230	101000	-
	Heat wave	2	62	-	-
Flood	Unspecified	31	44847	177076392	4024100
	Flash flood	11	261	7634577	729000
	General flood	41	7074	132446412	7285300
	Storm surge/coastal flood	2	51	473335	-
Mass Movement Wet	Landslide	3	96	55280	-
Storm	Unspecified	49	5706	2356857	850000
	Local storm	31	1976	1409079	16401
	Tropical cyclone	86	626859	74852031	4765979

Source: "EM-DAT: The OFDA/CRED International Disaster Database

TABLE 4.2 DISASTER, IMPACTS AND AREAS AFFECTED IN BANGLADESH

DISASTER	AREAS AFFECTED	IMPACT
Flood	Floodplains of the Brahmaputra- Jamuna, the Ganges-Padma and the Meghna river system	Loss of agricultural production, disruption of communication and livelihood system, injury, damage and destruction of immobile infrastructure, disruption to essential services, national economic loss, evacuation, loss of human lives and biodiversity, displacement and sufferings of people and biodiversity
Flash Flood	Haor Basins of the North-east region and South-eastern hilly areas	Damage to standing crops, disruption in lifestyle, evacuation and destruction of property.
Cyclone and Storm Surge	Coastal areas and offshore islands	Loss of agricultural production, disruption of communication and livelihood system, damage and destruction of immobile infrastructure, injury, national economic loss, loss of biodiversity and human lives, need for evacuation and temporary shelter
Tornado	Scattered areas in the country	Loss of human life and biodiversity, injury, damage and destruction of property, damage of cash crops, disruption in lifestyle, damage to essential services, national economic loss and loss of livelihood
Drought	Almost all areas, especially the Northwest region	Loss of agricultural production, stress on the national economy and disruption in life style
Hail Storm and Lightning	Any part of the country, especially the *Ganges-Padma* and the *Meghna river* systems	Damage and destruction of property, damage and destruction of subsistence and cash crops, loss of livelihood and livestock, disruption to economy, evacuation and loss of property
Landslide	Chittagong and Chittagong Hill Tracts	Loss of land, displacement of human population and livestock, evacuation, damage to property and loss of life

Source: UNEP RRCAP, 2001[8]

Floods

Floods regularly affect about 80 percent of Bangladesh. In a normal year, 20-25 percent of the country is inundated by river spills and drainage congestions. Approximately 37 percent, 43 percent, 52 percent and 60 percent of the country is inundated with floods of return periods of 10, 20, 50 and 100 years respectively (MPO, 1986). Floods of different scales occur annually in a number of locations in Bangladesh, and pose the greatest risk to life and property, damage crops, property and lead to epidemics. In addition to monsoon floods, flash floods are also common in Bangladesh. They generally occur in the north-east, south-east and Chittagong region. The most devastating and extended flash floods are recurrent phenomenon in the north-east region of Bangladesh (BWDB, 2012[9]).

The impact of floods in Bangladesh (1996 to 2007) is presented in Table 4.3. A case of severe flood in 2007 is presented in Box-4.1, which displays the vulnerability of Bangladesh.

TABLE 4.3 IMPACT OF SOME FLOOD EVENTS IN BANGLADESH 1986-2007

YEAR	NO. OF UPZILA AFFECTED	NO. OF PEOPLE AFFECTED	NO. OF DEATHS	CROPS DAMAGED IN ACRES	NO. OF DEAD LIVESTOCK, CATTLES AND GOATS	NO. OF HOUSES DAMAGED	NO. OF INSTITUTION DAMAGED	ROAD DAMAGE IN KM	NO. OF DAMAGED BRIDGE/CULVERT	EMBANKMENT DAMAGES
1987	347	24823376	1470	4856569	370129	1762676	3738	24158	3429	1272
1998	510	44670060	1621	11113434	398018	3687597	10486	66717	2709	1718
1993	224	11559586	162	1299717	29512	849729	2640	16584	2175	1013
1995	259	16382922	137	2356112	14221	1431695	6050	6127	2335	2398
1998	366	30916351	918	3231721	26564	3426966	24990	61823	6890	4528
2002	209	7606837	26	843097	25237	680038	4352	19410	9406	4734
2003	209	7874465	104	878359	7197	651135	4130	17512	2416	1535
2004	265	36337944	747	2644134	15143	4284055	25571	59799	5478	3158
2007	263	13343802	970	2226280	1,459	1043237	8594	30830	360 (Fully)	88 (Fully)

Source: DMB, 2012[10]. Note: Rows in Red indicate severe flood events

BOX 4.1 – 2007 FLOOD CASE STUDY

Characteristics – Agricultural Impacts

Approximately 26,000 sq. km was inundated during the flood of 2007, affecting almost 13.3 million people. A total of 1,066.69 million US $ were lost. About 1.12 million ha of cropland were either partially or fully damaged accounting for the 42165.8 million BDT (22270.63 in 1st spell flood and 19895.25 in 2nd spell flood). Source: DMB, 2007[11]

DAMAGE TO AGRICULTURE SECTOR FLOOD 2007

SECTOR	DAMAGE (MILLION US$)
Agriculture (crop)	620.08
Livestock	8.95
Fisheries	28.90
Deep and Shallow tube well	7.49
Seeds & irrigation	0.15
Forest	0.56

Source: DMB, 2007[12]

Cyclone

Cyclones are common and serve hazards in Bangladesh impacting various sectors. Agriculture is significantly affected with approximately 3.4 million ha of land damaged fully and 8.4 million ha of land damaged partially between the year 1970 to 2009. The impact of major cyclones in Bangladesh since the year 1970 is presented in Table 4.4. The case study of Sidr cyclone in 2007 is presented in Box 4.2

TABLE 4.4: IMPACT OF CYCLONES ON BANGLADESH (1970 TO 2009)

YEAR	NO. OF UPZILA AFFECTED	NO. OF DEATHS	NO. OF PEOPLE AFFECTED	CROPS DAMAGED IN ACRES	NO. OF DEAD LIVESTOCK, CATTLES AND GOATS	NO. OF HOUSES DAMAGED	NO. OF INSTITUTION DAMAGED	ROAD DAMAGE IN KM	NO. OF DAMAGED BRIDGE/CULVERT	EMBANKMENT DAMAGES
1970	99	250000	1100000	3350000	470000	3350000				
1985	30	10	167500	126090	2020	17230	0	32	11	10
1986	30	12	238600	102637	1050	4562	49	132		1
1988	131	9590	1006536	3913822	386766	1652552	7886	1491	39	18
1989	71	573	346087	77341	2065	32181	240	0		
1990	127	132	1015866	413996	5326	138647	694	0		
1991	100	76	121229	20485	25	55065	213	0		
1991	102	138882	13798275	924893	1061029	1702358	9666	764	496	707
1994	8	134	422020	81898	1296	69533	194	169	83	97
1995	67	91	305953	45237	1838	67059	664	0		
1996	9	545	81162	2431	4933	31844	149	0		
1997	66	127	3784916	314543	7960	743206	4824	1701	527	122
1997	61	78	2015669	89199	3196	214787	4756	2597	85	280
2007	200	3363	8923259	2473639	1778507	1522077	16954	8075	1687	1875
2009	64	190	3928238	323454	150131	613778	5033	8854	157	1742

Source: DMB, 2012

BOX 4.2: TROPICAL STORM SIDR CASE STUDY, 2007

Cyclone Sidr hit the south-west coast of Bangladesh on 15 November 2007, with winds up to 240 km/hr. The storm triggered tidal waves up to 5 meters high and surges up to 6 meters in some areas. High tides and surges breached coastal and river embankments, flooding low-lying areas and causing extensive physical destruction. High winds and floods damaged housing, roads, bridges, and other infrastructure. Electricity and communication were also damaged. Roads and waterways became unusable. Around 2.3 million people from 30 districts were affected. The economic loss estimated by the Joint Damage, Loss, and Needs Assessment (JDNLA) team was 115.6 billion BDT which is US$ 1.7 billion.(GoB, 2008[13])

TABLE 4.5 ECONOMIC LOSSES

SECTORS	DISASTER EFFECTS (US$ MILLION)		
	DAMAGE	LOSSES	TOTAL
Infrastructure	1,029.9	30.9	1,060.8
Social Sectors	65.0	21.1	86.0
Productive Sectors	25.1	465.0	490.1
- Agriculture	21.3	416.3	437.6
- Industry	3.8	29.5	33.3
- Commerce	—	18.2	18.2
- Tourism	—	0.9	0.9
Cross-Cutting Issues	**6.1**	**0.0**	**6.1**
Total	**1,158.0**	**516.9**	**1,674.9**

Source: Estimates by JDNLA Team cited in GoB, 2008[14]

Drought

Drought is a common hazard affecting the agricultural sector in the north-western part of the country. Poor rainfall distribution reduces ground water table and crop yield in this area. Percentage of area under different drought risk categories in the western part of Bangladesh is noted in Table 4.6 revealing that 21.9 percent of the area is exposed to very high risk, 12.7 percent to high risk, and 30.4 percent to moderate risk during a 3 month drought period. On the other hand, 18.9 percent of the area is exposed to very high risk, 13 percent to high risk, and 19.7 percent to moderate risk during 6-month drought period.

TABLE 4.6 PERCENTAGE OF AREA UNDER DIFFERENT DROUGHT RISK CATEGORIES IN WEST BANGLADESH

DROUGHT PERIOD (MONTHS)	PERCENTAGE OF AREA (%)			
	VERY HIGH	HIGH	MODERATE	LOW
3	21.9	12.7	30.4	35
6	18.9	13	19.7	48.4

Source: Shahid & Behrawan, 2008[15]

Bangladesh has been affected by severe and moderate droughts. Refer to Table 4.7. Past drought impacts indicate that a severe drought could impact 40 percent of the aus crop, cause significant damage to 2.32 million ha of cropland in kharif season and 1.2 million ha of cropland in the rabi season. Although droughts may occur at any time of the year, the impact of droughts during the pre-monsoon period is more severe in Bangladesh. High yield variety Boro rice, which is cultivated in 88 percent of the potentially available areas of the country, grows during this time. A deficit of rainfall during this period causes huge damage to agriculture and to the economy of the country.

Drought impacts not only agriculture, but also contributes to land degradation, livestock depletion, unemployment and poor health. The drought associated loss in crop production, assets and lower employment opportunities has contributed to increased household food insecurity. (Selvaraju & Stephen, 2007[16]). Some of the major droughts and its impacts on Bangladesh are presented in Table 4.8.

TABLE 4.7: FREQUENCY OF DROUGHT IN BANGLADESH FOR DIFFERENT SHORT-MONTH-LENGTH USING SPI AND CALCULATED FROM THE REGIONAL AVERAGE STATION DATA

SUB-REGIONS	MONTH 1		MONTH 3		MONTH 6	
	MODERATE	SEVERE	MODERATE	SEVERE	MODERATE	SEVERE
Central	52	3	49	10	58	8
Northern	32	4	50	4	58	1
Eastern	35	1	45	3	39	2
South Western	44	2	49	4	62	3
Bangladesh	163	10	193	21	217	14

Source: Rafiuddin, 2011[17]

TABLE 4.8 MAJOR DROUGHTS AND ITS IMPACTS IN BANGLADESH

YEAR	AREA (%)	POPULATION AFFECTED (%)	YEAR	AREA (%)	POPULATION AFFECTED (%)
1950	13.79	14.13	1970	9.1	10.55
1951	31.63	31.1	1971	4.8	5.66
1952	6.57	5.95	1972	42.48	43.05
1954	3.43	3.92	1976	5.02	5.48
1955	9.83	15.49	1978	3.66	4.51
1956	11.25	9.53	1979	42.04	43.90
1957	46.54	53.03	1981	NA	NA
1958	37.47	36.24	1982	NA	NA
1960	2.7	3.11	1989	NA	NA
1961	22.39	20.76	1994-95	NA	NA
1962	11.3	9.74	1995-96	NA	NA
1963	8.6	6.63	2003	NA	NA
1966	18.42	16.54	2006		

Source: (Chowdry and Hussain, 1983) cited in Boken et al.,2005[18]

FUTURE CLIMATE IMPACTS

Climate change and its related elements are expected to affect many sectors of development. Broadly, they will affect the following sectors directly (refer to Table 4.9):

TABLE 4.9 FUTURE CLIMATE RELATED IMPACTS

CLIMATE AND RELATED ELEMENTS	CRITICAL VULNERABLE AREAS	MOST IMPACTED SECTORS
Temperature rise and drought	North-west	Agriculture (crop, livestock, fisheries); Water; Energy and Health
Sea Level Rise and Salinity Intrusion	Coastal Area Island	Agriculture (crop, fisheries, livestock); Water (water logging, drinking water, urban); Human settlement; Energy and Health
Floods	Central Region North East Region Char land	Agriculture (crop, fisheries, livestock) ; Water (urban, industry); Infrastructure; Human settlement; Health; Disaster and Energy
Cyclone and Storm Surge1	Coastal and Marine Zone	Marine Fishing Infrastructure; Human settlement and Life and property
Drainage congestion	Coastal Areas Urban Areas South West	Water (Navigation) and Agriculture (crop)

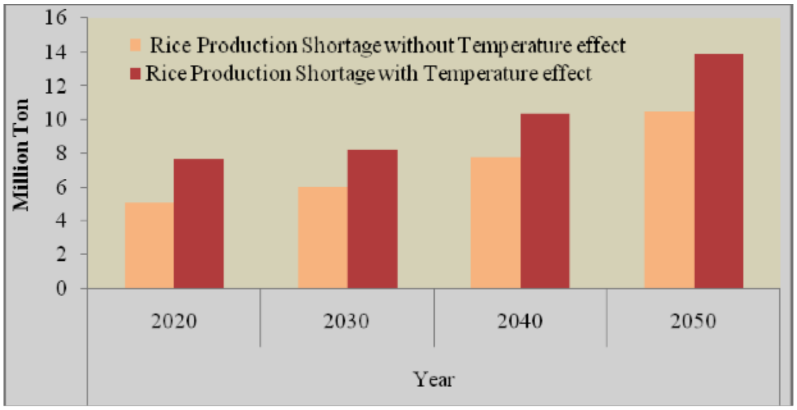
Source: MEF, 2005[19]

Agriculture

The increase in temperature (1°C to 4°C) is likely to affect the yield of rice crop. There will be 17 percent decline in overall rice production and 61 percent decline in wheat production based on the Geophysical Fluid Dynamics Laboratory (GFDL) Model. The Canadian Climate Change Model (CCCM) also predicts a significant fall in crop production. The dry season crop boro will also be constrained by moisture stress. It is estimated that 60 percent moisture reduction may lead to 32 percent decline in boro yield.

