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## Climate extremes and challenges to infrastructure development in coastal cities in Bangladesh

Sowmen Rahman<sup>a,\*</sup>, Mohammed Aatur Rahman<sup>b</sup><sup>a</sup> Department of Urban and Regional Planning, Jahangirnagar University, Dhaka, Bangladesh<sup>b</sup> Centre for Global Environmental Culture (CGEC), IUBAT—International University of Business Agriculture and Technology, Uttara Model Town, Dhaka, Bangladesh

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### ABSTRACT

Most of the coastal cities in Bangladesh are situated on the riverbanks of low-lying tidal zones at an average elevation of 1.0–1.5 m from the sea level. Construction and management of buildings, roads, power and telecommunication transmission lines, drainage and sewerage and waste management are very difficult and vulnerable to climate change disasters. Cyclonic storms associated with tidal floods impact seriously the infrastructures and thus the livelihoods. Although coastal cities are the ultimate shelters of the coastal people during the extremes events, the coastal cities are not safe and cannot support them due to poor infrastructure. This study analyses the challenges coastal urbanization faces under different situations like cyclones, floods and water-logging, salinity, land-sliding and erosion etc. during the disasters and their effects on city lives for water supply and sanitation, power and electricity and waste management etc., and puts forward recommendations towards sustainable planning of coastal cities.

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### 1. Introduction

Nearly a quarter of mankind lives in low-lying coastal areas, and urbanization is drawing still more people into them. Commercial activities mostly related to port, shipping, industry, agriculture etc. have delineated to commercial hubs. These hubs are catered by a huge forward and backward linkage activities and establishments like banks and insurance companies, clearing and forwarding agents, warehouses and hotels (NBC News, 2009). Most of the world's biggest cities have grown up around natural harbors. While people have been living in coastal areas for thousands of years, the huge cities and megacities that have grown over the past 100 years have quickly destroyed the natural marine and coastal habitats. Migration for shelter to the cities during the recent extreme climate events, and the sufferings of city-lives exacerbated. The rising sea level endangers several smaller island nations, such as Tuvalu, Maldives, etc., which are barely 2 m above the sea level (Brown, 2001). Millions of people in low-lying regions of many countries including Bangladesh, China (Strohecker, 2008) and Vietnam (Tanh and Furukawa, 2007) face the danger of being displaced.

\* Corresponding author.

E-mail addresses: [sowmenurp@gmail.com](mailto:sowmenurp@gmail.com) (S. Rahman), [marahman@iubat.edu](mailto:marahman@iubat.edu) (M.A. Rahman).

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The construction of general infrastructure such as roads, houses, shops, factories, airports, and ports completely replaces natural habitats. Estuaries, deltas, and their rivers are often dredged and deepened to cope with increased shipping. In addition to this, impacts such as increased erosion due to coastal development, increased pollution, boat traffic etc., which lead to further habitat loss and put increased pressure on marine species.

Many dams and dykes are constructed to protect coastal towns, cities and farmland from storm surges and high tides but these carry negative effects particularly for reclaimed land and drainage. These constructions have destroyed the natural coastal dynamics and functions, as well as, rare habitats like salt marshes (WWF, 2013; Stanley et al., 2011). Along with the coastal morphology; coastal slope is the major factor in estimating the impact of sea-level rise (SLR). On a steep coast, the impact of SLR is insignificant on contrary to a gently sloping coast where any rise in sea level would inundate large areas of land (Nageswara Rao et al., 2008). With a few exceptions, most of the coastal towns and cities are situated on the riverbanks of low-lying tidal zones of Bangladesh, at an average elevation of 1.0–1.5 m from the sea level and are prone to multiple threats such as cyclones, storm surges and floods, as well as earthquakes, tsunamis, and above all, climate change. SLR is a great threat to the 75 million people of Bangladesh, who are projected to be environmental refugees (Nitish Priodarshi, 2011). Analysis of available data on population displacement shows that 39 million people in Bangladesh were

displaced by major natural events from 1970 to 2009 (Tahera Akter, 2009).

The National Plan for Disaster Management 2010–2015 was prepared aiming at reducing vulnerability according to the Hyogo Framework for Action 2005–2015 and adopting the SAARC Framework. It emphasizes to work together with all stakeholders to build strategic, scientific and implementation partnerships with all relevant government departments and agencies, other key non-government players including NGOs, academic and technical institutions, the private sector and donors. The role of Government is mainly to ensure that risk reduction and comprehensive disaster management is a focus of national policy and programmes (DMB, 2010).

