Seminar Paper
on
CLIMATE CHANGE AND ITS IMPACTS ON THE AQUATIC BIODIVERSITY OF BANGLADESH

MS Seminar Course: FBE 598

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CLIMATE CHANGE AND ITS IMPACTS ON THE AQUATIC BIODEVERSITY OF BANGLADESH

Abstract

Climate change is projected to cause significant alterations to aquatic biogeochemical processes, (including carbon dynamics), aquatic food web structure, dynamics and biodiversity, primary and secondary production; and, affect the range, distribution and habitat quality/quantity of aquatic mammals and waterfowl. Nutrient and carbon enrichment will enhance nutrient cycling and productivity, and alter the generation and consumption of carbon-based trace gases. Consequently, the status of aquatic ecosystems as carbon sinks or sources is very likely to change. Climate change is also very likely affect the biodiversity of freshwater ecosystems across most of the Arctic. Projected effects on aquatic mammals and waterfowl include altered migration routes and timing; a possible increase in the incidence of mortality and decreased growth and productivity from disease and/or parasites; and, probable changes in habitat suitability and timing of availability. The effects of increased atmospheric CO2 concentrations-such as changes in ocean chemistry-will adversely affect the physical and biological characteristics of coastal systems, modifying their ecosystem structure and functioning. As a result, coastal nations face losses of marine biodiversity, fisheries, and shorelines. Coral reefs, which are among the most bio diverse ecosystems on Earth, are highly sensitive to increases in sea surface temperature. A 2°C increase, associated with CO2 concentrations of 500 ppm, threatens to destroy most coral reefs. Along with increasing temperatures, more acidic conditions in the ocean associated with dissolved CO2 from Earth's atmosphere threaten to transform living reefs into seaweed dominated mounds of rubble. These impacts will add to the stress already resulting from local anthropogenic effects; combined, they represent an unprecedented challenge to the global biosphere. While the impacts are being felt globally, some regions will be more acutely affected than others.

Key words: Climate change, Aquatic ecosystem, Biodiversity, Coral reefs.

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CHAPTER I

Introduction

Climate change is any significant change (either increase or decrease) in weather patterns e.g. temperature, precipitation, atmospheric pressure, wind, snowfall etc from decades to millions of years. According to United Nations Framework Convention on Climate Change (UNFCCC)—**"**a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." According to Intergovernmental Panel on Climate Change (IPCC) —"a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer". Re-configuration of tectonic plates, variations of solar intensity, variations in earth orbital, ocean variability, volcanic eruptions, and emission of Greenhouse gases (GHGs) through anthropogenic activities are several causes of climate change.

Greenhouse gases (GHGs) trap heat in the atmosphere and contribute to greenhouse effect by absorbing infrared radiation. The primary greenhouse gases and their percentage contribution to the greenhouse effect on the earth are: carbon dioxide (CO_2) 9-26%, methane (CH_4) 4-9%, ozone (O_3) 3-7%, water vapor (H_2O) 36-70% and nitrous oxide (N_2O) around 5% (World Bank, 2013). These gases absorb heat and radiate some of it back to the earth's surface, causing global warming (GW). GW is the increase of the global average temperature on the earth's surface and atmosphere due to increasing concentrations of GHGs. Climate change is the consequence of global warming (WB, 2013).

Aquatic biodiversity refers to the variety of life and the ecosystems that make up the freshwater, tidal and marine regions of the world and their interactions (Bibzy 1995). It encompasses freshwater ecosystems, including lakes, ponds and reservoirs, rivers and streams, groundwater and wetlands. Aquatic biodiversity has enormous economic and aesthetic value and is largely responsible for maintaining and supporting overall congenial environment and ecosystem. Among aquatic biodiversities fisheries diversity plays very important role in dietary requirement and economy in the world. Bangladesh rank as fourth largest country in fish production (FAO, 2014).

Climate change has both direct and indirect impacts on aquatic biodiversity which are exploited commercially. Direct effects act on physiology and behavior and alter growth, reproductive capacity, mortality and distribution. Indirect effects alter the productivity,

structure and composition of the marine ecosystems on which fish depend for food. However, even though the year-on-year rate of anthropogenic climate change may seem slow, this is very rapid compared with previous natural change and the accumulative value produces a significant difference from the "natural" state quite quickly.

Salinity is a current problem, which is expected to exacerbate by climate change and sea level rise. Salinity intrusion due to reduction of freshwater flow from upstream, salinization of groundwater and fluctuation of soil salinity are major concern of Bangladesh. Cyclones and tidal surge is adding to the problem. Tidal surge brings in saline water inside the polders in the coastal area. Due to drainage congestion, the area remains waterlogged, increasing the salinity (Allison, 2009).

The climate in Bangladesh is changing and it is becoming more unpredictable every year. The impacts of higher temperatures, more variable precipitation, more extreme weather events, and sea level rise are already felt in Bangladesh and will continue to intensify. Climate change poses now-a-days severe threat mostly in fisheries sector and food security among all other affected sectors.

It then considers why climate change needs to be a priority in development planning, including the inequitable burden it places on the poor and developing countries as like as Bangladesh. Considering the above facts the present study was undertaken to fulfill the following objectives.

Objectives

- ✓ To illustrate the effects of climate change on coastal region in Bangladesh
- ✓ To present the impacts of Climate related change on aquatic biodiversity especially fisheries sector in the context of Bangladesh
- ✓ To share experiences on climate change adaptation and mitigation in coastal fisheries of Bangladesh

CHAPTER II

Materials and Methods

This seminar paper is exclusively a review paper so all of the information has been collected from the secondary sources. During preparation of this paper I went through various relevant books, journals, proceedings, reports, publications etc. Findings related to my topic have been reviewed with the help of the library facilities of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) and Bangladesh Agricultural University (BAU). Information also collected from Bangladesh Fisheries Development Corporation (BFDC), Department of Bio-Environmental Science (BES). I have also searched related internet web sites to collect information. I got valuable suggestion and information from my major professor and course instructors. After collecting all the available information, I myself compiled and prepared this seminar paper.

