

CHAPTER 15

Impacts of Climate Change on Water Resources and Human Health: Empirical Evidences from a Coastal District (Satkhira) in Bangladesh

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INTRODUCTION

Impacts of climate change on both water and human health are increasing global concerns. In reality, climate change related hazards like flood, drought, salinity intrusion, cyclone and storm surge, water logging, erratic behavior of rainfall have direct and indirect adverse impacts on water resources system and human health all over the country particularly in coastal region. Many people are already struggling for access to water resources for sustaining livelihoods, domestic uses and health services. Salinity in both surface and groundwater in the coastal zone and scarcity of water in North West part of the country due to drought and lack of rainfall are really vulnerable to the health of local communities. Climate change would cause reduction of access to freshwater sources in most parts

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of the country particularly in the mentioned areas. Incidences of diarrhea and cholera are quite significant during flood and storm surges. Some of the recent studies found association of incidences of diarrhea with climate parameters e.g. temperature and rainfall pattern. It is reported that the number of non-cholera diarrhea cases in urban area increases with higher temperature, particularly those individuals at a lower socioeconomic and sanitation status. The health implications may be severe for the communities who are exposed to both climate and non-climate factors. Non-climate factors including poverty, access to water supply and sanitation, poor housing, inadequate health services would catalyze the vulnerability of the people.

This chapter will emphasize observations on the impacts of climate change on water resources and human health with special reference to the coastal zone.

COUNTRY BACKGROUND

Bangladesh is located in the north eastern region of South Asia and is bounded by India to the West, North and North-east and by Myanmar to the South-east and the Bay of Bengal to the South. The country has an area of 147,570 km² and a population of about 145million (BBS 2009). It has an ideal tropical monsoon climate with warm wet summers and cool dry winters. The country has three broad categories of land including the floodplain (80 percent), Pleistocene terrace (8 percent) and tertiary hills (12 percent), based on its geographic formation (MoEF 2005). Flood plains are situated in the north-western, central, south-central and north-eastern regions. These areas are exposed to both regular floods and seasonal droughts. The coastal plains located on the south face cyclones and storm surges, salinity intrusion and coastal inundation. The Pleistocene land is characterized by moisture stress while flash floods often affect hilly areas. The literacy rate of the country is 58 percent.

STATE OF CLIMATE CHANGE, WATER AND HEALTH ASPECTS IN BANGLADESH

Climate Change and Bangladesh

Bangladesh is exposed to a number of climate change induced primary and secondary hazards including temperature and rainfall variations, droughts, cyclone and storm surges, floods, saline intrusion and rise of sea level. The temperature is predicted to increase 0.7°C in the monsoon and 1.3°C increases in winter (World Bank 2000). Increased temperature

especially during pre-monsoon (March-April-May) is a major problem as expressed in different recent studies especially in the coastal zone. The World Bank study also indicated increase of annual rainfall in Bangladesh but in reality many areas/locations are facing erratic behavior e.g. decreasing pattern, early or late rainfall, excessive downpour in short periods. For example, the northern districts are experiencing lack of rainfall. Cyclones and storm surges recently became catastrophic events for the coastal people and indirectly for many people in the country. Both the frequency and intensity of cyclonic events along the Bay of Bengal is on an increasing trend over the years although this contradicts the prediction of the IPCC fourth assessment report in terms of frequency of cyclonic events. Intrusion of salt in surface and groundwater due to low flow of freshwater in the rivers/streams, inadequate rainfall in the season, cyclone and tidal surges, rise of sea level remain serious concerns and challenges for the rural communities in the coastal zone. Freshwater in some coastal districts including Patuakhali, Pirojpur, Satkhira, Bhola, Khulna, Feni and Noakhali are already affected by salinity (Islam 2004). Drought is another climate-induced hazard that adversely affects the north-western districts of the country almost every year during March-April-May.

The flood and water logging due to overflow of the rivers system or excessive rainfall affect the country every year. The recent floods in 1998, 2004 and 2007 devastatingly affected many of the districts. Some of the districts were affected by recurrent floods in 2007, which was a completely unexpected event. Farmers had to face serious problems as they were not prepared for such an event in the affected areas. Recurrent floods with increased intensity in the future under the changing climate system remains an enormous challenge for the largest community and livelihoods of the country. Sea level rise caused by the rapid melting of glaciers, ice caps and other factors might change both the geographic and topographic history of the country in the future.

