

BACHELOR-THESIS

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ECONOMIC IMPACTS OF CLIMATE CHANGE ON BANGLADESH

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Abbreviations

ADB	Asian Development Bank
BCAS	Bangladesh Center for Advanced Studies
BEMP	Basin Environmental Monitoring Plan
BRAC	Bangladesh Rural Advanced Committee
CBO	Community Based Organisation
CCC	Climate Change Committee
CCIA	Climate Change Impact Assessment
CCS	Carbon Capture and Storage
CDM	Clean Development Mechanism
CFC	Chlorofluorocarbon
CH ₄	Methane
CLACC	Capacity Strengthening of Least Developed Countries for Adaptation to Climate Change
CO ₂	Carbon Dioxide
COP	Conference of Parties
CPP	Cyclone Preparedness Programme
DFID	Department for International Development
DMB	Disaster Management Bureau
DMP	Disaster Management Programme
EPA	Environmental Protection Agency
EU	European Union
FAP	Flood Action Plan
FCD/I	Flood Control and Drainage / Irrigation
FiFYP	Fifth Five Year Plan
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GNI	Gross National Income
GoB	Government of Bangladesh
HCFC	Hydro Chlorofluorocarbon
HIPC	Heavily Indebted Poor Countries
LDC	Least Developed Country
LECZ	Low Elevation Coastal Zone
ICZM	Integrated Coastal Zone Management
IFC	International Finance Cooperation
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change

KfW	Kreditanstalt für Wiederaufbau
MCS	Multi Purpose Cyclone Shelters
MIGA	Multilateral Investment Guarantee Agency
N ₂ O	Nitrous Oxide
NAPA	National Adaptation Programme of Action
NWMP	National Water Management Plan
O ₃	Ozone
OECD	Organisation of Economic Cooperation and Development
PPM	Parts Per Million
PRSP	Poverty Reduction Strategy Paper
SEDF	South Asia Enterprise Development Facility
SEMP	Suburban Emergency Management Project
SMEs	Small and Medium-Size Enterprises
UN	United Nations
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
UNISDR	United Nations International Strategy for Disaster Reduction
WMO	World Meteorological Society

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Terminology

Definitions on climate change and disaster risk reduction vary. Therefore, it is essential to make a distinction of definitions used in context of this thesis. The terminology is literally cited from the UN Environment Programme (UNEP), the UN International Strategy for Disaster Reduction (UNISDR), Sarker, the Digital Opportunity Channel, Dow and Downing.

Adaptation: Degree to which adjustments are possible in practices, processes or structures.¹

Annex I

Countries: Include all developed countries in the OECD and economies in transition as amended in 1998 to the United Nations Framework Convention on Climate Change (UNFCCC).²

Anthropogenic: Human induced climate change.

Carbon

Sequestration: Removal and storage of atmospheric carbon dioxide (CO₂) in carbon sinks.

Carbon sink: Reservoirs, processes, activity or mechanisms that store more CO₂ than they release, such as forests and oceans.

Char land: In the process of erosion and accretion pieces of land or islands are created.³

Clean Development

Mechanism: To meet two objectives: 1) assist in achieving sustainable development; and 2) to assist in achieving compliance with emission limitations.⁴

Climate: Average weather or statistical description of the mean temperature adjoined with variability over a period of time (the classical period is 30 years).

Climate Change: Climate is changed if over an extended period a significant change in the mean state or variability of the climate occurs.⁵ Changes in climate may be due to natural processes or to persistent anthropogenic changes.

Disaster: Serious disruption of a community or society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources.⁶

¹ UNISDR, 2004

² Definitions Annex I Countries to Carbon Sink are literally cited from Dow / Downing, 2007, p. 13

³ Sarker et al, 2003, p. 1

⁴ Definitions CDM to Climate are literally cited from Dow / Downing, 2007, p. 14

⁵ UNISDR, 2004

⁶ Definitions Disaster are literally cited from UNISDR, 2004

Disaster Risk

Management: Systematic process of administrative decisions, organization, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters.

Disaster Risk

Reduction: Conceptual framework to minimize vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards, within the broad context of sustainable development.

Greenhouse Gas: A gas consisting of water vapour, carbon dioxide, methane, chlorofluorocarbons and hydro chlorofluorocarbons which absorbs and re-emits infrared radiation warming the earth's surface and contributing to climate change.⁷

IPCC: Intergovernmental Panel on Climate Change (IPCC) established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) in 1988 to assess scientific, technical and socio-economic information relevant to the understanding of climate change.⁸

Kyoto Protocol: Legally binding commitments of the United Nations Framework Convention on Climate Change (UNFCCC) came into force in 2005. Most countries agreed to reduce anthropogenic GHG emissions by 5% below 1990 levels during 2008-2012.

Least Developed

Countries: Countries with per capita incomes below USD 750 a year, low levels of literacy and nutrition, plus a higher level of vulnerability to natural disasters and economic shocks.⁹

Mitigation: Structural and non-structural measures undertaken to limit the adverse impact of hazards and environmental degradation.¹⁰ Defined as anthropogenic intervention to reduce the sources or enhance the carbon sinks of greenhouse gases.¹¹

Preparedness: Activities and measures taken in advance to ensure effective response to the impact of hazards, including the issuance of timely and effective early warnings and the temporary evacuation of people and property from threatened locations.¹²

⁷ UNEP, 1998

⁸ Definition of IPCC and Kyoto Protocol are literally cited from Dow / Downing, 2007, p. 14, 16

⁹ Digital Opportunity Channel, 2008

¹⁰ UNISDR, 2004

¹¹ Dow / Downing, 2007, p. 15

¹² Definitions of Preparedness to Sustainable Development are literally cited from UNISDR, 2004

Prevention:	Activities to provide outright avoidance of the adverse impact of hazards and means to minimize related environmental, technological and biological disasters.
Recovery:	Decisions and actions taken after a disaster with a view to restoring or improving the pre-disaster living conditions of the stricken community, while encouraging and facilitating necessary adjustments to reduce disaster risk.
Relief:	The provision of assistance or intervention during or immediately after a disaster to meet the life preservation and basic subsistence needs of people affected. It can be of an immediate, short-term, or protracted duration.
Resilience:	The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing to reach and maintain an acceptable level of functioning and structure.
Risk:	Harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions.
Sensitivity:	Degree to which a system will respond to climate change.
Sustainable Development:	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
Thermohaline Circulation:	Large-scale density-driven circulation in the ocean, caused by differences in temperature (thermo) and salinity (haline). ¹³
UNFCCC:	United Nations Framework Convention on Climate Change signed in 1992 by more than 150 countries and the EU. Objective is the “stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.”
Vulnerability:	Extend to which climate change may damage or harm a system. ¹⁴ The conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards.

¹³ Definitions Thermohaline Circulation and UNFCC are cited from Dow / Downing, 2007, p. 16

¹⁴ See UNISDR, 2004

“We know that dramatic changes are still to come and they will result in huge economic costs.”

Brett Orlando, IUCN Climate Change Advisor, 2003

1. Introduction

Today, humanity is facing the unchallenged growth of economic and social inequalities with a world population of six billion.¹⁵ Climate change at its current rate is not appearing naturally: humans induced it.¹⁶ Evidence for this strong accusation is the elevated amount of atmospheric carbon dioxide (CO₂), which is beyond any quantities recorded in the preceding 650,000 years.

In the past, Bangladesh has always been subject to multiple natural disasters.¹⁷ Strong consensus prevails on the fact that Bangladesh is one of the most affected countries by climate change.¹⁸ The Intergovernmental Panel on Climate Change (IPCC) highly recognized the vulnerability of Bangladesh's economy towards climate change.¹⁹ Sectors related to the economy such as health, water supply, food security, and coastline development are dependent on climate.²⁰ Economic growth is the only solution for Bangladesh to independently act against climatic threats which increase poverty. Hence, time has arrived to discuss economic impacts of climate change on Bangladesh leading to a new phase of adaptive economic development.

The Stern Report has revealed that action against climate change is not too costly. Social mitigations, adaptations to change, as well as strategies for intergovernmental cooperation are the focus in reducing economic impacts of climate change. Individuals rather than governments or companies are the driving force behind mitigation of greenhouse gases (GHGs). Nevertheless, reducing GHG emissions is not enough. Long-term economic adaptation strategies are essential as change is unavoidable.²¹

¹⁵ See Kjellen in Dow / Downing, 2007

¹⁶ See Dow and Downing, 2007

¹⁷ See Flood Hazard Research Centre, 2008

¹⁸ See Bangladesh Centre for Advanced Studies, 2008

¹⁹ See Thomalla et al, 2005

²⁰ See World Bank, 2008a

²¹ See Goodall, 2007, p. 3-4

1.1 Scope and Objectives of the Study

This work assesses the economic impacts of climate change in Bangladesh. It is based on an appraisal of global and regional variations in climate and an analysis of findings and predictions derived from models, empirical studies and scientific publications.²² Predictions about climate are combined with socio-economic and sectoral data to evaluate and rank economic impacts of climate change on Bangladesh, in particular on coastal zones and riverine settlements.²³ This study does not offer a complete overview of potential impacts on the economy of Bangladesh, yet rather a selection of significant highlights.²⁴ Suggestions will be made on possible strategies for risk reduction.

The study examines structures for the mitigation of, and adaptation to, climate change risks facing Bangladesh, as well as the varied approaches of civil society, the Government of Bangladesh (GoB), international donor agencies, industry and commerce to these risks.²⁵ Further, the interaction among these institutions and the compatibility of their various projects is reviewed. Development priorities of the GoB are assessed to evaluate if they measure up to the identified risks. The study examines the problems of combining environmental action, sustainable economic growth and sound management of resources. Finally, alternative strategies are suggested that may help establish a more effective consensus among policy makers, the GoB, Non Governmental Organisations (NGOs) and donor agencies.²⁶

²² See OECD, 2003b

²³ See OECD, 2003a, p. 9

²⁴ See Ali, 2005, p. 1

²⁵ See OECD, 2003a, p. 9

²⁶ See UNDP, 2008a

1.2 Structure of the Study

The thesis is divided into seven chapters.²⁷ The *Introduction, Scope and Objectives of the Study* along with the *Structure of the Study* constitutes *Chapter 1*. The *2. Chapter* deals with the issue of climate change in general, highlighting the causes and impacts.²⁸ In the *3. Chapter*, the study introduces the coastal and riverine territories of Bangladesh, emphasising the economic value of these areas to development activity.²⁹ In the *4. Chapter*, the economic implications of climate change are estimated. Economic analysis deals with risk, the probability of major (or non-marginal) change and potential impacts of such change. Possible impacts of climate change and a rise in sea level are delineated. The effects of extreme weather conditions (cyclones, storm surges, back water effects) on agriculture, forestry, fisheries, the mangrove ecosystem and biodiversity are presented together with the problems of drought, flooding, erosion and the intrusion of salt water.³⁰ A special section looks at the threatened *4.2.5 Loss of the World Heritage Site – The Sundarbans*.³¹ The *5. Chapter* discusses and evaluates current *National Policies and Programmes*. The *6. Chapter* outlines *Alternative Strategies* for creating policies that incorporate both the latest predictions about global warming and possible mitigation or adaptation.³² Such policies will be based on a re-examination of current development projects that are exposed to the impacts of climate change and will establish the necessary mitigations and adaptations. In *Chapter 7* a *Conclusion* of the research and evaluation of data is presented.

²⁷ See Radix, 2008

²⁸ See Project of Climate Change in Canada, 2008

²⁹ See Flood Hazard Research Centre, 2008

³⁰ See Ali, 2005, p. 1

³¹ See Greenhouse, 2008

³² See Rahman / Huq / Uddin Ahmed, 1999

2. Causes and Impacts of Climate Change

The atmosphere of planet earth is thinner than the peel of an apple - so vulnerable is our climate system.³³ In the past, climate change has occurred as a result of natural changes: climate change happened over time.³⁴ However, over the last two centuries human activity has introduced a new era of change to the climate through industrialization, massively increased use of fossil fuel and the clearing of forests.³⁵ If we speak of climate change today we refer to the changes which have occurred in the climate since the 1790s. Scientists have been measuring change in atmospheric composition since the Industrial Revolution.³⁶

The mechanism of GHGs is central to an understanding of climate change, for the admixture of these gases controls the warmth of the planet.³⁷ According to the IPCC, all scientists agree that global GHG emissions increased with industrialization.³⁸ Recently, the pace of emissions has greatly accelerated; a 70% augmentation of GHG emissions from the 1970s – 2004 has been recorded. Through extensive GHG emissions a heat trapping blanket is created and thickened.³⁹ This GHG effect has induced an increased global temperature.⁴⁰ Consequently, the entire climate system is adjusting to an increase of heat trapped in the earth's atmosphere.⁴¹

Despite present mitigation policies geared to sustainable development, it is predicted that global GHGs will further increase within the next 10 - 30 years.⁴² Some forecasts suggest that long-term economic stability depends on mitigation of global GHG emissions over the next 10 - 30

³³ See WWF, 2006

³⁴ See BBC, 2008a

³⁵ See Huq, 2008

³⁶ See Dow / Downing, 2007, p. 30-33

³⁷ Note: For details see *Section 2.1* below

³⁸ See IPCC Working Group III, 2007, p. 3, 4

³⁹ See WWF, 2006

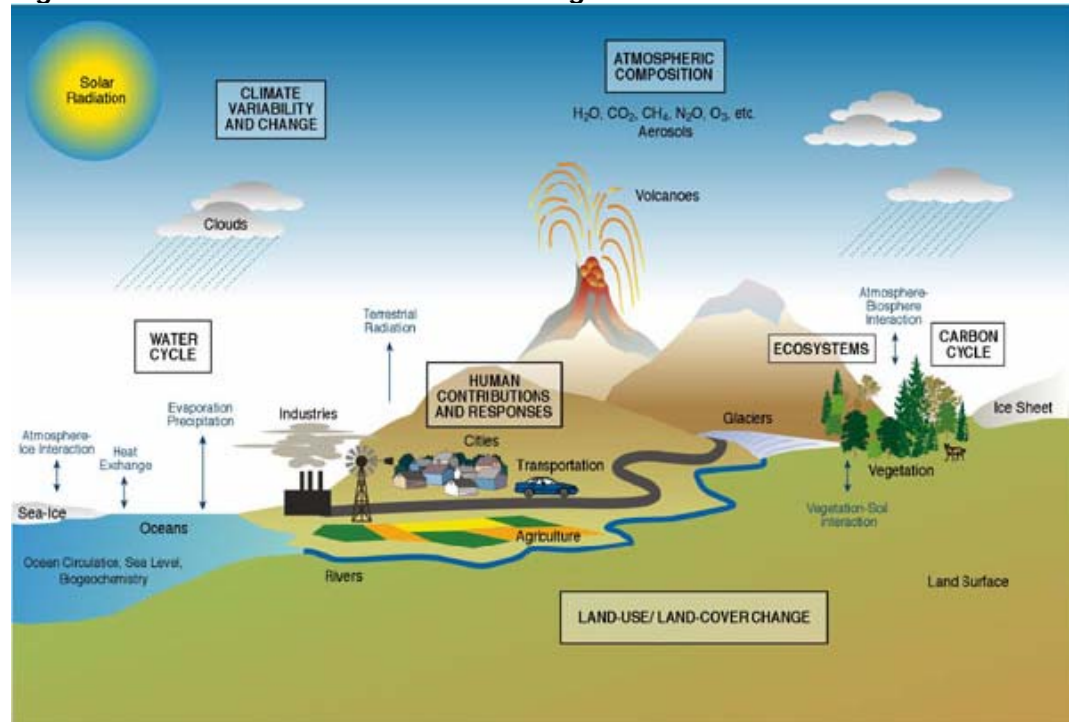
⁴⁰ See IPCC Working Group III, 2007, p. 3, 4

⁴¹ See Dow / Downing, 2007, p. 30-33

⁴² See IPCC Working Group III, 2007, p. 4, 9

years: climate change is increasingly seen as the biggest challenge facing humanity.⁴³ Civilization is currently and will continue to be impacted by climatic variations. The world's impoverished nations will be affected most.

Figure 1: Factors within the Climate Change Process



Source: Climate Science, 2003

2.1 Causes of Climate Change

The modification of climate is triggered by mounting quantities of greenhouse gases (GHGs) in the atmosphere.⁴⁴ The greenhouse effect is created by the sun rays which reach and are absorbed by the atmosphere.⁴⁵ Without this effect the earth would reach a temperature of only -19°C (climate of the moon) instead of the present average $+15^{\circ}\text{C}$.⁴⁶

When the earth heats up it radiates its own heat in the form of infrared rays.⁴⁷ If these infrared rays can not escape the atmosphere they are absorbed by GHGs. These particular gases warm the earth and establish

⁴³ See World Development Movement, 2008, p. 1

⁴⁴ See United Nations, 2008

⁴⁵ See International Test Center for CO₂ Capture, 2005

⁴⁶ See United Nations, 2008

⁴⁷ See BBC, 2008a

its present temperature.⁴⁸ Global warming is caused by too many GHGs being released into the atmosphere, and absorbing too much heat, thus warming the planet.⁴⁹

The most important GHGs in the atmosphere are: carbon dioxide (CO₂), methane (CH₄), chlorofluorocarbon (CFC), ozone (O₃) and nitrous oxide (N₂O).⁵⁰ CO₂ can be more easily measured in the atmosphere than other gases. Perhaps that is the reason why CO₂ is often presented as the greatest danger to the planet, whereas more harmful gases exist, e.g., methane (CH₄).⁵¹

Table 1: Origins of Greenhouse Gas Emissions

Originator	%	Gases	Effects and Impacts
Energy including traffic	50%	40% CO ₂ 10% CH ₄ and O ₃	Use of fossil energy carriers
Chemical products	20%	FCKW, Halon (halogenated hydrocarbon) etc.	Direct emissions
Destruction of tropical rainforest	15%	10% CO ₂ 5% vestiges gases	Destruction of tropical rainforest
Other e.g., agriculture	15%	15% CH ₄ , N ₂ O, CO ₂	Cattle, fertilizer, waste deposits, cement

Source: Henrichs, 2001, p. 7 taken from Rentz, 1995, p. 26

Unsurprisingly, the smallest contribution to GHGs comes from Least Developed Countries (LDCs).⁵² Also unsurprisingly, these are the very countries that will suffer most from the impacts of climate change and have the lowest ability to adapt to its threats.⁵³

⁴⁸ See Physics Forum, 2008

⁴⁹ See UNEP, 2007

⁵⁰ See American Geophysical Union, 1999

⁵¹ See Henrichs, 2001, p. 3

⁵² See UNCTAD, 2001, p. 45

⁵³ See Vidal, 2008

2.1.1 Historical Pattern of Climate Change

When studying past climates, it becomes evident that concentrations of carbon dioxide (CO₂) and methane (CH₄) are higher now than they have ever been during the last 650,000 years.⁵⁴ The temperature of the planet is warmer than at any time within the last 1,000 years. Warming in the polar region and on the world's glaciers is driving large-scale melting of ice that will have both local and global consequences. Weather related disasters are becoming increasingly common around the world, although some part of the apparent increase may be due to better reporting.

One fundamental question is: do records exist that show a rise in average global temperature? The U.S. Environmental Protection Agency (EPA) affirms that from 1880 – 1910 temperatures remained steady.⁵⁵ A rise in temperature was documented lasting until 1945 followed by a cooling period until 1975.⁵⁶ From that time a solid rise has occurred lasting until today. Overall, according to the American National Research Council the average global temperature has warmed by 0.6°C during the last century.⁵⁷ Various reasons for this phenomenon have been suggested: a variation in the earth's flight path or in the concentration of radiation from the sun that activates warming or cooling periods. The most commonly stated reason for the present day temperature rise, however, is the volume of greenhouse gases (GHGs) in the atmosphere. As early as 1990, the IPCC stated that GHGs were increasingly being released and present concentrations of gases were affecting global climate.⁵⁸ Furthermore, the IPCC indicated an increase of 35% in CO₂ since the beginning of industrialization in Europe. EPA in the United States confirms that CH₄ has been recorded at 151% above pre-industrial levels, while nitrous oxide (N₂O) surged by 18% during the previous 200 years.⁵⁹

⁵⁴ See Dow / Downing, 2007, p. 34-35, 22-27

⁵⁵ See CNN, 2008

⁵⁶ See Environmental Protection Agency, 2008

⁵⁷ See CNN, 2008

⁵⁸ See Huq, 2008

⁵⁹ See Environmental Protection Agency, 2008

Is climate change really happening, or is it simply the result of inefficient computer simulations? The *Fourth Assessment Report* of the IPCC took the view that climate change is “for real.” Observations document that hurricanes, floods, and droughts are the short-term outcome of long-term climatic causes.⁶⁰ Disastrous events have occurred with greater frequency during the last decade.⁶¹ Some changes are irreversible, further changes are inevitable, but if international action is taken now, outright catastrophe may still be avoided. Climatic variation is a global problem; it cannot be solved nationally.

2.1.2 Predictions, Forecasts and Scenarios

Although scientific teams use the most sophisticated software available today to predict climate change scenarios, the real consequences of greenhouse gases (GHGs) are still not definitively established.⁶² Even so, ignoring the Armageddon scenarios, conservative estimates agree that temperatures will continue to rise.⁶³ For example, the IPCC predicts that if there is no change in current behaviour, this will result in a temperature rise of between 1°C and 3.5°C before the year 2100 as compared with the year 1900.⁶⁴ Unless political measures are taken to induce change in behaviour the following consequences are foreseen by the IPCC:

- Winter temperatures will be higher than summer;
- Continents will be warmer than oceans;
- Change of climate zones will cause shifts in natural habitats of animals and plants causing migrations, adaptations and mutations;
- Forests, which can survive a climatic change of only 1°C per 100 years, will vanish together with forest animals.⁶⁵

⁶⁰ See World Health Organisation, 2008

⁶¹ See *Appendices 9-15* for further details on disaster occurrence

⁶² See Henrichs, 2001, p. 5-6

⁶³ See Open Directory Project, 2008

⁶⁴ See IPCC, 2007, p. 10-13

⁶⁵ See IPCC, 2007, p. 12

One often cited result of climate change is a rise in sea level.⁶⁶ The IPCC projects that warmer oceans and the melting of glaciers will lead to an average sea level rise of 20 - 86cm before the year 2100.⁶⁷ Ignoring population growth, the number of affected people by floods will increase from 46 to 92 million.⁶⁸ This view may be alarming. Ralf Henrichs in his influential book *Die Implementierung der Kyoto Mechanismen* takes the position that the detailed consequences of climate change cannot be identified. In any case, he argues that a rise of sea level in the past 100 years of 10 - 25cm and a temperature change of 0.3 - 0.6°C lie within the framework of natural change yet these figures also overlap the minimum estimation of the IPCC.