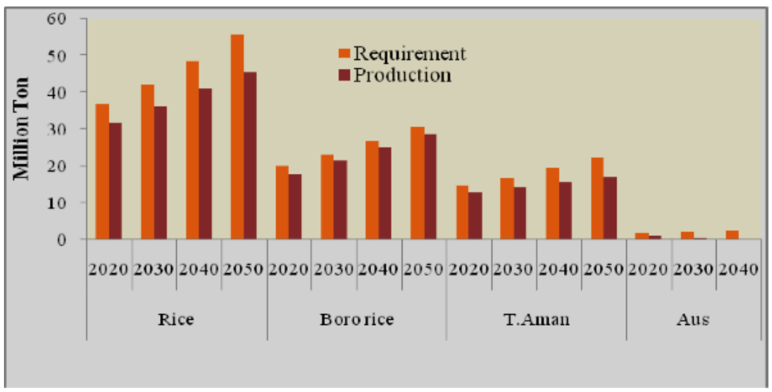
Overall shortfall in food grain production will threaten the food security of the poverty-ridden country. (GED, 2009). The challenge for crop production in Bangladesh is twofold: coping with population growth and facing climate change. These will be compounded by hazards such as cyclones, hurricanes, flood and droughts. Unexpected changes associated with global warming, such as temperature, carbon dioxide and rainfall are expected to impact rice production. Although increase in atmospheric concentration of carbon dioxide is expected to increase plant growth and consequently rice yields, increase in temperature nullifies the effects of carbon dioxide. (Ramirez, 2010[20])

While the country's population is growing at the rate of 1.6 percent per year, demographic pressures and increased urbanization have caused cultivated area to decline at a rate of 1 percent per year (WorldBank, 2011[21]). Crop production is potentially set to decline for at least one crop in each region. This simulated variability is projected to cost the agriculture sector US$26 billion in lost agricultural GDP during the 2005-50 periods. Overall, agricultural GDP in Bangladesh is projected to be 3.1 per cent lower each year as a result of climate change (Basak, 2009[22]).



Source: Basak, 2009

Figure 4.1: Impacts of temperature on rice production in Bangladesh



Source: Basak, 2009

Figure 4.2: Rice production and requirement in Bangladesh

The effects of temperature on yield of Boro rice have been assessed using the DSSAT (Decision Support System for Agrotechnology Transfer, version 4) model for the years 2020, 2030, 2040 and 2050. The study has been conducted on the basis of IPCC Fourth assessment report and has found a considerable yield reduction (1.5 percent, 2.5 percent, 4.4 percent and 5.4 percent respectively) which will directly affect the total rice production in the country. More than 6.5 million people would be deprived of their rice requirement by the year 2050 (Basak, 2009).

Forestry and biodiversity

Climate change impacts will add an extra threat to biodiversity and forest in addition to human interventions and fragmenting of habitats. Bangladesh's Climate Change Country Study noted the following impact of climate change on forest resources (*GED, 2009*)

- Increased rainfall during the monsoon might cause increased runoff in the forest floor instead of infiltration into the soil and thus increase soil erosion in forest areas;
- Prolonged floods would severely affect growth of many timber species;
- Tea plantations in the north-east would also suffer due to moisture stress;
- Sundarbans mangrove forest would be the most severely affected;
- 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 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 in the Sundarbans ecosystem (Ahmad et al., 1999).

Sea level rise

Sea level rise is a major threat in the future for low lying areas in Southern Bangladesh. A study indicates about 13 percent (46900ha) of land will be inundated in monsoon with 62cm sea level rise for high emission scenario A2. The most vulnerable areas are Patuakhali, Pirojpur, Barisal, Jhalakati, Bagerhat, Narail. Along with sea level rise, increased rainfall will also inundate about 16 percent (551,500 ha) of land in 2080. (GED, 2009)

CLIMATE SENSITIVITY

This section captures crop wise climate sensitivity for major food grains, their impact on the income of farming households, food security and nutrition. In light of the Government of Bangladesh's increased concern with mitigating hazards in agriculture, its ability to intervene is also discussed.

Farm Level

Aus crop: The Aus crop is grown in 2.43 million ha and its production is 1.7 million tonnes of food grains (2010). Aus is planted or broadcasted in mid-March utilizing pre monsoon rains and harvested in the last week of June or the first week of July. The early floods that could arrive just before the harvest of aus crop could destroy almost the entire crop. Since this crop is grown in highly variable in pre-monsoon rains, the aus crop has been affected by droughts. The flash floods in the northeastern region also affect the aus crop in some areas. High temperature in summer and norwesters could also reduce its yield.

Broadcasted Aman (B.Aman): B.Aman is grown in 1.17 million ha and contributes 0.56 million tonnes food grains. It is sown in March and April, and harvested in July. Early floods in June-July could severely affect the crop. Lower than normal rainfall in the pre-monsoon season affects germination and early development of the crop.

Transplanted Aman (T.Aman): T.Aman is grown in 3.5 million ha and its production is 12.23 million tonnes. This is a major crop contributing 40 percent of the total crop production. It is more sensitive to early floods during transplantation and to late floods and November cyclones during harvesting. It is also sensitive to drought, since it needs a large volume of water during transplantation in mid-August and the flowering stage. A dry spell during these critical stages could reduce production drastically. For example in 1997 August dry spell reduced T.Aman production by 600000 tonnes. In 2001, even though the monsoon was above normal in seasonal scale, there was a long dry spell in August and September and this seriously impacted 70 percent of T. Aman rice yield.

Boro: Boro crop is grown in 11.63 million ha of land producing 18.06 million tonnes. The early withdrawal of monsoon and inadequate moisture in the month of October could lead to low soil moisture and delays in sowing of boro, that would also delay its harvesting period to coincide with the early flood period. The prolonged flooding in low lands could affect the delayed sowing and also make it vulnerable to late floods. Other threats include heavy rainfall during the pre-monsoon period, early flood during harvest period, flash flood just before the harvest period and, cyclonic storms in May.

TABLE 4.10: LOSS OF RICE PRODUCTION BY DIFFERENT TYPES OF HAZARDS

YEAR	LOSS IN PRODUCTION (M.TONS)								
	FLOOD (ALL TYPES)			CYCLONE /STORM/HAILSTORM			DROUGHT		
	AUS	AMAN	BORO	AUS	AMAN	BORO	AUS	AMAN	BORO
1993	71,835	115,31 3	-	141	-	80,522			
1994	31,565	3,535	139,080	-	-	-			
1995	176,970	541,99 5	-	-	-	-			
1996	12,558	8,677	-	-	-	25,012			
1997	30,117	6,240	-	-	4,501	-			
1998	274,875	927,357	23,558	-	-	-			
1999	26,510	242,605	-	-	-	-			
2000	-	197,970	-	1,572	-	317,460			
2001	27,540	34,870	-	-		18,440			
2002	52,030	131,890	-	-		247,760			
2003	177,880	43,880	-		-	15,610			
2004	150,590	954,500	-	-		497,220			

Source: Bangladesh Bureau of Statistics cited in GED & UNDP, 2009[23]

In addition to the major crops, climate sensitivity also impacts the production of jute, maize and vegetables grown in the post monsoon and pre monsoon seasons. Recently the reduced ground water table in dry season has increased the cost of cultivation particularly when rainfall was deficient during previous monsoon seasons. However, no systematic studies have been undertaken on the comprehensive impact of climate variability on different crops including horticulture in Bangladesh. A field survey revealed crop damages during the 1998 floods (Table 4.11), impact on rural livelihoods, food security, health and nutrition (Box 4.3)

TABLE 4.11: CROP DAMAGE FOLLOWING THE 1998 FLOODS IN BANGLADESH

CROP	NUMBER	PERCENTAGE	CROP	NUMBER	PERCENTAGE
Aman	281	97	Sugarcane	24	8
Aus	232	80	Pulses	17	6
Jute	199	69	Til	17	6
Boro	147	51	Vegetables	9	3
Wheat	39	13	Onion/Garlic	8	3
Potatoes	36	12	Chillies	7	2
Kaon	30	10	Groundnut	6	2

Source: Paul, 1995[24]

BOX – 4.3 IMPACT OF THE 1998 FLOODS ON RURAL LIVELIHOOD, FOOD SECURITY, HEALTH AND NUTRITION

The average loss was equivalent to 16 percent of their pre-flood total value of assets. In all, 47 percent of households suffered damage or loss to housing, the average loss being 59 percent of the pre-flood value; 17 percent of households lost trees and 15 percent of households lost chickens.

Livelihoods: 78 percent of the households exposed to very severe floods and 69 percent of those exposed to severe flooding lost assets worth on average Tk 9,042 and Tk 6,679, respectively. The rural economy suffered serious disruption from the floods. The average monthly days of paid work decreased during the floods, but increased in the period after the floods to the same level as 12 months earlier for all workers except day laborers. Day laborers were the most severely affected: their employment fell sharply from 19 days per month in 1997 to only 11 days per month in July through October 1998. Wage earnings also fell during the floods and had not recovered to 1997 levels by October–November 1998. For day laborers, average monthly earnings in the period July–October 1998 were 46 percent below those in the same months in 1997, and in October–November 1998 were still 18 percent below 1997 levels. Underemployment increased as people worked fewer days, however most workers found some form of employment.

Food Security: The decline in crop production, losses of other assets, and lower employment opportunities contributed to increased food insecurity. Food consumption fell, along with the households' abilities to meet their food needs on a sustainable basis. Vegetables and many other foods were in short supply and the calorie consumption of flood-exposed households was 272 calories/person/ day fewer than that of households not exposed to flooding; 15.6 percent of flood exposed households became food insecure.

Health and Nutrition: The floods damaged or destroyed people's homes, reduced their access to safe water, and destroyed or damaged their toilet facilities. These factors, combined with the reduced food consumption, led to substantial increases in illnesses, even after the floodwaters had receded. In the immediate post-flood period, 9.6 percent of individuals in the sample suffered from diarrhoea, and 4.7 percent were affected by respiratory illnesses. Individuals in all age groups experienced deterioration in health status at this time, especially those who were severely or very severely exposed to the flood. Adolescents and children were severely affected. Increase in both wasting and stunting among preschool children was noted with 55 percent of children in the sample stunted and 24 percent wasted. Some evidence that the floods led to an increase in severe chronic energy deficiency among women was also found.

Source: Ninno et al., 2001[25]

National Level

The structural transformation of Bangladesh's economy from agriculture lead (till 1970s) to industry and service sector lead in recent times could attribute to the economies' reduced climate sensitivity. This perception is reinforced by the increasing contribution of Boro season crop and the decreasing contribution of monsoon season crop.

Nevertheless, since food security in Bangladesh is delicately balanced climate risks could endanger it and push more people to below poverty line. Although agriculture contributed 20 percent to GDP, it supports 65 percent of the rural population. Therefore the climate risk related impact on the agricultural sector could be transmitted to industrial and service sector through backward and forward linkages.

A study in the context of 1998 floods on public finance indicates a serious impact on industrial output leading to industrial recession. Although data on the impact of the 1998 floods on GDP is not available, there is indication that the government has to divert about 200 million US$ from development to relief expenditures. Another indicator was that drastic increase in inflation rate, impacted the purchasing power of the rural population. Thus there is a complex relationship between climate and economic variables that need to be systematically studied to understand the impact of disasters on national economy both in the short and long term.

ADAPTIVE CAPACITY AND DEVELOPMENT CHALLENGES

Most farmers in Bangladesh own less than one hectare of land resulting in low adaptive capacity and coping mechanism to manage periodic hazards. Climate related hazards have seriously impacted agricultural production leading to disruption of livelihood systems and adoption of negative coping mechanism. Refer to Box 4.4 for the 1998 floods household coping mechanism case study.