CLIMATE CHANGE, WATER AND HEALTH CONCERNS

The changes of the climate system or climate induced hazards pose direct and indirect impacts on water resources and human health in most of the areas of the country and especially in the coastal areas. About 74 percent of the people have access to improved drinking water sources while only 80 percent of the people are covered with improved sanitation (Planning Commission 2009). The water resources and safe water supply are threatened by both climatic and non-climatic factors. As mentioned above, a number of climate factors or climate induced hazards including cyclone and storm surges, floods, droughts, saline intrusion, erratic behavior of

rainfall and non-climate factors such as arsenic contamination, industrial pollution affect both surface and groundwater resources. On the health issues, incidences of a number of diseases including diarrhea, malaria, dengue, kalazar, HIV/AIDS, enteric fever, anthrax, avian influenza, Nipah virus infection, leptosporiasis, acute respiratory infections (ARI) in recent years are alarming. Of them, dengue, malaria, diarrhea, Kalazar have already been referred as climate sensitive diseases (Confalonieri et al. 2007). In addition, cholera is probably a re-emerging infectious disease in the country which is also sensitive to climate parameters (temperature and sun shine) (Wagatsuma et al. 2003; Confalonieri et al. 2007). However, some current key concerns in relation to climate change, water and health sectors are given below.

Increased Climate-induced Water Related Hazards

The country might experience increased frequency and intensity of climate-induced water related hazards as mentioned above which would significantly affect most parts of the country especially the coastal region. Some scientists are supporting this statement saying that the impacts of climate change are quite visible in the coastal ecosystem in Bangladesh and in many other countries. It is expected that increased snow melt from the Himalayan glaciers, due to increase in temperature would force more water to flow through the Ganges, Meghna, Brahmaputra river systems and their river networks creating additional flooding, water logging extending over the central flood plain of the country (Rahman et al. 2007). On the contrary, some areas are increasingly affected by lack of rainfall and drought conditions during the pre-monsoon season in particular. However, increased climate induced water related hazards (intensity and magnitude) due to climate change may affect large areas with multifaceted physical, social, economic and environmental impacts including high incidences and casualties, reduction of agricultural yields, loss of productive land, climate forced migration, damage of property, deterioration of quality and quantity of water and water associated products in the country.

Threats to Aquatic Ecosystem, Biodiversity

Changes in surface water due to temperature and rainfall variations, inundation, and salinity intrusion would cause pressure on the aquatic ecosystem. Combined effects of increase of temperature and waste from agriculture and domestic sectors may facilitate growth of algal bloom and eutrophication which might have an adverse impact on sensitive species. As ecosystem functions and services could be terribly affected which

would result in reduction of aquatic yields e.g. fisheries. This would ultimately affect the people who are dependent on the aquatic habitat for their livelihoods and consumption to some extent.

Threats to Human Health

Health risk due to climate change is predicted to increase all over Bangladesh. The country may be affected mostly by vector and water-borne diseases. Studies suggest that a number of diseases and health problems including malaria, dengue, Kalazar, cholera, malnutrition and diarrheal diseases are associated with climate related factors such as temperature, rainfall, floods, droughts etc. These were also found to be associated with non-climatic factors including poverty, lack of access to safe drinking water and sanitation and poor sewerage system etc. (Cruz et al. 2007). Some of the recent research findings on climate change and health issues in Bangladesh are stated below:

- Seasonal peak of *Escherichia coli* diarrhea coincides with the time when food is contaminated due to higher bacterial growth caused by high temperature (Rowland, in Shahid 2010).
- Increase in rotavirus diarrhea in Dhaka by 40.2 percent for each 1°C increase of temperature above 29°C (Hashizume et al. 2008).
- Increase of cholera incidences is associated with increase of sea surface temperature (Feldacker 2007).
- Number of non-cholera diarrhea cases in Dhaka increases with higher temperature, particularly those individuals at a lower socioeconomic and sanitation status (Hashizume et al. 2008).