CHAPTER III

REVIEW OF FINDINGS

1. Bangladesh: Country characteristics

The physical, social and economic conditions of Bangladesh are relevant to its status as one of the most vulnerable countries to climate change. Bangladesh is one of the largest deltas in the world, formed by a dense network of the distributaries of the rivers Ganges, Brahmaputra, and the Meghna, and more than 230 major rivers and their tributaries and distributaries. The total land area is 147, 570sq km2 and consists mostly of low, flat land. 80% of the land is floodplain, and only in the extreme northwest do elevations exceed 30 metres above mean sea level, making the majority of Bangladesh (with the exception of the highlands) prone to flooding at least part of the year, with the floodplains of the north western, central, south central and north eastern regions subject to regular flooding **(Choudhury, 2011).**Between 30-70% of the country is normally flooded each year. The extent of flooding is exacerbated by the sediment loads brought by the three major Himalayan rivers, coupled with a negligible flow gradient, which increases congestion.

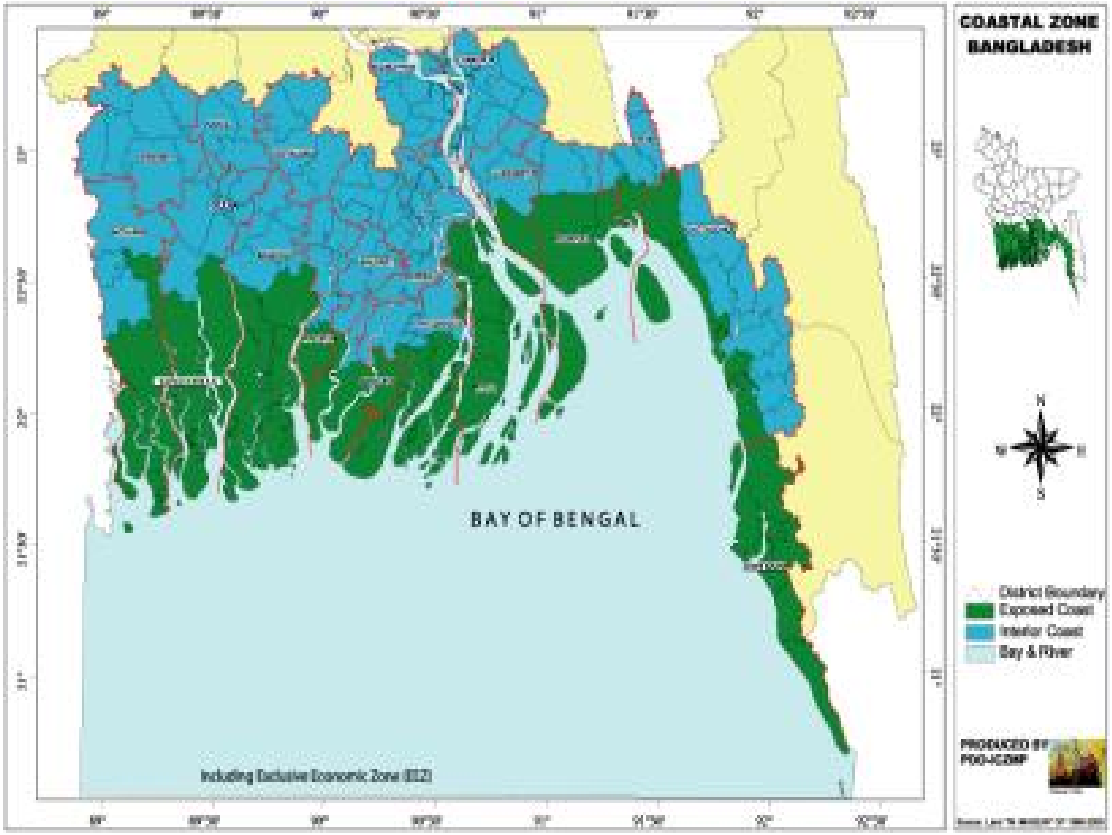


Figure.1. The coastal zone (710km) of Bangladesh. (Source: Choudhury, 2011)

1.1 The coastal zone of Bangladesh

The coastal zone covers 19 out of 64 districts facing, or in proximity to, the Bay of Bengal, encompassing 153 thanas (subdistricts, formerly called upazilas) and the EEZ (MoWR 2013). The zone constitutes 32 percent of the area and 28 percent of the population of Bangladesh (Islam et al., 2012). In 12 of these districts, 51 thanas face a combination of cyclone risk, salinity and tidal water movement above critical levels and are designated as "exposed coast" (Figure 1, green areas). The coastal zone covers an area from the shore of 37 to 195 kilometers, whereas the exposed coast is limited to a distance of 37 to 57 kilometers (Islam et al., 2012). The coastal population is projected to grow to about 43.9 million in 2015 and 60.8 million by 2050 (Ahmad, 2005).During the last 250 years, eight tsunamis, at most, have been reported to have affected the coast of Bangladesh (Choudhury, 2011). Because of Bangladesh's low elevation, Sadhuram predicted that a tsunami of one metre could severely damage coastal Bangladesh. It is estimated that at least 6.8 million people are at high risk from tsunamis (Islam et al., 2010).

1.2. Physiography of the coastal area

Tidal and estuarine floodplains cover almost 98% of the coastal area. Small areas (2%)with river floodplains and peat basins are found in the northern part of the coastal area.Tidal floodplains occur in Satkhira, Khulna, Bagerhat, Pirozpur, Jhalukhati, Barisal, Patuakhali, Chittagong and Cox's Bazar districts. They cover a total of 18,65,000ha orabout 65% of the coastal area. Estuarine floodplains occur in Noakhali, Bhola and Patuakhali districts and in the north-western part of Chittagong district. They cover about 9,37,000ha or about 33% of the coastal area (Haque, 2011).

1.3. Land characteristics of the coastal region

The coastal saline area lies about 1.5 to 11.8 meters above the mean sea level. The Ganges river meander floodplain systems are standing higher than the adjoining tidal lands. The tidal floodplain has a distinctive, almost level landscape crossed by numerable interconnecting tidal rivers and creeks. The estuarine islands are constantly changing shape and position as a result of river erosion and new alluvial deposition. These areas are subject to flooding in the monsoon season and water logging in parts of the basin areas in the dry season. Tidal flooding through a network of tidal creeks and drainage channels connected to the main river system inundates the soil and impregnates them with soluble salts thereby rendering both the top and subsoil saline (Haque, 2006).

