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Climate change and its impact on fisheries resource in Bangladesh

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Abstract— **Bangladesh is highly vulnerable to the effects of climate change in fisheries because of its economics, diets and social dependencies on fisheries sector. Climate change effects on fresh water culture fisheries in Bangladesh may be negative. Climate change affects the rainy season, increases the precipitation, creates the flood, and increases the fish habitat and if we take the proper adaptation method, it will boost up the production of inland capture fisheries. In coastal area, soil-water salinity and sea level rises have both positive and negative effect. Soil-water salinity and sea level rises may increase the shrimp and other brackish water fish and shell fish culture area, which will increase the production of high value fish products. Climate changes also affects the Sunderban, the world largest mangrove forest, resulting the loss of nursery ground of many marine fish species and also abolish them. As a consequence of climate change, pH change, temperature increase may affect the marine fish species and also increase the occurrences of intensive tropical cyclone and surge in the Bay of Bengal.**

INTRODUCTION

Climate driven change represents the cumulative effect globally through local-scale conditions, and understanding their manifestation at local scales can empower local management [1]. Climate change may directly affect fishery production along many pathways. Fish reproduction, growth and migration patterns are all affected by temperature, rainfall and hydrology [2]. Climate change is likely to adversely affect both the fresh water and marine fisheries in Bangladesh. World Fish Centre indentified four tropical Asian countries such as Bangladesh, Cambodia, Pakistan and Yemen as most vulnerable depending on the vulnerability of national economics to the impacts of climate change on fisheries [3]. This vulnerability was due to the combined effect of predicted warming, the relative importance of fisheries to national economics and diet, and limited societal capacity to potential impacts and opportunities. Bangladesh, a developing country, is primarily deltaic floodplain; elevations throughout the country do not exceed 10 m [4]. The fisheries sector of Bangladesh contributed 4.48% of GDP and is the 2nd highest foreign exchange earning sector contributing 4.83% in 2007-08 [5] and all earning comes from local contribution.

In Bangladesh, the total fish production was 2.56 million tons in 2007-08 [6], fisheries sector provides more than 12 million people with at least 58% of their average per capita protein intake [6]. In Asia, Bangladesh including Pakistan, Laos PDR and Nepal has the lowest adaptive capacity for climate change in fisheries [3].

The purpose of the review is to present current knowledge about climate change and its potential effects on fisheries resource in Bangladesh.

CAUSES OF CLIMATE CHANGE

Global atmospheric concentrations of green house gases like carbon dioxide, methane and nitrous oxide have increased as a result of human activities since 1750 A.D (as consequence of the industrial revolution). The global increase of carbon dioxide is primarily due to the use of land and fossil fuel, and increase of methane and nitrous oxide are due to agriculture [7]. In 2005, the global atmospheric carbon dioxide, methane and nitrous oxide concentrations were 379 ppm, 1732 ppb and 319 ppb respectively. The atmospheric concentration of carbon dioxide and methane in 2005, exceeds by far the natural range of the last 650,000 years and the growth rate of nitrous oxide has been approximately constant since 1980 [7]. Rising concentration of the green house gases in the atmosphere are causing global climate change.

EFFECT ON FRESHWATER FISHES IN BANGLADESH

Fish is a poikilothermic animal that cannot regulate their body temperature through physiological process and this is regulated by environmental process. Fish physiology like growth, reproduction and activity are directly influenced by the change of temperature. Increase of world temperature rise is thought to be ranged from 0.3 to 6.4°C at 2090-2099 relatively to 1980-1999 [7]. The temperate and polar latitudes are predicted to experience a higher temperature change than tropical and sub tropical latitudes [8]. Due to the location of Bangladesh in lower latitude, its temperature change is little compare to polar and temperate zone.