In addition, the following table shows the casualties due to major cyclone and storm surges between 1970 and 2008 in different locations of Bangladesh.

Table 15.1 Major cyclones and death cases in Bangladesh between 1970 and 2008.

Year	Deaths	Affected locations
October 1970	300	Chandpur
November 1970	275,000	Coastal districts
December 1973	83	Patuakhali/Islands
November 1983	300 fishermen unaccounted	Chittagong, Cox's Bazar
May 1985	11,069	Chittagong, Cox's Bazar/Islands
November 1988	5704: Unaccounted persons 6000	Khulna and adjacent Islands
October 1990	150	Barisal
April 1991	138,000	Chittagong-Cox's Bazar
November 2007	Over 3000	Coastal districts

Source: MoEF 2005; BCAS 1991; Sharif et al. 2007

Climate factors combined with social (non-climate) factors aggravate the health impacts further in a quite complex manner. The climate factors may devastatingly affect the communities where non-climatic factors including poverty, population density, living conditions, lack of health services, inadequate water supply and sanitation etc. are predominant. The consequences are expected to compound resulting in the increase of morbidity and mortality in the future. The following table shows the relationship between climate and non-climate factors with health disorders in Bangladesh.

CLIMATE CHANGE: POLICY AND STRATEGY TO ADDRESS WATER AND HEALTH

The government of Bangladesh through its relevant ministries and departments has taken a number of policy initiatives to address climate change related water and health problems in the country (details given above) The Ministry of Environment and Forests has developed National Adaptation Programmes of Action (NAPA) and Bangladesh Climate Change Strategy and Action Plan (BCCSAP). Both of these documents identified immediate and mid-term adaptation actions to reduce impacts and vulnerabilities at the community level. Many of these identified adaptation actions are in the implementation process by different line of ministries and associated agencies. All these adaptation actions are being supported by the Climate Trust Fund of the government and will be coordinated by Climate Change Unit (CCU) which was established on 24 June 2010. The Ministry of Health and Family Welfare also took initiatives in relation to climate change towards improving the health and well-being of the people. Table 15.3 shows the policy and strategic document related to climate change, water and health.

Climate change and associated vulnerabilities were first mentioned in Coastal Zone Policy (2005) of the government. Later, National Adaptation Programmes of Action (2005), Bangladesh Climate Change Strategy and Action Plan (2009) detailed the impacts, vulnerabilities and potential adaptation actions. In fact, BCCSAP has suggested action measures for the next 10 years to face the challenges Recommending periodic updates over the years. It also recognizes most of the climate-induced water and health related hazards including floods, droughts, Sea Level Rise (SLR), salinity intrusion, cyclone and storm surges. It states that the shortage of safe drinking water may be severe in the coastal zone and in drought-prone areas (in the north-west) of the country. If river bank erosion continues and sea level rises more than expected, then millions of people will be displaced from these areas. In fact, rural to urban migration is already

Table 15.2 Conceptual relationship between climate and non-climate factors with health disorders in Bangladesh.

Increasing Human Health Disorders	VULNERABILITY CONTEXT														
	Climate Change Factors					Social (Non-Climate) Factors									
	Temperature	Rainfall	Sea Level Rise	Drought	Flood	Cyclone and Storm Surge	Living Condition	Poverty	Education	Migration	Population Density	Water quality (domestic purpose)	Food Insecurity	Sanitation	Lack of Health service
Cholera	++		++		+++	++	++	++	+	+	+	++		++	
Diarrhea	+++		+	++	+++	+++	++	+++	++	+	+	+++	++	+++	++
Malaria	++	+++					++	+			+				++
Dengue	+++	+					++		+		+				++
Kala-azar	++				++		+								++
Malnutrition	++		++	+++	++	++		+++	+		++		+++	+	+
Cardio-respiratory diseases	++			++		+	++	+	+						++

Note: +++ refers high, ++ refers to moderate and + refers to low level relationship; conceptual linkage between climate and non-climate factors with health disorders, prepared by a group led by the author

Table 15.3 Bangladesh’s policy and strategic document related to climate change, water and health.

