

## **Present status of Impacts of climate change and adaptations in Bangladesh coastal areas**

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### **Abstract**

Climate is changing from its very beginning, but the impacts are becoming noticeable over last several decades. Coastal zone of Bangladesh is geomorphologically and hydrologically dominated by the Ganges Brahmaputra Meghna (GBM) river system and Bay of Bengal. This zone is being continually attacked by cyclones, sea level rise, storm surge which have caused terrible impacts on this low lying coastal area. Due to climate change and geographic location, coastal areas of Bangladesh are highly vulnerable to natural disasters. Climate change will create an additional stress and have direct a negative consequence coastal ecosystems, biodiversity livelihood, and economy and food security. This study aims to identify Background of present status of climate change and its impacts of regional scale, rationality of coastal risks assessment, environmental impacts, risks potentials, quantifying vulnerability, climate change adaptation strategies and coping mechanisms. Several studies are initiated to find out suitable adaptation measures and coping mechanisms that have the potential to help coastal communities adapt to climate changes.

**Keywords:** coastal zone; Bay of Bengal; Bangladesh; climate change; disaster;

### **Introduction**

700km long coastal region of Bangladesh covers about 20% of total land area. the population of coast will be growing to about 41.8 million in 2015 and 57.9 million in 2050 (Minar and Hossain, 2013). Coastal zone of Bangladesh consists of 19 coastal districts that are Jessore, Narail, Gopalganj, Shariatpur, Chandpur, Satkhira, Khulna, Bagerhat, Pirozpur, Jhalakati, Barguna, Barisal, Patuakhali, Bhola, Lakshimpur, Noakhali, Feni, Chittagong, and Cox's Bazar(PDO-ICZMP. 2003).

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Depending on geographic features, coastal zone of Bangladesh consists of three parts, a. The eastern zone, b. The central zone, c. Western zone. The western region known as Ganges tidal plain, comprises the semi-active delta and is criss-crossed by numerous channels and creeks. The central region is the most active and continuous processes of accretion and erosion. Meghna river estuary lies here in this zone. The eastern region is covered by hilly area that is more stable(Thomas and Wratten, 1992).



**Figure 1:** Coastal Zone of Bangladesh

The Coastal Zone of Bangladesh is known as zone of vulnerabilities and prone to various natural disasters. A number of developing countries have been experiencing climatic hazards, and some unavoidable risks can lead to more loss of life and property damage. coastal region of Bangladesh are facing continuously cyclones associated with storm surge, sea level rise ,water logging, and salinity intrusion , coastal flooding(Rakib et al. 2019).

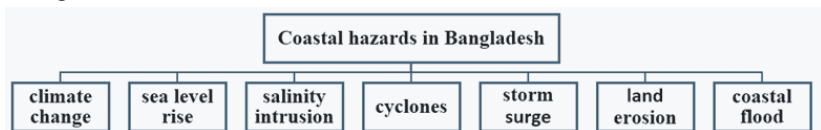
### Methods and Materials

This study was based of secondary information. To collect secondary data, an intensive literature review related to the climate change, its impact, current journal of climatic condition of Bangladesh, coastal government surveys, agriculture statistics issues in Bangladesh context were conducted through an online and offline .in addition, relevant policy documents and government reports were also collected from government agencies through

personal contacts .the secondary data and graphic illustrations also was collected from original researchers with permission and open sources software python, R and ArcGIS, MS Excel are used for data analysis and visualization. For data analyses, the "content analysis" method was used. This method is a research tool for interpreting and coding textual material (e.g. documents, books, oral communication, interviews, and graphics) to elicit meaningful information over different themes.

## Present state of impacts of Climate change

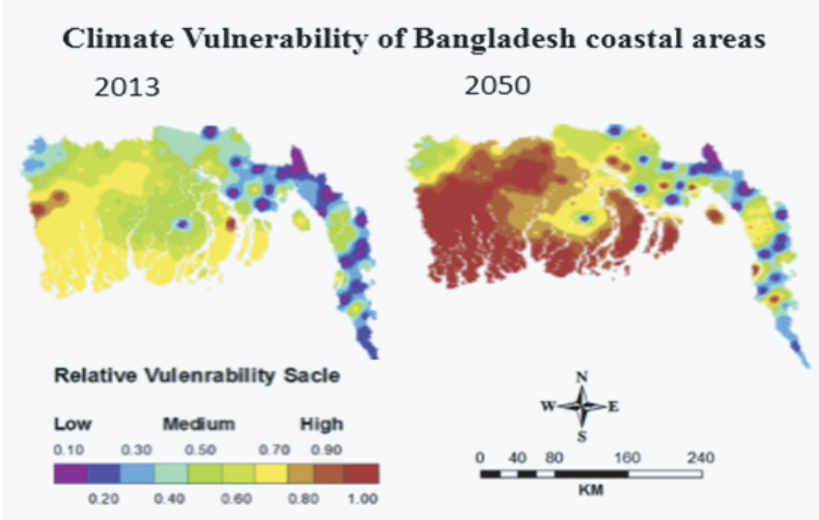
Bangladesh is the second most vulnerable country to climate change among the 27 most vulnerable countries due to its dense population in the coastal zone and low economic condition(Parry *et al.*, 2007). Coastal risks are mainly climate change, sea level rise, salinity intrusion, cyclone, storm surge, land erosion and coastal flooding. Most of them driven by climate change.