Low Elevation Coastal Zones (LECZs) are especially threatened by climate change.⁶⁹ Bangladesh, Vietnam and Egypt are the most affected countries in terms of overall persons living in the LECZ, and in terms of the proportion of the population in the risk zone. Particularly Bangladesh and Vietnam have numerous urban settlements in this zone. Although exact figures for carbon dioxide (CO₂) emissions cannot be established, the IPCC anticipates that emissions from Annex I countries will adversely affect economic patterns in other countries.⁷⁰

⁶⁶ See Climate Institute, 2008

⁶⁷ See IPCC, 2007, p. 11-12

⁶⁸ See Henrichs, 2001, p. 5-6

⁶⁹ See IIED, 2007, p. 27,

⁷⁰ See IPCC, 2007, p. 12

Table 2: Countries with Largest Population LECZ

Ranked by total population in the LECZ					Ranked by share of population in the LECZ			
Top Ten	Country	Overall Rank*	Population in the LECZ		Country**	Overall Rank*	Population in the LECZ	
			Counts ('000)	%			Counts ('000)	%
1	China	1	143,880	11	Bahamas	174	267	88
2	India	2	63,188	6	Suriname	170	318	76
3	Bangladesh	8	62,524	46	Netherlands	59	11,717	74
4	Vietnam	13	43,051	55	Vietnam	13	43,051	55
5	Indonesia	4	41,610	20	Guyana	157	415	55
6	Japan	9	30,477	24	Bangladesh	8	62,524	46
7	Egypt	16	25,655	38	Djibouti	160	289	41
8	USA	3	22,859	8	Belize	179	91	40
9	Thailand	19	16,478	26	Egypt	16	25,695	38
10	Philippines	14	13,329	18	The Gambia	150	494	38

Source: IIED, 2007, p. 26

* Refers to overall rank in total population

**Countries with a total population of under 100,000 people, or smaller than 1,000 square kilometres were excluded from this list. If all countries were included, 7 of the top 10 would be places with fewer than 100,000 persons, the top 5 having more than 90 per cent of their country in the LECZ (Maldives, Marshall Islands, Tuvalu, Cayman Islands, Turk and Caicos Island).

2.2 Impacts of Climate Change

Impacts caused by floods, heat waves, cyclones and hurricanes have in the past been recorded as historical costs of climate change.⁷¹ Andrew Dlugolecki of the General Insurance Development states: "In the year 2065, on current trends, damage from climate change will exceed global Gross Domestic Product (GDP)."⁷² The European Union (EU) Commission estimates costs of inaction which will be caused by various natural hazards to amount in € 74 trillion within the next decades.⁷³ Macro-economic costs for mitigation of various gases in the atmosphere, assuming constant emission levels of 445 - 710 parts per million (ppm) of carbon dioxide (CO₂), will range from a 3% reduction of GDP to a slight increase in GDP as measured from the baseline, even though local costs diverge notably.⁷⁴ Multi-gas mitigation aimed at achieving stable levels of 710 - 445ppm of

⁷¹ See WWF, 2006

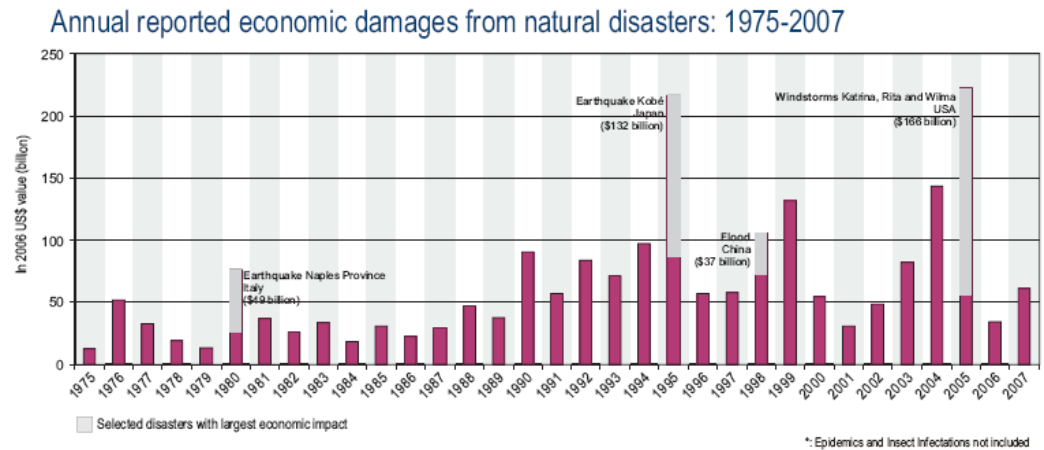
⁷² Earthfuture, 2008

⁷³ See Bruton, 2005

⁷⁴ See IPCC, 2007, p. 11, 18

CO₂ by 2050 will cost some 1% of GDP; this is in addition to shrinkage of 5.5% of GDP caused by the combined impacts of global warming.

Figure 2: Economic Damages from Natural Disasters 1975 - 2007



Source: Emdat, 2007

2.2.1 Vulnerabilities

Multiple definitions for the term *vulnerability* exist. This section defines vulnerability from (a) *a climate change perspective*, (b) *a development planning aspect*, and (c) *a disaster planning standpoint*.⁷⁵

Climate change impacts both environmental and social systems.⁷⁶ In industrial and developing countries impacts occur in different forms.⁷⁷ Impacts depend on the vulnerability of a system. Vulnerability in the context of (a) *climate change* means the extent to which a modification in climate might destroy or prejudice the environment.⁷⁸ In (b) *development planning and poverty assessment*, vulnerability is described as defencelessness and insecurity in the face of multiple stresses, shocks and risk over an extended time. In (c) *disaster planning*, risk is the outcome of vulnerability (social, economic and environmental exposure and sensitivity) and hazard (the probability and magnitude of an extreme event).

⁷⁵ See Thomalla et al, 2005, p. 6

⁷⁶ See Dow / Downing, 2007, p. 17

⁷⁷ See Thomalla et al, 2005, p. 6

⁷⁸ See Dow / Downing, 2007, p. 17

The Organisation for Economic Cooperation and Development (OECD) defines that the term vulnerability is including three “dimensions”: 1) *exposure*, 2) *sensitivity*, and 3) *adaptive capacity* of the affected system.⁷⁹ The term *sensitivity* means the level to which a system might react to variability in climate. The third dimension, *adaptability*, is the level to which adjustments are possible.⁸⁰ The three dimensions of vulnerability, as identified by the OECD, depend on an array of socio-economic features of a system, which are: (a) *certainty of impact*, (b) *timing*, (c) *severity of impact*, (d) *importance of the sector*: is this sector particularly critical in terms of its potential economic or cultural impact on other sectors?⁸¹

This concept of *vulnerability* offers a useful structure for assessing the probable course, scale, and pace of climatic modification to which a system is *exposed*, its *sensitivity*, and its *adaptive capacity*.

2.2.2 Global Impacts

Robert Watson of the IPCC emphasized on the following changes: "The decade of the 1990s was the hottest decade of the last century and the warming in this century is warmer than anything in the last 1,000 years in the Northern Hemisphere."⁸² Geographically, everyone is affected differently by climate change.⁸³ This section highlights the ecological and economic impacts of climate change worldwide.⁸⁴

Ecologically, we are experiencing climate change in form of the thermohaline circulation collapse, extreme weather events, sea level rise, and degradation of ecosystems.⁸⁵ Natural environments are affected by rapid melting of snow into glacial lakes and snow-fed rivers, instability of

⁷⁹ See OECD, 2003c

⁸⁰ See Rahman / Huq / Uddin Ahmed, 1999

⁸¹ See OECD, 2003c

⁸² Earthfuture, 2008

⁸³ See Huq, 2008

⁸⁴ See Tyndall Centre for Climate Change Research, 2007

⁸⁵ See The Climate Group, 2008a; Note: Thermohaline Circulation: Large-scale density-driven circulation in the ocean, caused by differences in temperature (thermo) and salinity (haline).

permafrost areas resulting in rock avalanches and sudden instability of Arctic and Antarctic ecosystems.⁸⁶ Hydrological systems are undergoing variations through greater release of water causing changes in sea level leading to higher vulnerability of island states.⁸⁷ Increase of temperature in lakes, rivers and oceans creates impacts on temperature schemes and water conditions such as acidity caused by extensive release of anthropogenic carbon into the atmosphere.⁸⁸ Observations of species show that global warming affects terrestrial biological systems: the advanced start of the spring season with unfolding of vegetation, the migratory patterns of birds, the premature laying of eggs, the poleward and upward shifts of plant and animal species are all examples. Satellite images show premature greening of vegetation and longer growing phases.

In terms of economic impacts Sir Nicholas Stern projected, in his economic report published in October 2006, that failure to introduce emission controls will lead to costs equivalent to losing at least 5% of global GDP per annum.⁸⁹ Industries that are dependant on climate such as tourism and agriculture will bear the consequences.⁹⁰ The economy faces not only indirect effects such as mass migration but also the direct impact of extreme weather events such as desertification and lack of drinking water.⁹¹ Stern proposes expenditures of 1% of global GDP per annum to reduce greenhouse gas emissions.⁹² He estimates that the longer the world economy waits to take action the higher the costs will be, and the less likely it will be to avoid the worst impacts.

⁸⁶ See IPCC, 2007;

⁸⁷ See Maman, 2007; See IPCC, 2001

⁸⁸ See Dow / Downing, 2007, p. 11; See Economist, 2008b; Note: The world's oceans absorb a million tonnes of carbon dioxide an hour, which helps to slow down global warming, yet causes acidity.

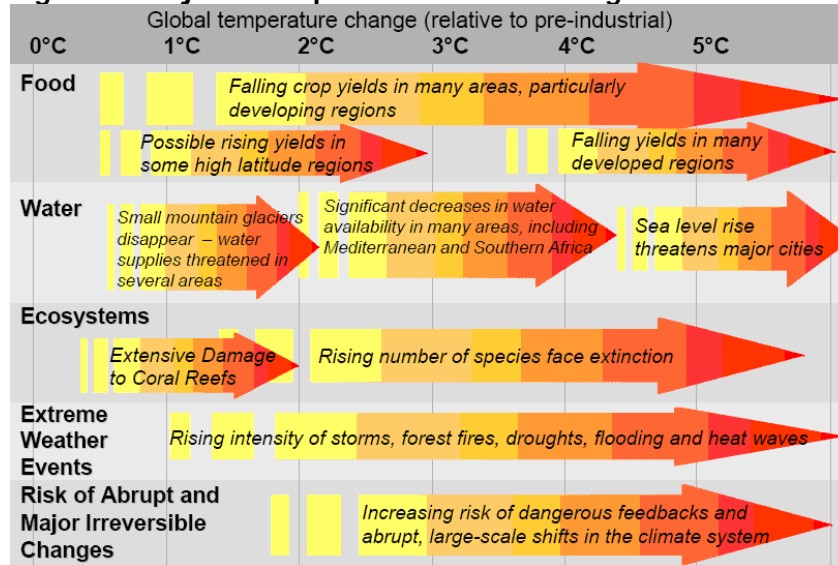
⁸⁹ See The Climate Group, 2008a

⁹⁰ See Chapters 4.3.4 and 4.3.5 on Agriculture and Tourism

⁹¹ See Chapter 6.2.3 *Migration and Employment*

⁹² See Heartland Institute, 1998

Figure 3: Projected Impacts of Climate Change



Source: Stern Review Slides, 2007, p. 2

2.2.3 Selected Regional Impacts

The *IPCC Fourth Assessment Report* states on 6 April 2007 that profound evidence indicates regional climate change on all continents and most oceans.⁹³ Since the 1970s, data of the IPCC records anthropogenic warming effects on physical and biological systems. Signs of change are overall temperature rise, extreme temperatures coupled with drought, and extreme precipitation and wind.⁹⁴

In continental Europe, 35,000 deaths occurred during the heat wave in summer 2003 with temperatures 3°C above average.⁹⁵ By 2040, this 3°C rise in summer temperatures for Europe will be normal and by 2060 the average temperatures will be even higher.⁹⁶ Mediterranean countries such as Spain which are already suffering from water shortages are severely threatened.⁹⁷ Some parts of the developing world will be facing even worse scenarios.⁹⁸

⁹³ See IPCC, 2007, p.2-3

⁹⁴ See Dow / Downing, 2007, p. 19

⁹⁵ See UNEP, 2003

⁹⁶ See Dow / Downing, 2007, p. 19

⁹⁷ See Marti, 2000

⁹⁸ See IISD, 2005

In 2050, the world will be warmer with an estimated population of 9 billion people facing degrading supplies of food and water.⁹⁹ China will be experiencing difficulties in feeding its growing population in the face of climatic hazards. Chinese and British scientists forecast that by the year 2080 the yields of wheat, maize and rice will decrease by 37%.¹⁰⁰ Worldwide food production is decreasing, which is visible in the statistics of grain harvest in the years of 2000 to 2003.¹⁰¹

In East Africa, the United Nations (UN) reports that 11 million people are in desperate need of food and water.¹⁰² Ethiopia has suffered severe droughts and famines and will continue to do so. Most plants in Ethiopia have reached their thermal maximum in coping with climate change and new crop varieties must be developed to tackle the problem.¹⁰³ Overall, regional impacts may differ but shortages and problems in one region necessarily have global effects.

2.3 Mitigation and Adaptation: Is it too late?

"If you think mitigated climate change is expensive, try unmitigated climate change."¹⁰⁴ (Dr. Richard Gammon, University of Washington, June 28, 1999)

Two possible approaches are recognised to deal with climate change. The first one is mitigation, the second is adaptation. The recent centre of attention has been mitigation, e.g., reducing greenhouse gas (GHG) emissions, rather than adaptation which means assuming impacts (e.g., storms, floods, and sea-level rise) will happen and finding ways to cope with them.¹⁰⁵ Mitigation comprises attempts to reduce the impacts of global warming, for example, the Kyoto Mechanism through joint

⁹⁹ See Climate Group, 2008a

¹⁰⁰ Note: Improved strains of seeds, disease resistant, drought resistant and improved agricultural techniques

¹⁰¹ See Climate Group, 2008a

¹⁰² See Climate Group, 2008a

¹⁰³ See Overseas Development Institute, 2003

¹⁰⁴ Earthfuture, 2008

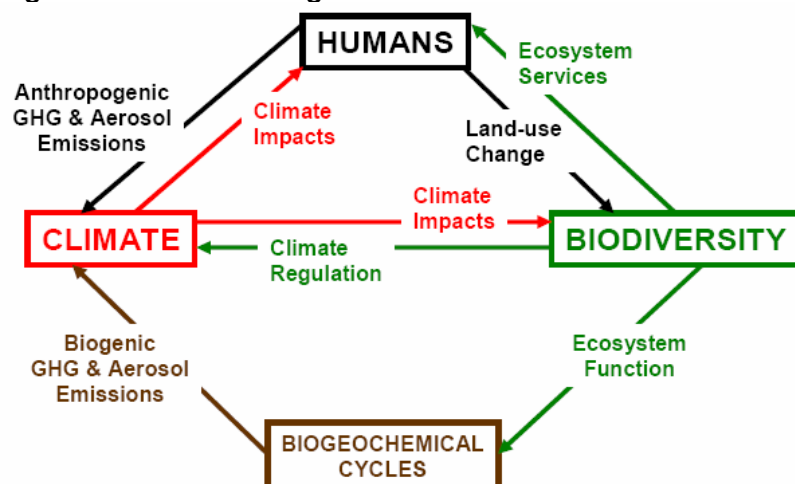
¹⁰⁵ See IIED, 2005

implementation, the clean development mechanism (CDM) and tradable emission rights. These economic instruments are already playing an important role in controlling global emissions.¹⁰⁶ Revolutionizing daily life and behaviour is the key to climate change mitigation.¹⁰⁷ For instance, reducing fuel consumption for cars and factories and preventing deforestation will cut the release of carbon dioxide (CO₂).¹⁰⁸

Mitigation is the subject of international agreements, whereas adaptation tends to be on a local level.¹⁰⁹ Although some impacts may not be felt for decades, action is required now through adaptation programmes. Construction and infrastructure ideally should be sensitive to present and future environmental risks. Adaptation to climate change is perhaps the greatest challenge facing society today at all levels: individuals, households, firms, governments and international organisations.¹¹⁰

In *Figure 4: Climate Change Interactions* mitigation needs to set in on anthropogenic GHG and aerosol emissions. Further mitigation is required in land use practices of humans inducing changes on biodiversity. Also, adaptation is required to climate impacts on humans and biodiversity.

Figure 4: Climate Change Interactions



Source: The Royal Society, 2007

¹⁰⁶ See Henrichs, 2001, p. 2

¹⁰⁷ See IPCC, 2007, p. 12

¹⁰⁸ See BBC, 2008a

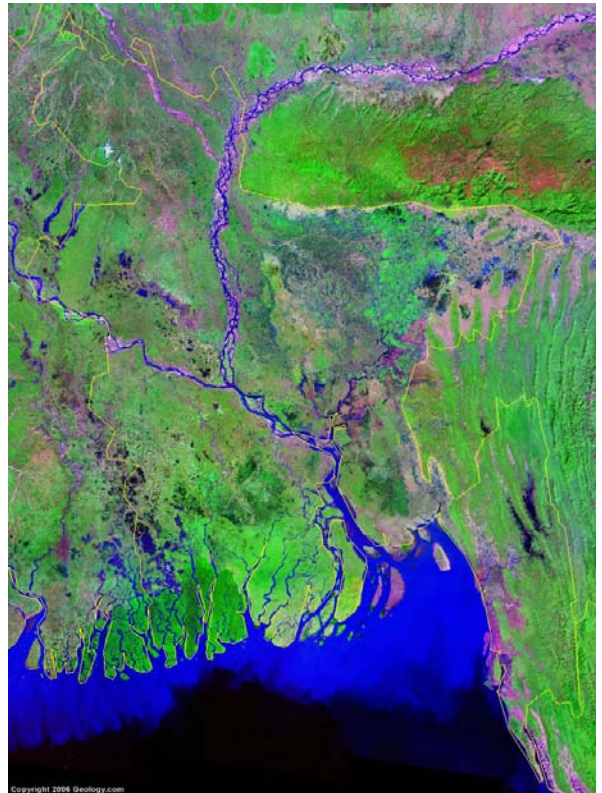
¹⁰⁹ See IIED, 2005

¹¹⁰ See Tyndall, 2008

3. Bangladesh

In *Chapter 3*, a brief description of Bangladesh is background information for the discussion on economic impacts of climate change in *Chapter 4*. A special section looks at the dynamics of Bangladesh's developing economy.

With a population of 158.9 million in 2007 and a population growth rate of 1.9%, Bangladesh is one of the most "disaster prone" countries on earth.¹¹¹



Geography of Bangladesh

Source: The Cooperator – Bangladesh (2008)

Seasonal monsoons and cyclones are among the most destructive phenomena affecting the country.¹¹² Bangladesh is situated at the crossing point of two contrasting environments: the Bay of Bengal with the North Indian Ocean to the south and the Himalayas to the north.¹¹³ Although this unique setting provides life-giving monsoons, it also generates periodically reappearing catastrophic disasters such as tropical cyclones, storm surges, floods, droughts and erosion.¹¹⁴ These disasters cause huge loss of life and property, impeding development activities.¹¹⁵ While Bangladesh has always contended with these natural disasters, the country is now facing an even bigger threat, this time human-made: climate change and sea level rise.¹¹⁶ The geographical location and

¹¹¹ See CIA World Factbook, 2008; Health Library for Disasters, 2007; Economist, 2008d

¹¹² See Fraser, 2007

¹¹³ See Ali, 2005, p. 1-2

¹¹⁴ See Flood Hazard Research Centre, 2008

¹¹⁵ See OECD, 2003a, p. 1-13

¹¹⁶ See Ali, 2005, p. 1-2

geomorphic conditions of Bangladesh, its almost flat topography, and high population density, have made the country almost uniquely vulnerable to environmental disaster.¹¹⁷ In particular this applies to the coastal areas of the country.¹¹⁸ Imperative today are a full appreciation of the climate threat and long-term policies to safeguard against catastrophe.¹¹⁹

3.1 Country Overview

Bangladesh has been identified as the 10th fastest developing economy among 31 developing countries with populations of over 20 million.¹²⁰ The World Bank records in September 2006 remarkable social and economic achievements since the 1990s.¹²¹ These consist of solid economic growth of a median 5% per annum with minimal inflation as well as stable national debt, interest and exchange rates. The drop in population growth, rated in the 1980s at 2.5% and down to 1.9% in 2006, has led to an immense annual per capita GDP growth from 1.6% in the 1980s to 6.5% in 2007.¹²² In terms of per capita GDP growth, Bangladesh surpassed all other LDCs and therefore, has the resources to improve its disaster management.¹²³ Bangladesh's progress toward its Millennium Development Goals is indicated by its outperformance of most low-income countries in the following social categories: increased primary school enrolment paired with eliminating gender disparity in school enrolment, decline in infant to child mortality, and poverty reduction.

Bangladesh has a long history of severe economic impacts from floods, droughts, tropical cyclones and storm surges.¹²⁴ The fertile alluvial land is used intensively for agriculture which provides the backbone of the country's economy. Other indicators of low socio-economic development

¹¹⁷ See Institute of Water Modelling Bangladesh, 2003

¹¹⁸ See Flood Hazard Research Centre, 2008

¹¹⁹ See World Bank, 2006a

¹²⁰ See World Bank, 2005

¹²¹ See World Bank, 2006a

¹²² See United Nations Data, 2007; See Economist, 2008d

¹²³ See World Bank, 2006a

¹²⁴ See Thomalla et al, 2005, p. 2

include a large rural population 75% in 2007, a low life expectancy of 62 years, a high illiteracy rate 59% and high infant mortality 52 per 1,000 births.¹²⁵ Many small impoverished communities lack the resources to cope with current climate variability and extreme climatic events. The average population density is 1,209 people per km². Higher population densities increase exposure to risk and limit the possibilities of migration within the country.

3.2 Geography and Climate

Located between 20° - 26° north and 88° - 92° east, Bangladesh is enclosed on the west, north and east by India, on the south-east by Myanmar, and on the south by the Bay of Bengal.¹²⁶ Topographically, 10% is barely 1m over sea level.¹²⁷ With one-third subject to tidal excursions, 80% of the country is floodplain.¹²⁸ Elevations range from less than 1m on tidal floodplains (1 – 3m on estuarine floodplains) up to 6m in the north-eastern Syleth basin.¹²⁹ The highest point is the Mowdok range (1,052m) in the southeast Chittagong Hill Tracts. Scientists agree 50% of the land will be flooded if the sea level rose by 1m.¹³⁰ The delta is formed by the confluence of three mighty rivers: the Ganges, the Brahmaputra and the Meghna, one of the biggest river networks in the world.¹³¹ In general, mighty rivers have many “distributaries, tributaries, sub-distributaries and sub-tributaries.” In all, Bangladesh is interlaced by 230 rivers totalling approximately 24,140km.¹³² International consensus is hard to reach on water concerns with 58 tributaries crossing borders with neighbouring countries.¹³³ The rich sediments deposited by these rivers create highly productive agricultural land.¹³⁴

¹²⁵ See Thomalla et al, 2005, p. 2; Islam, 2007

¹²⁶ See OECD, 2003a, p. 9; Newsfinder, 2002

¹²⁷ See Encyclopaedia Britannica, 2003a, p. 687

¹²⁸ See Ali, 2005, p. 2; Flood Hazard Research Centre, 2008

¹²⁹ See Encyclopaedia Britannica, 2003b, p. 789

¹³⁰ See OECD, 2003a, p. 9

¹³¹ See Flood Hazard Research Centre, 2008

¹³² See Encarta, 2007

¹³³ See CIA World Factbook, 2008

¹³⁴ See FAO, 2008

A hot and humid summer occurs in Bangladesh from March to June. In the winter months from October to March temperatures are moderate. Primarily monsoon and partly pre- and post-monsoon circulations last from June to October and supply most of the country's rainfall.¹³⁵ The monsoon is formed over the Indian Ocean and brings along with it warm, humid, unpredictable airstreams.¹³⁶

Thus, Bangladesh is fertile, well watered and productive. For the same reasons, it is climatically unstable and particularly vulnerable to change.¹³⁷

3.3 A Developing Economy

Bangladesh is considered a least developed country (LDC). To understand the current state of its fragile economy it is essential to look into the historical events that formed the country of what is now Bangladesh.