SL	Latest Policy/strategy	Time Frame for Policy Actions	Type of policy/strategy, Area/Sector Coverage
1	Coastal Zone Policy (CZP) 2005	Long term with periodic review	Coastal zone, water, health
3	National Adaptation Programmes of Action (NAPA) 2005	Urgent actions (before 2010)	National, climate change and major sectors including water and health
4	Bangladesh Climate Change Strategy and Action Plan (BCCSAP) 2008	2018	National, climate change and major sectors including water and health

taking place due to rapid erosion of the river banks. This might be severe in the future in case of SLR, saline intrusion and flood and storm surges. The National Adaptation Programmes of Action (NAPA) also recognized floods, droughts, cyclone and storm surges, SLR and salinity intrusion as climate related hazards. But it did not adequately emphasize on river bank erosion, which is now one of the major hazards of the country.

CLIMATE CHANGE IMPACTS ON SMALL ISOLATED WETLANDS (PONDS): A CASE STUDY FROM THE EXPOSED COASTAL DISTRICT (SATKHIRA) OF BANGLADESH

A preliminary investigation was carried out on climate change impacts on small isolated wetlands (ponds) in Satkhira in late 2010. This case study will emphasize some key findings in relation to water resources and health conditions of the preliminary investigation of academic research and the results of review of the secondary data/information.

Satkhira district is located in southern part of Bangladesh. The district is surrounded by a complex river network consisting of Kobadak, Sonai, Kholpatua, Morischap, Raimangal, Hariabhanga, Ichamati, Betrabati and Kalindi-Jamuna. The area of Satkhira district is 3,858.33 sq km with a population of over 2 million. Annual average temperature varies from a maximum of 31.6°C to a minimum of 21.4°C and annual rainfall is 1,742 mm. Average literacy rate is 30.35 percent (male 39.7 percent and female 21 percent). The main occupations are agriculture, fishing, pisciculture, agricultural laborer, wage laborer, commerce, industry, transport, service, etc.

The long-term trend in average maximum temperature shows a decline over the period of 1976–2005. It has, on average, reduced by 0.009°C per annum over the period. The average annual minimum temperature in the Satkhira region has also declined, on average, by 0.001°C over the period (1976–2005). In contrast, the annual rainfall increased by 9.5 mm over the

period of 1990–2005. While the annual average minimum temperature of Satkhira shows variations. Most of the years of the first of the last three decades experienced less than 21.5°C of annual average minimum temperature. The lowest average was observed during first half of the last decade. However, from 2000 to 2005 the minimum average temperature followed an increasing pattern.

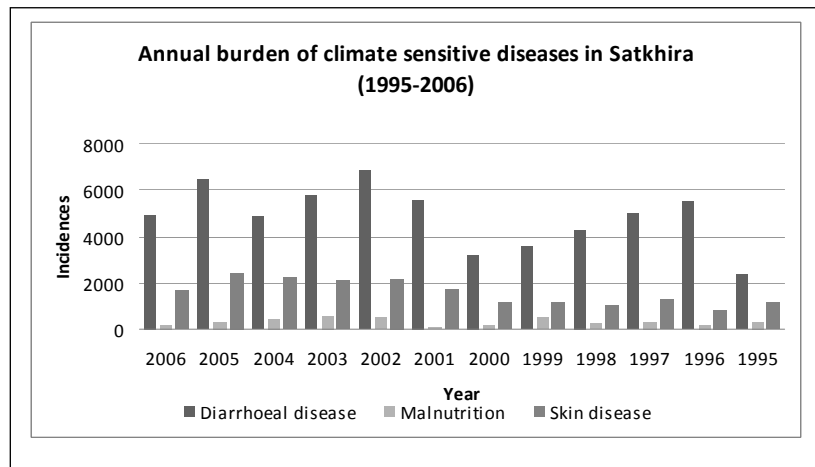


Figure 15.1 Annual incidences of some climate sensitive diseases in Satkhira study area over the period 1995–2006.

Annual and seasonal total rainfall of the study area was also observed. The pattern of total rainfall of different years of the last decade was quite irregular. Pre-monsoon rainfall followed a decreasing pattern (sharp and gradual) from 1997 to 2005. On the other hand, the monsoon of 2002 received the highest (1271 mm) rainfall compared to other years of the last decade. A gradually decreasing pattern of pre-monsoon rainfall was observed from 1997 to 2005 while the total rainfall of post-monsoon shows an increasing pattern from 2002 to 2005.