BOX 4.4 HOUSEHOLD COPING MECHANISMS AFTER THE 1998 FLOODS

Households adjusted to the shock of the floods in several ways: reducing expenditures, selling assets, borrowing. Borrowing was the most common coping mechanism, in terms of both the value of the resources and the number of households that borrowed. About 60 percent of households in the sample were in debt in the months immediately following the floods. Average household debt rose to almost 1.5 months of typical consumption compared with only a small percentage of monthly consumption in January 1998, about eight months before the floods. In addition, 56.6 percent of flood-exposed households in the bottom 3 quintiles resorted to purchasing food on credit in the month preceding the survey. This borrowing was sufficient to maintain the value of household expenditures vis-à-vis pre-flood levels but, because of higher prices (Figure 4.4), poor flood-affected households consumed fewer calories per capita per day than non-flood-exposed households, suggesting that targeted cash transfers and credit programs could have been an effective complement to direct food distribution.

Source: Ninno et al., 2001[26]

Assessment of the central government's adaptive capacity revealed that it diverted a significant portion of its Annual Development Plan (ADP) for emergency relief and rehabilitation purposes after disasters. (MOF, 2012[27]). Although the economy is growing at the rate of 6 percent in recent decades the disposable revenue income from GDP is only 10 percent. An assessment of public expenditure indicates that within the developmental expenditure, less than one-third is devoted to the climate sensitive institutions such as agriculture, rural development and water resources. Almost 50 percent is spent on subsidies and the resources for reducing climate risk, which is estimated to be only around US$ 200 million against the GDP of US$ 100 billion resource allocations do not match the goals and objectives in SFYP, as shown in Table 4.12.

TABLE 4.12: DEVELOPMENT RESOURCE ALLOCATION FOR AGRICULTURE, WATER RESOURCES & RURAL DEVELOPMENT IN THE SIXTH PLAN. (TAKA CRORE; FY2011 PRICES)

MINISTRY/SECTOR	FY2011	FY2012	FY2013	FY2014	FY2015
Ministry of Agriculture	1054	1454	1779	2127	2481
Ministry of Fisheries & Livestock	373	357	360	402	433
Food Division	320	338	305	344	374
Ministry of Water Resources	1407	1534	1627	1798	1917
Rural Development & Cooperatives Division	469	438	465	513	551
Total	3623	4121	4535	5184	5756

Source: PC, 2011[28]

The periodic climate shocks constrain the government's efforts to reduce poverty as evidenced from aftermath of major disaster events like the 1998 floods and the 2007 Sidr cyclone. Spatial distribution of poverty also indicates that most of high poverty zones are also high climate risk zones.

Disaster events have resulted in increased malnutrition. Due to high inflation, diminishing purchasing power and food insecurity in vulnerable households, it is estimated that US $ 1.2 billion was borrowed by rural households from different sources to cope with these disasters, affecting people's welfare in the long term. It has diverted development resources needed for basic infrastructure development such as power, roads etc. and reduced wages particularly from non-agricultural sources, with a recovery period of five to six years.

KEY MESSAGES ON CLIMATE IMPACT AND RISK FOR AGRICULTURE:

- Bangladesh is a high disaster prone country with increasing incidents of hydro-metrological disasters, that are projected to rise in intensity and frequency owing to climate risks.

- Floods of varying magnitudes and intensities have impacted lives and livelihoods almost every year in Bangladesh. The exposure of new development-driven facilities and production processes to floods is increasing significantly in the recent decades. The losses due to floods could be as much as 2.6 billion US $ or loss of 3 million tons of rice.

- Cyclonic storms also cause serious disruptions to livelihoods despite robust early warning systems. The loss per cyclone could be as much as 1.7 billion US$.

- Long dry-spells during monsoon season and soil moisture deficiency during post monsoon season cause periodic droughts, a serious risk to agriculture particularly in north western Bangladesh. Due to high intensity of crops and their exposure, crop production in all regions of Bangladesh could suffer during droughts.

- Bangladesh's high exposure to climate variables could aggravate the intensity and magnitude of hydro-metrological hazards.

- Climate sensitivity of different crops indicate that pre-monsoon and monsoon-season crops are more at risk than post-monsoon crops.

- Severe floods cause serious impairment of lives and livelihoods. Estimates indicate that US$1.2 billion is borrowed by affected population following floods leaving them in debt for several years and undoing poverty reduction efforts. Food security, health and nutrition are also impacted to a considerable extent. Inflation associated with severe hazards could rise as much as 30 percent thus eroding purchasing power of poor people.

- As most of the farmers own less than 1 ha of land, they have low adaptive capacity and coping mechanism to manage periodic climate events. Most of them use negative coping capacities like reducing expenditures, selling assets and borrowing, consuming fewer calories and or nutritionally deficient food, that often pushes them into deeper poverty and ill health.

- Despite recent improved economic growth, climate risks in Bangladesh pose a serious threat to development. Climate risks have set back food security, and poverty reduction, by diverting the governments meagre resources from development to disaster relief and through negative adaptive capacities of the affected at the household level.

CURRENT CLIMATE RISK MANAGEMENT

This chapter examines the current capacities and gaps related to CRM in Bangladesh. It reviews the development planning, DRM and CC frameworks to assess institutional and policy arrangements for CRM. It also reviews existing capacities for developing and implementing CRM through functions such as assessment, prioritization, coordination, information management and climate risk reduction.

INSTITUTIONAL AND POLICY ARRANGEMENTS FOR CRM

In Bangladesh, three distinct frameworks address climate risk concerns- development planning, disaster management, and climate change adaptation, with a myriad of institutional structures and systems. There is limited integration of climate risk management processes across these frameworks. Opportunities for strengthening these linkages need to be built at both the institutional and the operational level.

A. Development Planning Framework

The Bangladesh Planning Commission undertakes development planning in Bangladesh. It is chaired by the Prime Minister with the Minister for Planning serving as Vice Chair. It is responsible for formulating the medium-term (five year) plans within the framework of the long-term (15 to 20 year) perspective plans, the Three Year Rolling Investment Programme, as well as the poverty reduction strategy papers and annual development plans.

The Outline Perspective Plan (OPP) for 2010-2021, was formulated in 2010 around Vision 2021 to provide a broad framework for development emphasising food security through a marked reduction in poverty and unemployment levels. It is cognizant of the challenges posed by climate change especially in exacerbating existing disaster and climate risks such as increase in floods and inundation of coastal areas due to sea level rise, floods, droughts and cyclones. The OPP notes the objectives and targets of the Bangladesh Climate Change Strategy and Action Plan 2009. Within the environmentally sustainable development framework, it examines key climate risks and concerns and outlines strategies for floods, tropical cyclones and droughts. It recommends key sectoral adaptation strategies for coastal zones, water resources, agriculture, droughts, floods and cyclones.

The Sixth Five Year Plan (SFYP) 2011-2015 also addresses environmental, climate change and disaster management concerns and makes specific allocations for each during its five year implementation period. Climate change priorities are identified in the Bangladesh Climate Change Strategy and Action Plan 2009. Forty four programmes are formulated around six key themes - food security, social protection and health, comprehensive disaster management, infrastructure, research and knowledge management, low carbon development and capacity building. Among these areas, the SFYP prioritises the repair and maintenance of coastal polders and defences damaged by recent cyclones (Sidr and Aila), and capacity building for mainstreaming climate change issues of adaptation and mitigation.

B. Disaster Risk Management Framework

Institutions and Mechanisms:

The Ministry of Food and Disaster Management (MOFDM) is the lead ministry for disaster management in Bangladesh. Within the Ministry, the Disaster Management and Relief Division and its Disaster Management Bureau (DMB) are responsible for DRR and emergency response. A Disaster Management Information Centre (DMIC) is set up within the DMB and tasked to assist the ministry and the GoB with risk information before a disaster and, warning and activation, emergency response, and relief and recovery after a disaster. (GoB, 2010)[29]

The National Disaster Management Council (NDMC) is the highest level mechanism for disaster management and is chaired by the Prime Minister. It comprises of key Ministers, Secretaries of relevant Ministries and the Chiefs of Staff of the Armed Forces. It provides policy guidance for disaster management and emergency response. Its decisions are to be implemented by the Inter-Ministerial Disaster Management Coordination Committee (IMDMCC).

The IMDMCC chaired by the Minister of Food and Disaster management comprises of the Secretaries of relevant Ministries, Director Generals of responsible entities within the Ministry and the Bangladesh Red Crescent Society to facilitate policy making, planning, programming and implementing measures relating to DRR and emergency response management.

The National Disaster Management Advisory Committee (NDMAC) has also been created to provide advisory inputs to the NDMC, IMDMCC, the Ministry of Food and Disaster Management and the DMB. It includes Members of Parliament, Chairmen and heads of relevant sectoral organisations, representatives of universities, UN, international organisations and Director Generals of DM entities.

To facilitate coordination and consultations on DRR, a National Platform for Disaster Risk Reduction (NPDRR) chaired by the Secretary of the Disaster Management & Relief Division (DM&RD) of the MoFDM, has also been formed.

The National Disaster Response Coordination Group (NDRCG), chaired by Minister, MoFDM comprises of Secretaries of relevant ministries, is tasked to manage and coordinate support for disaster affected communities. Cyclone Preparedness Programme (CPP) Policy Committee is chaired by Minister of the MoFDM and provides policy directives and guidelines to CPP Implementation Board (CPPIB).

Committee for Speedy Dissemination and Determination of Strategy of Special Weather Bulletin is chaired by the Director General of the DMB to identify and agree on means of dissemination of weather advisories, warnings, bulletins etc.

At the local level, Disaster Management Committees (DMC) are established to undertake activities for disaster preparedness, response, relief, prevention and mitigation, at City Corporation, District, Upazila, Pourashava and Union levels. For a visual on disaster management arrangements from the national to the local level refer to Annex 1.

Policies, strategies, programmes:

Standing Orders on Disaster (SOD) has guided disaster management in Bangladesh since its formulation in 1997, with recent revision (in 2010). It outlines disaster management arrangements in Bangladesh and details the roles and responsibilities of Committees, Ministries, Departments and other organizations involved in disaster risk reduction and emergency response management. It outlines the necessary actions required in implementing Bangladesh's Disaster Management Model, e.g., defining the risk environment, managing the risk environment, and responding to the threat environment (GoB, 2010).

National Plan on Disaster Management (NPDM) for 2010-2015 is a strategic, yet comprehensive guidance for relevant sectors and committees at various levels about the vision, and strategic focus for disaster management in Bangladesh. It takes note of all existing policies and mechanisms relevant to DRR, climate change adaptation, food and livelihood security, capacity building etc. NPDM provides a roadmap and an outline for formulating disaster management plans by sectoral ministries at all administrative levels, multi-sectoral plans to address natural hazards and man-made disasters. The NPDM also articulates an action plan to mainstreaming DRR and CCA and other strategic goals (GoB, 2010 b).[30]

The Disaster Management Act and the National Disaster Management Policy are currently in draft form and are expected to provide the legislative backing to enforce the specific roles and responsibilities of relevant agencies, and provide an enabling framework for disaster management in the country.

In addition to the above policies and strategies, two key programmes have positively influenced disaster management in Bangladesh- the Cyclone Preparedness Programme (CPP) and the Comprehensive Disaster Management Programme (CDMP). The CPP has mobilised thousands of volunteers in the cyclone-prone districts to assist in reception and dissemination of storm warning information and community level preparedness.

The Comprehensive Disaster Management Programme (CDMP) Phase 1 was a five year multi-donor programme on DRR implemented from 2004-2009. It focused on a multi-hazard framework and led a paradigm shift from relief and response to vulnerability and risk reduction. It also facilitated the adoption of DRR within MoFDM and other sectoral ministries and departments. In addition to its several achievements in the seven pilot districts, it also facilitated policy reform through review and redrafting of the Disaster Management Act, Disaster Management Policy, National Plan for Disaster Management and a revised Allocation of Business for the MoFDM to include risk reduction. It also supported the drafting of the SAARC (South Asian Association of Regional Cooperation) Regional Framework on Comprehensive Disaster Management. (GoB, UNDP, 2009)[31]

C. Climate Change Framework

Institutions:

Ministry of Environment and Forests (MoEF) is the focal ministry for climate change related activities including international negotiations. Its National Environment Committee provides a strategic overview of environmental issues and is chaired by the Prime Minister. (MoEF, 2009)[32] The Climate Change Unit has been set up, to support the National Steering Committee on Climate Change. It works to set up climate focal points in all ministries. (*ibid*). Five technical working groups have also been set up by the ministry on adaptation, mitigation, technology transfer, financing and public awareness.

National Steering Committee on Climate Change is headed by the Minister, MoEF and comprises secretaries of all relevant ministries and civil society representatives. It is tasked with developing and overseeing implementation of the National Climate Change Strategy and Action Plan. It reports to the National Environment Committee, chaired by the Prime Minister. (*ibid*)

Policies, strategies, programmes:

Bangladesh Climate Change Strategy and Action Plan (BCCSAP) was first developed in 2008 and revised and adopted in 2009 as part of its overall development strategy to facilitate integration of climate change concerns and opportunities into national plans, including the SFYP, and programmes of sectors and processes for its economic and social development. It builds on the priorities identified in the National Adaptation Programme of Action (NAPA).