European trade commenced in the vicinity of what was then Bengal in the year 1600 and through British colonisation the area developed into British India.¹³⁸ In 1947, the largely Muslim states of West Pakistan and East Bengal detached from India, which was predominately Hindu, to bring into existence the new country of Pakistan. In the year 1955, East Bengal became East Pakistan. The impracticable division of a country into two parts with a geographic separation of 1,600km marginalized the Bengalis and created dangerous unrest. After a bloody civil war with endless victims, East Pakistan broke away from West Pakistan in 1971 and was renamed: *The People's Republic of Bangladesh*. Nation-building is never easy. In its quarter century of existence, Bangladesh has confronted social, economic, and political problems. Perhaps it is for this reason that environmental problems have taken a back seat.

¹³⁵ See Auswärtiges Amt, 2008

¹³⁶ See United Nations, 2007

¹³⁷ See Appendix 16: Geographic Facts for further details

¹³⁸ See CIA World Factbook, 2008a

Each year during the monsoon season, roughly a third of the country is submerged, a serious obstacle to economic development. Prioritizing economic growth, the Government of Bangladesh (GoB) has seen disaster preparedness primarily within a short-term economic perspective.¹³⁹ The long-term threat of cyclones, storm surges, floods, droughts, tornadoes, river-bank erosion and earthquakes has never been fully addressed.

LDCs are more vulnerable to economic shocks than developing countries.¹⁴⁰ Turbulences on the world market such as rapid rises in commodity prices, oil and wheat are current examples, dramatically affect the economy. When the whole economy relies on a narrow range of exports, in the case of Bangladesh textiles and agricultural products, the country is at high risk.¹⁴¹

According to the Asian Development Bank (ADB) and the Economist, Gross Domestic Product (GDP) is estimated to be almost 6% in fiscal year 2008.¹⁴² Although half of GDP is generated through the service sector, two-thirds of Bangladeshis work in agriculture, many growing rice which is one of the most important products of the country.¹⁴³ In 2007, this key sector suffered severe damage caused by flooding and a ruinous cyclone. With one quarter of the country's GDP derived from agriculture, GDP is highly sensitive to climate change.

Despite this disruption to agriculture, the economy appears to be reasonably stable, an impression that may be deceptive. What suggests stability? Revenue performance has improved though fiscal challenges remain.¹⁴⁴ The volume of exports increased in September 2007 as compared with July and August 2007.¹⁴⁵ Foreign exchange reserves have

¹³⁹ See Asian Disaster Reduction Center, 2007, p. 2

¹⁴⁰ See UNCTAD, 2001, p. 43

¹⁴¹ See Economist, 2008d

¹⁴² See ADB QEU, 2007, p. 5; See Economist, 2008d

¹⁴³ See OECD, 2003a, p. 10

¹⁴⁴ See Appendix 17: Economic Indicators for Bangladesh in 2007 for further details

¹⁴⁵ See ADB QEU, 2007, p. 5

remained stable, despite pressure on the current account balance. Inflation in Bangladesh remains high in September 2007. The economy has grown 5 - 6% annually over the past few years despite incompetent government-owned ventures, delays in natural resource exploitation, inadequate electricity generation, and sluggish execution in reforming the economy.¹⁴⁶ Garment exports and remittances from Bangladeshis working overseas, mainly in the Middle East and East Asia, continue to fuel economic growth. Soon after winning the *Nobel Peace Prize* last year, *Mohammad Yunus* published an article called *A Vision for Bangladesh*, in which he pointed out a startling fact: "expatriate Bangladeshis send more money home per capita than their Chinese and Indian counterparts."¹⁴⁷ Last year, over USD 5 billion went directly into the Bangladeshi economy, sent from Britain, the US, and most substantially, from the Middle East.¹⁴⁸ All this suggests some measure of stability though at a low level.

Militating against this image of stability are other less encouraging figures. Per capita income in Bangladesh is USD 370 per month somewhat below average South Asian per capita income and per capita income for low income countries. More than 36% of the population live in poverty, of which 40% are found in rural areas.¹⁴⁹ According to the OECD, Bangladesh ranks low in all measures of economic development.¹⁵⁰ Its negative trade balance expanded at a yearly pace of 5.4% from 2001 - 2005 caused to a degree by elevated oil prices.¹⁵¹ This negative balance has certainly become worse in 2008. Does Bangladesh have any workable plans for escaping the poverty trap? If it does it is keeping them secret.

Added to these economic woes the overwhelming long-term threat of climate change may be turning a difficult situation into one that is almost insoluble.

¹⁴⁶ See CIA World Fact Book, 2008

¹⁴⁷ See Anam in The Guardian, 2007

¹⁴⁸ See Anam in The Guardian, 2007

¹⁴⁹ See OECD, 2003a, p. 10

¹⁵⁰ See OECD, 2003a, p. 10

¹⁵¹ See UNCTAD, 2006a

4. Climate Change: The Economic Impacts

"Every time someone in the West turns on a kettle, he or she is helping to flood Bangladesh." (George Monbiot, *The Guardian Weekly*, 10 February 2000)

Why does *The Guardian Weekly* columnist *George Monbiot*, who won the *United Nations Global 500 Award* for outstanding environmental achievement, utter such a provocative statement?¹⁵² Is it really true that human-induced climate change, largely created through the industrialization in Europe and the United States, currently destroys the economic survival of 158.9 million Bangladeshis? Understanding the reality behind Monbiot's statement, this Chapter identifies the economic impacts of climate change within sectors of the economy in Bangladesh.¹⁵³

The analysis of economic impacts of climate change is introduced by an elaboration of the *4.1 Methodology for Impact Assessment* used in the study. A depiction of *4.2 Current Scenarios and Key Vulnerabilities* within the country generates a comprehension of climatic threats on the economy. The section *4.2 Current Scenarios and Key Vulnerabilities* focuses on five distinct scenarios that impede economic development, namely: *4.2.1 Sea Level Rise Projections; 4.2.2 Frequency and Intensity of Cyclones; 4.2.3 Flooding and Erosion; 4.2.4 Drought; and 4.2.5 Loss of the World Heritage Site – The Sundarbans*. Once key vulnerabilities, implied through climate change scenarios, are identified the study then proceeds with the evaluation of climatic impacts on sectors of the economy in the sections: *4.3.1 Society in a fragile Economy; 4.3.2 Industry and Services; 4.3.3 Infrastructure; 4.3.4 Agriculture and Forestry; 4.3.5 Ecosystems, Biodiversity and Tourism; and 4.3.6 Health as the Basis for Education and Employment*.

¹⁵² See Monbiot, 2006

¹⁵³ See Ericksen et al, 1993, p. 33

4.1 Methodology of Impact Assessment

To categorize economic impacts of climate change on Bangladesh the methodology of an *Impact Assessment* is installed in this study. An *Impact Assessment* ascertains types and levels of impacts on the economy. The objectives of an *Impact Assessment* in this work are to: 1) judge if impacts are acceptable; 2) design, and implement monitoring, mitigation and management measures.¹⁵⁴

An *Impact Assessment* is a criterion for cooperation with international donor agencies and is fundamental for economic development in environmentally vulnerable regions such as Bangladesh. The *Climate Change Impact Assessment (CCIA)* conducted in *Chapter 4* focuses on economic sectors in Bangladesh. This CCIA helps in the establishment of integrated planning approaches to circulate and present impact assessments to responsible authorities.¹⁵⁵ The applied CCIA judges the climatic primary hazards: sea level rise, cyclones, floods, erosion, drought and loss of biodiversity in sections 4.2.1 - 4.2.5.¹⁵⁶ In section 4.3.6 *Employment, Health and Education*, secondary hazards such as illnesses caused by severe flooding and the spread of water borne diseases are examined.¹⁵⁷

4.2 Current Scenarios and Key Vulnerabilities

Current Scenarios and Key Vulnerabilities of this Chapter are regarded as baseline scenarios of climate change. A baseline scenario is defined as the assumed condition for evaluation and projection.¹⁵⁸ Projections of climate baseline scenarios such as temperature and precipitation change (in the form of sea level rise, cyclones, flooding, erosion and drought) are

¹⁵⁴ See Business Dictionary, 2008

¹⁵⁵ See Rahman / Huq / Uddin Ahmed, 1999

¹⁵⁶ See National Disaster Association, 2008

¹⁵⁷ See Ericksen et al, 1993, p. 36

¹⁵⁸ See Business Dictionary, 2008

reviewed in this section.¹⁵⁹ Key vulnerabilities in economic sectors are presented in order of importance.¹⁶⁰ This order of importance is based on subjective judgements of significant climate change impacts.¹⁶¹

Climate change is a reality for millions of people living in developing countries.¹⁶² Documentation shows that more than 98% of the 443,000 people killed and 2.5 billion affected by weather-related incidents in the last 10 years are from developing countries.¹⁶³ The IPCC propose that internationally the “balance of evidence” is indisputable that Bangladesh will experience the most severe impacts from climate change.¹⁶⁴ Bangladesh has a low adaptive capacity to climate change because of the poverty in the country.¹⁶⁵ Scientists predict that climate change is set to inundate Bangladesh with floods and erosion for four reasons:

- 1) Rainfall increase of 10 - 20% in the next 100 years;
- 2) Melting glaciers in the Himalayas result in higher water run-off;
- 3) Rising sea levels will result in flooding and slow the water run-off;
- 4) Higher sea temperatures and wind speeds make cyclones worse.¹⁶⁶

Estimations of climate models predict a firm increase in temperature for Bangladesh with little inter-model discrepancy.¹⁶⁷ Specifically, more warming is estimated for winter than summer. Regarding all these estimations of climate models, the height of capacity for Bangladesh to respond to climate change is questionable.¹⁶⁸ Furthermore, climate change prognosis suggest various outcomes for the environment of Bangladesh over the next 40 - 60 years, these include:

¹⁵⁹ See Ericksen et al, 1993, p. 34

¹⁶⁰ See Business Dictionary, 2008

¹⁶¹ See OECD, 2003a, p. 11

¹⁶² See Tearfund, 2008

¹⁶³ See The Guardian, 2007

¹⁶⁴ See Rahman / Huq / Uddin Ahmed, 1999

¹⁶⁵ See Thomalla et al., 2005, p. 3

¹⁶⁶ See World Development Movement, 2008, p. 1

¹⁶⁷ See OECD, 2003a, p. 13

¹⁶⁸ See Ericksen et al, 1993, p. 13, 36

- Multi-hazard core areas;
- Rising sea level, cyclones, flooding, and erosion in the coastal zone;
- Severe flooding and erosion in the river-margin zone;
- And drought in the mid-western zone.

Multi-hazard core areas most exposed are located in:

- The **coastal zone** west of Feni district, particularly within the districts of Noakhali, Lakshmipur, Jhalakati, and Pirojpur where cyclones, floods, riverbank erosion and salinity problems occur;
- The **mid western zone** reaching north-west from districts of Narail, Gopalganj and in the south through Magura, Jessore, Rajbari, Faridpur and Pabna to Siraganj, Natore and Rajshahi where droughts, floods and riverbank erosion is recorded;
- The **river-margins zone** where flooding and riverbank erosion take place in scattered, linear patterns through the length of the country;
- And **major cities** where their life-line systems are exposed to several natural events.

This paragraph focuses on the multi-hazard core area of the coastal zone, which is of profound economic value to Bangladesh's development.¹⁶⁹ Two major harbours, Chittagong and Mongla, are located in the coastal area supporting economic activity.¹⁷⁰ Income generating opportunities are the reason for settlements of over a quarter of the population.¹⁷¹ Estimates project the coastal population to reach 45 - 55 million by 2050. The 720km coastline and coastal waterways supply fisheries and offer routes for inland and marine transport.¹⁷² Since the 1980 extensive parts of the coastal zones have been transformed for shrimp cultivation. Coastal plains are used for agriculture, especially rice production and livestock grazing, throughout the year.¹⁷³ The eastern coastal plains are used for salt production and few coastal islands are used for drying fish. The Industrial activity has been constrained by the limited availability of saline-free

¹⁶⁹ See Ali, 2005, p. 2

¹⁷⁰ See Auswärtiges Amt, 2008

¹⁷¹ See OECD, 2003a, p. 34

¹⁷² See Flood Hazard Research Centre, 2008

¹⁷³ See OECD, 2003a, p. 34

process water.¹⁷⁴ The Sundarbans mangrove area located in the coastal zone is a giant source of income for the country's economy.¹⁷⁵ A big prospect constitutes oil and gas in the coastal territories.¹⁷⁶

Table 3: Physical Vulnerability Context of Sectors in Bangladesh

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

(a) Legend: + equivalent to minimal vulnerability, ++ medium vulnerability, +++ high vulnerability, - no vulnerability

Source: Shaheduzzaman, 2005, p. 7

4.2.1 Sea Level Rise Projections

Increasing sea level is a current scenario of climate change that exposes key vulnerabilities of economic sectors and settlements along the coastline. To comprehend the economic costs created by sea level rise it is important to look at estimations made by leading scientist around the world. Ayres and Walter estimate that 1.5m of sea level rise create global costs of USD 2.5 - 5 trillion. Whereas global costs for the loss of productive land during a sea level rise of 1.5m are as high as USD 15 trillion.¹⁷⁷ These figures do not include social costs, such as loss of life, and environmental costs, such as irreversible damage to biodiversity. In

¹⁷⁴ See OECD, 2003a, p. 34

¹⁷⁵ See Ali, 2005, p. 2; See Section 4.2.5 for details on the Sundarban's economic value

¹⁷⁶ See Encyclopaedia Britannica, 2003a

¹⁷⁷ See Loske, 1996, p. 187

practice, loss of life is still not quantified in costs and environmental economics is still in its infancy stage.¹⁷⁸

Large scale subsidence of coastal areas combined with climate change induced sea level rise result in a relative rise of sea level which is more than twice the predicted global rate in Bangladesh.¹⁷⁹ The OECD suggests that the coastal lands in Bangladesh are receiving additional sediments due to tidal influence, while other parts of the country are subsiding due to tectonic activities.¹⁸⁰ Changes in flow dynamics as a result of sea level rise could result in the erosion of river and estuary banks.¹⁸¹ Overall, *Damage and Cost Categories* for sea level rise in Bangladesh are the following ones:

- 1) Capital costs for construction of coastal protection e.g., embankments;
- 2) Costs caused by loss of property and productivity units;
- 3) Costs caused by frequent flooding.¹⁸²

The worst case scenario is the permanent displacement of people from the coast. A rise in sea level of 1m would reduce Bangladesh's land area by 20%, forcing 15 million people to migrate.¹⁸³ However, the number of people affected will be greater than that. A total of 46 million people in Bangladesh already live in flood endangered areas. Therefore, a 1m rise in sea level would increase the number of target victims to 118 million.

4.2.2 Frequency and Intensity of Cyclones

Bangladesh retains extreme vulnerability to cyclones on account of its unique location and topography that creates an inverted funnel effect.¹⁸⁴

¹⁷⁸ See Tietenberg, 2007, p. 1-35

¹⁷⁹ See Thomalla et al, 2005, p. 4

¹⁸⁰ See OECD, 2003a, p. 15

¹⁸¹ See Thomalla et al, 2005, p. 4

¹⁸² See Loske, 1996, p. 187

¹⁸³ See World Development Movement, 2008, p. 1

¹⁸⁴ See OECD, 2003a, p. 14

Given this current vulnerability the critical question is: how climate change might influence the pattern and intensity of cyclones?¹⁸⁵

Cyclones appear suddenly out of the Bay of Bengal, and their paths are relatively unpredictable.¹⁸⁶ They originate in the deep Indian Ocean and track through the Bay of Bengal where the shallow water contributes to huge tidal surges when cyclones make landfall.¹⁸⁷ While cyclones tend to make landfall they also extend inland sometimes reaching the north-east corner of the country.¹⁸⁸

Climate change induced increase of sea surface temperature causes heat energy to be dissipated in the form of reoccurring high intensity cyclones.¹⁸⁹ The IPCC noted that the fast melting of Himalayan ice and significant rise in sea levels would greatly magnify the impact of tidal storm surges during the cyclone season in the Bay of Bengal. According to the *IPCC Third Assessment Report*, some evidence suggests that regional frequencies of tropical cyclones may change.¹⁹⁰ Conversely, their target locations will remain the same by peak intensity increases of 5 – 10% with precipitation rates augmentation by 20%. This clearly states that cyclone tracks will not shift under climate change indicating that they will continue to hit Bangladesh.¹⁹¹

On average, society and institutions encompass low capacity to cope with such extreme events.¹⁹² Success in disaster management has reduced the lives lost, however, the economic and infrastructural damage remains significant.¹⁹³ A cyclone brings severe winds, storm surges, heavy rainfall and surface as well as riverine floods which impact on lives, crops and

¹⁸⁵ See Bangladesh Centre for Advanced Studies, 2008

¹⁸⁶ See Ericksen et al, 1993, p. 13

¹⁸⁷ See Economist, 2007a

¹⁸⁸ See Economist, 2007b

¹⁸⁹ See Fraser, 2007

¹⁹⁰ See IPCC, 2001

¹⁹¹ See Fraser, 2007

¹⁹² See OECD, 2003a, p. 14-15

¹⁹³ See Economist, 2007b

property.¹⁹⁴ Consequently, cyclones are a disruption of economic activities. The most devastating natural disasters affecting Bangladesh are the cyclones of 1970, 1991, 1997, 1998 and 2007.¹⁹⁵

4.2.3 Flooding and Erosion

Between 30 - 70% of the country is normally flooded each year.¹⁹⁶ Floods and erosion are part of life in Bangladesh. Flooding is vital for the renewal of land but due to climate change they are becoming more frequent and intense in appearance.¹⁹⁷ Climate change is likely to exacerbate flooding for two reasons: 1) increased glacier melt through higher temperatures in the Himalayas into the Ganges and the Brahmaputra rivers; and 2) increased precipitation during the monsoon season leading to increased runoff.¹⁹⁸

Rivers in Bangladesh transfer vast amounts of water and sediments to the Bay of Bengal in the south where they are part of forceful processes by the formations in the Bay.¹⁹⁹ Flooding accelerates the erosion of soil, riverbanks and coasts.²⁰⁰

Barsha, the Bengali term for average flooding, occurs annually submerging 25% of the country.²⁰¹ *Bonya* is the term used for abnormal flooding, which affects more than 50% of Bangladesh. Ericksen defines that flood-prone land is of two varieties: active and stable. In this sense, active floodplains are connected to main tributaries. One may label them as highly vulnerable to floods and riverbank erosion. Stable floodplains deliver steady incomes of crops, yet are affected during *Bonya*, which is the term for abnormal flooding. This problem can be eliminated by

¹⁹⁴ See Ericksen et al, 1993, p. 13; Note: "Surface floods" as opposed to riverine floods affect extended areas of coastal land.

¹⁹⁵ See Thomalla et al, 2005, p. 3; See Appendix 22: Impacts of Cyclone Sidr

¹⁹⁶ See OECD, 2003a, p. 49

¹⁹⁷ See World Development Movement, 2008, p. 1

¹⁹⁸ See OECD, 2003a, p. 16

¹⁹⁹ See Ali, 2005, p. 2

²⁰⁰ See Ericksen et al, 1993, p. 13

²⁰¹ See Ericksen et al, 1993, p. 13

irrigation techniques as well as flood control. Agriculturally high producing districts such as Dhaka, Mymensingh, Tangail, Pabna, and Faridpur are flood-prone. Both coastal flooding and inland flooding are expected to increase.²⁰²

Millions lost their homes and 2,000 people were killed during the August 2007 South Asian floods.²⁰³ During this incident, 8 million had been displaced in Bangladesh and 300 died as victims of the floods. The floods in 2007 during the months of July to September coincided in two short spells and covered 46 districts.²⁰⁴ Access to drinking water and sanitation facilities was inhibited as a result of damages to wells and latrines leading to outbreaks of waterborne diseases.

The economic impact of these floods was a sharp rise in food and commodity prices due to their limited availability.²⁰⁵ Extensive damage was caused to households and infrastructure as well as the water resource sector. The damage, as calculated, was destruction of 8,891km of paved rural infrastructure, municipal infrastructure in 77 municipalities including urban roads, bridges, culverts, water supply, drainage, and sanitation systems.²⁰⁶ Another 1,420km of national, regional district roads including 114 bridges and culverts were destroyed. Furthermore, water resource structures such as large- and medium-scale flood control and irrigation schemes were seriously affected. Education and health services were largely damaged leading to a combined loss of assets and output of an estimated USD 1 billion equivalent to 1.4% of GDP.

The Bangladesh flood assessment of the World Bank observed that the government worked closely with developing partners, stakeholders and

²⁰² See OECD, 2003a, p. 15

²⁰³ See World Bank, 2006

²⁰⁴ See ADB QEU, 2007, p. 10

²⁰⁵ See Bangladesh News, 2007

²⁰⁶ See ADB QEU, 2007, p. 10

relief distribution in times of crisis.²⁰⁷ In times of disaster, food, clothing and shelter is provided for the victims of the 39 flood affected districts. The Government of Bangladesh (GoB) distributed cash grants of USD 50,000 to the flood affected districts. The reaction from the international community has been as such that local NGOs deliver humanitarian aid to flood affected areas supported by the UN and other agencies. The World Bank has been involved in immediate relief work as well as post-flood recovery assistance.

Table 4: Coastal Zone Cyclone Risk, Flooding and Salinity

No.	Name of District	Area	Population	Eligibility Criteria for Coastal Zone		
		Km ²	('000)	Effect of Salinity	Tidal Fluctuation	Cyclone Risk
1	Bagerhat	3,959	1,515,815	✓	✓	
2	Barguna	1,832	837,955	✓	✓	✓
3	Barisal	2,791	2,330,960	✓	✓	
4	Bhola	3,403	1,676,600	✓	✓	✓
5	Chandpur	1,704	2,210,162		✓	
6	Chittagong	5,283	6,545,078	✓	✓	✓
7	Cox's Bazar	2,492	1,757,321	✓	✓	✓
8	Feni	928	1,196,219	✓	✓	✓
9	Gopalganj	1,490	1,132,046	✓	✓	
10	Jessore	2,567	2,440,693	✓	✓	
11	Jhalokathi	758	696,055	✓	✓	
12	Khulna	4,395	2,334,285	✓	✓	
13	Laksmipur	1,458	1,479,371	✓	✓	✓
14	Narail	990	689,021	✓	✓	
15	Noakhali	3,601	2,533,394	✓	✓	✓
16	Patuakhali	3,205	1,444,340	✓	✓	✓
17	Pirojpur	1,308	1,126,525	✓	✓	
18	Satkhira	3,858	1,843,194	✓	✓	
19	Shariatpur	1,181	1,057,181		✓	
	Total	47,203	34,846,215			

Source: OECD, 2003a, p. 34

²⁰⁷ See World Bank, 2006

4.2.4 Drought

It does seem a bit irritating discussing droughts in the context of Bangladesh; however, droughts occur frequently in winters.²⁰⁸ In contrary to floods and cyclones, droughts are slow to manifest, yet pervasive.²⁰⁹ Economic output is severely affected by dry seasons, leading to a loss of potential income and stability.²¹⁰ When the monsoon is curtailed, drought impacts more severely on the western districts. To cope successfully with drought, irrigation techniques need to be established. Trans-boundary dimension is of concern when addressing the problem of drought.²¹¹ The effect of water diversion upstream on dry season flows and salinity levels in the Sundarbans is a point of conflict. The *Ganges Water Sharing Treaty* has to be re-examined in relation to droughts.