Satkhira is one of the most vulnerable coastal districts of the country. The district is the hotspot for any type of climate induced hazards. The most recent cyclone events e.g. Cyclone Sidr and Cyclone Aila hit most parts of the district. Many people died or were injured by both cyclones. Some people had to migrate from Satkhira to either associated urban areas, city (e.g. Khulna) or even to the capital city (Dhaka).

Data and information of some of the major available climate sensitive diseases including diarrhea, skin diseases and malnutrition record of Upazilla Health Complex of Satkhira were collected and analyzed accordingly. Annual burden of diarrhea was higher than the other sensitive diseases in each reported year. It was found that the diarrhea occurrences

ranged between 2356 and 6,875 from 1995 to 2006. The highest occurrences were found in 2002 while the lowest was in 1995. Skin diseases were found to have an increasing trend from 1996 to 2005 while occurrences of malnutrition show irregular patterns.

The following sections highlight some of the key findings of the preliminary investigation of the research on climate change impacts on small ponds conducted in Satkhira district. The study targeted 90 households in two villages of Shamnagar sub-district/Upazilla. The major issues in the survey include sources of water during normal and disaster period in the research site, perception on climate induced hazard type, impacts on climate induced hazards and health implications due to changes in the climate system.

In response to the question, it appears that more than one-third of the people depend on the small isolated wetlands or ponds for drinking water. But most of the households boil the pond water before they drink it. While only 4 percent of the studied households mentioned that they used to collect pond water for drinking purposes during cyclone Aila. Most of the households depended on aid water provided in bottle/small container by government organizations, international organizations, donors and others e.g. private organizations during and immediate post cyclonic event. On the other hand, most of the people use pond water for washing, bathing and sanitation purposes. It indicates that more than 70 percent of households used pond water for sanitation purposes after the disaster. The details can be found in Figs. 15.2, 15.3, 15.4 and 15.5 below

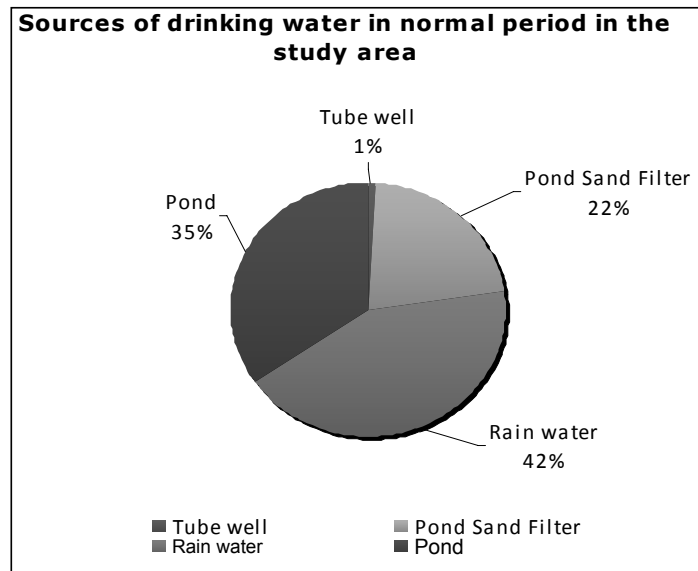


Figure 15.2 Sources of drinking water in the normal period in the study area.

Sources of drinking water during last Cyclone Aila

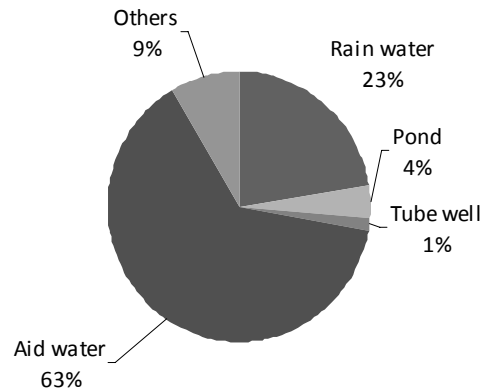


Figure 15.3 Sources of drinking water in the study area during cyclone Aila.