**Figure 2:** Major Coastal Risks in Bangladesh

Climate change can bring a significant coastal hazards in low lying countries .Bangladesh is one of the countries most likely to suffer adverse impacts from anthropogenic climate change. Although Bangladesh emits less than 0.1% of global greenhouse gas emissions (CCC, 2001). It is one of major coastal risks in Bangladesh because it is associated with other natural hazards in a complex way. The climatic conditions of Bangladesh are influenced by a number of global and regional scale factors. These factors include geographical location, the effect of North-South continental scale atmospheric pressure, the influence of the jet stream stretched from South East Asia to Northern Africa on the monsoon wind system, changes in the solar albedo due to land use, land cover change in the region and its impacts on wind pattern, and fluctuations in the terrestrial and sea surface temperature(Kabir *et al.*, 2016). This is of great concern, since the location and geography of Bangladesh makes it not only particularly susceptible to the effects of climate change, but also extremely hard to protect(Karim and Mimura, 2008). The future vulnerability in the coastal region of Bangladesh will be significantly higher than present condition(Uddin *et al.*, 2018).

Natural disasters such as cyclone, storm surge, floods, and drought will be more frequent and intense in the future. The climate vulnerability will be enhanced in the coastal region of Bangladesh due to geographic settings, dense population, and poverty.



**Figure 3:** 2013 and Future (2050) Climate Vulnerability in Coastal Areas of Bangladesh (Uddin *et al.*, 2018)

**Sea level rise**

Sea level rise (SLR ) along the coastline of Bangladesh is one of the major threats which may intensify the vulnerability of global climate change. SLR will cause significant impacts on wetlands and its biodiversity; water resources; agriculture, fisheries, and aquaculture; public health; displacement and migration; displacement and migration, assets (Castro Ortiz 1994; Kibria, 2016). A study showed that In the South West region at Hiron point the mean annual change in water level has been found as 5.5 mm/year .Maximum rise in the water level is observed in the South East region at the Maheshkhali which is 7.4 mm/year followed by 7.04 mm/year in the Sandwip and 5.05 mm/year in the Cox's Bazar(Nishat and Mukherjee, 2013b) .A 1m rise in sea level would submerge a full 18 % of the total land area in Bangladesh (Minar and Hossain, 2013). A research showed that deeply flooded area (depth above 100 cm, duration more than 9 months) would increase by 29% (from the base year 2000) due to 88 cm SLR by

2100 (CEGIS, 2006). In the southern region of Bangladesh it is projected that a 65 cm sea level rise by 2080s, will result in loss of 40% of the productive land. About 20 million people of the coastal area have already been affected by salinity (CCC, 2009).

### **Salinity intrusion**

Salinity intrusion in the coastal aquifer is the biggest challenge to ensure potable water at the household level. Increased salinity from saltwater intrusion poses an imminent threat to livelihoods and public health through its impacts on agriculture, aquaculture, infrastructure, coastal ecosystems, and the availability of freshwater for household and commercial use (Hussain 2008). The total amount of salinity affected land in Bangladesh was 83.3 million hectares in 1973, which had been increased up to 102 million hectares in 2000 and the amount has raised to 105.6 million hectares in 2009 and continuing to increase (Mahmuduzzaman et al. 2014). With the increasing impacts of climate change, salinity intrusion gradually is going towards inland water.

### **Coastal flooding**

Coastal flood can be caused by tropical cyclone and tsunami (UNDRO. 1980). the intensity of coastal flooding depends on height of SLR, tidal level and storm surge. Bangladesh is one of the most flood prone countries in the world due to its unique geographical location, topography and exposure to tropical cyclones. With 50% of the land less than 8 meters above sea level, and a coastline of some 600km, coastal flooding is a common problem. About 45.5 million people are exposed to severe and moderate floods like river flood, flash flood and tidal flood. Floods of 1974, 1987, 1988 and 1998 caused death of 30,000, 1657, 2379 and 1000 lives respectively and damaged crops and infrastructures (CCC, 2009).