4.2.5 Loss of the World Heritage Site - The Sundarbans

A main section of the coast consists of a marshy jungle, the Sundarbans, home to one of the richest natural gene pools for flora and fauna, such as the *Royal Bengal Tiger*.²¹² The flora contains at least 69 species.²¹³ A total of 425 wildlife species have been identified in the Sundarbans, including 42 mammal species, 300 bird species, 35 reptiles, and 8 amphibian species.²¹⁴ With a total area of 100,000km², the Sundarbans constitute the world largest contiguous mangrove ecosystem. The second largest is only one tenth in size. Roughly, 60% of the Sundarbans fall on Bangladesh located on the northern limits of the Bay of Bengal and the Ganges delta.²¹⁵ In 1997, this region, which stretches across south-western Bangladesh and the adjoining coast in the Indian State of West Bengal, was declared endangered, receiving the title of a *World Heritage Site* by the *United Nations Educational Scientific Cultural Organization (UNESCO)*.

²⁰⁸ See Ericksen et al, 1993, p. 13

²⁰⁹ See National Drought Mitigation Center, 2006

²¹⁰ See Ericksen et al, 1993, p. 13

²¹¹ See OECD, 2003a, p. 7

²¹² See OECD, 2003a, p. 41

²¹³ See SDNP Bangladesh, 2004

²¹⁴ See OECD, 2003a, p. 41

²¹⁵ See Encyclopaedia Britannica, 2003b

The high economic value of the area of the Sundarbans is based on the fact that it acts as an enormous carbon sink, absorbing excessive amounts of carbon dioxide (CO₂).²¹⁶ A reduction of the Sundarbans would instigate a huge loss of this valuable function. Modification of climate is anticipated to have significant impact on the flow of major rivers in Bangladesh, e.g, Ganges.²¹⁷ The viability of the Sundarbans rests on the hydrology of the Ganges and its tributaries which supply fresh water influx.²¹⁸ In addition to altered hydrology, sea level rise will also have adverse impacts on the forest, directly through enhanced inundation and indirectly by enhancing saline intrusion in river systems.²¹⁹ Examples have shown that settlements have disrupted ecosystems by lowering levels of species population and preventing species from migration.²²⁰

4.3 Climate Change and the Economy

In this section, selected economic sectors are used for assessing the defencelessness of Bangladesh to variations in climate and sea level.²²¹ The first section gives an overview of the *4.3.1 Society in a fragile Economy*. Subsequently, the sectors: *4.3.2 Industry and Services; 4.3.3 Infrastructure; 4.3.4 Agriculture and Forestry; 4.3.5 Ecosystems, Biodiversity and Tourism* as well as *4.3.6 Health as the Basis for Education and Employment* are discussed. The Stern Review identifies that these sectors are exposed to extreme weather events and will be subject to abrupt irreversible changes.²²²

Economic goals in Bangladesh have been concerned with: economic growth; poverty alleviation; self-reliance; primary education; empowerment of women in society; reduction of the population growth

²¹⁶ See Bhaumik, 2003

²¹⁷ See OECD, 2003a, p. 43, 45

²¹⁸ See Centre Nationale de la Recherche Scientifique, 2007

²¹⁹ See OECD, 2003a, p. 43, 45

²²⁰ See Rahman / Huq / Uddin Ahmed, 1999

²²¹ See Ericksen et al, 1993, p. 17

²²² See Stern Review, 2007, p.2

rate; better healthcare and water supply.²²³ Poverty alleviation has remained the top priority with shifts in economic strategies.²²⁴ The most important shift has been the replacement of a planned approach by a market economy.²²⁵ In the past, planned development was very much dependant on investments and Gross National Product (GNP). To promote the market economy 1) privatisation, 2) deregulation and 3) globalisation were enforced in the early 1980s.²²⁶ The market economy now underpins all economic policies and programmes in Bangladesh.

In 50 years from now, projections are the doubling of population (from 158.9 million to 317.8 million inhabitants), intensification of settlements, rural and urban migration, and an expansion of the service industry.²²⁷ Furthermore, human development improves through economic progress, which is already creating an extensive middle class.²²⁸ However, an imbalance between a small wealthy class and masses of poor persists.

Table 5: Climate Change Impacts on Economic Sectors

Climatic Causes of Impacts	Vulnerable Areas	Most Impacted Sector
Temperature rise and drought	North-west	Agriculture (crop, livestock, fisheries) Water (water logging, drinking water, urban) Energy Health
Sea Level Rise and Salinity Intrusion	Coastal Area Island	Agriculture (crop, fisheries, livestock) Water Infrastructure Human settlement Life and property
Floods	Central Region North East Region Char land	Agriculture (crop, fisheries, livestock) Water (urban, industry) Infrastructure Human settlement Health Disaster Energy
Cyclone and Storm Surge	Coastal and Marine Zone	Marine Fishing Infrastructure Human Settlement Life and property
Drainage Congestion	Coastal Area Urban	Water (Navigation) Agriculture (crop)

Source: Shaheduzzaman, Bangladesh NAPA, 2005, p. 6

²²³ See United Nations, 2005, See Ericksen et al, 1993, p. 36

²²⁴ See World Bank, 2005

²²⁵ See Ericksen et al, 1993, p. 36

²²⁶ See Ericksen et al, 1993, p. 37

²²⁷ See Economist, 2008d

²²⁸ See Economist, 2008e

4.3.1 Society in a Fragile Economy

Characterising the society of Bangladesh helps in assessing possible response to climate change.²²⁹ When characterising society three aspects are analysed: 1) resiliency, 2) vulnerability, and 3) sustainability.

Socio-economic developments will be different in the future solely because the traditional farming society of Bangladesh is transforming into an industrial nation.²³⁰ Societies in transition are more vulnerable to climate and sea level change than traditional or industrial societies. Mechanisms of traditional societies for coping with disasters are disrupted by economic development.

Landless and small farmers constitute over 50% of the population with 55.39% of total land area under cultivation.²³¹ Industrial and service sectors expand at a rate that is insufficient to absorb surplus rural labour.²³² Major pressures on natural resources are the rapidly growing population and the subdivision of land holdings in successive generations.²³³

It has been foreign aid in the past that has helped cope with the country's vulnerability.²³⁴ The sequence of large-scale natural disasters throughout the last 30 years has disrupted economic development. Social changes brought about by economic development paired with social disruptions as a result of natural disasters will continue to dominate the future.

²²⁹ See Ericksen et al, 1993, p. 15, 17, 37

²³⁰ See Ericksen et al, 1993, p. 15, 17, 37

²³¹ See CIA World Factbook, 2007

²³² See Islam, 2007

²³³ See Rahman / Huq / Uddin Ahmed, 1999

²³⁴ See Ericksen et al, 1993, p. 16, 34

4.3.2 Industry and Services

Majority of industries are located on floodplain, in urban areas on elevated land or land that is protected by embankments.²³⁵ Thus, industries are vulnerable to flooding and cyclones, especially in Chittagong and Khulna.

Despite impacts of destructive weather events on the industry and service sector, records showed an annual growth rate of 9.5%. This expansion rate was initiated by enlarging manufacturing units for domestic demand and export purposes.²³⁶ Bangladesh intends of availing the *Generalized System of Preference* of the European Union (EU) to boost exports.²³⁷ Consequently, the client base shall be broadened by new export targets. Joint ventures supporting new export destinations could easily emerge under the *South Asian Free Trade Agreement (SAFTA)*. Agricultural commodities are largely the base for industries, such as jute, cotton, sugarcane, tea and hides. Heavy industries in Bangladesh include steel, pharmaceuticals, chemicals, machine tools and diesel plants.

Increase of trade could be one solution in mitigating the economic impact of climate change.²³⁸ The estimated impact of increased trade on GDP growth is small. However, flooding as described is a threat to export industries such as the garment industry. The business climate remains rather uncertain.²³⁹ Nevertheless, recent reform initiatives and the installation of ports, power, customs and safety as well as labour standards in Bangladesh led to an overall optimistic atmosphere concerning the future of the industries.²⁴⁰ Projections of industrial expansion, based on large availability of rich energy resources, may be inhibited by amplified incidence of hurricanes, inundation along with diminished amounts of water.²⁴¹

²³⁵ See Ericksen et al, 1993, p. 21-22

²³⁶ See ADB QEU, 2007, p. 6-9

²³⁷ See Ericksen et al, 1993, p. 21-22

²³⁸ See World Bank, 2006

²³⁹ See Economist, 2008d

²⁴⁰ See ADB QEU, 2007, p. 6-9

²⁴¹ See Rahman / Huq / Uddin Ahmed, 1999

4.3.3 Infrastructure

In evaluating potential to adapt to climate change, the state of infrastructure needs to be examined.²⁴² In 2000, only 9.5% of a network of 207,500km of roads was paved, putting it well below the average of low income countries, which is 16.5%. This present situation creates major obstacles to trade through high energy and transport costs. The seriousness of improving existing infrastructure is hereby undermined.²⁴³

A rise of urbanisation is recorded as a response to in-migration from rural areas, and urban infrastructural systems that are unable to keep up with demand.²⁴⁴ The maintenance of infrastructure has been regarded as extremely tedious in Bangladesh due to annual flooding of deltaic systems of tributaries and distributaries. Waterways account for 50% of inter-district movement, however, during the monsoon riverbank erosion and dry season siltation hampers steamers. Irrigation expanded over two decades to cover 33% of cultivable area of around 9 million hectares. Road and embankment development protected the corridor from Dhaka to the port in the face of natural hazards enabling further manufacturing as well as export activities.²⁴⁵

4.3.4 Agriculture and Forestry

The climate sensitive sectors agriculture and fisheries are economically important because Bangladesh has limited human, institutional and financial capacity to anticipate and respond to direct and indirect effects of climate change.²⁴⁶ Prolonged inundation, drought, salt water intrusion coupled with loss of land due to erosion is a risk for the agricultural sector.²⁴⁷ Droughts and salinization in winter and long-lasting inundation during the monsoon season will alter areas suitable for growing crops.

²⁴² See OECD, 2003a, p. 9

²⁴³ See ADB QEU, 2007, p. 6-9

²⁴⁴ See Ericksen et al, 1993, p. 16, 20

²⁴⁵ See World Bank, 2006

²⁴⁶ See Tearfund, 2008

²⁴⁷ See Rahman / Huq / Uddin Ahmed, 1999

Bangladesh will experience a general reduction in crop yields coupled with decreased water availability of 10 - 30% in water-scarce regions.²⁴⁸ Earlier spring melting will shift the peak water supply earlier in the year from summer to spring, before peak water supply is required.²⁴⁹ Fishing units may be experiencing increased temperatures in coastal waters, loss of brackish-waters and reduced flows of fresh water.²⁵⁰ Therefore, malnutrition is widely the result of low agricultural output caused by climate change.

Agriculture growth in FY2008 is moderate declining to 2.2% from 3.2% in FY2007 caused by flooding in July - September and impacts of *Cyclone Sidr* in November.²⁵¹ Crops, livestock, poultry and aquaculture were affected by these floods and replantation was destroyed by second flooding. Production loss is estimated to be at 1.3 million tons of agricultural output. In November 2007, *Cyclone Sidr* destroyed most of coastal area plantations. Domestic supply shortages lead to increasing prices of food grains and essentials. Government intervention liberalized imports into the market under higher international market prices.

4.3.5 Ecosystems, Biodiversity and Tourism

The most exposed sector to climate change is ecosystems, biodiversity and tourism.²⁵² The essence of environmental degradation is not the loss of endangered fauna and flora; it is the loss of substantial resources which ensure the survival of millions. Economic activity is dependant on natural resources, as Bangladesh is not sufficiently industrialized. The nation's vision for sustainability is severely tested by failure in biodiversity management along with loss of economic productivity.

²⁴⁸ See IPCC, 2007

²⁴⁹ See ADB, 2008b

²⁵⁰ See Rahman / Huq / Uddin Ahmed, 1999

²⁵¹ See ADB QEU, 2007, p. 5

²⁵² See Rahman / Huq / Uddin Ahmed, 1999

Economic losses due to environmental damage account for 2.7% of Gross Domestic Product (GDP).²⁵³ Air pollution, degradation of water quality and the regression in fish capture account for 2.7% loss in GDP.²⁵⁴ Poor water management in Dhaka instigated losses of USD 500 million in 2007. Overall, an alarming 30% of fish species are in danger of extinction.²⁵⁵ Furthermore, demand for fuel wood and agricultural land has caused forested land to be halved in 20 years.²⁵⁶

A deficiency of programmes addressing the vulnerability of ecosystems remains.²⁵⁷ Institutionalizing ecosystem protection is still in its formative years and lacks funding. ADB, through its *Project of Biodiversity Corridors* in Southeast Asia, exemplifies the prevention of ecosystem loss. Land is crucial for economic production and can not be turned into national parks in densely populated Bangladesh. To present, NGOs and Community Based Organisations (CBOs) run small-scale initiatives of ecosystem protection. These specific projects need to be linked to state-run programs to be of greater impact. Target Projects are: the *Sustainable Environmental Management Program*, the *Fourth Fisheries Project*, the *Sundarbans Biodiversity Conservation Project* and the *Forestry Sector Project*. Interference with protection of vulnerable areas is caused by national policies of infrastructural developments for tourism promotion, e.g., the Khulna region. Encouraging eco-tourism in the Sundarbans might stress the fragile environment that will be impacted by sea level rise and salinity concerns.²⁵⁸

4.3.6 Health as the Basis for Education and Employment

High levels of health risk occur induced by climate change.²⁵⁹ Two factors responsible for improved health conditions are: 1) drinking water and 2)

²⁵³ See Dow / Downing, 2007, p. 19

²⁵⁴ See New Age, 2007

²⁵⁵ See New Age, 2007

²⁵⁶ See Ericksen et al, 1993, p. 16

²⁵⁷ See Rahman / Huq / Uddin Ahmed, 1999

²⁵⁸ See OECD, 2003a, p. 6-7

²⁵⁹ See Rahman / Huq / Uddin Ahmed, 1999

upgraded sanitation facilities. At present, a target project incorporating these two factors is the *Third Water Supply and Sanitation Project*.

Temperature, precipitation and humidity heighten the occurrence of water-, vector- and air-borne diseases.²⁶⁰ In Bangladesh, 80% of all illnesses are linked to water-borne diseases.²⁶¹ Drought and flood transmit cholera bacteria. Therefore, drainage congestion and standing water often facilitate cholera epidemics. Climate is one of five main epidemiological factors contributing to the transmission of malaria. The main causes of death are diarrhoeal diseases, malnutrition and pneumonia.

Bangladesh's social and human capital is its potential to adapt to climate change. Shockingly, Bangladesh only has 51 scientists and engineers per a million people.²⁶² Low numbers of skilled workers is partly caused by the "Brain Drain", in which intellectual and technical labour migrate "to more favourable geographic, economic or professional environments."²⁶³ Majority of people are illiterate, which means higher vulnerability and less capacity of adapting to climate change. An adaptation-based strategy to economic impacts of climate change is anchored on the factors: 1) *basic education*, 2) *skill training*, and 3) *organisation*. *Basic education* gives literacy, numeracy and life skills to people. *Skill training* enables people to conduct economic activities on a self-employment or wage employment basis. *Organisation* consists of the following components: credit, information, technology, extension services, and marketing assistance to undertake economic activities or to find wage-employment.

²⁶⁰ See IPCC, 2007

²⁶¹ See Ericksen et al, 1993, p. 16, 33

²⁶² See Ericksen et al, 1993, p. 16, 33

²⁶³ See Deardorff's Glossary of International Economics, 2008; Answers, 2007; Note: The term "Brain Drain" originated about 1960, when many British scientists and intellectuals emigrated to the United States for a better working climate.

5. National Policies and Programmes

By adopting policies and interventions effects of climate change may be reduced.²⁶⁴ The Government of Bangladesh (GoB) has ratified 18 international conventions, treaties and protocols on environmental management.²⁶⁵ Bangladesh is a party to the following international environmental conventions: *UN Framework Convention on Climate Change (UNFCCC)*, *UN Convention to Combat Desertification (UNCCD)*, *UN Convention on Biological Diversity (UNCBD)*, the *RAMSAR Convention on Wetlands* and the *Conferences of Parties (COP)*. National policies of relevance to climate change are: the *National Water Policy*, the *National Water Management Plan (NWMP)*, the *National Environmental Action Plan*, the *National Land Use Policy*, the *National Forest Policy*, and the *National Tourism Policy*.

The need for a national policy on climate change has been addressed since the early 1990s.²⁶⁶ Nevertheless, there is still no national policy in place to comprehensively address risks of climate change.²⁶⁷ After the cyclones of 1991, 1994, 1998 it became evident that development of an international climate adaptation regime was necessary.²⁶⁸ The GoB together with the World Bank and UN Development Programme (UNDP) prepared a *Poverty Reduction Strategy Paper (PRSP)* and a *National Adaptation Programme of Action (NAPA)*. The PRSP and NAPA are key national planning documents which inform and guide investments, yet the NAPA is still subject to revision. In addition to mitigation policies, development of adaptation policies to climate change is fundamental.²⁶⁹ The signatories of the UNFCCC agreed in 2001 to set up three funds to support adaptation initiatives in developing countries. The Marrakech Fund is one of these funds aimed at supporting NAPAs in Least Developed

²⁶⁴ See Ericksen et al, 1993, p. 38

²⁶⁵ See UNCTAD, 2006b, p. 30

²⁶⁶ See Ericksen et al, 1993, p. 38

²⁶⁷ See OECD, 2003a, p. 31-32

²⁶⁸ See Thomalla et al, 2005, p. 1-2

²⁶⁹ See Thomalla et al, 2005, p. 13

Countries (LDCs).²⁷⁰ NAPAs may not be able to fully consider local knowledge and local priorities regarding climate variability and change due to limited time and resources.²⁷¹ This mismatch of information needs to be addressed and an exchange of information is taking place where local knowledge, insights and know-how is inserted into national and international policy debates on adaptation to climate change.

Through education and training programs in projects, the GoB improved in providing information about safe drinking water, disaster protection facilities and reaction when disaster strikes.²⁷² Project Sites are the *Sustainable Environmental Management Program*, the *Fourth Fisheries Project*, the *Sundarbans Biodiversity Conservation Project*, the *Forestry Sector Project* and the *Third Water Supply and Sanitation Project*.²⁷³ Table 9 below highlights the most important initiatives undertaken in Bangladesh to date to protect people from the impacts of climate-related disasters.

Table 6: Timeline of Initiatives to Reduce Vulnerability in Bangladesh

1960s	Construction of cyclone shelters
1970s	Cyclone Preparedness Programme (CPP) by the International Federation of Red Cross / Red Crescent Societies, Bangladesh Red Crescent Society and the GoB
1986-1994	Construction of 30 cyclone shelters by multiple Red Cross societies and the German Bank for Reconstruction (KfW)
1989	Bangladesh Flood Action Plan (FAP)
1993	Instalment of Disaster Management Bureau (DMB)
1996-2002	German Red Cross / Bangladesh Red Crescent Community Based Disaster Preparedness Programme
1997	Establishment of the Network for Capacity Strengthening of Least Developed Countries for Adaptation to Climate Change (CLACC)
2003-2005	Implementation of CLACC
2002-2005	Reducing Vulnerability to Climate Change Project
2003	Creation of Comprehensive Disaster Management Programme with funding from UNDP and Department for International Development (DFID)
2003	Interim PRSP for Bangladesh
2004-2005	Bangladesh NAPA to Climate Change

Source: Thomalla et al, 2005, p. 7

²⁷⁰ See Sustainable Development Networking Programme Bangladesh, 2008

²⁷¹ See Thomalla et al, 2005, p. 13

²⁷² See World Bank, 2006

²⁷³ See Rahman / Huq / Uddin Ahmed, 1999

5.1. Climate Risk Management

South Asian countries are more capable of conducting climate risk reduction and adaptation than 10 years ago.²⁷⁴ A regional framework of action and cooperation is beneficial for the management of risks as disasters often strike in at least three neighbouring countries. Apparently, the diasporic community from Bangladesh living in industrialized nations is financing research on response to climate risks through remittances.²⁷⁵ Climate Risk Management is a discipline conducted by climate experts. An equation frequently used for climate risk management is: risk = disaster consequences x probability of disaster.²⁷⁶

During the 1990s there was a major shift in the approach to risk management. NGOs moved from post-disaster relief and humanitarian aid to a more preventive approach of risk management. The attempt was to increase the ability of local communities to prepare for natural hazards and to adapt to long-term impacts on their livelihoods.²⁷⁷ Civil society organisations have played an important role in strengthening the disaster management capabilities at district and village levels.²⁷⁸ The *Disaster Management Bureau (DMB)* was established in 1993 under the *Ministry of Disaster Management and Relief* with funding from various donors.²⁷⁹ The DMB aims at reducing loss of lives and property as well as at achieving self-reliance and sustainable development by: 1) collecting risk related data; 2) developing disaster preparedness plans; 3) conducting risk awareness training; and 4) coordinating disaster management.²⁸⁰ Risk preparedness through 70 cyclone shelters saved more than 10,000 lives during the adverse effects of Cyclone Sidr.²⁸¹

²⁷⁴ See World Bank, 2006

²⁷⁵ See Anam, 2007

²⁷⁶ See World Bank, 2006

²⁷⁷ See Health Library for Disasters, 2007

²⁷⁸ See UNISDR, 2006

²⁷⁹ See Health Library for Disasters, 2007

²⁸⁰ See Thomalla et al, 2005, p. 8

²⁸¹ See The Guardian, Kelly, 2007; See UNCTAD, 2006b, p. 30

5.1.1 Disaster Action Plans

Overtime, the Government of Bangladesh (GoB) has been developing strategies for dealing with large-scale disasters.²⁸² Such developing strategies are the prevention of human, economic and environmental costs of disaster through a structured approach of mitigation in disaster action plans.²⁸³

A distinction is made between structural and non-structural mitigation. Structural Mitigation includes the construction of shelters, flood protection embankments, drainage channels, sluice gates and regulators. Structural mitigation in Bangladesh has initiated the construction of 1,941 cyclone shelters and 200 flood shelters. A number of 482 water and flood control projects have been conducted which resulted in 8,200km of embankment, 3,400km of drainage channels and 9,000 sluice gates and regulators on waterways as protection against inundation by tidal waves, storm surges and flooding. Non-Structural Mitigation centres on preparedness for disasters. It attempts to provide rapid cooperation between the GoB, NGOs and communities.²⁸⁴ It involves the term *disaster mitigation and preparedness* which includes: 1) coping capabilities of community members; 2) information about risk areas; and 3) identification of socially vulnerable groups.