The Bangladesh Climate Change Strategy focuses on increasing resilience to climate change, reducing and/or eliminating the risks to national development posed by climate change and to undertake activities based on adaptation to climate change, mitigation, technology transfer and adequate and timely flow of funds for investment within a framework of food, energy, water and livelihoods security. The strategy is built around the implementation of an action plan comprising of six pillars or thematic areas:

i. Food security, social protection and health to ensure that the poorest and most vulnerable in society, including women and children, are protected from climate change and that all programmes focus on food security, safe housing, employment and access to basic services, including health;

ii. Comprehensive disaster management to further strengthen the country's disaster management systems to deal with increasingly frequent and severe disasters/extreme events;

iii. Infrastructure to ensure that existing assets (like coastal and river embankments) are well maintained and required infrastructure (like cyclone shelters and urban drainage) is put in place to deal with the likely impacts of climate change;

iv. Research and knowledge management to predict the likely scale and timing of climate change impacts on different sectors of the economy and socio-economic groups; to underpin future investment strategies;

v. Mitigation and low carbon development options as the country's economy grows over the coming decades;

vi. Capacity building and institutional strengthening to enhance the capacity of government ministries and agencies, civil society and the private sector to meet the challenge of climate change (*MOEF, 2009*).

National Adaptation Programme of Action (NAPA) was prepared by the MOEF in 2005 through a consultative process involving six sectoral working groups. It resulted in identification of fifteen priority activities including one on managing floods and three directly addressing agriculture (drought/ flood/ salinity tolerant crop varieties, adaptation of coastal agriculture to salinity, adaptation to flash floods); two addressing fisheries (adaptation to enhanced flooding, and adaptation of coastal fisheries through salt tolerant species) and; two covering multiple sectors including agriculture and fisheries (mainstreaming climate change into sectoral policies and insurance as option to cope with climate risks).

Bangladesh Climate Change Fund: is created by the GoB with Taka 21 billion (through GoB budgetary allocations in 2010, 2011 and 2012) and a Taka 4 billion in 2012-13 to fund adaptation activities that facilitate climate change resilience. This is within the legal framework of the Climate Change Trust Act of 2010 which stipulates that 66 percent of the funds would be used for implementation of the projects prioritised in the BCCSAP and the remaining 34 percent maintained as a fixed deposit for emergencies. (*Khan et al, undated*)[33]

Bangladesh Climate Change Resilience Fund is a multi-donor trust fund- with funding from Sweden, Denmark, United Kingdom, Australia, Switzerland and the European Union. The US $ 113.5 million fund is currently managed by the World Bank.

EXISTING OR UPCOMING INTERVENTIONS FOR CLIMATE RISK MANAGEMENT

The above institutional frameworks and funds have resulted in the development of several CRM activities and initiatives in Bangladesh. The Bangladesh Climate Change Trust Fund, now known as the Bangladesh Climate Change Resilience Fund (BCCRF) has approved 62 projects amounting to 6.75 billion Taka (or US $ 100 million), mostly from public sector institutions addressing one of the six thematic areas for funding, as per the table 5.1 below. Some examples include a project for building multipurpose cyclone shelters, with funding of US $ 25 million, initiatives with the MoA on 'Agricultural Adaptation in Climatic Risk Prone Areas of Bangladesh - Drought, Flood and Saline prone areas for US $ 22.8 million and; with the MoEF on 'Afforestation and Reforestation for Climate Change Risk Reduction in Hilly and Coastal Areas' for US $ 24.95 million.(*Khan et al, undated*).

TABLE 5.1. NUMBER OF PROJECTS AND FUNDING APPROVED UNDER BANGLADESH CLIMATE CHANGE TRUST FUND BY THEMATIC AREA

THEMATIC AREA	APPROVED PROJECTS	APPROVED FUNDS (BILLION TAKA)
Food Security, Social Protection and Health	11	1.06
Comprehensive Disaster Management	3	0.73
Infrastructure	21	2.28
Research and Knowledge Management	7	0.43
Mitigation and Low Carbon Development	16	2.00
Capacity Building and Institutional Strengthening	4	0.25
Total	**62**	**6.75**

Source: Climate Change Unit, MoEF, GoB

The Pilot Program on Climate Resilience of the Strategic Climate Fund under the Climate Investment Fund has also resulted in several initiatives. Refer to Table 5.2.

TABLE 5.2. PROJECTS AND FUNDING APPROVED UNDER PILOT PROGRAM ON CLIMATE RESILIENCE

PROJECT TITLE	FUNDS	STATUS
Climate Resilient Infrastructure Improvement in Coastal Zone Project	USD 600,000	Approved on September 1, 2011
Climate Change Capacity Building and Knowledge Management	USD 500,000	Approved on June 7, 2011
Climate Change Capacity Building and Knowledge Management	USD 25,000	Approved on October 18, 2011
Climate Resilient Agriculture Program		Under preparation
Promoting Climate Resilient Agriculture and Food Security		Approved on January 25, 2011 (50% funds)
Coastal Embankments Improvement and Afforestation	USD 218,000	Approved on January 25, 2011 (50% funds)
Coastal Climate Resilient Water Supply, Sanitation, and Infrastructure Improvement	USD 218,000	Approved on January 25, 2011 (50% funds)
Feasibility Study for a Pilot Program of Climate Resilient Housing in the Coastal Region		Approved on January 25, 2011 (50% funds)

Source: http://www.climateinvestmentfunds.org/cifnet/?q=country-program-info/bangladeshs-ppcr-programming

The CDMP Phase II (2010-2014) continues to work in risk-prone districts of Bangladesh with a funding of US $ 50.75 million towards the following outcomes that include reducing climate risks:

i. Development of strong, well-managed and professional institutions to implement a comprehensive range of risk reduction programmes and interventions at the national level and contributing to regional actions, international learning and best practice;

ii. Reduced risk to rural populations through structural and non-structural interventions, empowerment of rural communities and improved awareness of, and planning for, natural hazard events, including the likely impacts of climate change;

iii. Reduced risk to urban populations through structural and non-structural interventions, improved awareness of natural hazard events and the piloting of urban community risk reduction methodologies targeting the extreme poor;

iv. Improved overall effectiveness and timeliness of disaster preparedness and response in Bangladesh by strengthening management capacity, coordination and networking facilities at all levels;

v. Better disaster-proofing of development funding across eleven government ministries. This will be achieved by generating increased awareness of hazard risks, provision of technical information, and advisory services and resources to stimulate positive changes in planning and investment decisions over the long-term;

vi. Community-level adaptation to disaster risks from a changing climate is effectively managed.

CAPACITY ASSESSMENT FOR CLIMATE RISK MANAGEMENT

Given the changing and long term need for CRM in Bangladesh, it is imperative to take stock of and build existing capacities in Bangladesh. With this objective the CRM-TASP conducted a capacity assessment using the World Resources Institute's National Adaptive Capacity framework (WRI, 2009). The assessment focussed on the following functions related to CRM - assessment, prioritization, coordination, information management and climate risk reduction, and revealed the following trends:

i. Assessment function:

National capacities exist for undertaking multi-hazard risk assessments. Areas prone to floods, cyclones, droughts have been mapped and risks assessed. The agriculture sector has to a large extent assessed climate risks and their impacts. Guidelines have also been developed to assist stakeholders at all levels—Ministries, NGOs, DMCs and civil society—to conduct and contribute to risk assessments. These include the Disaster Impact and Risk Assessment Guideline, Community Risk Assessment Guidelines and Hazard Specific Risk Assessment Guidelines. Community risk assessment tools and participatory methodologies have been used by various NGOs and CSOs in several communities in Bangladesh.

The Ministry of Lands (MoL) is making efforts to undertake risk assessment and identify safe human settlement zones for national land zoning and national land use planning. For example, people in the Chittagong Hill Tract, which is vulnerable to flash floods and landslides, are likely to be resettled through a plan formulated by the government. The MoL is also collaborating with the MoEF, and Ministry of Water Resources (MoWR) to conduct assessments in coastal zones to identify vulnerable areas and protect settlements from coastal hazards.

A detailed National Multi-Hazard Risk and Vulnerability Assessment, Modeling and Mapping initiative is also being developed at DMB through the World Bank supported Emergency Cyclone Recovery and Restoration Project. (*DMB, 2011*)[34]

Despite these significant efforts, the agriculture sector lacks systematic assessment on mapping impacts of current and emerging climate risks. For instance, current risks faced by crops during different seasons (outlined in Table 5.3) and their implications on the economy and societal welfare are not adequately captured. As a result, requisite policy initiatives sensitive to these trends are notably absent.

TABLE 5.3: CLIMATE RELATED RISKS TO MAJOR CROPS IN VARIOUS SEASONS

CROP	SEASON	RISKS
Rice	March-early July (*Aus Broadcasted)*	Early Flood at harvest stage destroying almost all production
	March- July *(Aus Transplanted)*	Early Flood at harvest stage destroying almost all production
	March-July *(Aman Broadcasted)*	Dry spell during pre-monsoon and Early flood
	July-November *(Aman Transplanted)*	Early flood impacting transplantation process; Late flood and cyclonic storms destroying harvest; Dry spells during July-August and in September impacting transplanting and panicle initiation
	December-May *(Boro)*	Pre-monsoon water stress and high cost of irrigating with ground water
	January-mid June *(Boro HYV)*	Pre-monsoon water stress and high cost of irrigating with ground water, Early flood, Flash Flood
Wheat	November- April	Pre-monsoon water stress
Maize	October- May	Pre-monsoon water stress

Also emerging risks due to new cropping patterns have also not been captured. For example, the depleting groundwater resources in North Western Bangladesh as a result of the increasing intensity of Boro rice cultivation, resulting in both environmental and financial costs that are not fully assessed. Another example is the trend of increased monoculture (rice) across most parts of Bangladesh which has in many cases almost eliminated cultivation of other vital crops such as oil seeds and pulses.

Other potential climate risks, whose impacts extend beyond agriculture to other sectors of the economy, are also not adequately assessed:

a) Increasing impacts of pre-monsoon floods on rice cultivation during Boro season: Delayed harvest of Aman crop results in shifting of Boro rice crop, which exposes the Boro season crop, previously thought of as a safe (hazard free) season, to the impacts of pre-monsoon floods;

b) Increasing exposure of crop: Eastern Bangladesh is considered relatively safe from hazards (floods and droughts) that are common in the other parts of the country. However, the intensification of cultivation throughout the year all over available land has increased exposure its risks associated with different seasons and areas;

c) Increased exposure of assets: Development planning has prioritised agriculture and is creating favourable conditions through new roads, embankments, storage facilities and irrigation facilities. As the development spreads more assets are likely to be exposed to impacts of riverine and flash floods;

d) Impacts on manufacturing and other sectors: The cascading impacts of disasters on non-agriculture sectors are also not adequate assessed. This includes agro-processing, public, private institutions, banking, micro-finance, state-owned institutions and mechanisms. For instance, the floods of 1998 impacted Grameen Bank (a micro-finance institution) to the tune of US $ 86 million (1998 figures), and over US $ 1.2 billion in borrowings by affected communities were lost;

e) Risks on public finances and GDP: Impacts of disaster events and risks on revenue collection, GDP projections, public funding allocations and thereby on foreign exchange due to exports and imports losses are not factored in current assessments. This is because most projections assume a static climate and do not provide for occurrence of hazards based on their return periods.

ii. Prioritization function:

Based on the various assessments conducted and the perceived significance of hazards, several prioritization exercises have been undertaken at the national level . These include:

- NAPA prioritises fifteen actions under the two broad heads of intervention and facilitation actions. Agriculture, including fisheries is among the sectors proposed for climate change adaptation (CCA);
- BCCSAP further develops NAPA priorities and lists 44 priority programmes under six themes, including two on comprehensive disaster management systems and capacity building of national systems;
- SFYP notes the huge funding requirement for implementing BCCSAP priorities and prioritised capacity building to mainstream CCAand the repair and strengthening of coastal defences (damaged by the two past cyclones- Sidr and Aila);
- OPP and SFYP, prioritise the sector of agriculture, after noting significant contribution to employment, livelihood and food security.

However, within agriculture sector, several important and practical risk management options are not prioritised, despite their significance to national food security. Refer to Table 5.4.

TABLE 5.4: CLIMATE RISK MANAGEMENT OPTIONS IN AGRICULTURE

RISKS	CLIMATE RISK MANAGEMENT OPTIONS
Drought risks on T.Aman rice cultivation	Use of improved climate information products
Floods risks on T.Aman rice cultivation	Use of improved climate information products, eg: 10 to 15 day lead time flood forecast information
Flood risks on Boro rice cultivation	Use of improved climate information products Reduce pressure to grow Boro rice in high risk areas by increasing T.Aman cultivation through expanded use of improved climate information products, eg: 10 to 15 day lead time flood forecast information
Increasing and unsustainable extraction of ground water, especially in N.W Bangladesh	Adoption of a water-budget model integrated with climate forecast information, monitoring/ observations of ground water recharge following rains until October. This would result in planning Boro rice cultivation based on the estimated water recharge and in accordance with the water budget Crop-switching to oil seeds and pulses in areas with a low water recharge.

These options could be prioritized to reduce the risks faced by copping systems, and also to reduce the environmental impacts, i.e., declining water levels due to ground water extraction for irrigating rice crops. Increasing the areas under T.Aman by linking their cultivation with improved climate information systems would also help the very poor who are largely dependent on this crop.

iii. Coordination function:

Several committees and task forces are in place at the national levels to facilitate coordination, (as noted in Section 5.1) both within and across frameworks for development planning, disaster risk reduction and climate change adaptation.

A range of institutions exist within the agriculture sector (as in Table 5.5). They need to be coordinated to adopt and operationalize the prioritised options for CRM. Support of existing crop-specific research institutions should be sought to plan and implement these options.

