

SEA LEVEL RISE AND THREATS TO THE GROWTH OF INFRASTRUCTURE IN BANGLADESH'S COASTAL CITIES

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ABSTRACT

The coastal cities of Bangladesh face significant vulnerabilities stemming from their location along riverbanks and limited community resources. Rising sea levels in Bangladesh have had increasingly detrimental effects on these cities and their communities, impacting critical infrastructure such as water supply, sewerage systems, drainage, and electricity. Moreover, coastal cities contend with a range of challenges, including floods, salinity, earthquakes, cyclones, climate change, land-sliding, water-logging, and erosion, all of which affect the well-being of their residents. This paper aims to comprehensively analyze the repercussions of sea-level rise on Bangladesh's coastal cities, emphasizing the vulnerabilities arising from their geographical positioning and limited resources. Additionally, it explores the far-reaching consequences of escalating sea levels on infrastructure development, community life, and society as a whole. By shedding light on these challenges, this research underscores the urgency of resilient urban planning and adaptation strategies to secure the future of coastal city residents and advocates for improved governance, coordination among authorities, and sustainable resource management to address these issues effectively.

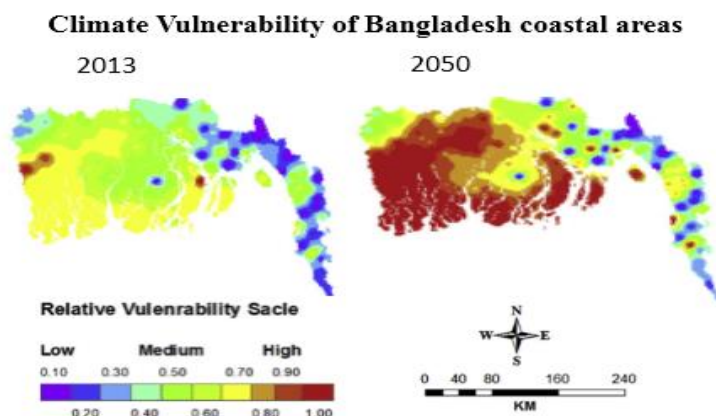
Keywords: Bangladesh, sea-level rise, coastal cities, infrastructure development, vulnerability threats

INTRODUCTION

Bangladesh is vulnerable to many issues such as poor labour force, lack of resource utilisation and infrastructure, the force of the environment such as hazards, and climate change (M. A. Rahman and Rahman 2015). The country has a high population density with low elevation, ineffective resource planning, and inadequate infrastructure. These all are outing the country in negative ways. Hazards and risks of the country have been increasing which results in the intensification of climate change (Yoo, Hwang, and Choi 2011). Sea level rises due to storms, erosion, cyclones, and flooding has been displacing large numbers of people in the country (Rashid et al. 2013).

The Coastal Zone (CZ) is a dynamic and diverse environment that reflects the interaction between the land, ocean, and atmosphere (Sillmann et al. 2017). In Bangladesh, 19 coastal districts, encompassing areas like Barisal, Barguna, Bagerhat, Bhola, Chandpur, Chittagong, Cox's Bazar Feni, Gopalganj, Jessore, Jhalakati, Khulna, Lakshmipur, Narail, Noakhali, Patuakhali, Pirozpur, Satkhira and Shariatpur, have been playing a role in the rise of sea levels (Sohel and Ullah 2012). Based on the Figure 1, it has been estimated that by 2050, climate change in Bangladesh will bring so much danger and hazards for regions and people. Due to rising sea levels, one out of every seven individuals in Bangladesh is projected to experience displacement. Global warming causes the sea-level rise and it affects low lying coastal areas in the country (M. A. Rahman and Rahman 2015).

Figure 1: 2013 and Future (2050) Climate Vulnerability in Coastal Areas of Bangladesh. Source: (Ahmad 2019)



Sea level rise in this country has various impacts (Matin, Hasan, and Ahmad 2020). Mostly it has impacts on the infrastructure development in developing countries like Bangladesh. Bangladesh is a well-known coastal nation, boasting a coastline stretching 710 kilometers along the Bay of Bengal. The sea level rise has already affected the country by flood, land erosions, salinity intrusion and global warming (Mallick and Vogt 2015). However, potential threats and risks are yet to come in Bangladesh. The potential threats of sea level rise are coming to the people due to riverbank erosion, flood, damage of the resources and infrastructure, fisheries, salinity intrusion, crop failure, destruction, and loss of biodiversity (Sarker et al. 2016). The sea-level rise (SLR) will have more negative impacts on the coastal area in Bangladesh's flood plain zone (Biswas et al. 2019). In Bangladesh, sea levels are rising in coastal areas which can affect the resources, agriculture, water resources, and the ecosystem of Bangladesh (M. A. Rahman and Rahman 2015). Hence, the authority is trying their best to mitigate the factors supporting sea level rises and Coastal effects of rising sea levels.