The state project *Support for Disaster Management* has components such as: 1) legislation, policy, planning; 2) training and public awareness; 3) institutional arrangements; 4) warning systems; and 5) local disaster action plans. The two existing warning systems in Bangladesh, *Flood Warning* and *Cyclone Warning System*, have been undergoing corrective measures since 1972.²⁸⁵

²⁸² See Ericksen et al, 1993, p.15

²⁸³ See Asian Disaster Reduction Center, 2007, p. 1

²⁸⁴ See Matin / Taher, 2000, p. 4

²⁸⁵ See Asian Disaster Reduction Center, 2007, p. 2

Death tolls are commonly used to measure the human impact of disasters and shape the humanitarian response.²⁸⁶ The August 2007 flooding claimed over 1,000 lives and *Cyclone Sidr* of the same year left at least 3,500 dead. Compared to the 1991 cyclone of similar scale and intensity 138,000 Bangladeshis were killed which is an astonishing death toll even within a population of over 158.9 million.²⁸⁷ What saved the population during *Cyclone Sidr* was the actualisation of a model for disaster risk reduction.²⁸⁸ This is becoming a crucial framework for protecting lives and livelihoods in the midst of environmental disasters. The GoB initiated a cyclone warning 72 hours prior to landfall through its comprehensive *Disaster Management Program (DMP)*.²⁸⁹ Based on improved satellite imaging and meteorological modelling which pointed to the location, time and intensity of the cyclone, the government was able to relay this message through its *Disaster Management Department* and the local *Red Crescent* to 15 districts directly under threat.²⁹⁰

The cyclical nature of these disasters has led the GoB to pursue a more holistic approach to disaster management, which addresses the risks and vulnerabilities.²⁹¹ This rationale contends that a better-prepared government and disaster resilient communities will mitigate the impact of natural disasters.²⁹² Furthermore, ensuring affected communities are reached during the critical survival phase, while reducing financial aid and external recovery commitments. Bangladesh has taken significant strides towards a paradigm shift in disaster management from a conventional response to a more comprehensive risk reduction culture. As demonstrated through the Sidr response, the GoB has invested heavily to remodel its central and district level disaster management systems within

²⁸⁶ See Fraser, 2007

²⁸⁷ See Radix, 2008; See Economist, 2008d

²⁸⁸ See Economist, 2007a

²⁸⁹ See Fraser, 2007

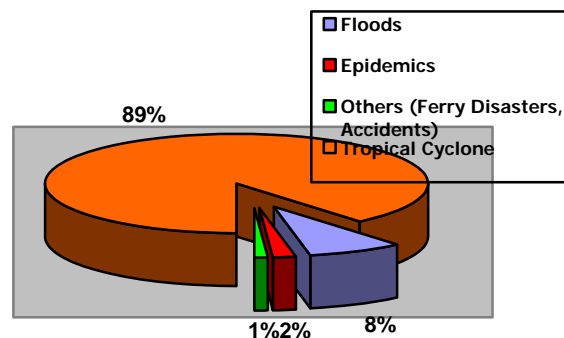
²⁹⁰ See Economist, 2007b

²⁹¹ See Ministry of Food and Disaster Management, 2008

²⁹² See Fraser, 2007

a longer term development context, recognising that entrenched poverty is a key determinant of disaster vulnerability.

Figure 5: Disaster Death Tolls in Bangladesh



Source: WHO, 2008b

Table 7: Impacts in Disaster Prone Areas in Bangladesh

Types of 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, and loss of human life and biodiversity, displacements and suffering of human population and biodiversity
Cyclone and Storm Surge	Coastal areas and offshore islands	Loss of agricultural production, disruption of communication and livelihood system, injury, national economic loss, loss of human life and biodiversity, need for evacuation and temporary shelter
Tornado	Scattered areas of the country	Loss of human life and biodiversity, injury, damage and destruction of property, damage of cash crops and loss of livelihood
Drought	Almost all areas, especially the Northwest region of the country	Loss of agricultural production, stress on national economy and disruption in life style
Flash Flood	Haor Basins of the North-east region and South-eastern hilly areas	Damage of standing crops, disruption in life style, evacuation and destruction of properties
Hail Storm and Lightning	Any part of the country	Damage and destruction of property, damage and destruction of subsistence and cash crops and loss of livelihood
Erosion	Banks of the Brahmaputra-Jamuna, the Ganges-Padma and the Meghna river system	Loss of land, displacement of human population and livestock, disruption of production, evacuation and loss of property
Landslide	Chittagong and Chittagong Hill Tracts	Loss of land, displacement of human population and livestock, evacuation, damage of property and loss of life
Earthquake	Northern and central parts of the country	Damage and destruction of property, loss of life and change in geomorphology

Source: BCAS, 2008

5.1.2 Flood Action Plans: Critique on Embankments

Renewed international interests in implementing Flood Action Plans (FAPs) occurred after the disastrous flood of 1987 and 1988.²⁹³ In 1989, a 5 year FAP was initiated with the support of 14 international donors.²⁹⁴ Reports suggested costs of up to USD 5 billion for a 5 year FAP.²⁹⁵ In principal, two opposing approaches exist in dealing with abnormal flooding:

- 1) All major rivers need to be progressively contained to reduce the risk of abnormal floods and enhance economic activity.
- 2) Technically and economically embankments create as many problems as they solve. To prevent abnormal flooding is infeasible, therefore a solution would be to build on the ability to cope with and recover from flooding.

The first approach has become part of a long-term government policy.²⁹⁶ To evaluate which of these opposing views is in effect the most efficient studies financed by international donors are conducted examining the following areas:

- Cyclone protection;
- Dhaka town protection, secondary town protection, and resettlement;
- Flood forecasting, early warning, flood preparedness and response;
- Environmental impact: agricultural studies;
- Geographic Information Systems, river survey, and flood modelling;
- Bank protection, floodplain management, and flood-proofing;²⁹⁷
- And institutional development.²⁹⁸

The FAP aims at examining advantages and disadvantages for dealing with abnormal flood problems. Long-term goals of the FAP are: productivity (economic development), stability (insulation of incomes against minor disturbances), sustainability (continued growth over time

²⁹³ See Kolhoff, 1995, p. 1

²⁹⁴ See Wiebe, 2000, p. 3

²⁹⁵ See Ericksen et al, 1993, p. 21

²⁹⁶ See Ericksen et al, 1993, p. 21

²⁹⁷ Note: Flood-proofing is preventing or reducing damages to the structure and / or content of buildings located in flood hazard areas.

²⁹⁸ See West Virginia University, 2008, p. 1

despite flooding) and equity (gains evenly distributed over the population).²⁹⁹

Since the 1960s, a series of coastal embankments has been constructed to protect low lying islands from tidal inundation and salinity penetration.³⁰⁰ Many of these lands have now become high productivity agricultural areas and are valued considerably more than lands outside the embankments. Paradoxically, these same coastal embankments tend to block efficient drainage of freshwater on the other land side at times of excess rainfall and riverine flooding.

Further critique regarding embankments is assembled around the fact that they are not capable of dealing with storm surges.³⁰¹ The World Bank identified that a system of embankments for cyclone protection established in 1960 - 70 has been neglected over the years and is thus not functional. Following the devastating 1988 floods, through the FAP several thousands kilometres of flood embankments along Bangladesh's three major rivers were constructed until 1990.³⁰² The plan was widely criticised for: a) high cost; b) the displacement of millions of people; c) damage to inland fisheries through the disruption of fish migration paths; d) failure to protect from extreme cyclone induced tidal surges; and e) lack of understanding or disregard of the beneficiary effects of monsoon floods for rural agriculture. The understandings from the FAP led to the composition of a thorough *National Water Policy* and a *National Water Management Plan (NWMP)*.³⁰³ To incorporate lessons learned into FAPs from poor maintenance of embankments, physical infrastructure and failure of embankments to cope with large floods is crucial.³⁰⁴

²⁹⁹ See Kolhoff, 1995, p. 1

³⁰⁰ See OECD, 2003a, p.35

³⁰¹ See Ericksen et al, 1993, p. 13

³⁰² See Thomalla et al, 2005, p. 7

³⁰³ See Casavaria, 2003

³⁰⁴ See Ericksen et al, 1993, p. 38-39

5.2 Financing Disaster Relief: Donors and NGOs

External assistance to cope with large-scale disasters involves resources of states, relief funds through supplies from overseas countries and voluntary organisations.³⁰⁵ The scale of aid depends on the magnitude of the disaster.³⁰⁶ Aid has played an important role in relieving losses following natural disasters, and helping the government to develop ongoing emergency preparedness programmes.³⁰⁷ Aid will remain to be a pillar for Bangladesh's economic development. As economic development precedes the capacity of the government to respond to climatic disasters through preparedness, emergency services and shelters will improve. About 49% of aid disbursed has been in loans and credits.³⁰⁸

When governments rely on immediate aid delivered by foreign donors the International Monetary Found (IMF) labels it a "Samaritan Dilemma", whereby governments and decision-makers postpone responsibility for risk reduction.³⁰⁹ Monetary assistance is used to recuperate Bangladesh after macroeconomic shocks by offering food imports, medical supplies, and cash grants to recover sources of income and livelihood.³¹⁰ Financial support has been obtainable for infrastructure, especially damage to embankments, flood mitigation and shelter infrastructure. Furthermore, the assistance addresses coastal zone management to face challenges by implementing mitigation and adaptation strategies.

The involvement of NGOs is vital for rapid disaster relief for their target is immediate aid for communities.³¹¹ The head of the NGO Tearfund, Andy Atkins, states that aid packages during times of crisis are not sufficient in preventing disastrous impacts of climate change.³¹² Aid needs to be in the

³⁰⁵ See Ericksen et al, 1993, p.15, 20

³⁰⁶ See European Commission's Delegation, 2008

³⁰⁷ See Ericksen et al, 1993, p. 20

³⁰⁸ See Figure 6: Current Lending in Bangladesh

³⁰⁹ See Fraser, 2007

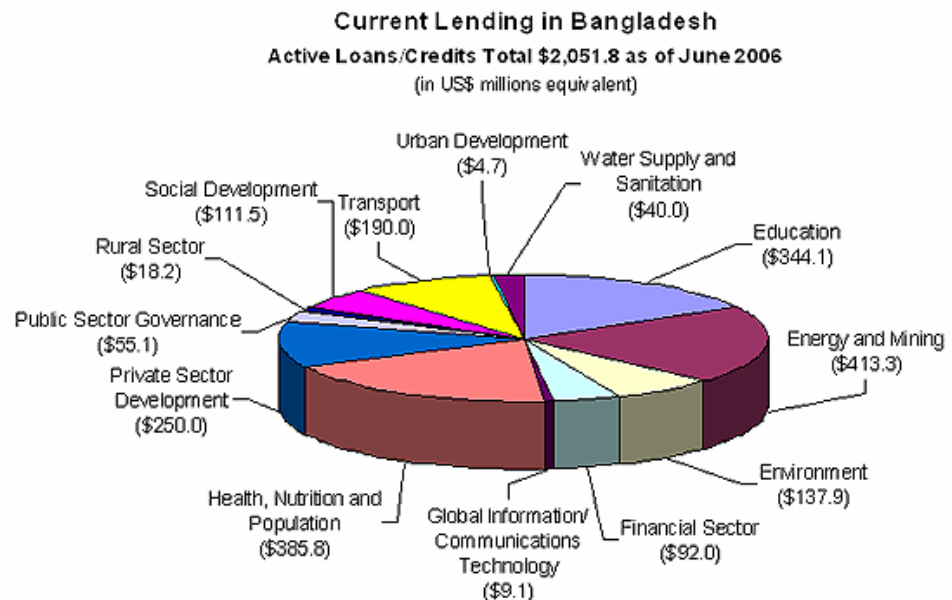
³¹⁰ See World Bank, 2006

³¹¹ See World Bank, 2006

³¹² See Guardian, 2007

form of long-term economic development strategies in mitigation and adaptation to empower the people in their independence of coping with climate change.³¹³

Figure 6: Current Lending in Bangladesh



Source: World Bank, 2006b

5.2.1 Financing, Loans, Credits and FDI

External aid dropped gradually as Bangladesh improved its ability to cope with natural disasters.³¹⁴ From 7.6% of Gross Domestic Product (GDP) in 1990 foreign aid decreased to 1.4% in 2005.³¹⁵ Partly, this is also caused by rigid donor expectations and a reduction in global aid disbursement. Nevertheless, external aid is still a central supply of finance, providing Bangladesh with around 40% of government revenue and about 50% of foreign exchange.

In 2005, Bangladesh received USD 600 million from the World Bank comparable to USD 4.5 per capita for improving development in the country.³¹⁶ Bangladesh is number three of major borrowers of the World

³¹³ See European Commission's Delegation, 2008

³¹⁴ See Economist Intelligence Unit, 2005, p. 24

³¹⁵ See Economist Intelligence Unit, 2005, p. 26

³¹⁶ See World Bank, 2005

Bank for International Development Association (IDA) credits of 35 - 40 years with no interest repayment.

The outstanding external debt is USD 20.25 billion in 2007, whereas the public debt amounts to 37.9% of GDP.³¹⁷ The GDP of purchasing power parity in 2007 is USD 209.2 billion and GDP under the official exchange rate is USD 75.17 billion.³¹⁸ On a per capita basis, Bangladesh's aid receipt is one of the lowest at USD 15 per person.³¹⁹ Aid is the main source of public investment budget. A substantial portion of government revenue receipts is derived from duties and taxes on aid-financed imports. Only 40% of the imports are paid out of the country's export earnings. The current account balance of 0.2% of GDP in 2008 is aid financed to a significant extent, after foreign remittances have been taken into account.³²⁰ Bangladesh is not one of the *Heavily Indebted Poor Countries (HIPC)*s as the amount of external debt USD 20.25 billion in 2007 decreased from a higher figure of 34.13% of GDP in 1991.³²¹

The UN Conference on Trade and Development (UNCTAD) ranks Bangladesh on 121st place in the *Inward FDI Performance Index*.³²² This clearly is an underperformance. Foreign Direct Investment (FDI) net inflows account for 1.3% of GDP and private investment numbers 0.2% of GDP.³²³ Investments are still inhibited by political instability, natural disasters and corruption.³²⁴

Donor induced policies and programmes have increased the donor influence in the economic management of the country.³²⁵ Drastically as it may sound, aid has failed to move the economy forward. The economy remains trapped in a low growth and high poverty syndrome. Aid

³¹⁷ See CIA World Factbook, 2007

³¹⁸ See Economist, 2008d

³¹⁹ See World Bank, 2005

³²⁰ See Economist, 2008d; Note: Current Account Balance in 2007 is 1.1% of GDP

³²¹ See UNCTAD, 2006b; See IMF, 2008

³²² See UNCTAD, 2007, p. 2; See Economist Intelligence Unit, 2005, p. 31

³²³ See UNDP, 2008b; See Economist, 2008d; Note: 2006 FDI inflows were 0.8% of GDP

³²⁴ See Economist Intelligence Unit, 2005, p. 31

³²⁵ See UNCTAD, 2006b

utilisation has been rather poor due to bad planning, managerial deficiency and corruption.³²⁶

Bangladesh has been initiating dialogue on how to discover novel financial support for adaptation.³²⁷ The Kyoto protocol established funding for adaptation measured on voluntary funding assistance together with the *Clean Development Mechanism (CDM)* levy.³²⁸ By running low emission projects in developing states, companies can earn carbon credits.³²⁹ Earned credits may be traded on international markets for carbon, with 2% of the price saved for an adaptation fund. The CDM level of development has been rather low limiting benefits in Bangladesh.³³⁰

5.2.2 Climate Matters in Donor Conduct

Bangladesh receives over USD 1,320.5 billion a year of official development assistance (ODA), equivalent to about 2.2% of Gross Domestic Product (GDP).³³¹ Distribution of aid by development sector and donor reveals that donor strategies lack attention to climate change.³³² Only a total of 22 - 53% of ODA by relief sum, or 22 - 37% by donor undertaking is in segments affected by climate change.³³³ Japan remains the largest bilateral donor to Bangladesh.³³⁴

Table 8: Development Aid to Bangladesh 1999 - 2005

Foreign Aid (USD million; fiscal years July to June)							
	Food Aid	Commodity Aid	Project Aid	Total Aid	Principal Payment	Net Foreign Aid	% of GDP
1999/2000	142.2	282.9	1,150.0	1,575.1	396.1	1,179.0	2.5
2000/01	50.8	183.7	1,134.3	1,368.8	416.5	952.3	2.0
2001/02	35.8	154.9	1,250.1	1,440.8	420.9	1,019.8	2.1
2002/03	47.8	175.2	1,362.1	1,585.0	452.0	1,133.0	2.2
2003/04	35.0	11.5	907.0	953.5	397.0	556.5	1.0
2004/05	24.3	0.0	1,234.7	1,259.0	449.0	810.0	1.4

Source: Economist Intelligence Unit, 2005, p. 24

³²⁶ See Export Finance and Insurance Corporation, 2005

³²⁷ See Guardian, 2007

³²⁸ See Kelly, 2007

³²⁹ See UNFCCC, 2008

³³⁰ See Kelly, 2007

³³¹ See SEOR, 2005, p. 12; See UNDP, 2008b; See OECD, 2003a, p. 24; Note: ODA defined as grants and loans, with at least a 25% grant element, administered with the aim of promoting economic and social development.

³³² See OECD, 2003b

³³³ See OECD, 2003a, p. 6

³³⁴ See Economist Intelligence Unit, 2005, p. 13; See OECD, 2008; See OECD, 2005

Net Official Development Assistance (USD million)					
	1999	2000	2001	2002	2003
Bilateral	607.3	616.5	578.4	520.8	694.9
Japan	123.7	201.6	125.6	122.7	115.3
United Kingdom	114.9	103.4	124.5	101.8	260.5
United States	113.6	62.5	87.1	72.1	56.6
Germany	46.6	36.7	30.1	30.0	32.4
Netherlands	36.1	32.6	43.2	44.3	57.4
Multilateral	588.2	519.5	437.5	379.8	689.3
International Development Association	339.6	275.2	217.9	195.1	394.7
Asian Development Bank	214.1	198.0	126.6	93.2	96.1
UN Development Programme	13.9	18.8	12.2	14.4	15.9
UN Children's Fund	13.9	12.5	12.8	11.3	10.9
UN High Commission for Refugees	0.8	1.9	2.2	2.4	2.2
Total (including others)	1,203.1	1,171.3	1,029.9	912.8	1,393.4

Source: Economist Intelligence Unit, 2005, p. 55

5.2.3 IFC, SEDF and MIGA Programs

The *International Finance Corporation (IFC)* established in 1956 is a member of the *World Bank Group* and was set up to increase private sector investment with particular stress on infrastructure, energy, and manufacturing assignments in developing nations.³³⁵ A present portfolio of USD 132.5 million is invested in nine projects.³³⁶ At present, the establishment of a stock exchange attached to a banking sector that withstands competition is financed.

Another institution important to name is the *South Asia Enterprise Development Facility (SEDF)* which resumes facilitating technological expertise to monetary intermediaries, small and medium-size enterprises (SMEs), and expert companies that offer services to SMEs.³³⁷

The *Multilateral Investment Guarantee Agency (MIGA)*, with coverage of USD 112 million in five projects, intends to fund sponsors from abroad in communications, infrastructure, and natural resources with providing technological knowledge for the *Board of Investment* and the *Export*

³³⁵ See IFC, 2008

³³⁶ See World Bank, 2006

³³⁷ See SEDF, 2008

Processing Zones Authority.³³⁸ Main donors, ADB and the Government of Bangladesh (GoB), take in a sequence of credit contracts for rural and municipal infrastructure as well as roads and water resources damaged by cyclonic storm surges and floods.³³⁹

5.2.4 Adaptation through Civil Society Alliances

Bangladesh is a democratic country with a healthy civil society.³⁴⁰ About 10,000 non governmental organizations (NGOs) operate in the country with some of the worlds largest NGOs such as BRAC formerly known as the Bangladesh Rural Advanced Committee.

At the community level, a range of initiatives has been piloted to protect lives and mitigate disaster impacts.³⁴¹ Numerous *village-level disaster management committees* have been established and have conducted mock evacuation drills targeting high risk groups. Preparedness measures include raising homes above flood zones, pre-positioning food rations and first aid equipment, as well as better management of environmental resources through soil conservation and tree planting. Records show that public knowledge, resilient mitigation measures and clear response procedures have reduced exposure to risk.

Presently, limited information is being exchanged between civil society organizations and the Government of Bangladesh (GoB). Lack of information prevails at the local level about potential risks of climate change, national and international approaches and policies to reduce these risks. Furthermore, understanding of local vulnerabilities, adaptation needs and development opportunities needs to be promoted. Hope arises regarding the development of a climate policy from the civil society.³⁴² Environmental institutions, scientists, media and parts of the economy as

³³⁸ See Multilateral Investment Guarantee Agency, 2008

³³⁹ See ADB, 2008

³⁴⁰ See Thomalla et al, 2005, p. 6

³⁴¹ See Fraser, 2007

³⁴² See Loske, 1996, p. 305-307

non-governmental bodies have an enormous influence on the climate-political decision-making of society. Within disaster-prone communities, local knowledge and experience of extreme weather events including disaster patterns need to be treated equally within strategy modelling for disaster risk reduction and response.³⁴³ Investments should ensure a safer and more viable existence in the midst of climatic uncertainty. With the eventuality of future disasters, this reaches hopefully, towards a new measure recognising lives saved as opposed to lives lost.

5.3 Evaluation

Is there truly no point between the contact of macroeconomics and the environment as stated by *World Bank economist Herman Daly*, a leading student of the problem?³⁴⁴ In scheming Gross National Product (GNP) natural resources are not depreciated as machinery or buildings. Why is loss of topsoil not calculated as an economic loss? Improvements in productivity are the single most significant measure of economic progress. Hidden costs are not properly accounted, e.g., carbon reaching the atmosphere.

The World Bank, the International Monetary Fund (IMF), regional development banks, and state lending systems choose forms of credit and monetary assistance for developing countries to improve economic performance.³⁴⁵ Most frightening is that for all these institutions the single most important measure of progress in economic performance is the movement of GNP. Steady progress of an economy in the developing world is often coupled with irreversible natural degradation.³⁴⁶ GNP handles the hasty and uncontrolled devastation of nature as an excellent conduct.³⁴⁷ Ignorance prevails towards accounting of lost natural

³⁴³ See Fraser, 2007

³⁴⁴ See Gore, 1992, p. 183-200

³⁴⁵ See Gore, 1992, p. 183-200

³⁴⁶ See Goodland et al, 1992

³⁴⁷ See Gore, 1992, p. 183-200

resources.³⁴⁸ Current systems insist that natural resources are limitless free goods. The worst environmental devastation takes part in countries that have emerged from their colonial status only in the last generation.³⁴⁹ *John Maynard Keynes' "System of National Income"* was established at the end of the colonial era, during which supplies of natural resources seemed limitless.

The political elite of several developing countries embraces the opinion that an industrial process has to be conducted, before one can incorporate ecological politics into the economy.³⁵⁰ We have an accelerating destruction of the environment which is irreversible based on human avarice and the unstoppable hunger for exploitation.³⁵¹ Studies of environmental economics have so far not been integrated into economic theories, policies and development.

³⁴⁸ See Tietenberg, 2007a, p. 1-31

³⁴⁹ See Gore, 1992, p. 183-200

³⁵⁰ See Loske, 1996, p. 259

³⁵¹ See Gore, 1992, p. 183-200

6. Alternative Strategies

Does Bangladesh have the capacity to be green?³⁵² The Economist states that as long as there is no corruption “economic progress can ease environmental woes.” *Daniel Esty of Yale University* concluded at the *World Economic Forum in Davos, Switzerland* that least developed countries (LDCs) have been right to question the idea of green thinking which is against economic growth. As mentioned in *Chapter 5.3 Evaluation* countries are ranked according to Gross National Income (GNI). This figure does not mean that economic growth leads to improvement in the environment. Nevertheless, growth is equal to resources in order to mitigate the effects of environmental degradation. The analysis of Esty presents that as LDCs get wealthier, they automatically sponsor conservation of environmental assets. Good governance clearly is in relation to satisfying environmental performance. Bangladesh is ranked as the world’s eighth most corrupt country in 2007.³⁵³ A corrupt nation is not able to put in force regulations of green development.³⁵⁴ The conclusion is that “economic growth and transparent governance” will enable LDCs to avoid economic development that destroys natural resources.