TABLE 5.5: LIST OF AGRICULTURE SECTOR INSTITUTIONS AND THEIR ROLES IN BANGLADESH

INSTITUTIONS	ROLES AND RESPONSIBILITIES
Ministry of Agriculture	A key ministry of the government, responsible for formulating and implementing policies, plans, regulations and legislations, and monitoring and administering them to support agriculture in Bangladesh. It includes 18 agencies focusing on various crops and supports related research.
Department of Agricultural Extension (DAE)	The DAE is the largest public sector extension service provider in Bangladesh. Its mission is to provide needs based extension services to all categories of farmers and enabling them to optimize their use of resources, in order to promote sustainable agricultural and socio-economic development. The core functions of DAE include increasing agricultural productivity, human resource development and technology transfer. DAE has contributed significantly to crop production, particularly rice and wheat, and helped the Bangladesh attain self-sufficiency in food.
Department of Agricultural Marketing (DAM)	DAM's main objective is to provide improved marketing services to ensure fair returns to the growers for their produce and adequate supply to the consumers at reasonable prices. Its mandates are collection and dissemination of market information, monitoring and correcting price fluctuations, organizing movement and sale of farm products, construction of wholesale markets, provide advice on production targets of different crops, procurement programmes and support price of important crops and formulate policies on pricing, marketing, storage, distribution, export and import of different farm products of the country.
Agricultural Information Service (AIS)	AIS is responsible for providing mass media support to the agriculture sector in general and transferring agricultural technology from research station to the rural people of Bangladesh in particular.
Seed Certification Agency (SCA)	SCA is a regulatory agency of the MoA. It certifies and controls the quality of agricultural seeds of recommended varieties.
Cotton Development Board (CDB)	CDB undertakes the following activities: (1) organise Farmers' Association/ Committees for extension of cotton cultivation and supply of agricultural inputs including quality seed, fertiliser, plant protection materials, irrigation etc., (2) impart training to cotton farmers and establish demonstration plots, (3) encourage ginning system for processing of seed cotton produced by farmers, (4) facilitate the marketing of seed cotton at the growers level, and (5) conduct research for continued cotton extension and production programmes.
Bangladesh Rice Research Institute (BRRI)	BRRI is a major component of the National Agricultural Research System (NARS) of Bangladesh. It supports research and development in relation to rice production. So far it has released 60 rice varieties of which 56 are inbreds and 4 are hybrids. About 80 percent of the total rice cultivated is covered by BRRI varieties, which accounts for around 91 percent of the total rice production and contributes to the food self-sufficiency efforts of the government.
Bangladesh Agricultural Research Council (BARC)	BARC is the apex organization of the NARS. Its main responsibility is strengthening the national agricultural research capability through planning and integration of resources. It is also entrusted with the task of preparing the vision document and the national agricultural research plan according to national priorities. This involves coordination with several ministries including agriculture, forest and environment, fisheries and livestock, rural development, education, industries, commerce, science and technology, etc. BARC also has the following responsibilities: coordinate research and foster inter-institute collaboration, monitor and review research programs of NARS institutes, assist institutes in strengthening research capacities, establish system-wide operational policies and standard management procedures and; assure that each institute is optimally governed.
Bangladesh Jute Research Institute (BJRI)	BJRI was established in 1951 with the objective of conducting research for improving jute crops and products. Its focus is on agricultural and technological research on jute and allied fibers, and economic and marketing research on managing the Jute and Textile Products Development Centre.

TABLE 5.5 CONTINUED

INSTITUTIONS	ROLES AND RESPONSIBILITIES
Bangladesh Agriculture Research Institute (BARI)	BARI is the largest multi-crop research institute conducting research on a variety of crops, cropping and farming systems, plant protection, soil fertility management, water management, post-harvest handling and processing, farm implements and socio-economic aspects of production, processing, marketing and consumption.
Bangladesh Agricultural Development Corporation (BADC)	BADC was created in 1961 to spearheaded the revolution in minor irrigation in Bangladesh. Since the middle of 1980s, its roles in procurement and supply of agricultural inputs have diminished. BADC role is currently limited to generation and supply of some seeds and monitoring of minor irrigation.
Barind Multipurpose Development Authority (BMDA)	BMDA's scope of activities centres around- (a) zugmentation of surface water and it's use, (b) development of effective water distribution system, control and maintenance of irrigation equipment and the Area Development Programme, (c) electrification of irrigation equipment and that of small and cottage industries, (d) re-excavation of ponds for fish culture, (e) afforestation programme for maintaining environmental balance, (f) diversified crop production through production of potato, wheat, maize, pulses and oilseeds using DTWs, STWs and power pumps.
Soil Resources Development Institute (SRDI)	SRDI was established in 1983 with the mandate of collecting, storing and interpreting and disseminating knowledge on soil samples from different parts of the country. Its activities include (1) production of Upazila/Thana Land and Soil Resource Utilization Guide, (ii) production of maps, data series and other GIS services for research institutions, and (iii) promotion of soil tests for individual farmers.
Bangladesh Sugarcane Research Institute (BSRI)	BSRI is the only institute mandated to conduct research and provide sugarcane technology to meet the demand of the farmers in the mill zones and non-mill zones and to keep sugarcane cultivation a viable enterprise for the farmers in Bangladesh.
Bangladesh Institute of Nuclear Agriculture (BINA)	BINA was established in 1975 with the mandate of undertaking research using nuclear techniques for development of new varieties of crops, scientific management of land and water, appropriate technologies for improvement of quality and quantity of crops, methodologies for control of diseases and insects-pests, and; agronomic and soil-plant studies. The research activities of BINA are managed through eight divisions which include: Plant Breeding, Soil Science, Crop Physiology, Entomology, Plant Pathology, Agricultural Engineering and Training. BINA has made contributions to the development of crop mutants/varieties through induced mutations. These varieties of crops are rice, jute, mustard, mung bean, black gram, chickpea and tomato which have got approval of the National Seed Board of Bangladesh.

Source: Ministry of Agriculture, Bangladesh www.moa.gov.bd

iv. Information management function:

Bangladesh has one of the better developed databases for digital elevation model and flood inundation modelling in the region. However, it needs to be updated considering the changes taking place in the river beds, land use etc.

Bangladesh Meteorological Department (BMD) capacities for collecting, managing and processing information are being improved with support from the government and external agencies. Radar Stations are being set up with government and international funding. Despite this, information management capacities remain weak. For example funding constraints limit the gathering of upper air data through weather sounding (radiosonde) balloons, which are essential for monitoring and forecasting convective and thunderstorm events.

BMD conducts a Monsoon Forum to bring together information providers including FFWC and information users to a common platform. The forum is conducted before the commencement of the monsoon season to share the seasonal outlook and urge preparedness of agencies. At the end of the monsoon season, the forum seeks feedback on the forecasts and their applications.

Table 5.6 lays out the current status of information generation and potential application of weather and climate information for agriculture and disaster management. This is based on the discussions at the 3rd Monsoon Forum held from 29 to 30 June 2012.

TABLE 5.6: STATUS OF CLIMATE INFORMATION GENERATION AND APPLICATION IN BANGLADESH

INSTITUTIONS	APPLICATION OF WEATHER AND CLIMATE INFORMATION
Department of Agricultural Extension (DoAE)	Short range forecast: 12 hours forecast and past 12 hours rainfall (mm), maximum and minimum temperature information from 34 stations of BMD. 24 hours forecast and past 24 hour rainfall (mm), maximum and minimum temperature information from 34 stations of BMD. Additional information on forecasts of depressions, flash floods, floods, cyclones, rainfall, temperature changes, humidity, evapo-transpiration, fog, soil moisture, day length, wind speed and direction, upstream tidal information (water level) for better boundary estimation and downstream tidal boundary prediction
Department of Fisheries (DoF)	For fisheries production, the time of sun rise and sun set, relative humidity, cloud, temperature, storm warning are essential for fishermen and fish farmers to achieve maximum output. The DoF draws that information from TV and radio stations. DoF generally gets weather forecast from TV and radio and does not receive any weather forecast from BMD or other organizations. If received, DoF could deliver the weather information to its local level office. It suggests workshops and training on weather information products for their district and local level office to help them understand weather forecast products better.
Bangladesh Power Development Board (BPDB)	BPDB has no weather forecasting department and no mechanism to use weather predictions for the power generation and distribution process.
Directorate General of Health Services(DGHS)	Early warning information from BMD is utilised by the DGHS to prepare for: - Floods mortality, by stocking anti-venom for snakebites and counselling parents - Floods morbidity, through readiness efforts to deal with diarrhoea and acute respiratory infections, due to disruption in WATSAN. This includes stocking water purification tablets, bleaching powder, water treatment plant, emergency kits for displaced population etc. - Cyclone morbidity by ensuring availability of trained personnel for first aid, CPR and mass casualty management - Cold wave morbidity and resulting acute respiratory infections, chronic obstructive pulmonary disease by preparedness for distribution of warm clothes, comprehensive health care service using mobile hospitals and establishing makeshift hospitals etc.
Water Supply & Sewerage Authority (WASA)	Dhaka WASA does not get any weather, climate or meteorological forecasts from BMD. Early warning and weather forecasts information could help WASA take informed decisions related to drainage and water supply management.

Source: RIMES, 2010

10 Day Flood Forecasting: With regard to riverine flooding, Bangladesh has had a very successful experience in generating up to 10 days lead time forecast information through a project jointly funded by USAID, NOAA, CARE Bangladesh, called Climate Forecast Applications for Bangladesh (CFAB). This overcame the inherent problems of flood forecasting in Bangladesh, i.e., lack of upstream flow data for both the Ganges and the Brahmaputra rivers. Prior to this initiative flood forecasts were limited to a maximum of two to three days for the southern parts of Bangladesh and much lesser for the northern parts since they were based on actual water level and flow measurements at the points the rivers entered Bangladesh. This technology uses satellite based information, and forecasts from the European Centre for Medium-range Weather Forecast (ECMWF). It was successfully demonstrated during the 2007 Bangladesh floods and in operational forecasts during each season.

Despite this success, the technology has not been applied on a large scale, because it is:

a. Probabilistic and has an element of uncertainty requiring the adoption of a risk management framework, whereas the 3-day forecasts are deterministic. But local actors in several areas with high and moderate risk to crops have expressed willingness to adopt the 10 day flood forecasts, if provided in a proper risk communication package. Refer to Table 5.7 for details.

TABLE 5.7: ACCEPTANCE OF PROBABILISTIC FORECASTS BY RISK AREAS AND RISK TAKING ATTITUDES

	HIGH RISK AREA	MEDIUM RISK AREA	LOW RISK AREA
High risk taking farmers	High acceptance	Moderate acceptance	Low acceptance
Risk neutral farmers	Moderate acceptance	Low acceptance	Deterministic forecasts
Risk averse farmers	Low acceptance	Deterministic forecasts	Deterministic forecasts

b. Limited by inadequate human resources in the Flood Forecasting and Warning Centre (FFWC) to generate the flood forecasts on an operational basis. Despite staff trainings, the capacities are unavailable, primarily due to staff turnover.

   The CFAB technology is estimated to offer a cost-benefit ratio of over 400, i.e. every US $ invested on CFAB provides a benefit in terms of damage reduction of over 400 US $ (RIMES). This is based on the events of 2007-08. Similarly the technology could have benefited millions of farmers during the 1998 floods, refer to Table 5.8.

TABLE 5.8: RETROSPECTIVE APPLICATION OF CFAB FOR THE 1998 BANGLADESH FLOODS

CEREAL GROUP	CROP STAGE DURING FLOODS	DAMAGE ('000)		POSSIBLE ACTIONS BASED ON THE 5-10 DAYS CFAB FORECAST
		AREA (HA)	PRODUCTION (TONS)	
Aus (Rice)	Harvest	190	120	Stagger harvest, inform storage and logistics
B.Aman (Rice)	Early Vegetative state	320	430	-
T.Aman (Rice)	Seedbeds	55	-	Seedbeds in high elevation
	Standing crop	580	1060	
	Not transplanted	340	400	
Boro (Rice)	Delayed planting due to poor drainage	240	610	Drainage issues anticipated and addressed
Vegetables	Seedbeds, Vegetative, harvest	70	-	Higher elevations drainage arrangements for early harvest
Deuira	Land Variety Input	180		Early harvest planned
Livestock	Poultry, Cattle, Animal Feeds, Disease			Relocate to safer places

This technology has been recognised and accepted by the government. It has been included as a programme in the national budget for 2012-2013 to upgrade the 3 day forecast information to 7 days and beyond.

Cyclones and tropical storms are events that result in significant damages in coastal Bangladesh. Application of probabilistic forecast information could reduce damages significantly, as in Box 5.1.

BOX. 5.1 CYCLONE SIDR: RETROSPECTIVE ANALYSIS OF EWS BENEFITS

Cyclone Sidr (Nov 2007) struck the coast of Bangladesh with winds up to 240 kilometers per hour, and moved inland, destroying infrastructure, causing numerous deaths, disrupting economic activities, and affecting social conditions, especially in the poorer areas of the country. The category 4 storm was accompanied by tidal waves of up to 5 meters high and surges of up to 6 meters in some areas. The direct damage was estimated at US$1.15 billion and losses at 0.52 billion.