2. Indicators of Climate Change

There are total ten indicators for a warming world. Seven of these indicators would be expected to increase in a warming world and observations show that they are, in fact, increasing. Three would be expected to decrease and they are, in fact, decreasing.

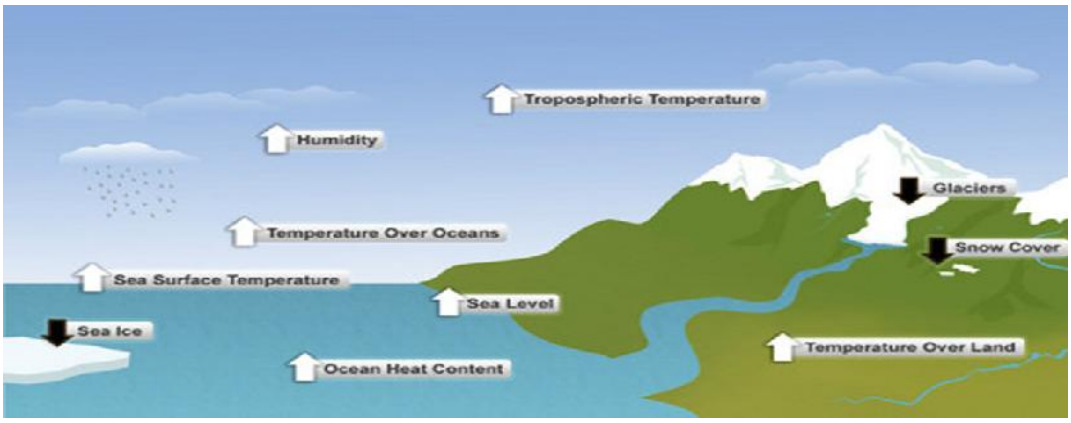


Fig.2. Ten indicators for a warming world, Past Decade Warmest on Record According to Scientists in 48 Countries. (Sources: IPCC 2007)

2.1. Sectorial Impact of Climate Change

Bangladesh is thought to be one of the most vulnerable countries of the world to climate change and sea level rise (CCSLR). IPCC estimates predict that due to the impact of climate change, sea level in Bangladesh may rise by 14cm by 2025, 32cm by 2050 and 88 cm by 2100. There are a number of environmental issues and problems that are hindering development of Bangladesh.

Table 1: Climate change scenarios for Bangladesh

Year	**Temperature Change (^{o}C) Mean**			**Precipitation Change (%) Mean**			**Sea Level Rise (cm)**
	Annual	Dec-Feb.	June-Aug.	Annual	Dec-Feb.	June-Aug.	Prediction
2030	1.0	1.1	0.8	5	-2	6	14
2050	1.4	1.6	1.1	6	-5	8	32
2100	2.4	2.7	1.9	10	-10	12	88

(Sources: IPCC 2007)

2.2. Increase Carbon Dioxide (CO_2) level

Carbon dioxide enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and also as a result of other chemical reactions (e.g., manufacture of cement). Carbon dioxide is also removed from the atmosphere (or “sequestered”) when it is absorbed by plants as part of the biological carbon

cycle. But due to deforestation and climate change CO_2 level increasing day by day (Fig 3).

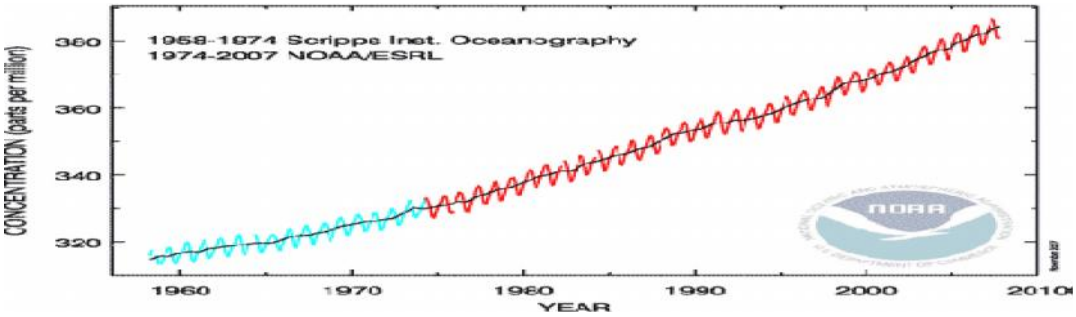


Fig.3.Increase Carbon Dioxide (CO_2) level (1960-2007). (Source: IPCC, 2007)

2.3. Sea level rising

The IPCC projections are derived from climate models. Using both tide gauge and satellite data, we can see that sea levels are rising. Unfortunately, sea level rise is already tracking the worst-case projections, as this graph shows(Fig 4):

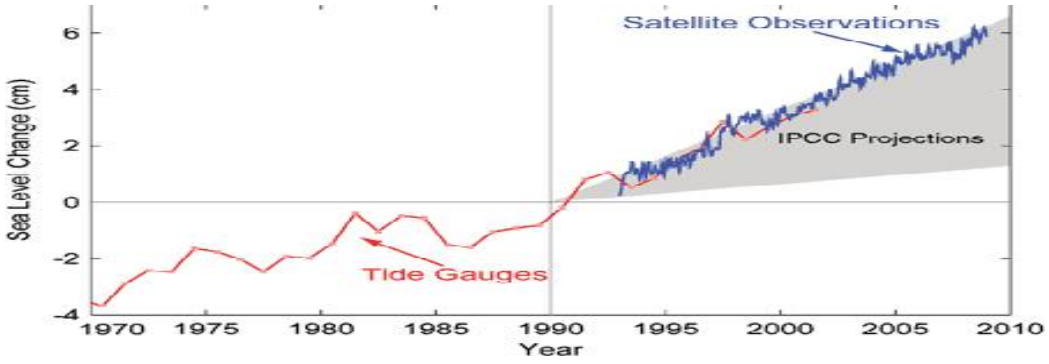


Figure 4: Sea level change. Tide gauge data are indicated in red and satellite data in blue. (Source: Allison, 2009).