Developing countries require the transfer of technology within a financing frame to mitigate and adapt to climate change.³⁵⁵ A state subsidy via monetary assistance, tax credits, setting standards, establishment of markets is the base for the emergence of new technologies. Limited solutions to the problem of climate change are: prices and markets for carbon dioxide (CO₂), enhanced scientific research, infrastructure investment and economic development.³⁵⁶

Sustainable economic development is the key solution for Bangladesh with an increasing population, a per capita Gross National Product (GNP) that is

³⁵² See Economist, 2008a

³⁵³ See Forbes, 2007

³⁵⁴ See Economist, 2008a

³⁵⁵ See IPCC, 2007, p. 20

³⁵⁶ See Stern Report, 2007

among the lowest in the world, limited natural resources and frequent natural disasters.³⁵⁷ Bangladesh faces the challenge of developing a strategy that accelerates economic growth, alleviates poverty and sustains its limited natural resources for future generations. An exchange of expertise has to be set up among development planners and climate sensitive sectors, the banking division, and the remaining donor commune.³⁵⁸ Progress will enable society to respond better to problems arising from natural hazards.³⁵⁹ The strategy must be people-centred if people are going to participate in the economic-transformation process. Hence, activities must be planned at the local level, with administrative decentralisation and political devolution.

The OECD in Paris underlines that a distinction between driving forces of economic globalisation is made which are: consumers, markets, producers, firms, technological change and communications patterns.³⁶⁰ Hereby, favourable and unfavourable environmental impacts on these driving forces are identified. Economists fear that environmental actions hinder economic growth. To promote economic growth by offering environmental incentives is the challenge. Insufficient economic growth of a country is equivalent to hunger, lack of education, loss of investments and deficient infrastructure.

6.1 Climate Change Policy

To ensure sustainable use of environmental resources, environmental policy can be based on two strategies: 1) engaging in public projects and programmes aimed at preventing, compensating, and eliminating environmental degradation; and 2) influencing decision making processes at the micro level, e.g., consumers, producers, and investors.³⁶¹ This process has been called the "command-and-control" approach of direct

³⁵⁷ See Ericksen et al, 1993, p. 16

³⁵⁸ See Rahman / Huq / Uddin Ahmed, 1999

³⁵⁹ See Ericksen et al, 1993, p. 39

³⁶⁰ See OECD, 1998, p. 27

³⁶¹ See OECD, 1994

regulations, economic incentives and market stimuli.³⁶² Bangladesh shall implement both *environmental policy strategies* to ensure sustainable use of environmental resources.

Environmental policy in Bangladesh is about social equity and social cohesion. Long-term effects of environmental degradation are ignored in present day economic policy making.³⁶³ Governance requires that national environmental objectives have to be in accordance to international goals. It has to be widely accepted that trade, investment and development are not anti-environmental. However, to be competitive globalisation tries to reduce the effect environmental policies have on domestic firms. Sectoral economic activities of enhancing environmental regulations are e.g., trade liberalisation, deregulation, and privatisation through reform pricing systems for instance subsidies and taxes in important sectors of the environment such as energy, transport and agriculture.

Bangladesh should develop into an active participant in international negotiations and policy formulation with a group of specialists within the Intergovernmental Panel on Climate Change (IPCC), the UN Framework Convention on Climate Change (UNFCCC) and the Conference of Parties (COP).³⁶⁴ Discussions on impacts, mitigation as well as adaptation shall exert a pull on international awareness towards economic impacts of climate change on Bangladesh. To reduce vulnerability, policies should be aimed at improving economic development through employment, increased incomes, and reduction of poverty, controlling population growth, access to education, technical training and healthcare.³⁶⁵ At the same time, policies which are aimed at reducing vulnerability must contain the following factors: embankments, irrigation, seed selection, planting regimes, storing reserves, emergency preparedness, land use management and disaster preparedness. This combination of economic

³⁶² See Lesser, 2007; See OECD, 1994

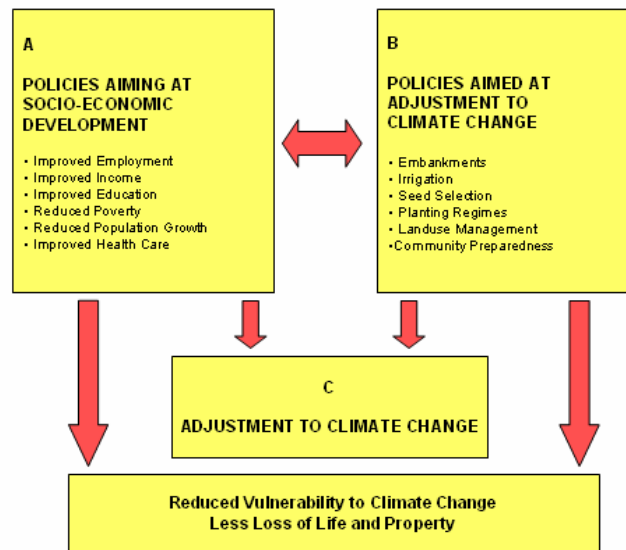
³⁶³ See Ericksen et al, p. 38-39

³⁶⁴ See Rahman / Huq / Uddin Ahmed, 1999

³⁶⁵ See Ericksen et al, 1993, p. 41

and climate change policies leads to the overall adjustment to climate change. The diagram below shows the main correspondence between three main elements for reducing vulnerability to climate change: socio-economic policies for alleviating poverty; hazard adjustments; and adaptation.

Figure 7: Climate Change Adjustment and Adaptation Policies



Source: Ericksen et al, 1993, p. 41

Table 9: Types of Climate Politics

Reactive politic type	
	Adaptation strategy
	<ul style="list-style-type: none"> ▪ Spontaneous adaptation ▪ Planned adaptation
	<ul style="list-style-type: none"> ▪ Coastal management ▪ Drinking water reserves ▪ Different crops in agriculture and forestry ▪ Soil protection programmes
	Intervention strategy
	<ul style="list-style-type: none"> ▪ Active influence on climate ▪ Geo-Engineering
Preventive politic type	
	Absorption Strategy
	<ul style="list-style-type: none"> ▪ Protection of forest ▪ Afforestation ▪ Protection of the oceans
	Limitation Strategy
	<ul style="list-style-type: none"> ▪ Banning products and technology that harm the climate ▪ Substitution products ▪ Enhancing energy productivity through technical innovation

Source: Loske, 1996, p. 305-307

Table 10: Selected Sectoral Policies, Measures and Instruments

Sector	Effective Policies	Constraints or Opportunities
Energy Supply	Reduction of fossil fuel subsidies Taxes or carbon charges on fossil fuels	Resistance by vested interests may make them difficult to implement
	Feed-in tariffs for renewable energy technologies Renewable energy obligations Producer subsidies	May be appropriate to create markets for low emissions technologies
Transport	Mandatory fuel economy, biofuel blending and CO2 standards for road transport	Partial coverage of vehicle fleet may limit effectiveness
	Taxes on vehicle purchase, registration, use and motor fuels, road and parking pricing	Effectiveness may drop with higher incomes
	Influence mobility needs through land use regulations, and infrastructure planning Investment in attractive public transport facilities and non-motorised forms of transport	Particularly appropriate for countries that are building up their transportation systems
Buildings	Appliance standards and labelling Building codes and certification Demand-side management programmes Public sector leadership programmes, including procurement Incentives for energy service companies (ESCOs)	Periodic revision of standards needed Attractive for new buildings. Enforcement can be difficult Need for regulations so that utilities may profit Government purchasing can expand demand for energy-efficient products Success factor: Access to third party financing
Industry	Provision of benchmark information Performance standards Subsidies, tax credits	May be appropriate to stimulate technology uptake. Stability of national policy important in view of international competitiveness
	Tradable permits	Predictable allocation mechanisms and stable price signals important for investments
	Voluntary agreements	Success factors include: clear targets, a baseline scenario, third party involvement in design and review and formal provisions of monitoring, close cooperation between government and industry
Agriculture	Financial incentives and regulations for improved land management, maintaining soil carbon content, efficient use of fertilizers and irrigation	May encourage synergy with sustainable development and with reducing vulnerability to climate change, thereby overcoming barriers to implementation
Forestry / Forests	Financial incentives (national and international) to increase forest area, to reduce deforestation, and to maintain and manage forests	Constraints include lack of investment capital and land tenure issues. Can help poverty alleviation.
	Land use regulation and enforcement	
Waste Management	Financial incentives for improved waste and wastewater management	May stimulate technology diffusion
	Renewable energy incentives or obligations	Local availability of low-cost fuel
	Waste management regulations	Most effectively applied at national level with enforcement strategies

Source: IPCC, 2007

Governments of a majority of states follow a preventive climate policy.³⁶⁶

Most industrial countries do not conduct a reliable climate policy even if

³⁶⁶ See Loske, 1996, p. 305-307

resources are available.³⁶⁷ For Bangladesh, a reactive climate policy with focus on adaptation would be appropriate (*See Table 8: Types of Climate Politics*).

6.1.1 Identify and Prioritise Risks

Risk is the likelihood of costs, or fatalities (such as loss of life, damage, disturbed source of revenue, disordered trade and industry commotion or surrounding damage) from natural or human-induced perils and vulnerable circumstances.³⁶⁸ The following equation may be applied: risk = hazards x vulnerability. Hazard appraisal verifies the character and coverage of hazards by scrutinizing latent exposure and assessing present forms of vulnerability. A hazard appraisal is supported by characteristics of dangers: 1) setting, 2) concentration, 3) rate of recurrence and chance.³⁶⁹ *Table 10* below identifies risks for Bangladesh, whereas *Table 11* gives a priority ranking of risks in Bangladesh.

Table 11: Identification of Climate Change Risks in Bangladesh

Risks	Economic Resources and Sectors affected
Changes in rainfall patterns	Water resources
Increased frequency of floods, droughts, storms, heat waves	Agriculture and Forestry
Changes in growing seasons	Food Security
Changes in water quality and quantity	Human Health
Sea Level Rise	Settlements Coastal Resources Industry and Energy Disaster Response and Recovery

Source: ADB, 2008b

Table 12: Priority Ranking of Climate Change Risks in Bangladesh

Resource/Ranking	Certainty of Impact	Timing of Impact	Severity of Impact	Importance of Resource
Water resources (flooding)	Medium-high	High	High	High
Coastal resources	High	Low	High	High
Human health	Low-medium	Medium	Medium-high	High
Agriculture	Medium	Low-medium	Low-medium	High

Source: OECD, 2003a, p. 22

³⁶⁷ See German Embassy Washington D.C., 2007

³⁶⁸ See UNISDR, 2004

³⁶⁹ See IPCC, 2007, p. 18

Water resources are ranked at greatest risk as flooding is already an important issue.³⁷⁰ Coastal resources are ranked as second most vulnerable because the country consists mainly of a delta. Sea level rise is most certain than increased flooding. The full impact of sea level rise will only be realized after many decades, thus, making it second in the place of risk ranking. Risks of sea level rise and flooding are clustered together. Other risks to human health and decreased yields of agriculture might not be identified as an outcome of climatic change.

6.1.3 Develop Risk Reduction Strategies

Risk reduction prevents or mitigates undesirable collisions of risks.³⁷¹ The risk reduction agenda of the *UN International Strategy for Disaster Reduction (UNISDR)* contains: a) risk awareness, b) risk measurement, c) risk investigation, and d) vulnerability examination. *Risk reduction strategies* are: technology transfer, natural resource administration, ground utilization and inner-city development, reinforcement of services, expertise, joint ventures, networks, and monetary utensils.

Development has to change to incorporate climate change mitigation into sustainability planning.³⁷² Forecasting and warning systems, land use planning, relief and rehabilitation are measures to be adopted.³⁷³ Individuals have been reluctant to evacuate disaster areas despite warnings in the past. Frequently, warnings were not given in time or lacked information about impending disasters. The government has a major role in improving the system for disaster warning and evacuation. Government programmes for building shelters against cyclones and floods continue to grow. To prevent settlement on unstable flood-prone land a "flood-proofing" strategy may be implied by testing stability of land and housing facilities. A large number of projects require periodic repetition.³⁷⁴

³⁷⁰ See OECD, 2003a, p. 22-23

³⁷¹ See UNISDR, 2004

³⁷² See IPCC, 2007, p. 21

³⁷³ See Ericksen et al, p. 38-39

³⁷⁴ See OECD, 2003a, p. 6-7

Monitoring and maintenance requires continued government and donor interest as well as participation of the local population far beyond the original lifetime of a project.

6.2 Integrated Coastal Zone Management

The shoreline, extending 30% on the national territory, is especially under attack from climatic variations.³⁷⁵ The coastal zone needs to be adaptable to protect economic activity from climatic hazards. *Coastal Water Management* (fresh water availability and drainage congestion) and enhancements in industrialization will ensure coastal development. This will make the coast less dependable on agriculture and coastal biodiversity.

Tidal Basin Management with a well-built participatory module and wide-ranging observation is entitled to be a future solution. Hereby, mangrove forests act as defence against tropical storms and promote the accumulation of sediments. Storm refuge and superior forewarning arrangements are established as successful instruments. In recent years, Bangladesh has improved its documentation on hazards.

6.2.1 Industry and Infrastructure

Industrialisation is essential in modernising the economy paired with adequate infrastructure to make it a success.³⁷⁶ Life lines of a nation are infrastructures such as transport, communication, energy and water supply. Part of the modernising process shall be conducted through flood control, drainage, and irrigation technologies. A steady expansion of flood control and drainage projects has been conducted since the 1960s. An extensive number of drainage systems are pre-colonial and colonial as

³⁷⁵ See Rahman / Huq / Uddin Ahmed, 1999

³⁷⁶ See Ericksen et al, 1993, p. 20-22

well as urban surge and flood protection systems that require serious refurbishment.³⁷⁷

At the moment, 190 projects protect a land area of 26,620km² which is about one-third of flood vulnerable land.³⁷⁸ A total of 114 projects are under construction or consideration. Projects to date have resulted in nearly 10,000km of coastal and riverine embankments and nearly 3,400km of drainage and sluices. Flood Control and Drainage/Irrigation Projects (FCD/I) studies have shown that some of them resulted in positive socio-economic impacts, whereas others created problems.

Modernisation of energy infrastructure and security for energy plants form chances for a cutback of greenhouse gas (GHG) emissions.³⁷⁹ The national profit incorporates air pollution abatement, progress in the trade balance, supply of up to date energy to rural areas and employment. Various mitigation options exist within the transport sector; however, the impact of these measures might be thwarted by advancement in the sector. Purchaser inclination and policy deficiency is a hurdle to mitigation efforts. Reduction in carbon dioxide (CO₂) coupled with net economic benefit could be caused by energy efficient construction and refurbishment of existing buildings.

6.2.2 Population and Settlement

After China on first place, Bangladesh ranks third on population living in the Low Elevation Coastal Zone (LECZ).³⁸⁰ Bangladesh's population is expected to grow to 213 - 291 million inhabitants by 2025.³⁸¹ For 2050, the medium projection of population is at 310 million. Population densities in rural and urban areas will increase, exposing settlements to the full range of climatic extremes. The most dense population centre is Dhaka,

³⁷⁷ See Revi, 2007, p. 20

³⁷⁸ See Ericksen et al, 1993, p. 20

³⁷⁹ See IPCC, 2007, p. 12-13

³⁸⁰ See IIED, 2007, p. 32-33

³⁸¹ See Ericksen et al, 1993, p. 15-16, 23-25

where population density averages 3,000/km² and on Narayanganj and Narsingdi, with population figures of over 1,500/km². The concentration in these areas reflects stable agricultural production and less risk from flood and drought than other parts of the country.

In Bangladesh, 75% of the population live in rural settlements.³⁸² The per capita arable land has shrunk and the proportion of rural households that are landless has increased. Most vulnerable inhabitants occupy sea-side villages, low lying char lands, and unprotected islands.

After adaptation practises have failed, relocation of settlements such as parts or entire cities can be identified as a policy option.³⁸³ Economic sensitive activities need to be eliminated or reduced by changing economic structures of cities and enhancing response to risk. Scheduling market and financial instruments will be essential to attend to relocation and rehabilitation needs. Residents need to be compensated for direct or indirect costs of relocation. As a political decision, partial city relocations necessitate to be unbiased, understandable and participative in conduct.

6.2.3 Migration and Employment

Migration is a necessary survival strategy in the face of poverty, political and environmental pressures as well as ethnic and religious marginalisation.³⁸⁴ Shortages of food, land and employment paired with floods, river silting and soil erosion are reasons for migration. Four types of migratory movements are apparent in Bangladesh: core to periphery, rural cycling, urban magnet and international movements.³⁸⁵ Relocation as a consequence of climate change forces rural poor to migrate to other risky rural areas or to urban slums. Rural to rural migration has been caused by overpopulation in relation to the capacity of the rural economy to absorb new labour forces.

³⁸² See Ericksen et al, 1993, p. 15-16; Islam, 2007

³⁸³ See Revi, 2007, p. 20

³⁸⁴ See Gillian, 2002, p. 4

³⁸⁵ See Ericksen et al, 1993, p. 16, 26-27

Traditional adaptation via seasonal migration to less vulnerable areas within the Indian subcontinent was curtailed half a century ago with the creation of East Pakistan.³⁸⁶ Floods caused by melting glaciers in the Himalayas lead to a rise in illegal migration to India.³⁸⁷ This has prompted India to build an immense border fence to block some 6,000 illegal newcomers per day. In 1999, Samaddar calls it the emergence of “footloose” capital and labour across national boundaries. A survey conducted suggests that 17% of total out-migration from rural Bangladesh is in fact, international migration.³⁸⁸

Frequently, migrants live at risks from social and environmental threats, e.g., seasonal labourers living in fields exposed to sudden cyclones and storm surges, while migrants in cities might be at risk from floods and diseases associated with overcrowding.³⁸⁹ To reduce the vulnerability of migrants infrastructure and employment opportunities need to be improved. The focus must be on employment rather than investment. A solution could be to establish food and processing industries in the countryside to create employment opportunities for villagers.

6.2.4 Health and Education

A healthy and educated population is geared to avoid poverty during climatic variations.³⁹⁰ Enhancements in healthcare, education, security and food production guard against impacts of climate change. The goal is to offer free and universal education to eradicate illiteracy and improve trade skills. Educational opportunities have slightly improved, nevertheless, inequality prevails. Mostly, the rural poor do not receive formal education. The NGO BRAC established 14,472 non-formal primary schools providing basic education with a focus on girls in several districts. Basic education and technical training needs to undergo improvement to bring about

³⁸⁶ See OECD, 2003a, p. 49

³⁸⁷ See Truth Out, 2008

³⁸⁸ See Ericksen et al, 1993, p. 27

³⁸⁹ See Ericksen et al, 1993, p. 27

³⁹⁰ See Ericksen et al, 1993, p. 27-31

changes in social well-being, such as health, employability, and the alleviation of poverty.

Table 13: Key Mitigation Technologies and Practices by Sector

Sector	Key mitigation technologies and practices currently commercially available	Key mitigation technologies and practices projected to be commercialized before 2030
Energy Supply	Improved supply and distribution efficiency; fuel switching from coal to gas; nuclear power; renewable heat and power (hydropower, solar, wind, geothermal and bio energy); combined heat and power; early applications of Carbon Capture and Storage (CCS, e.g., storage of removed CO ² from natural gas)	CCS for gas, biomass and coal-fired electricity generating facilities; advanced nuclear power; advanced renewable energy, including tidal and waves energy, concentrating solar and solar PV.
Transport	More fuel efficient vehicles; hybrid vehicles; cleaner diesel vehicles; bio fuels; modal shifts from road transport to rail and public transport systems; non –motorised transport (cycling, walking); land-use and transport planning.	Second generation bio fuels; higher efficiency aircrafts; advanced electric and hybrid vehicles with more powerful and reliable batteries.
Buildings	Efficient lighting and day lighting; more efficient electrical appliances and heating and cooling devices, improved cook stoves, improved insulation; passive and active solar design for heating and cooling; alternative refrigeration fluids, recovery and recycle of fluorinated gases.	Integrated design of commercial buildings including technologies, such as intelligent meters that provide feedback and control; solar PV integrated in buildings.
Industry	More efficient end- use electrical equipment; heat and power recovery; material recycling and substitution; control of non –CO ₂ gas emissions; and a wide array of process-specific technologies.	Advanced energy efficiency; CCS for cement, ammonia and iron manufacture; inert electrodes for aluminium manufacture.
Agriculture	Improved crop and grazing land management to improve soil carbon storage; restoration of cultivated peaty soils and degraded land; improved rice cultivation and livestock and manure management to reduce CH ₄ emissions; improved nitrogen fertilizer application techniques to reduce N ₂ O emissions; dedicated energy crops to replace fossil fuel use; improved energy efficiency.	Improvements of crops yields.
Forestry / Forests	Afforestation; reforestation; forest management; reduced deforestation; harvested wood product management; use of forestry products for bio energy to replace fossil fuel use.	Tree species improvement to increase biomass productivity and carbon sequestration. Improved remote sensing technologies for analysis of vegetation / soil carbon sequestration potential and mapping land use change.
Waste Management	Landfill methane recovery; waste incineration with energy recovery; composting of organic waste; controlled waste water treatment; recycling and waste minimization.	Bio covers and bio filters to optimize CH ₄ optimization.

Source: IPCC, 2007

6.3 Living with Climate Change

Adaptation is “living with climate change”.³⁹¹ Impacts and vulnerability may be reduced by the following forms of adaptation:³⁹²

- Anticipatory and reactive adaptation³⁹³
- Private and public adaptation
- Autonomous and planned adaptation
- Adaptation as a process of social learning

Adaptive capacity is the ability to understand climate changes and hazards; to evaluate their consequences for vulnerable people, places and economies; and to restrain impending injuries to obtain benefits from prospects, or to handle the costs.³⁹⁴ Adjusting to climatic modification is a precondition for sustainable development.³⁹⁵ Long-term adaptation and short-term adjustment have shown that the rice-growing society of Bangladesh has been quite resilient to adverse climate change.³⁹⁶ Within thousands of years, coping strategies to environmental variations have been developed. Farmers attempt to make up for a loss in one year by adjustments aimed at securing above normal production in the post-disaster season. Adjustments contain water pricing, quota setting, licensing and trading in emission rights.³⁹⁷ Adaptive measures are e.g., riverbank protection that has been exercised in the past.

6.3.1 Changing Procedures

Life is about change.³⁹⁸ As we change, the world changes with us. In 1996, it remained unclear whether economies would decide to pursue the green or the grey path. Presently, it has become evident that national

³⁹¹ See Rahman / Huq / Uddin Ahmed, 1999

³⁹² See Dow / Downing, 2007, p. 17

³⁹³ See IUCN and Potsdam Institute for Climate Impact Research, 2000

³⁹⁴ See IPCC, 2007

³⁹⁵ See Rahman / Huq / Uddin Ahmed, 1999

³⁹⁶ See Ericksen et al, 1993, p. 15

³⁹⁷ See Rahman / Huq / Uddin Ahmed, 1999

³⁹⁸ See Gore, 1992, p. 183-200

economies, depending on their budget, will decide on the green path.³⁹⁹ Some western environmental development models can be regarded as examples. These models indicate that climate protection will bear costs and risks as well as chances and profit opportunities. New employment opportunities and professions have been created by the “trend of climate change.” The new interest of economies in climate protection has led to political climate lobbies on national, European and international scale. Enterprises advertise their environmental concepts in an attempt to promote their products further. Environmental policies and environmental unions need to take the concerns of the economy seriously and adapt their strategies according to their needs. Industries have to publish their environmental data openly as environmental benchmarking.