Possible early warning

An advanced numerical weather prediction (NWP) technique, such as Weather Research Forecasting (WRF), in conjunction with a high performance computing system and trained human resource, could have provided a longer lead-time (over 5 days) for both the landfall point and the cyclone track. Also, associated hazard parameters, such heavy rainfall and strong wind over specific locations at a high resolution (up to 3 km or even 1 km grid), could have been provided.

Due to the probabilistic nature of forecasts generated using the NWP techniques, intermediary user institutions, such as the DAE and DMB are required to translate, interpret, and communicate forecast information to users at the district (*zila*) level, and to prepare appropriate response options at local and community levels.

Cost-benefit analysis

Table 5.9 lists the EWS costs calculated under one-off (fixed) costs, and variable costs that occur on a regular basis.

TABLE 5.9: EWS COSTS FOR SIDR CYCLONE

ITEM	FIXED COSTS (MILLION USD)	YEARLY VARIABLE COSTS (MILLION USD)	OTHER COSTS (MILLION USD)
Scientific component			
EWS technology development costs	1.0	-	-
High performance computing system	1.0	0.10	-
Additional training for human resources to generate forecast information	0.1	0.01	-
Institutional component			
Capacity building of national and sub-national (district) institutions for translation, interpretation and communication of probabilistic forecast information	-	0.20	-
Community component†			
Training of Trainers at local levels to work with ground level users – farmers, fishermen, small businesses, households	-	0.10	-
Total (million USD)	2.1	0.41	-

† Refers to the input costs at community level to enable communities to adopt forecast information, and respond appropriately

BOX. 5.1 CYCLONE SIDR: RETROSPECTIVE ANALYSIS OF EWS BENEFITS (CONTINUED)

EWS costs for 10 years

Fixed costs remain @ USD 2.1 million:	USD 2.1 million
Variable costs @ 0.41 million per year for 10 years:	USD 4.1 million
Total costs for 10 years	USD 6.2 million
Total costs for 10 years (cyclone only) (C):	USD 3.1 million

This investment has multiple uses. In addition to cyclone forecast improvement, it can also be used for heavy rainfall, thunderstorm and flash flood forecasting. Hence a proportion (50 percent) of the total costs is considered.)

Table 5.10 lists the qualitative impacts, i.e., the current scenario without this additional EWS when compared to the scenario with the additional EWS, to describe all changes that would take place as a result of the EWS. Impacts could be analyzed under natural, physical, economic, human, and social categories.

TABLE 5.10: IDENTIFYING EWS BENEFITS FOR BANGLADESH SIDR CYCLONE

TYPE OF IMPACT	WITHOUT EWS	WITH EWS	INCLUDED IN ANALYSIS
Natural	Damage to coastal forests, ecosystems	Damage to coastal forests, ecosystems	No
Physical and Economic	Housing damaged; household possessions lost	Housing damage avoided in some cases (damage due to fallen trees reduced in 10 percent of partially damaged houses by maintenance of trees), and many or most household possessions saved depending on lead time	Yes
	Agriculture: crops damaged; implements and equipment damaged or lost	Agriculture: damage to crops avoided, where applicable, by early harvesting; agricultural implements and equipment saved	Yes
	Fishery: fish, shrimps lost; nets and other fishing equipment damaged	Fishery: all fish, shrimps, prawns harvested; nets erected; equipment removed (70 percent reduction in damages)	Yes
	Livestock: most poultry, farm animals, forages, and straw damaged or lost	Livestock: all poultry, farm animals, forages, and straw moved to safety (45 percent reduction in damage)	Yes
	Offices and schools: cash lost; equipment and furniture damaged	Offices and schools: cash saved; equipment and furniture protected (15 percent reduction in damages)	Yes
Human	Several lives lost	Many lives lost	No
	Several injuries sustained	Many injuries avoided	No
	Several affected people exposed to various illnesses as a result of inadequate or no preparedness	Many illnesses avoided as a result of increased preparedness measures	No
Social	Trauma, suffering among affected and their relatives	Reduced trauma and suffering among affected and their relatives due to anticipation and preparedness	No

BOX. 5.1 CYCLONE SIDR: RETROSPECTIVE ANALYSIS OF EWS BENEFITS (CONTINUED)

Table 5.11 lists the benefits assessed for quantifiable areas and, for each quantifiable benefit, the calculated change in impact.

TABLE 5.11: QUANTIFYING EWS BENEFITS FOR BANGLADESH SIDR CYCLONE

IMPACT	MAGNITUDE WITHOUT EWS	MAGNITUDE WITH EWS	VALUE	TOTAL BENEFIT (AVOIDED COST)
Housing	957,110 houses partially damaged	Damage to 95,711 houses by fallen trees avoided	Repairs @ BDT 10,000	BDT 957.11 million (*USD 13.84 million*)
Household possessions	Possessions in most houses damaged are lost. Total housing damage is BDT 57.9 billion. Possessions damaged is 5 percent of this amount.	Possessions saved in additional 10% of the cases.	Total possessions damaged is 5% of BDT 57.9 billion = BDT 2.895 billion Additional 10% saved with EWS	BDT 2,895 million (*USD 41.87 million*)
Agriculture	Standing rice crop damaged	Standing rice crop damaged	-	-
	2,105 ha of Boro rice seed bed damaged	At least 50% Boro rice seed bed (1,050 ha) avoided by manually collecting and preventing exposure	1 ha = BDT 44,000	BDT 46.31 million (*USD 0.67 million*)
	177,955 MT (in 19,464 ha) vegetables damaged	Damage of at least 25%, i.e. 44,488 MT (in 4,866 ha) avoided by early harvesting	1 MT= BDT 12,000	BDT 533.86 million (*USD 7.72 million*)
	25,416 MT (in 3,614 ha) betel leaves damaged	Damage of at least 10%, i.e., 2,541 MT (in 361 ha) avoided by early harvesting	1 MT= BDT 25,000	BDT 63.54 million (*USD 0.92 million*)
	93,383 MT (in 5,676 ha) banana damaged	Damage of at least 10%, i.e., 9,338 MT (in 567 ha) avoided by early harvesting	1 MT= BDT 15,000	BDT 140.07 million (*USD 2.03 million*)
	24,488MT (in 1,322 ha) papaya damaged	Damage of at least 10%, i.e., 2,448 MT (in 132 ha) avoided by early harvesting	1 MT= BDT 10,000	BDT 24.49 million (*USD 0.35 million*)
Fishery	BDT 324.7 million worth of fish, shrimp, fingerlings washed away	70% of damages could have been avoided	-	BDT 227.29 million (*USD 3.29 million*)
	BDT 130.29 million worth of boats (1,855) and fishing nets (1,721) damaged	15% of damages could have been avoided	-	BDT 19.54 million (*USD 0.28 million*)
Livestock	BDT 1.25 bi of damages due to dead animals (cow, buffalo, sheep, goat), poultry (chicken, ducks), and feed	45% of damages could have been avoided	-	BDT 562.5 million (*USD 8.14 million*)
Schools and offices	BDT 16 mi of stationery, learning materials, etc. damaged	15% of damages could have been avoided	-	BDT 2.4 million (*0.03 million USD*)
Total			BDT 5,472.11 million (*USD 79.14 million*)	

Note: USD 1 = BDT 69.14

BOX. 5.1 CYCLONE SIDR: RETROSPECTIVE ANALYSIS OF EWS BENEFITS (CONTINUED)

Total benefit considering probabilistic forecasting (90%): 79.14 x 0.8 USD 63.31 million

Cost-benefit analysis for 10 years

Total costs for 10 years (C): USD 3.10 million

Total benefits for 10 years, assuming 2 instances of such damages over 10 years: 63.31 x 2 USD 126.62 million

$$\frac{\text{Total benefit}}{\text{Total costs}} = \frac{126.62}{3.10} \quad 40.85$$

In other words, for every USD 1 invested in this Cyclone EWS, there is a return of USD 40.85 in benefits.

v. Climate risk reduction function:

Risk reduction actions in Bangladesh are mostly focused on past disaster risk –cyclones, floods and droughts– and rarely consider new and emerging risks. The existing risk reduction options essentially include:

a. improved climate information products to reduce impacts on rice cultivation of Aus, Aman and Boro etc.;

b. climate information linked the water budget model to reduce negative impacts of unsustainable ground water extraction to grow rice in large parts of Bangladesh;

c. crop switching from rice to oil seeds and pulses, and;

d. increasing cultivation of oil seeds and pulses.

These options are not adopted optimally due to their weak risk reduction functions and limited capacities in the country. There are several additional risk reduction options that could be considered to address climate risks. These include:

a. *Agro-advisories system:* A climate risk management framework based on an agro-advisory system with improved weather and climate forecasts would be useful for Bangladesh. It could benefit the farmer with savings in pesticides use (through better timed and anticipatory action), optimal use of fertilisers and scheduling irrigation, sowing and harvesting operations. Its potential benefit for crop could amount to 184 billion Taka or US$ 2.3 billion. Refer to Table 5.12 for crop specific potential benefits;

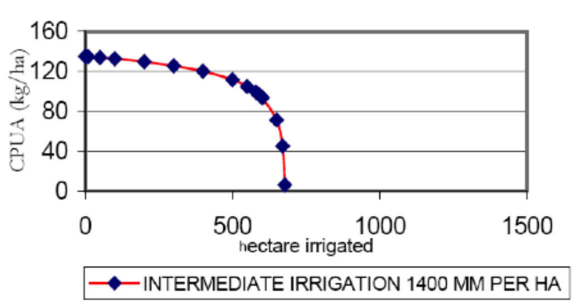
TABLE 5.12: POTENTIAL BENEFITS ACCRUED FROM CLIMATE INFORMATION FOR MAJOR CROPS IN BANGLADESH

CROP (1)	AVERAGE PROFIT - TAKA/ TON (2)	TOTAL PRODUCTION (MILLION TONS)	TOTAL POTENTIAL BENEFIT TO FARMERS DUE TO AGRO-ADVISORIES (BILLION TAKA)
Boro Rice	5175	17	51.0
Aman Rice	10350	12.8	76.8
Aus Rice	10350	2.1	12.6
Wheat	7950	0.9	4.2
Maize	64580	0.89	33.3
Pulses	14040	0.22	1.8
Mustard	32960	0.22	4.2
Total			184.0

Note: Based on calculations undertaken by National Council of Applied Economic Research Study, 2010[35]

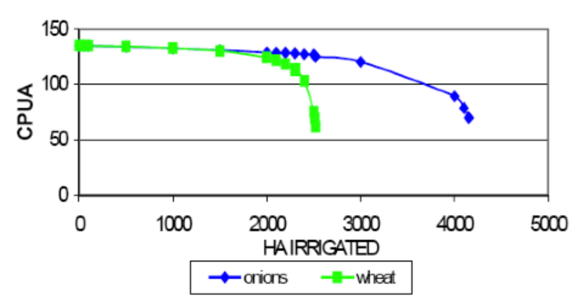
b. *Crop insurance* is a popular means for risk transfer in the agriculture sector. There is conflicting research about its viability in Bangladesh. One finds it marginally viable in riverine flood plains (Akter et al)[36] and another regards weather index based insurance as most viable (GoB, 2009)[37]. Nevertheless, application of forecast information by farmers for farm operations could result in a reduced insurance premium;

c. *Crop diversification* is considered a viable risk reduction option given the increasing impacts of boro cultivation on ground water abstraction. (Figures 5.1, 5.2 and Table 5.10). Some possible alternative crops to boro rice could be wheat, maize, brinjal, onion, potato and garlic (*Mokhlesur et al., 2005*).



Source: Mokhlesur et al., 2005

Figure 5.1: CPUA (kg/ha) in response to boro irrigation abstraction



Source: Mokhlesur et al., 2005

Figure 5.2: CPUA (kg/ha) in response to rabi irrigation abstraction

There are several benefits of Rabi crop diversification, including:

- requirement of less water than boro rice, leaving more surface water, and a better dry season habitat for fish;
- harvested several weeks prior to boro rice, which could reduce the risk of crop damage due to early flood/rains;
- early harvest also reduces the pressure to keep sluice gates closed during the early flood season, facilitating natural recruitment of fish;
- rabi diversification followed by deepwater Aman in the kharif season would improve wet season fish habitat conditions, since vegetation makes it harder to catch fish and permits fish growth;
- the fisheries gain, from increasing dry season water extent in low-lying basins, is substantial.

Diversification to grow pulses could also result in nutritional benefits to the soil, increase protein intake of people and reduce import of pulses, saving precious foreign exchange. Further, since Bangladesh aims to be a middle-income country within the next decade. Among other things, food patterns would also change resulting in increasing demand for nutrition in the form of vegetables and horticultural crops. A climate risk information-based vegetable and horticulture cultivation using Aus and Boro lands could serve this need.

KEY MESSAGES ON CURRENT CLIMATE RISK MANAGEMENT IN BANGLADESH:

- The GoB has made successful efforts to integrate CRM in development, DRR and CCA frameworks. However, CRM practices are not integrated at the intra-institutional level in the government in general and within the ministry of agriculture in particular. Limited mechanisms and tools for CRM also limit their integration at the district and local level.

- Where political and institutional arrangements exist, they are challenged by capacity gaps for assessing climate risks-both existing and emerging and informing risk reduction actions.

- Limited capacities for climate risk assessment have affected appropriate CRM efforts. A large number of adaptation portfolios have been developed without considering climate diagnostics, resource availability, affordability and acceptability at community levels.