Table 2. The area of the coastal area which supposed to inundate due to one (1) meter sea level rise

Region	Area (%)
Khulna	65
Barisal	99
Patuakhali	100
Noakhali	44
Foridpur	12

(Source: IPCC, 2007a)

Table- 3: Predicted changes in temperature and precipitation

Year	Sea Level Rise (cm)	Temperature Rise (^{o}C)	% of Changes in precipitation
2030	30	0.7 and 1.3 rises respectively in monsoon and winter	3% less in winter and 11 percent more in monsoon
2050	50	1.1 and 1.3 rises respectively in monsoon and winter	37% less in winter and 28 percent more in monsoon

(Source: Mahmood et al., 1998)

2.4. Increased flooding

Analysis of past floods suggests that, about 26 percent of Bangladesh is subject to annual flooding. An additional 42 percent is at risk of flood with varied intensity **(**Ahmed et al. 2009**).** A 10 percent increase in monsoon precipitation in Bangladesh could increase runoff depth by 18 to 22 percent, resulting in a seven fold increase in the probability of an extremely wet year (Fig 5).

Fig.5. Flooding.(Source: Ahmed et al. 2009).

2.5. Increased intensity of cyclone winds and precipitation

The IPCC conclude that there is evidence of a 5-10 per cent increase in intensity (wind speed) that would contribute to enhanced storm surges and coastal flooding, and also project a 20 per cent increase in intensity of associated precipitation that would contribute to flooding. Cyclone winds are likely to increase in intensity because of the positive

correlation with sea surface temperature. In November 2007, for example, the tropical cyclone Sidr, with a 100 mile long front covering the breadth of the country and with winds up to 240 km per hour, hit Bangladesh (Fig 6)

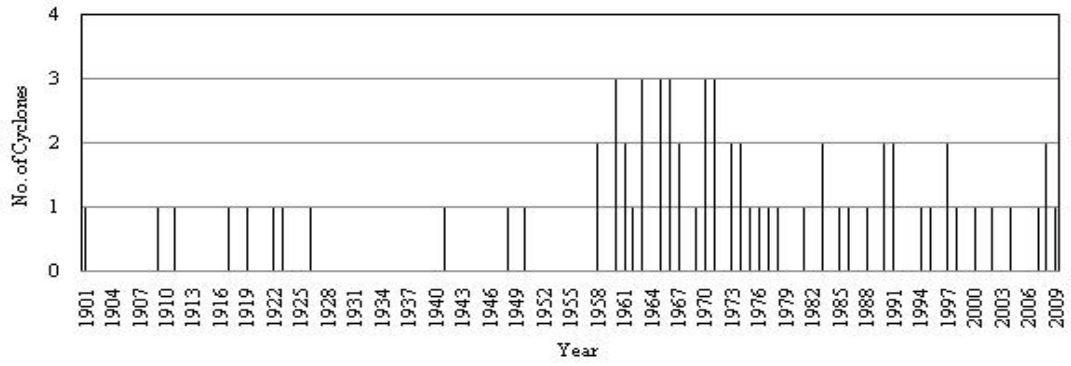


Fig.6. Number of cyclones making landfall on the coasts of Bangladesh each year from 1901 to 2009. (Source: MURTY et al., 2010).

2.6. Increased salinity

Saltwater intrusion is the movement of saline water into freshwater aquifers, which can lead to contamination of drinking water sources and other consequences (Fig 7). Saltwater intrusion occurs naturally to some degree in most coastal aquifers, owing to the hydraulic connection between groundwater and seawater. Because saline water has a higher mineral content than freshwater, it is denser and has a higher water pressure. As a result, saltwater can push inland beneath the freshwater. Certain human activities, especially groundwater pumping from coastal freshwater wells, have increased saltwater intrusion in many coastal areas. (Johnson, Teddy (2007)

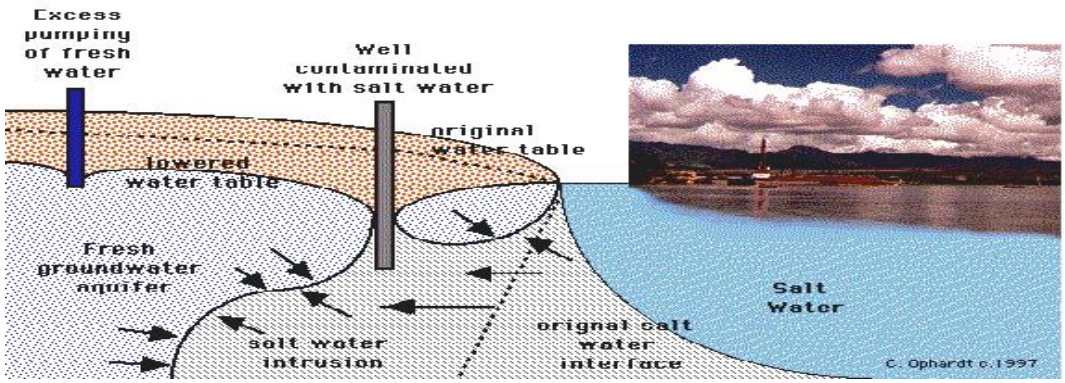


Fig.7. Salt water intrusion in coastal area (Source: Alam et al. 1999)