Sources of water for sanitation during Cyclone Aila

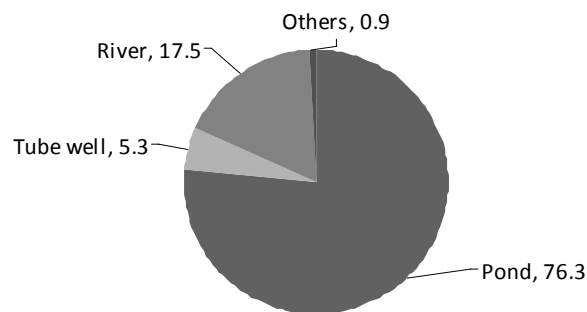


Figure 15.4 Sources of water for sanitation in the study area during cyclone Aila.

Perception on Climate Change Related Hazards

On average, about 70 percent of the responses were in favor of shorter winter, late rainfall, lack of rainfall and long summer as climate related hazards in the study area (Fig 15.5). More than 50 percent of the people mentioned that the frequency and intensity of cyclone and storm surges have increased in the last decade. It revealed that 95 percent of the people think that the temperature has increased especially during pre-monsoon.

Perception on climate related hazards in the study area

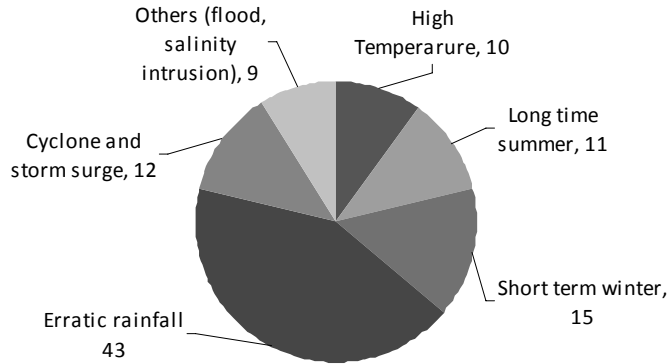


Figure 15.5 Perception on climate change related hazards in the study area.

Perception on Climate Change Impacts on Small Ponds

The local communities or households claimed that the ponds are affected by a number of hazards including cyclone and storm surges, inadequate rainfall in particular seasons, late rainfall, intrusion of salinity. The consequences of climate induced hazards include increase of salinity intrusion in pond water, mentioned by more than 20 percent of the respondents. But most of the respondents (50 percent) stated that the level of water in the pond falls during pre-monsoon. People in the study area really suffer from the water crisis in this particular season.

Health Problems in Study Area

More than 80 percent of the respondents mentioned that they mainly suffer from diarrhea, dysentery and skin diseases. About 75 percent of the respondents identified fever and headaches as second order of health problems. Other health problems include jaundice, diabetes, pneumonia, malnutrition etc. Most of the households (43 percent) clearly mentioned that the incidences are frequent during the pre-monsoon season.

CONCLUSION

The coastal districts from South West to South East of Bangladesh are vulnerable to climate change and climate variability issues. Some of the districts including Satkhira, Patuakhali, Barguna, Pirojpur, Bagerhat, Khulna, Barishal (out of 19) are particularly at a higher level of vulnerability

probably because of their geographic location and topography. Satkhira, for example, is predicted to be one of the most substantially affected districts in the country because of the proximity of a large portion of its populations to the coast who are dependent on the natural resources base. The local communities may lose alternative livelihoods and income due to the ultimate consequences of climate change. For example, many people in Satkhira and other vulnerable districts may not be able to continue fisheries cultivation in small ponds because of increased salinity and low level depth of water in the pond for long especially in summer. They will also face challenges in home/vegetable gardening due to lack of freshwater for irrigation caused by climate change. The people of Satkhira are also critically exposed to disadvantages of non-climatic factors e.g. lack of safe water supply and sanitation, health services, poverty, poor housing etc. It is expected that the climate change will be the significant barrier for the poverty alleviation efforts and attempts of both government and non-government organizations. Consequences in water and health sectors might be severe in the future in the coastal zone.

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