With rising environmental temperature, the physiological activity of the fishes also increases. Increase of physiological activity increases the oxygen demand. But the solubility of the oxygen in water inversely related to temperature and salinity [9]. Thus, dissolved oxygen availability in water will decreased, resulting the reduction of growth and reproduction success of fishes and preventing them from dealing as effectively with the other environmental changes. Increased temperature and decreased level of dissolved oxygen might cause harmful effect for pond fish culture in Bangladesh. There are two reasons underlying this effect. Firstly, increased temperature increases the metabolic activity of fishes. Secondly, increases temperature increases the evapotranspiration of water, which reduces the surface and volume of water in the fish pond. So, in pond culture system, critically low oxygen concentrations are occurred in the overnight when all aquatic organisms use the dissolved oxygen for respiration and the peak of low dissolved

oxygen concentration in the pond reaches before sunrise. As a consequence, fishes face hypoxic condition, frequent occurrence of which will cause the reduction of the growth rate and reproductive output of culture species. In 2007-2008, culture fisheries contributed 39.23% of total fish production of Bangladesh [6]. It is assumed that if the global climate change cannot be controlled, its negative impact will be reflected on our aquaculture production.

EFFECT ON OPEN WATER FISHERIES RESOURCES

Open water that contributing nearly 1 million metric ton of fish in 2007-08 [6] is very important for fisheries sector in Bangladesh. Open water is inundated during the flood stages and isolated from the main channel during the dry season. Regular flooding ensures the reproductive success of the fish species. Change in annual average temperature and precipitation over Bangladesh assessed by Different Global Circulation Models (GCM) are shown in table 1.

Table 1. GCM estimates of temperature and precipitation changes in Bangladesh

Year	Temperature change (°C)			Precipitation change (%)		
	Annual	Dec-Jan-Feb (dry season)	Jun-Jul-Aug (wet season)	Annual	Dec-Jan-Feb (dry season)	Jun-Jul-Aug (wet season)
Base line average	-	-	-	2278 mm	33.7 mm	1343.7 mm
2030	1.0	1.1	0.8	+3.8	-1.2	+4.7
2050	1.4	1.6	1.1	+5.6	-1.7	+6.8
2100	2.4	2.7	1.9	+9.7	-3.0	+11.8

*This model was run with the IPCC B2 SRES scenario.

Table 1 indicates that annual temperature will rise by 1-2.4°C and precipitation will increase by 3.5-9.7% from 1995-2100 AD in Bangladesh. It is also represented that in winter, temperature will be increased by 1.1-2.7°C, but the precipitation reduced by 3%, and finally evaporatranspiration will increase. In Mekong river system, 2-3°C increase of ambient temperature would increase evapotranspiration by 10-15% [11]. As Ganges-Brahmaputra-Meghna river system of Bangladesh and Mekong River system of Cambodia both are situated in the same geographical region, thus we can predict the same type of environmental changes in Bangladesh as predict to Cambodia. In winter, the increase of evapotranspiration and reduction of the volume and favorable fish habitats, increases the fish kill and challenge the survival of open water fishes including next year spawning broods. GCM estimates that temperature will increase by 0.8-1.9°C and precipitation will increase by 4.7-11.8% in monsoon. In Ganges, Brahmaputra and Meghna rivers, 2°C rise of temperature, increase 10% of precipitation and also increase the river runoff of 19%, 13% and 11% for Ganga, Brahmaputra and Meghna respectively [12]. This additional runoff with higher nutrient levels increase the floodplain area and productivity, which extend the feeding ground of fish. If the open water stocking program is introduced in the monsoon, it can bring a revolution in the fish production. On the other hand, increased water runoff create flood situation and destroy the aquaculture infrastructure and reduced the closed water aquaculture production.

Temperature incretion may also stimulate the growth of aquatic macrophyte and increase of 2-3°C could cause a 300-500% incretion of aquatic macrophyte [13]. Higher production of aquatic macrophytes c*a*n decrease the productivity of water, reduce the fish habitat and oxygen supply which will create the anoxic condition for fishes. This can lead to fish kill. Open water of Bangladesh might face this problem.

EFFECT ON COASTAL AREA

The main impacts of climate change on coastal area in Bangladesh are sea level rise, reduction of freshwater availability by salinity intrusion and increasing cyclone frequency. Water salinity of the coastal area of Bangladesh varies from 0-20 ppt [14]. Water salinity and its distribution in the coastal area are increasing with the increasing of sea level rise [15], [16], [17], [18]. Soil salinity in South Western part of Bangladesh is increasing (Table 2&3) [19].

Table 2. Increasing rate of soil salinity area in South Western part of Bangladesh.

Area	Year 2000 (hectare)	Year 2009 (hectare)
Khulna district	1,45,000	1,48,000
Satkhira district	1,25,000	1,31,000
Bagerhut district	1,47,000	1.53,000

Table 3. Area of soil salinity range in South Western part of Bangladesh.