- New generation of climate information instruments are available in the form of 5-10 day flood/ weather forecasts for minimising agriculture risks due to climate variations. The GoB has piloted and proposing to adopt this instrument for managing climate risks considering its potential gains could be as much as 2.3 billion US$.

- The EWS economics in Bangladesh indicated that 1 US$ investment could yield benefit of over 40$ in the case of cyclone warning, and as much as 500 US $ for flood warning system. Considering this significant benefit the GoB has proposed to upgrade its EWS to include new science based forecast generation tools.

- Vision 2021 document particularly focuses on shifting rice production from dry season to monsoon seasons considering the limitation of ground water resources and soil health. The new generation climate information instruments could fit into this new strategy and could be used to inform rice cultivation in pre-monsoon and monsoon seasons.

RECOMMENDATIONS FOR IMPROVED CLIMATE RISK MANAGEMENT IN BANGLADESH

The recommendations are focussed on addressing barriers in identifying and implementing potential climate risk management options in Bangladesh, with a focus on the agriculture sector.

A. STRENGTHEN CLIMATE RISK ASSESSMENT

Climate risk assessment provides critical evidence based data and analysis on the climate risks and risk reduction options for any country. In Bangladesh, the Department of Agriculture Extension (DAE) under the Ministry of Agriculture (MoA) is mandated to undertake climate risk management in the agriculture sector. However the DAE has limited institutional systems, practices and capacities in assessing climate risk. It can address the gaps in climate risk assessment by:

Capacity mapping and development by:

a. leveraging capacities available in country. This particularly includes capacities of research institutions to inform climate risk assessment in the agriculture sector;

b. strengthening capacities of its field services division to continuously assess and provide updated risk information related to the impact of changing climate on crops in different seasons;

c. strengthen its capacity to assess emerging climate risks in agriculture and its relevance for crop production in consonance with the Vision 2021 document;

d. develop risk assessment capacities of all the concerned institutions at the national levels both horizontally and vertically. This should include the BMD, Ministry of Water Resources, Ministry of Food and Disaster Management, Ministry of Local Government, and Ministry of Social Welfare etc. Capacity building at the districts and local levels must also be invested in expanding the scope of the assessment to include:

   i. potential impact of climate risks (existing and emerging) vertically integrated across assessments since they impact both agriculture and non-agriculture sectors, directly and indirectly;

   ii. the complex relationship between climate and economic variables to understand climate risk impact on the national economy in the short and long term. This includes the direct and indirect impact of the agriculture sector on the economy in general and its indirect impact on the industrial and service sector in particular;

   iii. the vulnerability of the rural groups and people just above and below the poverty line is particularly relevant to investigate;

   iv. the impact of rainfall related inundation within embankments. While floods in Bangladesh are largely due to rainfall outside the country, i.e., in upper catchments, there is recent and emerging risk of rainfall related inundation of agriculture fields within the areas protected by flood embankments built in the last 10- 15 years. These incidents have posed major risk to agriculture crops, and this threat needs to be assessed thoroughly to prepare appropriate response measures.

B. Prioritization of climate risk options:

Despite the importance given to the agriculture sector in different CCA and national planning documents, several important and practical risk management options are not prioritised. While the need for existing climate risk management options remain, the emerging risks demand new tailored options and technology solutions. These may include:

a. New Generation Forecast Technologies: In consonance with Vision 2021 and considering that the November to June crop season may not support Boro rice due to ground water depletion and soil fertility degradation; there is a need to evolve alternate climate risk management options. These may include the following:

i. A 10 day flood and weather forecast could reduce crop losses due to the risk of early flooding and droughts[§] RIMES in collaboration with BMD and FFWC with ECMWF datasets is already implementing the 10 days lead flood forecast on a demonstration basis. This forecast system has significantly reduced flood risks in pilot areas. Institutional capacities need to be built at BMD & FFWC to integrate this forecast technology into their operational forecast system;

ii. A farmer-need-based agro advisories system to guide farmer's decisions for supplementary irrigation during dry spells and to inform decisions related to fertilizer and pesticide applications, planting and harvesting. RIMES in collaboration with BMD, DAE is developing such a system. Capacities of BMD, FFWC and DAE will need to be built to integrate and operationalize these experimental agro-advisories to reduce climate risk for farmers.

b. *Crop restructuring:* Restructuring the crop pattern can minimize crop production losses during monsoon season particularly Aman crop by using advance climate information technology. Vision 2021 proposes restructuring of cropping system to gradually replace boro rice with other food grain crops in some areas. Currently, the MoA has policy options for crop restructuring in specific locations of hoar, saline prone and drought prone areas. This could be expanded and should be preceded by climate risk assessment. An appropriate cropping pattern based on climate risk, market risk and institutional capacity should be developed to support farmers and to consider their preferences.

c. *Crop diversification:* The agriculture development strategy of Vision 2021 encourages crop diversification to meet growing demands for quantity owing to the increasing population and, for quality owing to the increasing disposable income. Considering the limitation of land resource, and some risk in almost all seasons, crop diversification plans must consider sustainability of the new crop systems in different agro-climatic zones. Crop-diversification should also add value through agro-processing and vertical integration of value-added products. Climate risk assessment for the entire supply chain should guide informed decision-making for vertical integration of diversified crops to external markets.

d. *Crop insurance* challenges of moral hazards and adverse selection could be addressed by developing contextually relevant instruments. Also, the premium structure could be made favourable if the risk is reduced through application of new generation climate information.

e. *Ground Water Management:* The inadequate monsoon rains from Jun to Oct, particularly the deficient rainfall in Sep-Oct and low flooding seasons could lead to poor recharge of ground water. Poor recharge entails ground water drought and increased pressure on boro rice and other crops from December to June. Information on ground water budget based on rainfall, soil, topographic features, demand and supply of ground water can enable planners and farmers to plan for winter season crops including boro rice. There is a need to develop a ground water forecast system, transform it for operational users and develop capacities to use it for crop planning.

f. *Enhancing in-land fisheries habitat by controlling low-land boro rice cultivation:* Low-land boro cultivation is competing with and taking over the ideal habitat for several species of fish common in these areas. The impacts of boro cultivation on fishery habitats needs to be assessed urgently and appropriate measures devised to prevent complete loss of their habitat, since fisheries are a sustainable source of food security for the population.

C. Information Management for CRM:

A conservative estimate of the value of weather information to minimise climate risk and maximize potential agricultural management gains in Bangladesh is estimated to be 2.3 billion USD per annum. This benefit could be derived by building a dedicated and use-friendly climate information system for agriculture management within the MoA. It could address the following:

a. T*ailoring climate information to user needs*. Different users have different climate information requirements. Within the same group of users, information requirements are guided by the planning horizon, which could vary from 20-25 years at the organizational/ ministerial level to 5 years and below at the directorate level;

§ CRM TASP estimates that there is a potential risk of losing 3 million tonnes primarily from the risk of early flooding in June, high flooding in July-August, late flooding in September and long dry spells during August–September.

b. *Interpretation and translation of climate information*. Climate information should be interpreted in terms of sector-specific thresholds that are jointly determined by institutional users and communities;

c. *Characterizing and packaging uncertainties associated with climate information of different timescales*. Uncertainties inherent in longer-lead climate information need to be characterized and communicated to facilitate application in a risk management framework. This would also prevent untrained and non-technical users from attributing climate variability-related phenomena to global warming;

d. *Inherent risk in climate information:* Climate information is applied in planning and decision-making, cognizant of the risks due to uncertainties in the information;

e. *Demonstration of the economic benefits in using climate information and adopting the CRM framework*. Appreciation of the economic and social benefits derived from investment in an end-to-end climate risk management system, in terms of time, human resources, and finances would facilitate the adoption and institutionalisation of the CRM framework and system respectively.

D. Capacity development for effective and sustainable Climate Risk Reduction

Despite largely clear mandates for CRM, there are limited capacities within government ministries and agencies to operationalize CRM actions. Institutional, financial and technical capacities of the following key government stakeholders could be built in the long-term to ensure sustainable development of climate risk management and risk reduction systems in Bangladesh. These efforts should be aligned with the existing efforts of the GoB and MoFDM, including for example to upgrade the entire early warning system for all natural hazards, considering that investment of 1 US$ in EWS could bring benefit of 40 US$.

a. *Bangladesh Meteorological Department's (BMD)* capacity to generate user-need based information by strengthening observation capacities, data communication, data processing and appropriate risk communication capabilities to engage with users;

b. *Department of Agriculture Extension (DAE)* capacity to develop suitable disaster databases, and connect past disaster damage data with BMD's climate risk data, to generate climate risk information. A division or unit in DAE with appropriate human resources to build and use such an inventory systematically is needed along with policy, technical and resource support to sustain it in the long term;

c. *Flood Forecasting and Warning Centre (FFWC)* should retain its trained human resources beyond a project-based arrangement to generate a long-term flood forecast system. Their capacity for generating and sharing probabilistic, longer-lead time flood forecast information should also be enhanced to meet user demands for saving livelihoods and assets. A risk communication framework-based training and capacity development system that helps associate probabilistic forecasts with economic values of saved assets and livelihoods could help overcome this barrier;

d. *Disaster Management Bureau (DMB)* capacity to use 5-day forecasts from BMD and FFWC for assessing and communicate potential risk and impact information to district and local level institutions. This would help address the current response-based action approach. It would require policy, technical, and financial support.

In addition to the above, within the agriculture sector, the capacity development requirements of the key institutions under the MoA should include:

a. Ministry of Agriculture: Assessment of capacity building needs to integrate CRM into the agriculture policy and planning processes;

b. Department of Agricultural Marketing: Integrate CRM into market information generation capacities, to provide both climate and market risk information on potential behaviour of markets and response options;

c. Agricultural Information Service: Integrate probabilistic forecast and provide science-based agriculture risk information to the public through the media;

d. Seed Certification Agency: Integrate CRM as one of the criteria for certifying seeds for use in differential hazard environments;

e. Cotton Development Board: Assessment of current and emerging risks, and generation of response options;

f. Bangladesh Jute Research Institute: Integrate climate risk (both current and future) for developing and sustaining jute production;

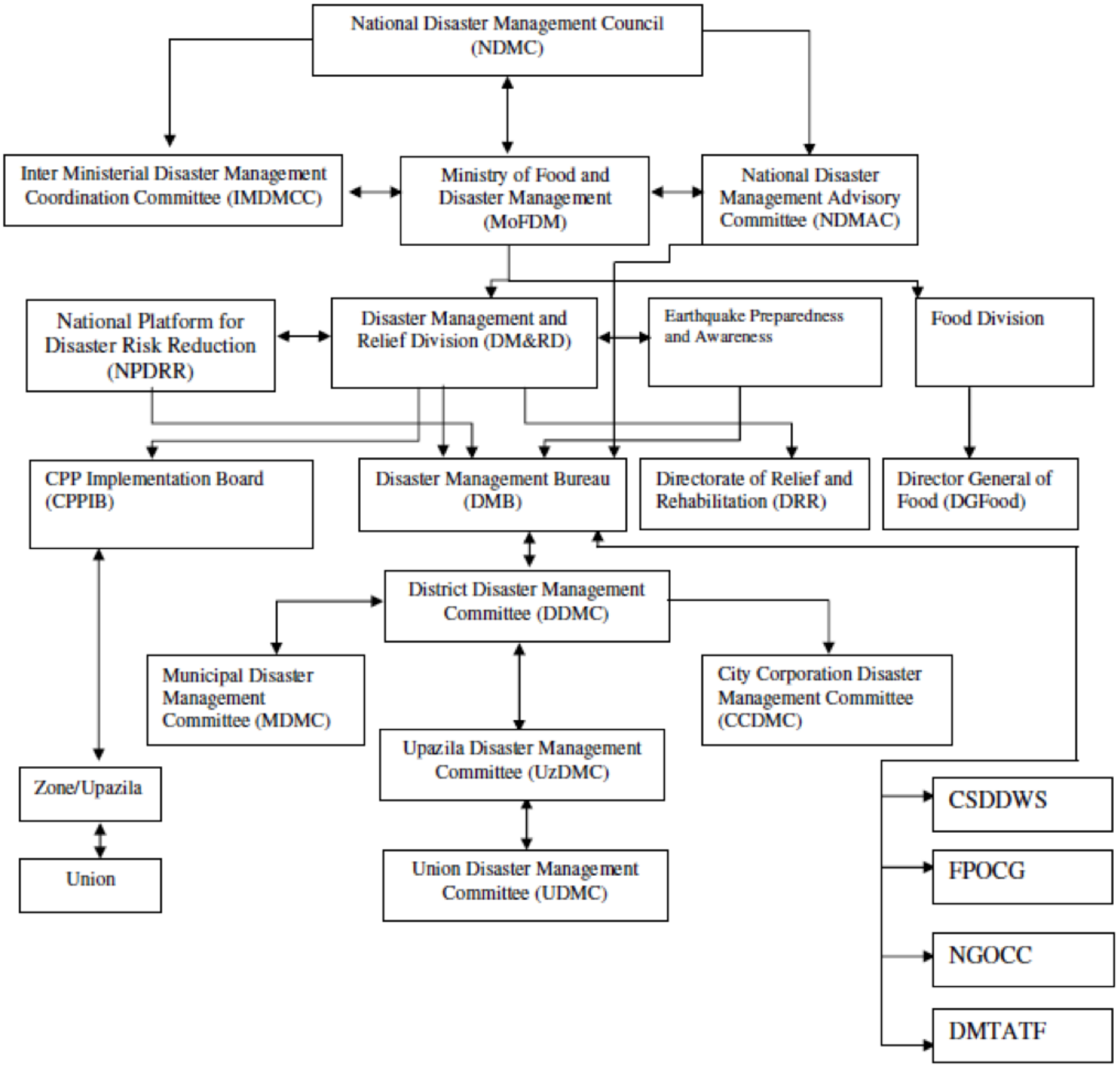
g. Bangladesh Agricultural Development Corporation: Capacities to assess climate risks to the supply and distribution of agriculture goods and design of irrigation systems with feedback loop to the DAE;

h. Barind Multipurpose Development Authority: Regulate ground water and manage surface water resources depending on dynamics of inter-seasonal and intra-seasonal variations and, future risks;

i. Bangladesh Sugarcane Research Institute: Integrate CRM into supply chain management, especially for managing sugar production on intra-annual and inter-annual scales.