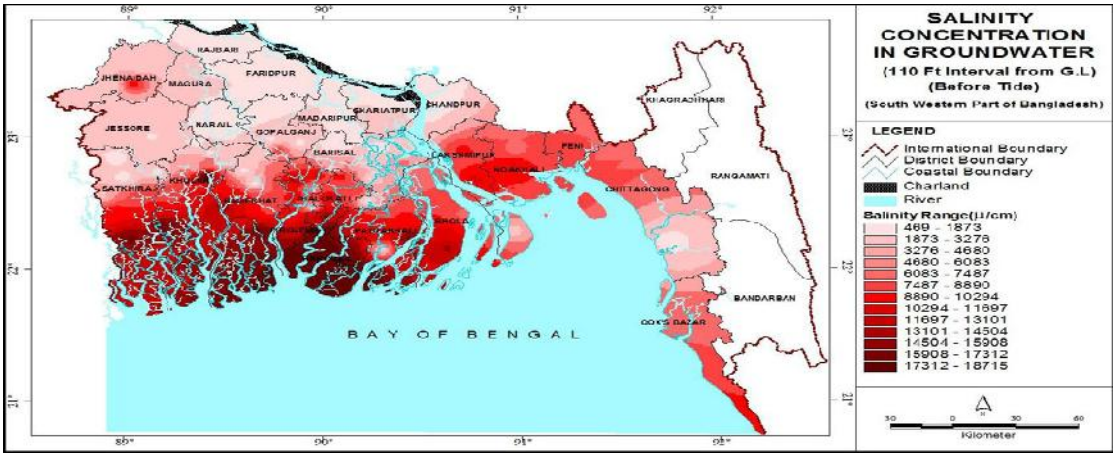


Fig.8. Salinity zone area in Bangladesh (Source: Alam et al. 1999)

3. Present status of aquatic biodiversity

Bangladesh is blessed with the world's richest and most diverse inland aquatic ecosystem having a wide variety of living aquatic resources. The country is also enriched with endemic fish resources including 475 marine fishes, 260 freshwater fishes belonging to 55 families, 20 exotic fish species, 24 freshwater prawn species, 36 marine shrimp species, 10 species of pearl bearing bivalves, 16 species of turtles (11 freshwater and 5 marine water species), 15 species of crabs (4 freshwater and 11 marine water species), 6 species of lobster, 7 species of squid, 600 species of birds belonging to 70 families (DoF, 2016). There is no well-ground official statistical of the species of fishes, which are almost extinct now. In spite of this, according to a research of the IUCN (International Union Code of Nomenclature) 54 species of fish had been enlisted as threatened (Ahmed et al, 2009).

3.1. Impacts of climate change on aquatic resources

Climate change is the global characteristics of temperature, humidity, rainfall, wind and storms. Bangladesh has a diverse range of aquatic ecosystems, including freshwater, marine water, brackish water and mangroves. Climate change will have a detrimental impact on all of the aquatic biodiversity in Bangladesh, and the Sundarbans are likely to be the worst affected.

3.2. Impacts on freshwater resources

Bangladesh' fresh water resources are most at risk from droughts and drainage congestion. Located on the floodplains of three major rivers, fed by an annual monsoon, Bangladesh is also under risk of more severe floods. Growing morphological activity will result in erosion and loss of land on some locations and sedimentation in others. Sedimentation and drainage

congestion go hand in hand, hampering the withdrawal of the water in flooded areas and increasing the period of inundation.

3.3. Impact on the coastal resources

In Fig.9 shows a simple diagram of the influences of climate change and sea level rise on the coastal environment. The coastal environment can be divided into two subsets: natural and societal. Terrestrial-sourced hazards include river floods and inputs of sediment or pollutants; marine-sourced hazards include storm surges, energetic swell and tsunamis.

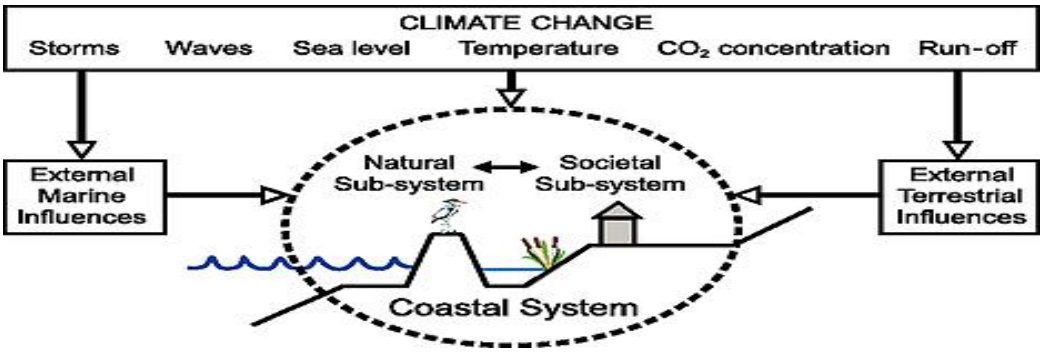


Fig.9. Coastal Impacts of Climate Change (Source: IPCC, 2011

3.4. Impacts on marine resources

Climate change and especially rising temperatures influence the periods of reproduction and/or migration of some species, the length of the growth phase, frequency of parasite infestations and the emergence of new diseases. The composition of most of the present ecosystems will probably change and there will be a greater risk of the extinction of species especially those that are already vulnerable and in particular those species with a restricted climatic distribution, those that need highly specific habitats and/or small populations which are naturally more vulnerable to modifications in their habitats.

Finally the introduction of new exotic species could be facilitated and this is a phenomenon whose long term consequences are difficult to foresee.