Table 14: Existing Knowledge on Coping Strategies for Changing Procedures
<ul style="list-style-type: none"> ▪ Cyclone shelters ▪ Flood shelters ▪ Coastal embankment ▪ Drainage channels ▪ Creation of green belts through coastal afforestation ▪ Rain water harvesting ▪ Floating agriculture ▪ Saline tolerant species ▪ Shallow tube-well for irrigation ▪ Supplementary irrigation ▪ Drainage control ▪ Short duration crop variety based on depth, timing and recession of flood ▪ Artificial management of temperature for poultry and livestock

Source: Shaheduzzaman, 2005, p. 9

6.3.1.1 Adaptation for Management of Coastal Flooding

This section identifies three main strategies for adaptation management of coastal flooding. The first most important adaptation strategy is the installation of appropriate *drainage infrastructure* along coastal

³⁹⁹ See Müller-Kraenner / Knospe, 1996, p. 7, 101, 174

embankments.⁴⁰⁰ In fact, flow regulators have been incorporated in the design of existing embankments. In many cases, the required number of regulators was not built and lacked proper maintenance. Embankment regulators caused saline flooding and severe damage of agro-ecology which resulted in the dislocation of the population. Therefore, building new drainage regulators along coastal embankments and a refurbishment of existing regulators is required.

The second most important adaptation strategy will be to *reduce the threats of increasing salinity* particularly during the low flow period. Ganges Water will have to be diverted in the following ways⁴⁰¹: river restoration, central pumping, and barrages. Target projects are: the *Coastal Embankment Rehabilitation Project*, the *Coastal Greenbelt Project*, the *Integrated Coastal Zone Management*, and the *Kulna-Jessore Drainage Rehabilitation Project*.⁴⁰²

The third most useful adaptation aiming at saving the Sundarbans from sea-level rise induced submergence would be to *modify the threats of permanent inundation*.⁴⁰³ Since most of the projected sea level rise would occur from tectonic subsidence, it would not be possible to stop the processes. However, controlled and guided sedimentation will have a balancing influence on the subsidence process and could help prevent the permanent inundation of the forest floor.

6.3.1.2 Adaptation within Sectors

Five sectors have been recognized as being in need of adaptation measures: coastal resources, water reserves, agriculture, ecosystems, and health.⁴⁰⁴ The planned adaptation methods are to be applied among all

⁴⁰⁰ See OECD, 2003a, p. 35

⁴⁰¹ See OECD, 2003a, p. 48

⁴⁰² See Rahman / Huq / Uddin Ahmed, 1999

⁴⁰³ See OECD, 2003a, p. 45

⁴⁰⁴ See Rahman / Huq / Uddin Ahmed, 1999

sectors. Nonetheless, this section only focuses on water reserves and the agricultural sector.

The water reserves are exposed to droughts and drainage blockage.⁴⁰⁵ To minimize water consumption is essential and requires an incorporated process of water resource management which directs engineering, infrastructure, and embankments. Main projects to enforce adaptation include the *National Water Management Plan (NWMP)*, the *Water Sector Improvement Project*, the *Small-Scale Water Resources Development Sector Project* and the *River Bank Protection Project*.

Agricultural adaptive capacities transform water effectiveness and diversify harvest.⁴⁰⁶ Expertise in plant development (new species and diffusion methods) is to be disseminated. Plant development needs intense investment from international agencies. A prerequisite for rapid recovery on the market from climatic disasters is the removal of subvention and restraints on farming. Through additives such as credit, diesel, fertilizer, and seeds to farmers, the governing body attempts to heighten harvest.⁴⁰⁷ The Bangladesh Bank allowed flood-affected farmers to receive credits renewed by rescheduling previous loans for one year. Furthermore, a post flood agriculture rehabilitation program is conducted by the government. Without large scale investment the agricultural and forestry sector can not enhance the number of soil carbon sinks for GHG emission reduction and availability of biomass feedstock of energy use.⁴⁰⁸

6.3.1.3 Preventive Adaptation

Preconditions for aid in times of adversity are preventive adaptation measures.⁴⁰⁹ The list below highlights preventive adaptations presently conducted or planned:

⁴⁰⁵ See Rahman / Huq / Uddin Ahmed, 1999

⁴⁰⁶ See Rahman / Huq / Uddin Ahmed, 1999

⁴⁰⁷ See ADB QEU, 2007, p. 5

⁴⁰⁸ See IPCC, 2007, p. 14

⁴⁰⁹ See Rahman / Huq / Uddin Ahmed, 1999

- Well-formulated **frameworks and codes of conduct for policy makers** are essential;
- **Management of natural resources** shall be moved into the foreground of project structuring;
- **Water resource management** supported by the *National Water Council* and the *Water Resources Planning Organization (WARPO)* require years to become functional;
- Hope for coastal resource management comes from the **Integrated Coastal Zone Management (ICZM)** process directed by the *Ministry of Water Resources* and *World Bank*;
- The operation of a **National Environmental Management Plan** is currently run by the *Ministry of Environment*;
- Improvements in structure need to regulate **land use and physical planning**;
- **Decentralization** and lower level **empowerment** enable long-term adaptations;
- **Education and knowledge dissemination** speed up environmental management.

6.3.2 Changing Attitudes

The overall attitude towards climate change has to change. Forms of changing attitudes are enhanced responsiveness, dissemination and the establishment of a climate change knowledge base.

6.3.2.1 Responsiveness and Dissemination

Nationwide programmes for *responsiveness and dissemination* of expertise on global warming impacts are mandatory.⁴¹⁰ The *Suburban Emergency Management Project (SEMP)* and *Basin Environmental Monitoring Plan (BEMP)* implement ecological alertness projects. Through the *Bangladesh Water Partnership* knowledge on hydrological adaptation may be further disseminated. Correspondingly, the *Climate Change Committee (CCC)* shall spread knowledge in governmental bodies. NGOs such as the *Association of Development Agencies in Bangladesh (ADAB)* in collaboration with the *Coalition for Environmental NGOs (CEN)* may publicize knowledge. Vast effectiveness can be installed by national and international media coverage, e.g., *Federation of Environmental Journalists of Bangladesh* and the *Ministry of Information*. The specified acts are advocated in Bangladesh to form operations and to manage climate change action:

⁴¹⁰ See Rahman / Huq / Uddin Ahmed, 1999

- Engage the *Climate Change Committee (CCC)* in frameworks, research scheduling, responsiveness programs, adjoined with international activity;
- Institute a functioning technical secretariat to maintain the *CCC*;
- Involvement of grassroot organizations and incorporate water resource management;
- The *Integrated Coastal Zone Management (ICZM)* needs to concentrate on defence, soil usage and water resource administration;
- Manuals on basic knowledge of *Climate Change Impact Assessments (CCIA)*;
- Expertise pooling and dissemination on effects of global warming;
- Alertness through the *Basin Environmental Monitoring Plan (BEMP)* and *Suburban Emergency Management Project (SEMP)* projects, engaging the *Ministry of Information*, the *Federation of Environmental Journalists of Bangladesh*, *Community Based Organisations (CBOs)* and *NGOs*.
- International appearance involves: (i) panel discussions on impacts, mitigation and adaptation, and (ii) *water sharing negotiations* with neighbouring countries.⁴¹¹

6.3.2.2 Climate Change Knowledge Base

An expertise pool to improve legislation and planning on climate change is desirable for progress in Bangladesh.⁴¹² District surveillance of climatic variations coupled with dissemination of records across South Asia, especially in the target territory of the Bay of Bengal should be practised and strengthened.⁴¹³ This requires enhanced information systems including *Geographic Information System* and *Remote Sensing* for shoreline territories.

On the one hand, technical adjustments such as seed varieties and planting dates might help.⁴¹⁴ On the other hand, traditional knowledge on climatic impacts is hard to recover. Traditional adaptive mechanisms shall be moved into the foreground of adaptation. These traditional methods of coping need adequate documentation and it is compulsory to transform them into modern equivalents.

⁴¹¹ See Rahman / Huq / Uddin Ahmed, 1999; See IPCC, 2007

⁴¹² See IPCC, 2007, p. 22

⁴¹³ See Rahman / Huq / Uddin Ahmed, 1999

⁴¹⁴ Note: To schedule the date for planting seeds according to climatic variations.

7. Conclusion

The previous chapters have described the climate crisis and its impact on Bangladesh as it affects economic growth by uprooting lives and livelihoods of millions of people.⁴¹⁵ This uprooting of lives and livelihoods of millions of people is defined as economic vulnerability. Economic vulnerability adds more to risk than actual hazard exposure. Instead of sole concentration on mitigation, economic vulnerability caused by climate change requires emphasis on adaptation in economic policy, mobilisation and enterprise management. The anchor for this must be an institutional and political focus on the most vulnerable sectors of the economy through policy, regulatory, fiscal and financial, institutional and mobilisational instruments.

Climate Change risk assessment, adaptation and mitigation is to be incorporated into existing economic hazard mitigation programmes in Bangladesh.⁴¹⁶ Economic mitigation and adaptation has to be conducted prior to any relocation and rehabilitation measures. At national, state, municipal and community level a climate change adaptation framework for the economy is vital for the bondage of state, private and civil society sectors. Grass-root mobilization of communities is the key for climate adaptation to sustain economic production in the face of climate impacts. The *Climate Change Committee (CCC)* is planned to act as an executing institution in the conduct of economic climate change mitigation and adaptation in Bangladesh.

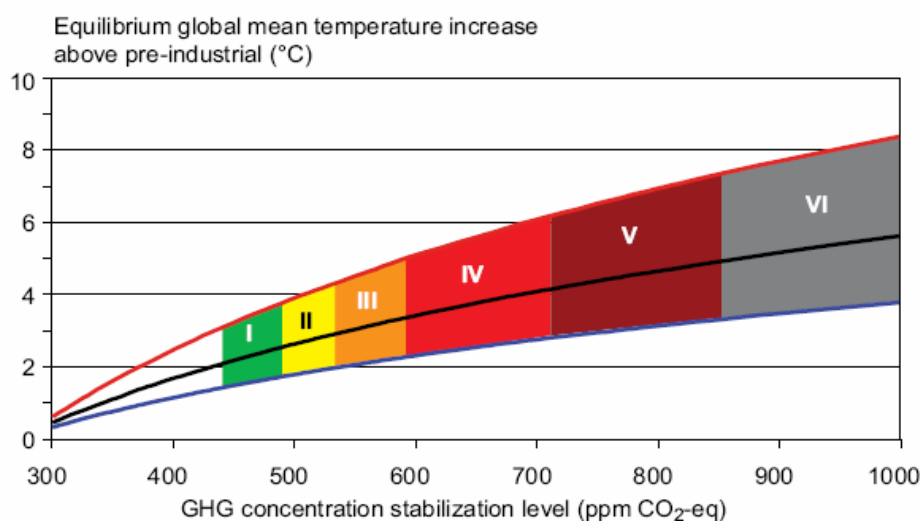
This thesis has outlined the economic impacts of climate change in Bangladesh. To create an international level of awareness regarding the vulnerability of Bangladesh's economy towards climate change is the function of this work.

⁴¹⁵ See Revi, 2007, p. 23

⁴¹⁶ See Revi, 2007, p. 24

Appendices

Appendix 1: Global Temperature Increase and GHG Stabilization



Source: Stern Review Slides, 2007, p. 2

Appendix 2: Countries with Large Amount and Share of Land in the Low Elevation Coastal Zone (LECZ), 2000

Ranked by total land area in the LECZ					Ranked by share of their land in the LECZ			
			Land Area in LECZ				Land Area in LECZ	
Top Ten	Country	Overall Rank *	('000km ²)	%	Country**	Overall Rank *	('000km ²)	%
1	Russia	1	276	2	Bahamas	158	12	93
2	Canada	2	262	3	Suriname	132	31	75
3	USA	4	235	3	Netherlands	93	54	40
4	China	3	182	2	Vietnam	171	1	32
5	Indonesia	15	177	9	Guyana	163	3	26
6	Australia	6	122	2	Bangladesh	131	11	26
7	Brazil	5	122	1	Djibouti	162	3	23
8	Mexico	13	93	5	Belize	102	23	21
9	India	7	82	3	Egypt	65	66	20
10	Vietnam	65	66	20	Gambia	137	7	19

Source: IIED, 2007, p. 29

* Refers to overall rank in total population

**Countries with a total population of under 100,000 people, or smaller than 1,000 square kilometres were excluded from this list.

Appendix 3: Urban Population for China and Bangladesh in the LECZ

Country	Population ('000)		Annual Growth Rate 1990-2000 (%)
	1990	2000	
China	1,138,676	1,262,334	1.04
Urban China	336,577	423,730	2.33
LECZ China	119,103	143,880	1.91
Urban LECZ China	56,059	78,278	3.39
Bangladesh	110,024	123,612	1.17
Urban Bangladesh	23,097	26,865	1.52
LECZ Bangladesh	50,568	62,524	2.14
Urban LECZ Bangladesh	11,686	15,429	2.82

Source: IIED, 2007, p. 32

Appendix 4: Top 10 Countries Most Hit by Natural Disasters in 2006

	Country	No. of Natural Disasters
1	China	38
2	United States	31
3	India	21
4	Philippines	20
5	Indonesia	20
6	Afghanistan	13
7	Viet Nam	11
8	Pakistan	9
9	Bangladesh	8
10	Romania	8

Source: Emdat, 2006

Appendix 5: Natural Disaster Occurrence by Continent

Continent	2006	2005	2000-04 Average
Africa	79	60	65.0
Americas	75	98	97.8
Asia	187	166	147.8
Europe	68	94	65.6
Oceania	18	15	16.8
Total	427	433	393
Continent	2006	2005	2000-04 Average
Africa	18.50%	13.86%	16.54%
Americas	17.56%	22.63%	24.89%
Asia	43.79%	38.34%	37.61%
Europe	15.93%	21.71%	16.69%
Oceania	4.22%	3.46%	4.27%
Total	100%	100%	100%

Source: Emdat, 2006

Appendix 6: Economic Damages of Natural Disasters in 2006 USD Million

Continent	2006	2005	2000-04 Average
Africa	229	30	1,733
Americas	5,398	178,083	18,884
Asia	25,132	24,883	27,272
Europe	2,428	6,308	9,986
Oceania	1,286	226	898
Total	34,474	209,530	58,773

Continent	2006	2005	2000-04 Average
Africa	0.66%	0.01%	2.95%
Americas	15.66%	84.99%	32.13%
Asia	72.90%	11.88%	46.40%
Europe	7.04%	3.01%	16.99%
Oceania	3.73%	0.11%	1.53%
Total	100%	100%	100%

Source: Emdat, 2006

Appendix 7: Asian Economic Damages of Natural Disasters 2006 in USD Million

Major Types of Natural Disasters	2006	2005	2000-04		
			Average	Min	Max
Geological	3,226	5,243	9,200.6	371	38,285
Floods & related	5,438	11,177	8,743.6	1,679	13,411
Droughts & related	3,741	477	1,610.2	n.a.	3,036
Windstorms	12,727	7,986	7,717.8	537	16,328
Total	25,123	24,883	27,272.2	371	38,285

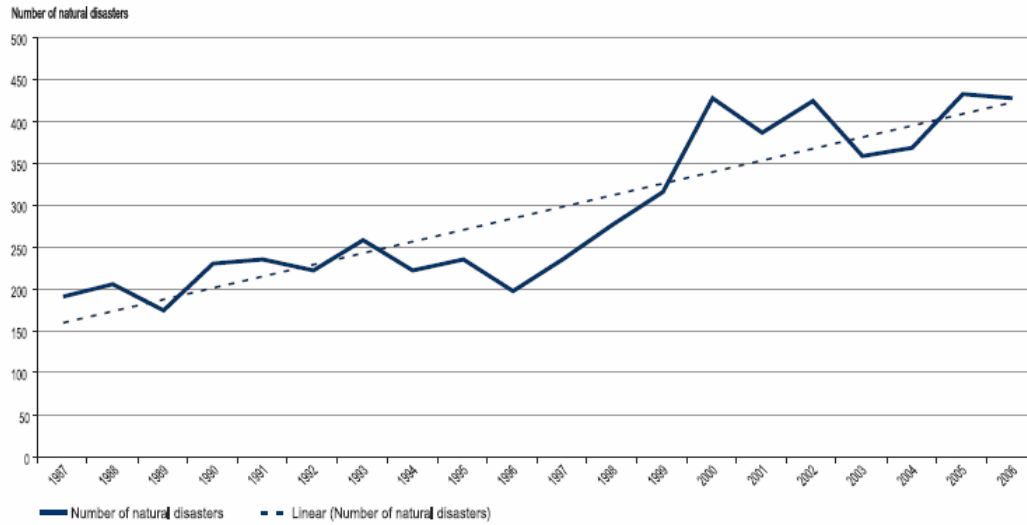
Source: Emdat, 2006

Appendix 8: Top 10 Natural Disasters by Number of Deaths 2007

Cyclone Sidr, November	Bangladesh	4234
Flood, July-August	Bangladesh	1110
Flood, July-September	India	1103
Flood, August	Korea	610
Flood, June-July	China	535
Earthquake, August	Peru	519
Heatwave, July	Hungary	500
Cyclone Yemyin, June	Pakistan	242
Flood and landslides, June	Pakistan	230
Flood, July	India	225

Source: Emdat, 2007

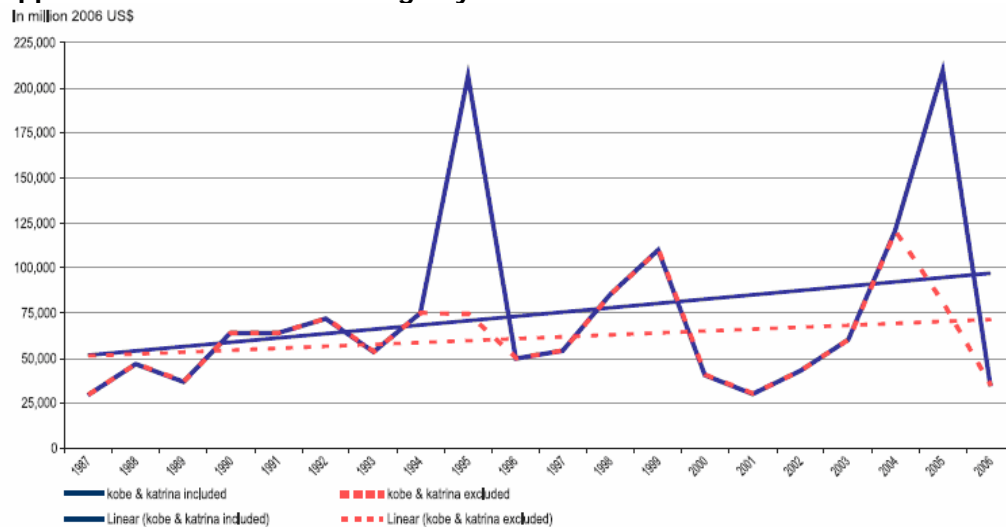
Appendix 9: Global Overview of Natural Disasters 1987-2006



Source: CRED, 2008

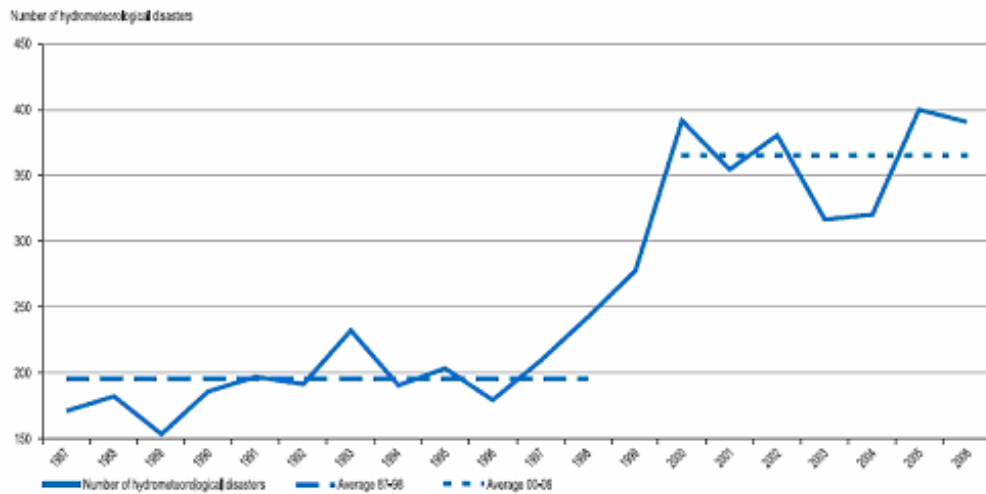
Two periods can be distinguished: 1987-1997, with the number of disasters varying generally between 200 and 250; and 2000-2006, with the number of disasters increasing by nearly a multiple factor of two. An increase of this magnitude can be partially explained by increased reporting of disasters, particularly by press organizations and specialized agencies.

Appendix 10: Economic Damage by Natural Disasters 1987-2006



Source: CRED, 2008

Appendix 11: Occurrence Hydrometeorological Disasters: 1987-2006 with averages for periods 1987-1998 and 2000-2006

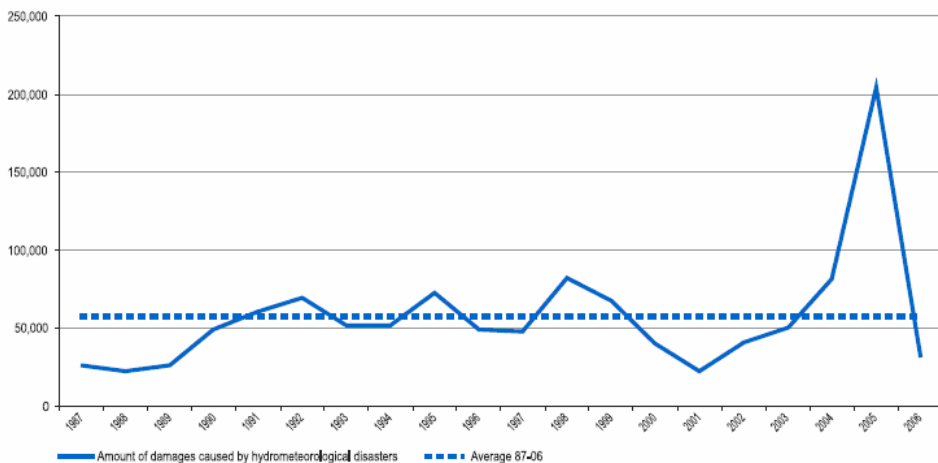


Source: CRED, 2008

- During the period 1987-2006, hydrometeorological disaster show an significant increase
- The years 1998, 1999 and 2000 reflect a turning point and an escalation in the number of disasters reported, with 1999 showing the most dramatic inflection. Accordingly, for purposes of comparing the two periods, data for 1999 has been excluded.
- For 1987-1998, the average number of hydrometeorological disasters reported was 195; for the years 2000-2006, this number increased by 187% to an average of 365.