### **Cyclones**

Cyclone causes significant loss of lives and damage to properties, coastal infrastructures, ecosystems, and economy of Bangladesh. Coastal zone is subject to disastrous cyclone almost every years. Bangladesh is especially vulnerable to tropical cyclones with around 718,000 deaths from them in the past 50 years. The Bay of Bengal is vulnerable to cyclones predominantly in the pre-monsoon months of April-May and the post-monsoon months of October- December (Sarker, 2018). A study predicted

intensified tropical cyclones and associated storm surges with an increase in Sea surface temperature (Emanuel, 2005) .

### **Storm surge**

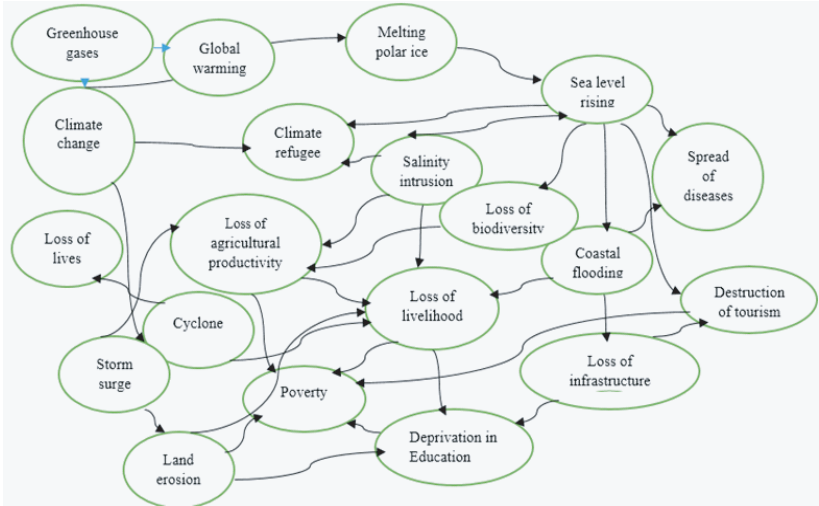
Storm surges associated with severe tropical cyclones constitute the world's worst coastal marine hazard which can cause heavy loss of life and property, damage to the coastal structures and losses of agriculture in affected countries. The western coastal zone is particularly vulnerable to surge flooding due to its low-lying land and very poor defenses against surge waves (Karim and Mimura, 2008). The Bay of Bengal is the area of the world having the highest potential for massive loss of life from a storm surge associated with a tropical cyclone. The frequency of the storms is greater towards the southern parts of Bangladesh, and they occur in Chittagong, Noakhali, Barisal, Patuakhali, and Khulna and in some inland areas in Comilla, Faridpur, and Dhaka.(Jakobsen *et al.*, 2006).

### **Land erosion of Coastal areas**

Erosion alone has rendered millions of people homeless and has become a major social hazard. People, who live adjacent to riverbank, become victim of erosion and be forced to change their livelihood and community(Nishat and Mukherjee, 2013a). Erosion of coast in the central coastal part is horrible because it is the most morphologically active area in Bangladesh coastal zone .se level rise , storm surge , coastal flooding , high flow of GBM are the main driving force of this area. Coastal area along Meghna river estuary is one of the most morphological dynamic areas in the world. A GIS based study showed that A total of 1183 km<sup>2</sup> of land has eroded with rate 118.3 km<sup>2</sup> /year from 1995 -2005 and 1194 km<sup>2</sup> from 2005 to 2015 around central part of Bangladesh coastal zone .Major erosions occurred in the areas of Meghna estuary and along the coasts of major islands such as the eastern coast of Bhola, the northern coast of Hatiya and the south-western coast of Sandwip (Ahmed *et al.*, 2018).

### **Chain analysis of impacts of climate change in Bangladesh**

Event-Consequence Chain is a popular tool for analyzing consequences, root causes, and consecutive events of a potential hazard, called "the casual anatomy of hazard".



**Figure 4:** Events chain analysis of coastal risk, Bangladesh

The chain begins with emission of greenhouse gases that causes climate change and global warming. The consequences of coastal starts from here. Global warming causes SLR, on the other hand, climate change driven events also generate cyclone with storm surge , both create coastal hazards. There is a strong relationship among, climate change SLR, coastal flooding, disease outbreaks, loss of agricultural production, and unemployment (Colwell and Huq 2001; Kibria 2016; Begum and Fleming 1997; Taylor et al., n.d.; Researcher 2014). A number of climatic risks have been associated with the rising sea level, increase in the magnitude of cyclones, changes in the pattern of rainfall, and increases in drought, coastal ooding, sea-surface temperature, and salinity (N. Ahmed 2013).Coastal livelihoods are greatly aected by climate change driven extreme events through loss of agricultural production, livestock, and natural resources extraction.Due to the loss of production, coastal businessmen and traders will be aected in ways that disrupt their businesses, capital, and income. Nowadays, coastal people are gradually losing their household assets and social capital owing to those disasters (Rakib et al. 2019). Coastal resources highly endangered by the climate change include land and water resource as well as the mangroves forests (Development, South, & Region, 2000). SLR will have adverse impacts on the forest (Sundarbans) in two ways, one is directly through enhanced inundation and another is indirectly by enhancing saline intrusion