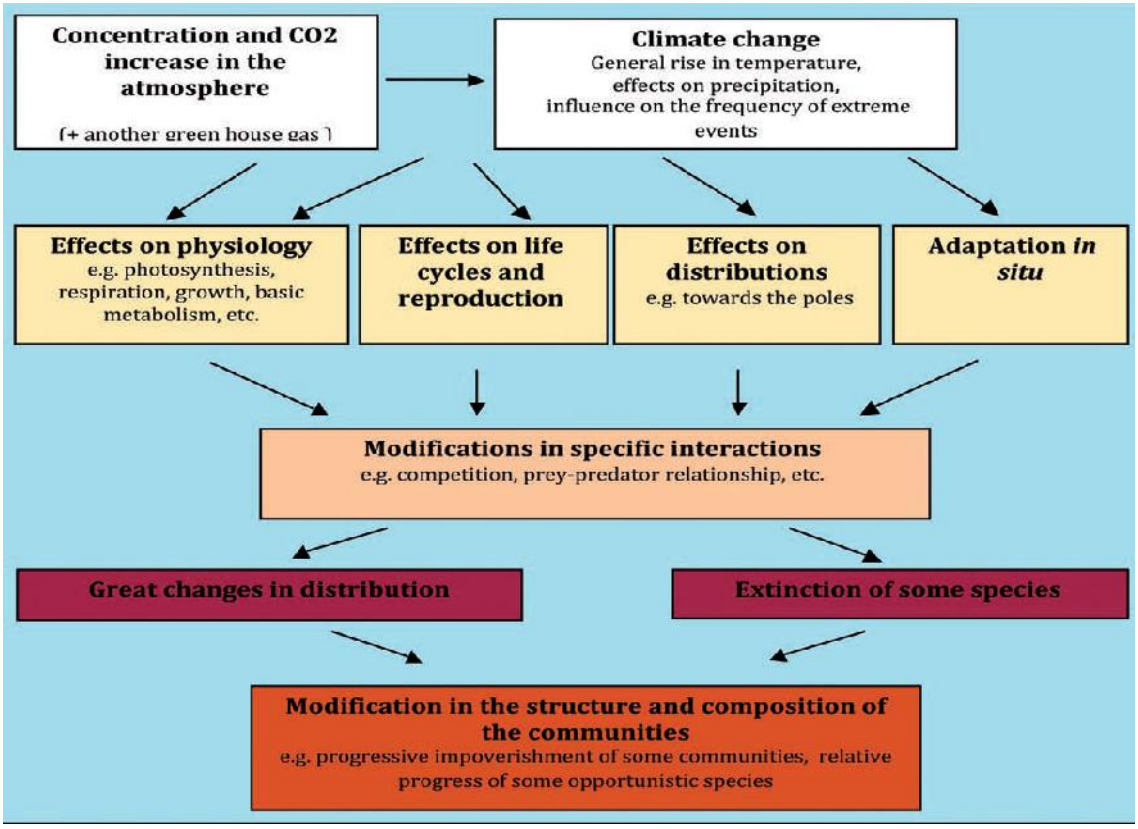


Figure 10: Impact of climate change on marine biodiversity (Source: Hughes, 2000)

3.5. Impacts on Sundarbans ecosystem

On the basis of different vulnerability indicators for accelerated sea level rise, the Woods Hole Oceanographic Institute (WHOI), 1986 produced a list of 27 low-lying countries. The list was headed by Bangladesh. The Bay of Bengal acts as a funnel for storm events, creating severe storm surges. These can raise sea level above tidal height and devastate a low-lying coast like that of Bangladesh. The Sundarbans can be wiped out by a 1- meter rise in sea level (World Bank, 2013). Loss of the Sundarbans would be catastrophic – a loss of heritage, of biodiversity, of fisheries resources, of life and livelihoods and of a very high productive ecosystem. Sea level rise can decrease availability of light for corals and thereby their growth. It can destroy St. Martin's island, the only highly productive coral island of Bangladesh.

3.6. Climate changes affect fishing mortality

The Intergovernmental Panel on Climate Change (2007) predicts that as sea temperatures change, fish numbers will change and fish will move to different areas, some species will go extinct in particular areas, predators and prey will move to different areas, disrupting food chains, wetlands and other low lying habitats where fish reproduce will be covered by rising sea levels. Water in lakes will get warmer, bad weather may stop fishers going to sea and increasing fishing mortality (Fig 11).

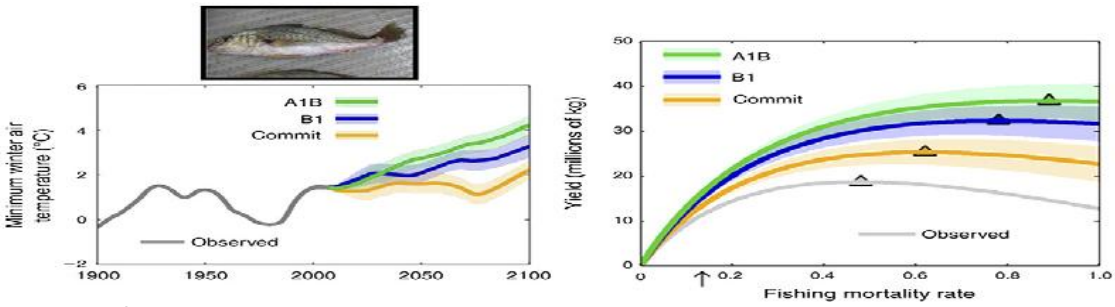


Fig. 11.Climate change affects fishing mortality Source: IPCC, 2014

3.7. Climate Change on fishes migration

In this century, temperatures in the region will likely exceed both thresholds. Many aquatic species can find colder areas of streams and lakes or move northward along the coast or in the ocean. However, moving into new areas may put these species into competition with other species over food and other resources. Some diseases that affect aquatic life may become more prevalent in warm water. Changes in temperature and seasons could affect the timing of reproduction and migration (Fig 12).