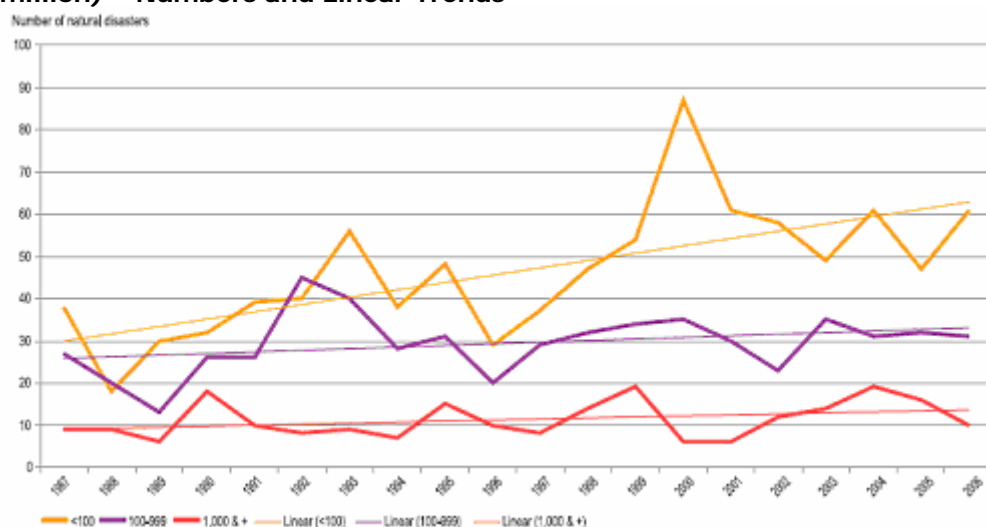
Appendix 12: Hydrometeorological Disaster Damages in 2006 USD Million

In 2006 US\$ million



Source: CRED, 2008

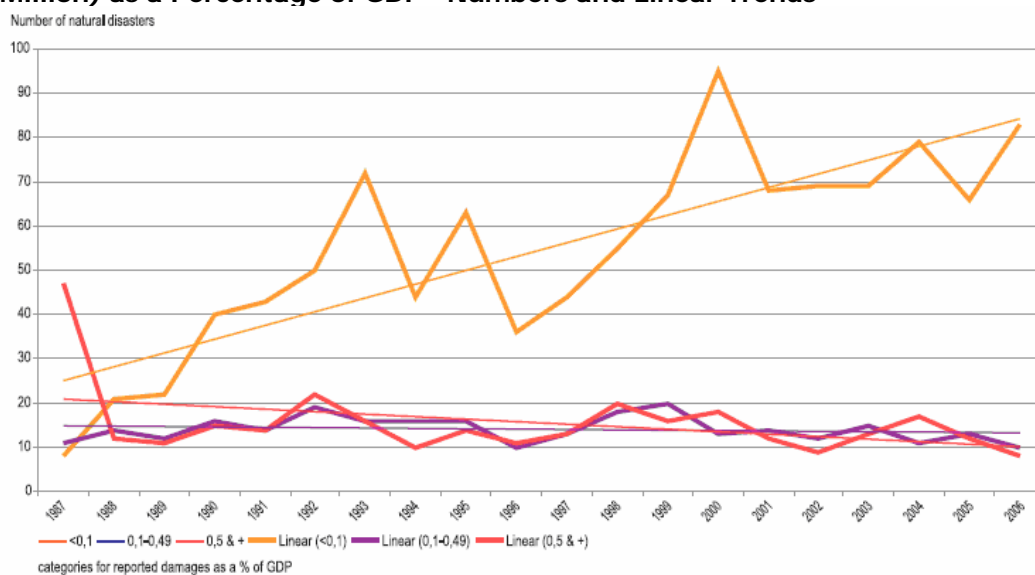
Appendix 13: Natural Disasters Categorized by Amount of Damages (in 2006 USD million) – Numbers and Linear Trends



Source: CRED, 2008

- As explained above, three categories were empirically determined: disasters causing damages of less than USD 100 million (in 2006 USD), disasters causing damages of USD 100-999 million and disasters causing damages of at least USD one billion.
- The evolution of the two first categories appears clearly in 1997, 1998 and 1999. Thereafter the number of disasters causing damages of less than USD 100 million increase faster than those in the range of USD 100-999 million. The first category doubled between 1987 and 2006. The second category grew about 1.3 times.
- The number of disasters causing damages of at least USD one billion, which an annual average 11.25, grew around 1.4 times during the period.

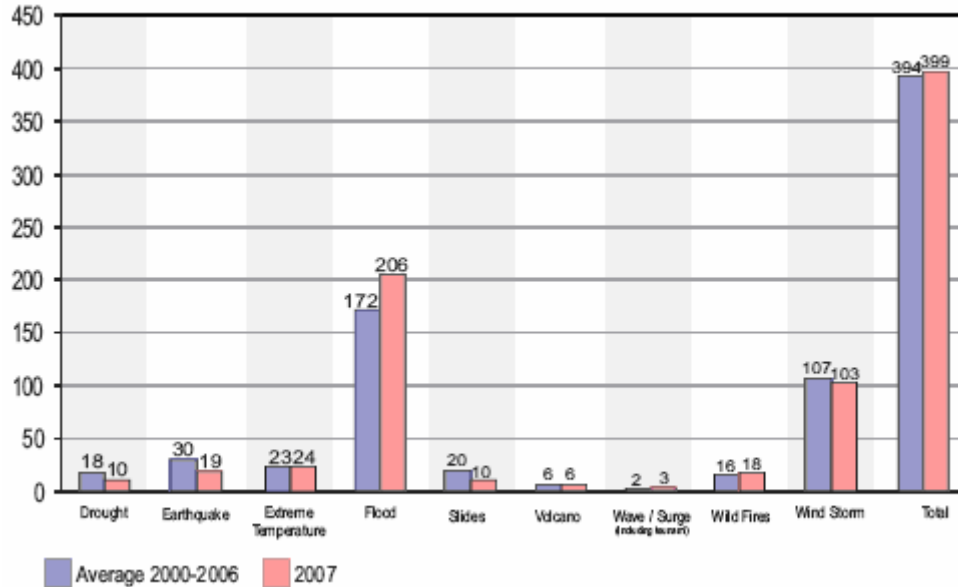
Appendix 14: Natural Disasters Categorized by Amount of Damages (in 2006 USD Million) as a Percentage of GDP –Numbers and Linear Trends



Source: CRED, 2008

- Damages from natural disasters categorized according to the percentage of GDP of the affected country gives a figure which differentiates disasters causing damages equalling less than 0.1% of GDP, from those disasters for which the economic impacts were more severe (i.e., between 0.1 and 0.49%, and 0.5% and greater).
- The number of the first category grew around three times between 1987 and 2006.
- The number of disasters causing damages in the range of 0.1-0.49% of GDP and those more severe with damages representing 0.5% of the GDP or more, remain in a range of 10-20 disasters annually.
- The decrease in the number of disasters causing damages in the range of 0.1-0.49% of GDP declined around 15% by 1987 and 2006.
- The decrease in the number of disasters causing at least damages of 0.5% of GDP is more pronounced, declining around 50% between 1987 and 2006. However this higher decrease is attributable to 1987 number. When it is excluded the decrease is about 13%.

Appendix 15: Natural Disaster Occurrence by Disaster Type



Source: Emdat, 2007

Appendix 16: Geographic Facts

Location	Southern Asia, bordering the Bay of Bengal, between Burma and India
Geographic Coordinates	24 00 N, 90 00 E
Area	Total: 144,000 km ² Land: 133,910 km ² Water: 10,090 km ²
Land boundaries	Total: 4,246km Border countries: Burma 193km, India 4,053km
Coastline	580km
Maritime Claims	Territorial sea: 12 nm Contiguous zone: 18 nm Exclusive economic zone: 200 nm Continental shelf: up to the outer limits of the continental margin
Climate	Tropical; mild winter (October to March); hot, humid summer (March to June); humid, warm rainy monsoon (June to October)
Terrain	Mostly flat alluvial plain; hilly in southeast
Elevation Extremes	Lowest point: Indian Ocean 0m Highest point: Keokradong 1230m
Natural Resources	Natural gas, arable land, timber, coal
Land Use	Arable land: 55,39% Permanent crops: 3,08% Other: 41.53% (2005)
Irrigated Land	47 250km ² (2003)
Total Renewable Water Resources	1210.6km ³ (1999)
Freshwater Withdrawal (domestic/industrial/agricultural)	Total: 79.4km ³ /yr (3%/1%/96%) Per capita: 560m ³ /yr (2000)
Natural Hazards	Droughts, cyclones; much of the country routinely inundated during the summer monsoon season
Environment – Current Issues	Many people are landless and forced to live on and cultivate flood-prone land; water-borne diseases prevalent in surface water, water pollution, especially of fishing areas, results from the use of commercial pesticides; ground water contaminated by naturally occurring arsenic; intermittent water shortages because of falling water tables in the northern and central parts of the country; soil degradation and erosion; deforestation; severe overpopulation
Environment – International Agreements	Party to: Biodiversity, Climate Change, Climate Change – Kyoto Protocol, Desertification, Endangered Species, Environmental Modification, Hazardous Wastes, Law of the Sea, Ozone Layer Protection, Ship Pollution, Wetlands
Geography - Note	Most of the country is situated on deltas of large rivers flowing from the Himalayas: the Ganges unites with the Jamuna (main channel of the Brahmaputra) and later joins the Meghna to eventually empty into the Bay of Bengal

Source: CIA World Fact Book, 2008

Appendix 17: Economic Indicators for Bangladesh in 2007

GDP (purchasing power parity)	USD209.2 billion (2007 est.)
GDP (official exchange rate)	USD75.17 billion (2007 est.)
GDP – real growth rate	6% (2007 est.)
GDP – composition by sector	Agriculture: 19% Industry: 28.7% Services: 52.3% (2007 est.)
Labour force	69.4 million Note: extensive export of labour to Saudi Arabia, Kuwait, UAE, Oman, Qatar, and Malaysia; workers' remittances estimated at USD4.8 billion in 2005-06. (2007 est.)
Labour force – by occupation	Agriculture: 63% Industry: 11% Services: 26% (FY95/96)
Unemployment rate	2.5% (includes underemployment) (2007 est.)
Population below poverty line	14%
Distribution of family income – Gini index	33.4 (2000)
Inflation rate (consumer prices)	8.8% (2007 est.)
Investment (gross fixed)	26% of GDP (2007 est.)
Budget	Revenues: USD7.078 billion Expenditures: USD9.642 billion (2007 est.)
Public debt	37.9% of GDP (2007 est.)
Agriculture products	Rice, jute, tea, wheat, sugarcane, tobacco, pulses, oilseeds, spices, fruit; beef, milk, poultry
Industries	Cotton textiles, jute, garments, tea processing, paper newsprint, cement, chemical fertilizer, light engineering, sugar
Industrial production growth rate	9.5% (2007 est.)
Current account balance	USD683 million (2007 est.)
Exports	USD11.25 billion (2007 est.)
Export - commodities	Garments, jute, leather, frozen fish and seafood (2001)
Exports - partners	US 25%, Germany 12.6%, UK 9.8%, France 4.9% (2006)
Imports	USD14.91 billion (2007 est.)
Import - commodities	Machinery and equipment, chemicals, iron and steel, textiles, foodstuffs, petroleum products, cement
Imports - partners	China 17.7%, India 12.5%, Kuwait 7.9%, Singapore 5.5%, Hong Kong 4.1% (2006)
Economic aid - recipient	USD1.321 Billion (2005)
Reserves of foreign exchange and gold	USD5.293 Billion (31 December 2007 est.)
Debt - external	USD20.25 Billion (31 December 2007 est.)
Stock of direct foreign investment - at home:	USD4.208 Billion (2006 est.)
Stock of direct foreign investment - abroad	USD105 Million (2006 est.)
Market value of publicly traded shares:	USD3.61 Billion (2006)
Currency (code)	taka (BDT)
Exchange rates:	taka per US dollar - 69.893 (2007), 69.031 (2006), 64.328 (2005), 59.513 (2004), 58.15 (2003)
Fiscal year:	1 July - 30 June

Source: CIA World Factbook, 2007

Appendix 18: Transnational Issues

Disputes - International:	discussions with India remain stalled to delimit a small section of river boundary, exchange territory for 51 small Bangladeshi exclaves in India and 111 small Indian exclaves in Bangladesh, allocate divided villages, and stop illegal cross-border trade, migration, violence, and transit of terrorists through the porous border; Bangladesh resists India's attempts to fence or wall off high-traffic sections of the porous boundary; a joint Bangladesh-India boundary inspection in 2005 revealed 92 pillars are missing; dispute with India over New Moore/South Talpatty/Purbasha Island in the Bay of Bengal deters maritime boundary delimitation; 21,000 Burmese Rohingya Muslim refugees reside in two camps in Bangladesh
Refugees and Internally Displaced Persons	<i>refugees (country of origin):</i> 21,053 (Burma) <i>IDPs:</i> 65,000 (land conflicts, religious persecution) (2006)
Illicit Drugs	transit country for illegal drugs produced in neighbouring countries

Source: CIA World Fact Book, 2008

Appendix 19: Climate Change Data Comparison

	Bangladesh	Germany
1) Population in thousands 2004	140,494	82,631
2) GNI per capita USD 2004	440	30,120
3) Human Development Index rating 2003	0.520	0.930
4) Water withdrawn as % of renewable water resources 2002 or latest available data	1%	26%
5) Coastal population as % of total population 1995	55%	15%
6) Weather related disasters		
Number 2000-05	49	13
Average annual deaths per million people 1980-2000	68	-
7) Carbon dioxide emissions		
From burning of fossil fuels million tonnes 2002	32	828
Tonnes per person 2002	0.2	10.2
tonnes per person 1950-2000	435	47,314
From transportation million tonnes 2003	4	162
8) Methane emissions		
Million tonnes CO ₂ e 2000	47.6	86.5
tonnes CO ₂ e per person 2000	0.4	1.1
from agriculture (plus N ₂ O) million tonnes CO ₂ e 2003	71.5	89.4
9) Carbon intensity		
Tonnes of CO ₂ per USD1,000 GDP		
2003	0.68	0.45
change 1993-2003	0.14	-0.09

Source: Dow / Downing, 2007

Appendix 20: Climatic Impacts on Bangladesh

November 1970	A cyclone with 222km winds causes a 20ft tidal surge and kills 500,000 people.
July 1974	Severe flood devastates the grain crop, leading to an estimated 28,000 deaths.
1988	Floods cover three-quarters of the country, killing more than 5,000 and leaving millions homeless.
April 1991	A cyclonic 15ft tidal wave kills up to 138,000.
1998	Flooding from July 12 to September 14 covers 67% of the country, killing 1,200 and causing damage worth USD14.5bn.
November 15 2007	Cyclone Sidr hits Bangladesh, killing at least 3,200 and leaving more than two million struggling for necessities such as food, water, shelter and medicines.

Source: Chevallot in the Guardian, 2007

Appendix 21: Identified Vulnerabilities for Bangladesh

1) Water resources
2) Agriculture, livelihoods and food security of communities
3) Life, assets and property
4) Energy (Hydropower)
5) Infrastructure (Highways, bridges, airports, ports)
6) Revenue earning sectors (e.g., tourism)

Source: ADB, 2008b

Appendix 22: Impacts of Cyclone Sidr

Cyclone Sidr Hits Bangladesh on 15 November 2007

On 15-16 November 2007, Bangladesh was hit by a major cyclone accompanied by a tidal wave.⁴¹⁷ This cyclone had been called "Sidr" and its severe impacts were widely discussed in the global media. With winds over 220km/hr the cyclone destroyed southern coastal districts such as household dwellings, crops, livestock, shrimp farms as well as disconnecting communication nation wide. The uprooting of trees caused severe damage to the environment, especially to the Sundarbans World Heritage Site. Infrastructure including power, roads and embankments in southern districts were disrupted. Saddening but hardly surprising many of the dead from cyclone Sidr were fishermen ignoring the cyclone warning in search of a plentiful catch.⁴¹⁸ On 20 November 2007, the World Bank offered an aid assistance sum of USD 250 million to the victims of Cyclone Sidr in Bangladesh to strengthen the countries disaster mitigation systems.⁴¹⁹ The entire amount of cyclone damages has not yet been assessed.

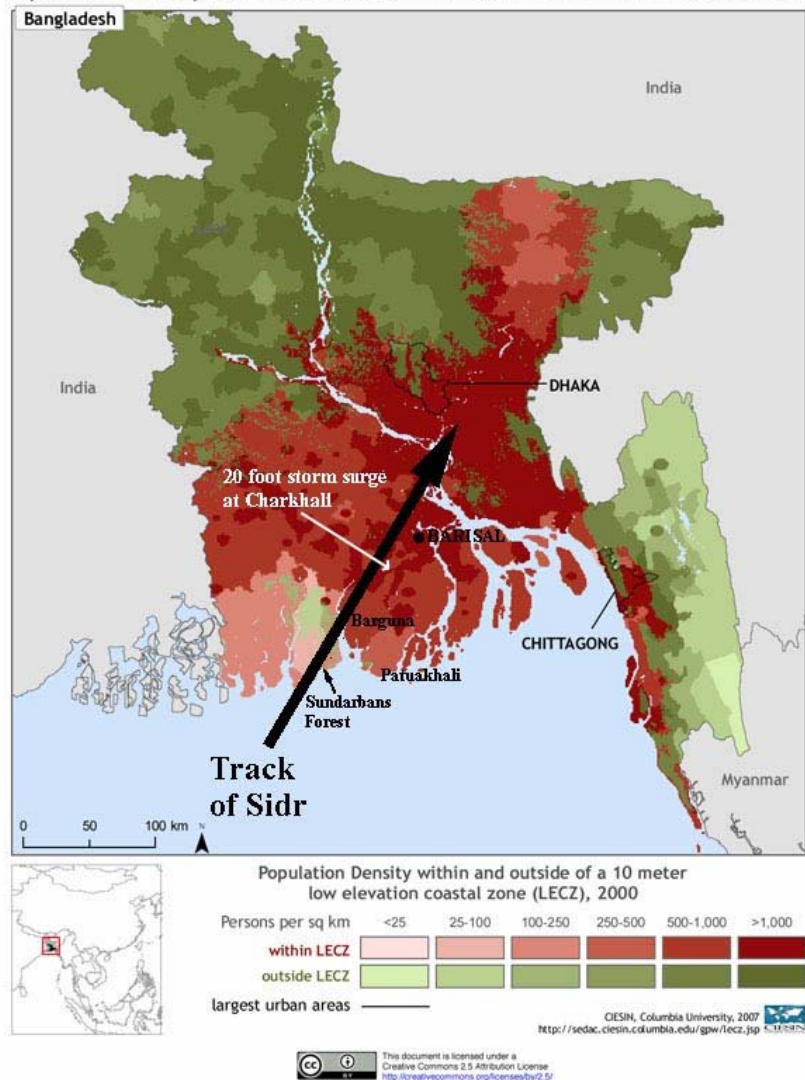
⁴¹⁷ See ADB QEU, 2007, p. 10

⁴¹⁸ See Fraser, 2007

⁴¹⁹ See World Bank, 2006

Appendix 23: Population Density Affected by Cyclone Sidr 2007

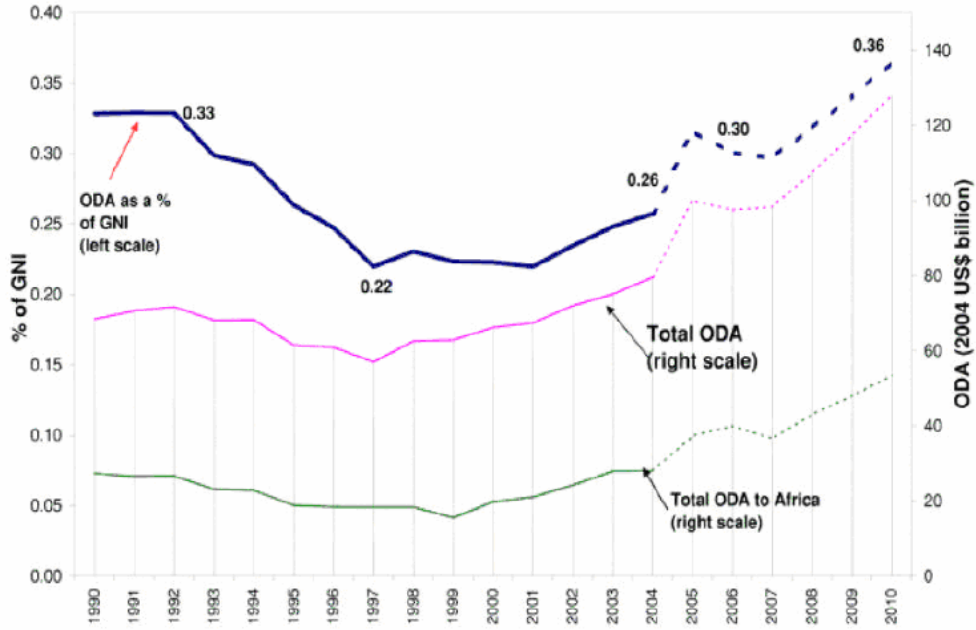
Population Density within and outside of a 10m Low Elevation Coastal Zone



Source: Image credit: CIESIN, Columbia University, Wunderground, 2007

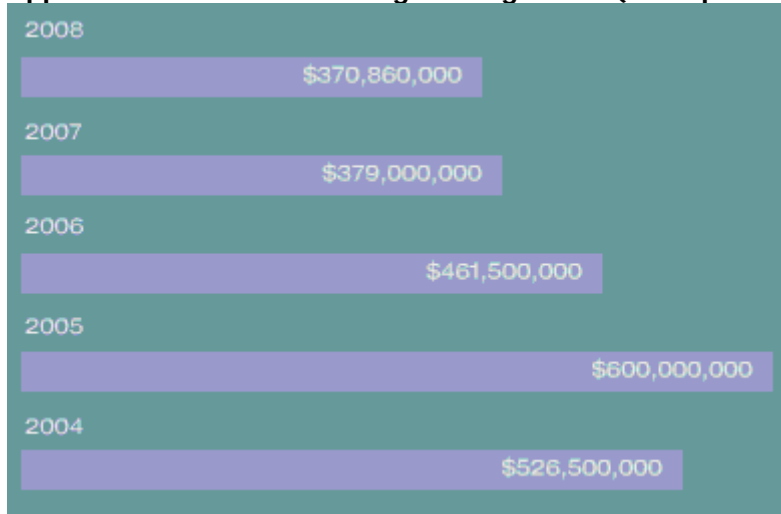
The Population Density Map on the following page is for regions less than 10 m in elevation (red areas) and higher than 10 meters (green areas). The path of Tropical Cyclone Sidr took it inland over the Sundarbans Forest, the least populated region of the coast. However, the more heavily populated provinces Barguna and Patuakhali received a storm surge of 10-20 feet. Sidr passed near the city of Barisal, where sustained winds of 92 mph were measured at midnight local time. The deadliest cyclones for Bangladesh have always taken a more easterly track, near the city of Chittagong.

Appendix 24: Adaptation Scaling up Overseas Development Aid



Source: Stern Review Slides, 2007, p. 7

Appendix 25: Current Lending in Bangladesh (Total per fiscal year, in USD)



Source: World Bank, 2006a

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Statutory Declaration

I hereby declare that this Bachelor Thesis with the title:

“Economic Impacts of Climate Change on Bangladesh”

is a result of my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgement has been made in the text.

Wiesbaden, 15 April 2008

Saira Moinuddin