ANNEXES

ANNEX 1: DISASTER MANAGEMENT INSTITUTIONS IN BANGLADESH



Source: GoB, 2010. National Plan for Disaster Management- 2010-2015

ANNEX 2: POLICIES GOVERNING AGRICULTURE AND ITS SUB-SECTORS IN BANGLADESH

SUB-SECTOR POLICIES	MAJOR GOALS AND POLICY THRUSTS	IMPLEMENTING MINISTRY
A. Crop sub-sector		
1. National Agriculture Policy (NAP), 2010	Food security, productivity, improved technologies, research and development, commercialisation, self-reliance and sustainable agriculture adaptive to climate change.	Ministry of Agriculture
2. New Agricultural Extension Policy (NAEP), 1996	Provision of efficient decentralized & demand led extension services to all types of farmers, training extension workers, strengthening research-extension linkage, and helping environmental protection	Ministry of Agriculture
3. DAE-Strategic Plan, 1999-2002	Adoption of Revised Extension Approach, assessment of farmers' information needs, supervision, use of low or no cost extension methods, promotion of food and non-food crops, and mainstream gender and social development issues into extension service delivery.	Ministry of Agriculture
4. Agricultural Extension Manual, 1999	Annual crop planning, seasonal extension monitoring, participatory technology development and rural approval partnership, technical audit, attitude and practice surveys.	Ministry of Agriculture
5. Seed policy, 1993	Breeding of crop varieties suitable for high-input and high output agriculture, multiplication of quality seeds, balanced development of public and private sector seed enterprises, simplification of seed important for research & commercial purposes, provision of training and technical supports in seed production, processing & storage monitor, control and regulate quality and quantity of seeds.	Ministry of Agriculture
6. Seed Rules 1997	Delineation of rules and regulations regarding changing functions and of national seed board, registration of seed dealers, seed certification, marking truthful labels, and modalities of seed inspection.	Ministry of Agriculture
7. Plan of Action on NAP, 2003	Reviewing NAP and its implementation, setting out strategies and actions, and identifying institution and programme framework	Ministry of Agriculture
8. Actionable Policy Brief (APB), 2004	Prioritize immediate medium-term and long-term policy measures with respect to seed, fertilizer, land, irrigation, mechanization, marketing, agricultural research and extension with a view to increasing labour & water productivity, investment in agriculture and improve risk management.	Ministry of Agriculture
9. National Jute Policy, 2002	Keeping jute production at a desirable level, stabilizing supply and prices of jute, developing commercially viable jute industries, accelerating privatization of jute industries, and developing multiple uses of jute & jute goods.	Ministry of Jute

SUB-SECTOR POLICIES	MAJOR GOALS AND POLICY THRUSTS	IMPLEMENTING MINISTRY
B. Non-crop sub-sector		
10. Livestock Policy and Action Plan, 2005	Improvement of small scale poultry and dairy farming replicating CLDDP, reform of DLS, enforcement of low and regulations towards animal feeds, vaccines and privatization of veterinary services adoption of breeding policy, and establishment of livestock insurance development fund and livestock credit food.	Ministry of Fisheries and Livestock
11. National Fishery Policy, 1998	Development of fishery resources, increasing fish production and self-employment, meeting demand for animal proteins accelerating fish exports, and improvement of public health.	Ministry of Fishery and Livestock
12. National Forest Policy 1994	Bringing 20 percent area under afforestation, enriching bio-diversity, extending assistance to forestry sector development through development of land and water resources, implementation of national and international efforts and agreements relating to global warming, desertification control of wild bird and animal trade, and prevention of illegal occupation of forest lords, felling of trees, encroachment and hunting of wild animals.	Ministry of Environment and Forest, 1994
C. Cross-Cutting policies		
13. National Land use policy	Minimizing loss of cropland, stopping indiscriminate use of land, preparing guidelines for land use for different regions, rationalizing land acquisition, and synchronization of land use with natural environment.	Ministry of Land
14. National Water Policy, 1998	Development and management of surface and groundwater in an efficient manner ensuring access of the poor, women and children to water, accelerating development of sustainable public and private water delivery systems, development of a legal and regulatory framework for private sector investment in water development, and capacity building for designing future water resource management plans.	Ministry of water Resources
15. Environment Policy 1992 and Implementation Programme	Protection of environment, identification and control of pollution, sustainable use of natural resources and participation in all international initiatives to protect environment	Ministry of Forests and Environment
16. National Food Policy, 2004	Ensuring dependable food security system, adequate and stable supply of safe and nutritious food at affordable prices, increasing access and food purchasing power of people.	Ministry of Food
17. National Rural Development Policy, 2001	Improving income and employment of rural people, ensuring participation of rural people in development process, improvement of rural infrastructure and marketing facilities, local level planning, training of youths and women, and development of disadvantaged, small minority communities and hill tract regions.	Ministry of Rural Development and Cooperatives
18. Agriculture and Rural Development section, PRSP, 2005	Creation of enabling environment and plying supportive roles for intensification of major crops i.e. (cereals) diversification to high value non-cereal crops, (i.e. fruits & vegetable) development of non-crop enterprises (i.e. livestock, fishery, poultry), and promotion of rural non-farm economy, and outlining a policy matrix on future actions.	Planning Commission, Ministry of Planning

Source: (Adapted) A Synthesis of Agricultural Policies in Bangladesh. Agriculture Sector Review. Ministry of Agriculture, Government of Bangladesh, July 2006

REFERENCES

1. GoB, 2006. A Synthesis of Agricultural Policies in Bangladesh. Agriculture Sector Review. Ministry of Agriculture, Government of Bangladesh, Dhaka, July 2006

2. Islam, undated: "Analyzing Changes of Temperature over Bangladesh due to Global Warming Using Historic Data" by Akm Saiful Islam. Available at http://teacher.buet.ac.bd/akmsaifulislam/publication/Paper_TWAS_Islam.pdf

3. Shahid, 2010: Trends in extreme rainfall events of Bangladesh, Theor Appl Climatol (2011) 104:489–499

4. BARC, 2000: Flood prone areas map of Bangladesh by Bangladesh Agriculture Research Council, July 2000. Available at http://www.foodsecurityatlas.org/bgd/country/vulnerability/shocks-files/image001.jpg

5. RIMES. (2011). Bangladesh country report.

6. CCC, 2009: Characterizing Long-term Changes of Bangladesh Climate in Context of Agriculture and Irrigation. Climate Change Cell, DoE, MoEF; Component 4b, CDMP, MoFDM. Month 2009, Dhaka

7. EMDAT: The OFDA/CRED International Disaster Database – www.emdat.be, Université Catholique de Louvain, Brussels (Belgium)

8. UNEP RRCAP, 2001: Bangladesh State of Environment, 2001, Available online at http://www.rrcap.unep.org/reports/soe/bangladesh_disasters.pdf

9. BWDB, 2012: Article on Flash Flood. Available online on http://www.bwdb.gov.bd/index.php?option=com_content&view=article&id=177&Itemid=150

10. DMB, 2012: Outline of Most Severe Disaster, Disaster Management Bureau, Bangladesh. Available online at http://www.dmb.gov.bd/s-disaster.html

11. DMB, 2007: "Consolidated Damage and loss Assessment,Lessons Learnt from the Flood 2007 and

12. Future Action Plan", November 2007

13. DMB, 2007: "Consolidated Damage and loss Assessment,Lessons Learnt from the Flood 2007 and

14. Future Action Plan", November 2007

15. GoB, 2008: Cyclone Sidr in Bangladesh Damage, Loss and Needs Assessment For Disaster Recovery and Reconstruction. A Report Prepared by the Government of Bangladesh Assisted by the International

16. Development Community with Financial Support from the European Commission

17. GoB, 2008: Cyclone Sidr in Bangladesh Damage, Loss and Needs Assessment For Disaster Recovery and Reconstruction. A Report Prepared by the Government of Bangladesh Assisted by the International

18. Development Community with Financial Support from the European Commission

19. Shahid & Behrawan, 2008: Drought risk assessment in the western part of Bangladesh, Nat Hazards (2008) 46:391–413

20. Selvaraju & Stephen, 2007: Climate variability and change: adaptation to drought in Bangladesh, A resource book and training guide. Asian Disaster Preparedness Center and Food and Agriculture Organization of the United Nations, Rome, 2007

21. Rafiuddin, 2011: "Diagnosis of Drought in Bangladesh using Standardized Precipitation Index", 2011 International Conference on Environment Science and Engineering, IPCBEE vol.8 (2011) © (2011) IACSIT Press, Singapore

22. Boken et al., 2005: Monitoring and Predicting Agricultural Drought, A Global Study, Oxford University Press, 2005.

23. MEF, 2005, National Adaptation Programme of Action (NAPA) from Ministry of Environment and Forest, November 2005.

24. Ramirez, A. (2010). The impact of climate change on rice production.

25. WorldBank. (2011). Bangladesh: Priorities for Agriculture and Rural Development. Retrieved 7th Jan, 2011, from web. worldbank.org › ... › Agriculture › Countries

26. Basak, J. K. (2009). Effects of Increasing Temperature and Population Growth on Rice Production in Bangladesh: Implications for Food Security. Unnayan Onneshan-The Innovators.

27. GED & UNDP, 2009: Policy Study on " The probable impacts of climate changes on poverty and economic growth and the options of coping with adverse effect of climate change in Bangladesh"

28. Paul, 1995: "Quick Response Report #76, Farmers' and Public Responses to the 1994-95 Drought in Bangladesh: A Case Study". Available at http://www.colorado.edu/hazards/research/qr/qr76.html#18

29. Ninno et al., 2001:"The 1998 Floods in Bangladesh Disaster Impacts, Household Coping Strategies, and Response", International Food Policy Research Institute

30. Ninno et al., 2001:"The 1998 Floods in Bangladesh Disaster Impacts, Household Coping Strategies, and Response", International Food Policy Research Institute

31. MoF, 2012: "A Chronicle of Last Three Years: Building the Future – Budget Speech 2012-2013". Ministry of Finance, Government of People's Republic of Bangladesh

32. PC, 2011: Sixth Five Year Plan FY2011-FY2015: Part2- Sectoral Strategies, Programs and Policies. By Planning Commission, Ministry of Planning, Government of the People's Republic of Bangladesh

33. GoB, 2010. Standing Orders on Disaster. Ministry of Food and Disaster Management, Disaster Management & Relief Division, Disaster Management Bureau, April 2010. Government of the People's Republic of Bangladesh

34. GoB, 2010. National Plan for Disaster Management- 2010-2015. Disaster Management Bureau, Disaster Management & Relief Division. April 2010. Government of the People's Republic of Bangladesh

35. Comprehensive Disaster management Programme (CDMP) Phase II- 2010- 2014. Project Document. Ministry of Food and Disaster Management, Government of People's Republic of Bangladesh and United Nations Development Programme.

36. MoEF, 2009. Bangladesh Climate Change Strategy and Action Plan 2009. Ministry of Environment and Forests, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh. xviii + 76pp.

37. Khan, S M Munjurul Hannan., Huq, Saleemul., Shamsuddoha, Md., undated. The Bangladesh National Climate Funds, A brief history and description of the Bangladesh Climate Change Trust Fund and the Bangladesh Climate Change Resilience Fund. LDC Paper Series. Accessed from: http://ldcclimate.files.wordpress.com/2012/05/bangladeshnationalfund.pdf

38. DMB, 2011. National progress report on the implementation of the Hyogo Framework for Action (2009-2011). Disaster Management Bureau, Disaster Management and Relief Division, Ministry of Food and Disaster Management, Government of People's Republic of Bangladesh.

39. National Council of Applied Economic Research, 2010. Impact Assessment and Economic Benefits of Weather and Marine Services. Government of India.

40. 2009. Akter S., Brouwer, R., Choudhury, S., & Aziz, S., Is there a commercially viable market for crop insurance in rural Bangladesh? Mitig Adapt Strateg Glob Change (2009) 14:215–229 DOI 10.1007/s11027-008-9161-6. Springer.

41. GOB, 2009. Crop Insurance as a Risk Management Strategy in Bangladesh, June 2009. Climate Change Cell, Department of Environment, Government of People's Republic of Bangladesh.

Empowered lives.
Resilient nations.

For more information: **www.undp.org**

United Nations Development Programme

One United Nations Plaza • New York, NY 10017 USA