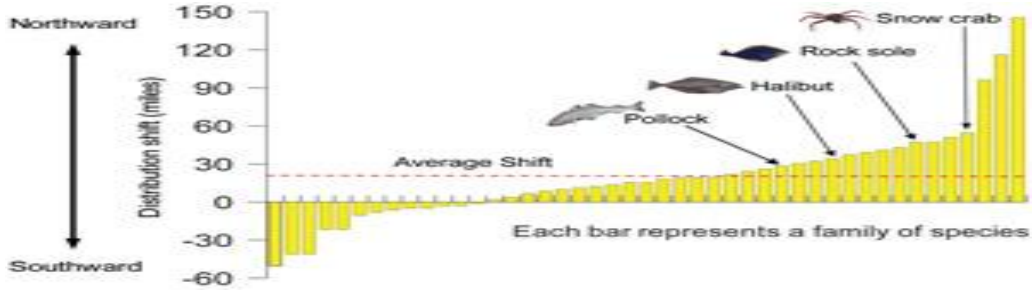
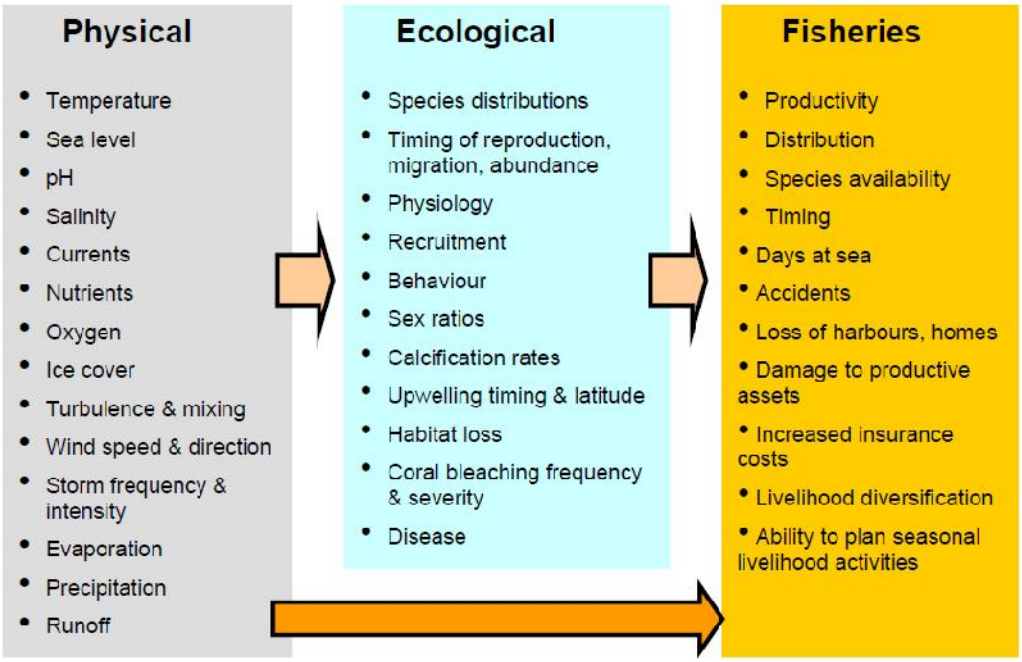


Fig.12. Climate change affects migration of fishes Source: Ahmed et al. (2009)

3.8. Climate Change and Fisheries: Pathways of Impact

Climate change can affect the productivity or distribution of fishery resources of both marine and inland waters in a variety of ways: Changes in water temperature, precipitation and extreme events affect the dynamics of ocean currents, the flow of rivers and the area covered by wetlands. This will have effects on ecosystem structure and function and on the distribution and production of fish stocks. Sea level rise, melting of glaciers at the headwaters of major rivers and other large-scale environmental changes will have unpredictable effects



on coastal and wetland environments and livelihoods.**(Source: Modified from Allison, E. H. et al. (2009).**

Fig.13. Climate induced changes in fisheries system (Modified from Allison, E. H. et al.,2009).

3.9. Impacts on Hilsa (*Tenualosa ilisha*)

Alteration of marine ecosystems due to climate change has both direct and indirect effects on fish – their reproduction, migration and survival. Hilsa (*Tenualosa ilisha*) is the national fish of Bangladesh. It accounts for 13-14 percent (valued at around Tk. 6000 million, 1.3 % of GDP) of the total fish production of Bangladesh. During the last two decades Hilsa production from inland waters declined about 20 percent, whereas marine water yield increased threefold. (Dof , 2010)

3.10. Ocean Acidification and Coral Reefs

In addition to warming, the world's oceans are gradually becoming more acidic due to increases in atmospheric carbon dioxide (CO_2). Increasing acidity could harm shellfish by weakening their shells, which are created from calcium and are vulnerable to increasing acidity. Acidification may also threaten the structures of sensitive coral reefs upon which some fish and shellfish rely. Higher sea surface temperatures and ocean acidification would increase the risks of coral bleaching events that can lead to loss of critical habitat(Fig 14).

Fig.14. Ocean acidification harms shellfish and increases the risks of coral bleaching (IPCC, 2014).

3.11. Climate change and shrimp production

Weather related fishing delays in the coastal reason's shrimp season this summer appear to have scrambled normal landing patterns. While the catch out of non-climatic areas in July was a bit higher compared to the month's typical average, landings out of climatic areas are trending well below their historical range and the total catch is down from last year (Fig 15).

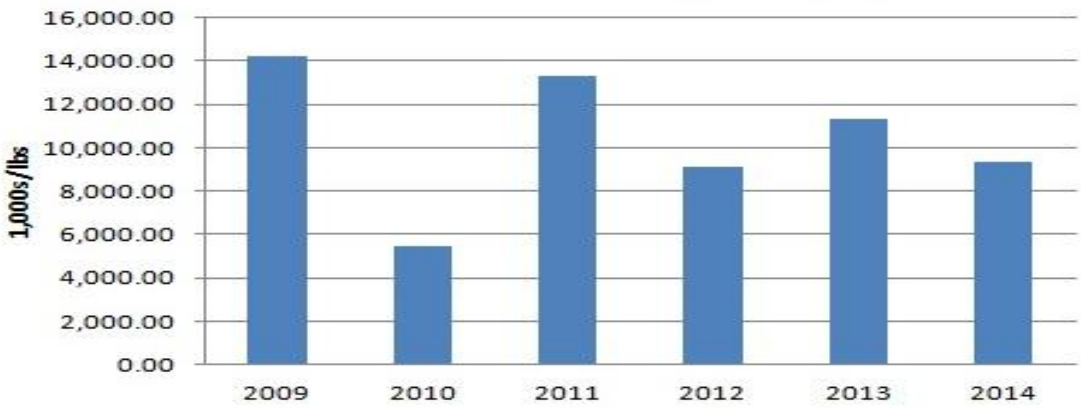


Fig. 15. Total Shrimp landing in July 2009-2014. Source: IPCC, Nov. 2014

3.12. Potential impacts of climate change on the economics of fisheries

Climate changes influences the abundance, migratory patterns and mortality rates of wild fisheries stocks and determine what species can be farmed in certain regions. These climate effects on fisheries have social and economic consequences for people dependent on fisheries and aquaculture –from workers to coastal communities to consumer of fish.