In 2005, Bangladesh developed the National Adaptation Program of Action (NAPA). In 2008, Bangladesh prepared Bangladesh Climate Change Strategy and Action Plan (BCCSAP) to strengthen its six pillars: Food security, Social protection and health; Comprehensive disaster management; Infrastructure; Research and knowledge management; Mitigation and Low carbon development and capacity building and institutional strengthening (MoEF, 2009). Bangladesh has also formulated a Coastal Zone Policy (CZPo) in 2005 but that paid very little attention about SLR (CZPo, Coastal Zone Policy, 2005) as well as the challenges of the coastal cities and their infrastructure. CZPo has identified the zone as an “agro-ecologically disadvantaged region” (Government of Bangladesh (GoB), 2005). Scarcity of drinking water, land erosion, the high groundwater arsenic content, water-logging, water and soil salinity and various forms of pollution have also slowed down social and economic developments (Islam, 2007; Islam and Ahmed, 2004)

Although human death has significantly been reduced but overall economic loss increased a lot (Table 1). There are some drawbacks in the policies and in the implementation level and lack of coordination among the agencies is one of the failures. On the other hand, poor coordination among the government departments hampers quick response in times of emergency. As the role of the agencies is not clearly defined, confusion about jurisdiction of work destroys the congenial atmosphere. There is a huge lack of grant monitoring system. The foreign grants are not monitored to ensure proper allocation of funds (TIB Report, 2013).

## 2. Vulnerability of the coastal area

Bangladesh is situated at the interface of the two contrasting settings with the Bay of Bengal to the south and the Himalayas to the north. Land characteristics with low and almost flat topography, multiplicity of rivers and the monsoon climate render Bangladesh highly vulnerable to natural hazards. The coastal morphology influences the impact of natural hazards in the area, increases the vulnerability of the coastal dwellers and slows down the process of social and economic development. The waterways are the main transportation mode in eastern and central coastal zone (Sarwar, 2013). The huge river networks are the greatest

influential factor for poor transportation infrastructure. Most of the rivers and rivulets are flowing from the north and a few from the east and discharging water to the Bay. The unplanned road transportation networks of the coastal zone are being connected to different cities including Dhaka and Chittagong but in many cases across the water flow *i.e.* east to west, thus interfering the natural water dynamics. In addition, erosion of the river banks and fragile land mass have worsened the situation. The rivers discharge water which is heavily laden with sediments funneling to the coastal area. Many islands between the channels, shallow northern Bay of Bengal and strong tidal, wind action etc. are the significant features of the coastal zone of Bangladesh (National Plan for Disaster Management, 2010).

The vulnerable low-elevated coastal zone with 54 thousand km<sup>2</sup>, about 40% of the country, is facing the consequences of growing pressure on the environment resulting in rising demand for water, inadequate maintenance of existing embankments and other environment protection measures, and rapid unplanned urbanization and industrialization. Climate change-induced frequent and severe floods, cyclones, storms, tidal surges, SLR, salt water intrusion, river and coastal erosions etc. force many rural people to migrate to the coastal cities thus creating new environmental problems in the country's fast urban slums (McGranahan et al., 2007; IOM, 2010).

The coastal urban areas include three city corporations: Chittagong, Barisal and Khulna, 74 municipalities and many towns including Upazila Headquarters (Fig. 1).

The oldest municipalities were set up in Jessore and Chittagong in 1864 followed by Cox's Bazar and Satkhira in 1869 and the recent municipality is Shariatpur, established in 1983. After independence of Bangladesh, all municipalities were renamed as Pourashava. Tungipara has the least area, 132 ha and Banaripara has only 1300 households (LGED, Local Government Engineering Department, 2002; BBS, 2003). The urban expansion has occurred only in terms of population size, devoid of urban facilities. Since 1901, data indicate that Dhaka, Chittagong and Barisal have never changed their rank throughout the century. This is indicative of regional primacy (Ahmed, 2004). Khulna, once a small town under Jessore district, rose to prominence since the 1960s and now Khulna is the third largest city of Bangladesh having a population of about 1.3 million on about 47 km<sup>2</sup> area. There is no sewerage system in Khulna City and most of the areas have neither piped water supply nor any permanent drain (ERMP, 2001; Hasan et al., 2004).

According to the Asian Development Bank, in 19 coastal districts towns including Khulna, Chittagong and Barisal infrastructure is still inadequate in many areas as they are either damaged by natural disasters or otherwise no longer functioning effectively. World Bank economist Stephane Hallegatte reported that “Coastal cities face a high risk from increasingly costly flooding. Their current defenses will not be enough as the water level rises.” “Coastal defenses reduce the risk of floods today, but they also attract population and assets in protected areas and thus put them at risk in case the defense fails, or if an event overwhelms it.” According to his report, Khulna is at number 8 out of 10 most vulnerable cities when measured as

**Table 1**

Coastal zones affected by tropical cyclones.

Sources: (Rahman, 2010; Miyan 2012; Rahman 2013).

Cyclones	Affected regions	Wind Speed (km/h)	Deaths	Damages (million US\$)
Bhola Cyclone-1970	Bangladesh, India	205	500,000	86.4
Bangladesh Cyclone-1991	Bangladesh	260	138,000	1500
Sidr-2007	Bangladesh	260	4036	1700
Nargis-2008	Myanmar Bangladesh India, Srilanka	215	138,366 (126 in Bangladesh)	10,000
Aila-2009	Bangladesh India	120	325 (26 in Bangladesh)	552.6
Mahasen- 2013	Bangladesh, Myanmar, India	95	107 (17 in Bangladesh)	5.14

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