in river systems(Minar, Hossain, and Science 2013). The biodiversity of Sundarbans will be abridged by this way. The hazards creates other consequences the chain is endless, the ultimate result of those risks are poverty, loss of lives, climate refugee and loss of land. Long-term impacts from a rise in sea level and global temperature could displace millions of people(USAID 2016).

### **Adaptation against coastal risks and coping mechanisms**

Adaptation to climate change is now important in the coastal zone of Bangladesh .Climate change adaptation is understood as consisting of initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects(Rajib Shaw , Fuad Mallick 2013). Coastal areas of Bangladesh mainly are affected by several vulnerability factors due to climate change. There are mainly unemployment, housing problems, shortage of drinking water, frequent cyclone and flood, lack of education, low wage rate. The potential impacts of climate change can be reduced adaptation and copying with environment. Individuals and societies will adapt and have been adapting to climate change over the course of human history. Some adaptation by individuals is undertaken in response to climate threats and other adaptation by government(Conway et al. 2015). Coastal areas of Bangladesh have a great potentiality of the climate resilient alternative and disaster adaptive livelihood activities(Amin et al. 2018) .Some adaptation strategies are blowing for the coastal zone that can be taken for Bangladesh. There are 3 adaptive options : those are retreat , accommodation and protection(Minar, Hossain, and Science 2013).Constructions of embankments, mangrove plantation along coastline are also option of adaptation. Mangrove can provide both mitigation, through the sequestration of carbon, and adaptation, through stabilizing shoreline erosion, reducing storm surges, and preventing inland soil salinization(Chow 2018).As people remain vulnerable to various kinds of critical factor, they could build their own coping strategies and mechanisms to deal with those. Individual, groups, or communities who remain successful in devising strategies of coping with vulnerabilities, gradually build "interfaces of resilience"(CEGIS-RTI 2004).Coastal people of Bangladesh can adapt or copy with extreme climate disasters in following ways (table 1). These mechanisms is adopted from analysis of previous published national and international published journals.



**Table:** coping mechanism to major Bangladesh coastal vulnerabilities (modified (Fakhruddin and Rahman 2014)

No.	Vulnerability factors	coping mechanisms
1	Lack of employment opportunities	Livestock rearing, Credits from NGOs, change of occupation etc.
2	Lack of safe drinking water	harvest rain water, boil pond water, drink surface water, saline water from innovative tool by solar evaporating etc.
3	Low wage rate	Limit family consumption/expenses, seek credit loan, mortgage/sell assets, out-migration etc.
4	Lack of cash /savings	rely on middlemen/broker, seek NGO support, seek support from the relatives, rear livestock etc.
5	Cyclone	Take shelter in cyclone shelters with live livestock,
6	Hosing problems	Floating night over, migrate out, slum dwelling, share space
7	Lack of skills	work long hours, seek Govt./NGO support, listen to radio/TV/Media, work for credit, food for work etc.
8	Flood/tidal flood	Raise protective embankments, shift to crops that grow in different seasons

**Conclusion**

Due to climate change, sea-level rise and other extreme weather events, coastal areas are continuously being affected by natural hazards in different ways. Climate change driven Coastal hazards and their impacts lead to inevitable threat, and continued loss of life and property. Western and central coastal zone of Bangladesh are highly susceptible to the risks. Adaptation and coping with nature might be practical solution of climate change affected coastal communities of Bangladesh. The natural and traditional adaptation practices should be evaluated scientifically through habitat research, interaction with communities and in-depth analysis in the workshops and seminars involving stakeholders for a sustainable national and regional policy for coastal zone management(Ataur Rahman and Rahman 2015). Further research to build the optimistic model for proper coastal risks assessment by different scenarios is needed.

## Recommendations

1. identification of coastal vulnerabilities and suitable adaptation issues and options.
2. building coastal risks assessment monitoring technology and database for identifying more associated risks
3. prioritizing community based coastal adaptation methods by understanding their needs and vulnerabilities.
4. adoption of sustainable coastal resources management policy and guideline.
5. creating green belt by mangrove plantation along central and western coastal zone
6. Using floating platforms such vella in order to produce seedlings at multi peak and longer coastal flooding
7. giving emphasis on cooperation between international and national level.

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