Salinity range Ec:ds/m	Year 2000 (hectare)	Year 2009 (hectare)
2-4	2,8900	3,28000
8-12	3,07,000	2,74,000
12-16	1,92,000	1,89,000
16+	87,000	1,01,000

Source: protom alo [19]

Cyclone, Sidr (15 Nov., 2007) and Aila (27 May, 2009) hit South and South West part of Bangladesh and destroy the coastal embankment infrastructure and increase the salinity. This salinity intrusion including sea level rising creates harmful effect on existing fish species. Water salinity exceeds the expected salinity level that especially required for fresh water fish production. So, salinity intrusion threatened fresh water fisheries, at the same time, creating opportunities for catching and cultivating brackish and marine species [20]. Bangladesh coastal area is important for *Penaeus monodon* (Indian Tiger Shrimp) production. Increase salinity increases the culture area for *P. monodon* whose growth reaches maximum at 5-25 ppt [21]. But the *P. monodon* is highly vulnerable for diseases. *P. indicus* (Indian White Shrimp) and *P. vannamei* (Western White Shrimp) is alternative species for this area.

P. indicus can tolerate salinity up to 42 ppt and *P vannamei* can tolerate a wide range of salinity starting from 0.5-45 ppt. *P. indicus* is already exist in the culture system of Bangladesh and now we can introduce the *P. vannamei* for higher production and disease resistance capacity.

We can also introduce *Chanos chanos* (Milk Fish), *Mugil cephalus* (Mullet) and *Tilapia nilotica* (Tilapia) for coastal culture fisheries. For adaptive income generation of other works are cage culture of some fishes, pen culture, shell fish culture and sea weed culture.

The Sundarban mangrove forest that located in the Gangetic delta (Ganges-Brahmaputra-Meghna) of India and Bangladesh is the largest single chunk of continuous mangrove forest in the world [22], [23]. Over 120 species of fish are commonly caught by commercial fishermen in the Sundarban area [24]. Sundarban is highly vulnerable for sea level rise and will be disappeared by 1 meter rise of the sea level [18]. The Sunderban also have been playing a very important role as a protecting wall against the devastating cyclones and tidal surges by deflecting and reducing energy. The mangrove also supports offshore and deep sea fisheries by playing a significant role as nursery ground for many deep sea fishes and shrimps including the *P. monodon*, which is the major species of the industrial bottom trawl fishery of Bangladesh [25].

Effect on Bay of Bengal

Average tropical sea surface temperature is predicted to increase by 50-80% of the average atmospheric change over the same period [26]. Increased temperature may affect the distribution pattern of some fish species where some of them may be migrate to the higher latitude for cooler place. Sea level rise may destroy the mangrove forest as well as destroy the marine fish nursery ground. Atmospheric CO_2 concentration is thought to be increased from 380 ppm to 540-979 ppm by the end of the century [7] and this will cause the average ocean pH to drop by 0.4-0.5 compared to pre industrial period [27]. Fish embryos and larvae are more sensitive to pH change than juvenile and adults [28]. Eggs of the pelagic fishes might be more susceptible to pH change. Increased level of dissolved CO_2 also reduces the pH of animal tissue [29] and it may affect the marine fish physiology.

Global warming may cause changes in the regional climate of the Bay of Bengal and can cause increase in the occurrence of intense tropical cyclone and surge [30]. There is some evidence that regional frequencies of tropical cyclones peak intensity may be increased by 5% to 10% and precipitation rates may be increase by 20% to 30% [17]. It predicts that Bangladesh is likely to face more cyclone and intensity and precipitation is also high. Tropical cyclones often cause a temporary decline in the abundance of some fishes due to loss of critical habitat of food for certain species [31] and also increase the disturbance regime for fish community. Cyclone Sidr and Aila affected the coastal fishery and fishing ground.

Conclusion

Fisheries are the second largest export sector in Bangladesh. So, Bangladesh economy is vulnerable to climate change impact, which could affect our food security and level of poverty by elevating stress on fisheries production. But the detailed effects on climate change affecting the fisheries sector is yet uncertain. It might bring economic hardship or might increase the opportunity to higher fish production through adaptive measure and increase the economic growth.

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