Table-4: Potential impacts of climate change on the economics of fisheries.

IMPACTS	REGIONS	CATCH	PRICES	COST	
				Fishing	Adaptation
Shift in distribution of species	Arctic	• **Catch potential:** Increase • Invasion of warmer water species	↓	↓	↑
	Temperate	• **Catch potential:** no change • Changes in species composition resulting from both species gains and losses	Not yet known	Not yet known	↑
	Tropics	• **Catch potential:** decrease • Species losses	Not yet known	↑	↑
Ocean acidification	Global	• **Catch potential:** decrease	↑	↑	↑
Expansion of oxygen minimum zones	Global	• **Catch potential:** decrease	↑	↑	↑
Reduction in body size	Global	• No change	↑	No change	↑
Increased variability	Global	• No change	↓ Variable ↑	↑	↑
Increased extreme weather	Global	• **Actual catch:** decrease	↑	↑	↑

(Published literature, 2012)

3.13. Climate change on live food used as fish feed

Live food encompasses both phytoplankton and zooplankton used as the major dietary requirements for fish and shellfish. Due to climate change their abundance are decreasing which directly hamper the growth of fishes (Fig 16)

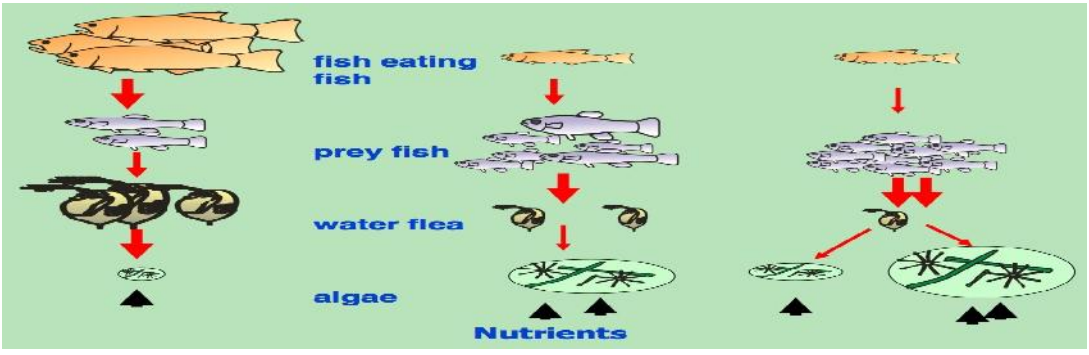


Fig.16. Climate change reduces the availability of phytoplankton and zooplankton (WB, 2013)

3.14. Impacts on Aquatic Plants

Tropical Asia is well known for its richness in biodiversity. Climate change could alter the biodiversity, either increase or decrease certain flora by the increase or decrease in precipitation, temperature or carbon dioxide levels.

3.15. Climate change on food security

With a larger population facing losses in arable lands, climate change poses an acute risk to the already malnourished population of Bangladesh. Although the country has managed to increase the production of fish since the nation's birth, from 7 metric tons (MT) to over 30 MT, around 30% of the population is still malnourished. Climate change threatens the fishery economy, which, although it counts for just 4% of GDP, contributes to over half the population's labor force. As pointed out before in the book, in 2007 after a series of floods and cyclone Sidr, food security was severely threatened. Given the country's infrastructure and disaster response mechanisms, the food yield situation got worse. The loss of fish production was estimated at around 2 million metric tons (MT), which could potentially feed 10 million people. This was the single most important catalyst in the 2008 price increase, which led to around 15 million people going without much nutrition.

4. Adaptation and mitigation to climate change

To protect our Aquatic Biodiversity and Ecosystem Services, we need to:

1. Extend our aquatic monitoring efforts;

- ✓ appropriate spatial and temporal scale & resolution
- ✓ including all key processes
- ✓ including all relevant life phases of key species

2. Extend our knowledge on the regional factors that determine the vulnerability and resilience of marine communities to climate change;

- ✓ relationship between marine biodiversity and ecosystem services
- ✓ local drivers & structuring factors

3. Extend our knowledge on sensitivities and adaptation capabilities of marine key species to climate change;

- ✓ consequences for species 'interactions'

4. Develop "fit-for-purpose "models to project impacts and adequately manage our aquatic environment.

4.1. Role of Bangladesh Fisheries Research Institute

The Bangladesh Fisheries Research Institute (BFRI) is at the primary stage of a climate change study. BFRI has a long-term study programme on Hilsa fishery in Bangladesh. Recently, a programme was initiated on the impact of climate change on the maturity and spawning of Hilsa in relation to habitat degradation. Another technical support programme is going on – to identify and analyze sound fisheries and aquaculture risk adaptation options in drought-prone areas of North West and coastal areas of South West Bangladesh. BFRI should in future heighten its focus on climate change impact on fisheries; it should in particular strengthen research as well as survey and monitoring capacity in marine fisheries – which is presently weak because of absence of infrastructure (vessel) and technical manpower.

5. Positive effects of Climate change

To every action there is an equal and opposite reaction. Climate change on aquatic biodiversity has both positive and negative effects. Severe stress can tolerate some stress tolerant species. Climate change positively impacts on some salt tolerant fish species. During flooding condition nutrient availability and species distribution are occurred prominently. But the positive impacts are little bit than negative impacts.

CHAPTER IV

Conclusions

Climate change impact in Bangladesh as well as in world is high, though the country's greenhouse gas emissions are low. The government needs to pay keen attention to issues related to climate change impact, organize research, develop salinity-tolerant species in both agriculture and fisheries, and develop a strategy to combat impact. Adaptation costs should be recovered from coastal resources using economic instruments. Research is also needed to preserve the country's aquatic biodiversity. Technical and financial assistance from the international community is essential. Depending on the species, the area it occupies may expand, shrink or be relocated. No specific research has yet been conducted in these issues in Bangladesh and other countries. A coordinated long-term research project on the impact of climate change on aquatic biodiversity in the Asia-Pacific region is an urgent need. It is highly recommended that next steps to reduce Bangladesh' vulnerability to impacts of climate change and sea level rise, concentrate on the adaptation mechanisms of planning, information management and international actions.

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