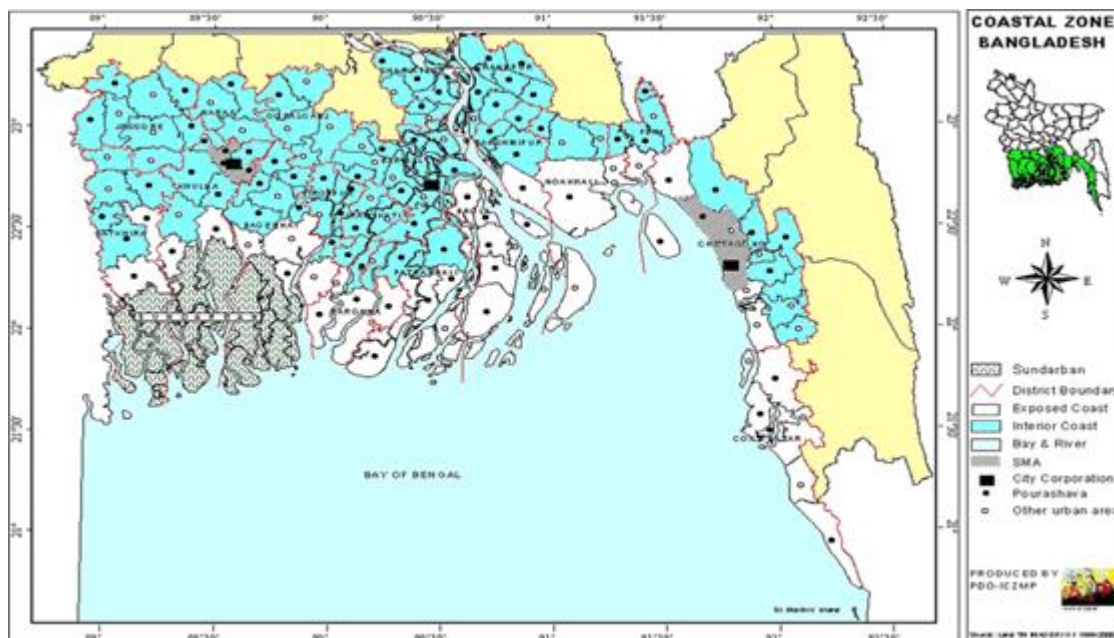
The paper centers its attention on Bangladesh due to its status as one of the nations most susceptible to the consequences of climate change, specifically the rising sea levels. The country is located in a low-lying delta region that is highly susceptible to flooding, storms, and other natural disasters. Bangladesh's coastal cities are particularly at risk, as they are home to critical infrastructure that is essential for the country's economic growth and development. However, this infrastructure is not designed to withstand the impacts of climate change. With the ongoing elevation of sea levels, it is probable that coastal cities in Bangladesh will encounter more frequent and intense flooding, potentially leading to catastrophic impacts on the nation's infrastructure and economy. Therefore, immediate measures are required to address and alleviate the dangers presented by the rising sea levels in the coastal cities of Bangladesh.

The paper contributes to the understanding of the threats posed by sea level rise to the growth of infrastructure in Bangladesh's coastal cities. It highlights the urgent need for action to mitigate these threats and provides recommendations for policymakers, urban planners, and other stakeholders. The paper also emphasizes the importance of building resilience in infrastructure and adopting a sustainable approach to development in coastal cities. Moreover, the paper sheds light on the vulnerability of low-lying and poor countries to the impacts of climate change and the need for global action to address this issue. Overall, the paper provides important insights into the challenges facing Bangladesh's coastal cities and the steps that need to be taken to ensure their sustainable development in the face of climate change.

THEORETICAL UNDERPINNINGS

In terms of both geomorphology and hydrology, the Ganges Brahmaputra Meghna river system and the Bay of Bengal have a predominant influence on the Coastal zone of Bangladesh (Sohel and Ullah 2012). An area of 47,201 km², which is around 32% of the country, represents the whole coastal area of Bangladesh (M. A. Rahman and Rahman 2015). 29% of the population, estimated at around 35 million people, lives in this Coastal Zone and that is consists of three parts representing the eastern zone, the central zone, and the western zone (Matin, Hasan, and Ahmad 2020) in Figure 2.

Figure 2: Coastal Zones in Bangladesh. Source: (S. Rahman and Rahman 2015)



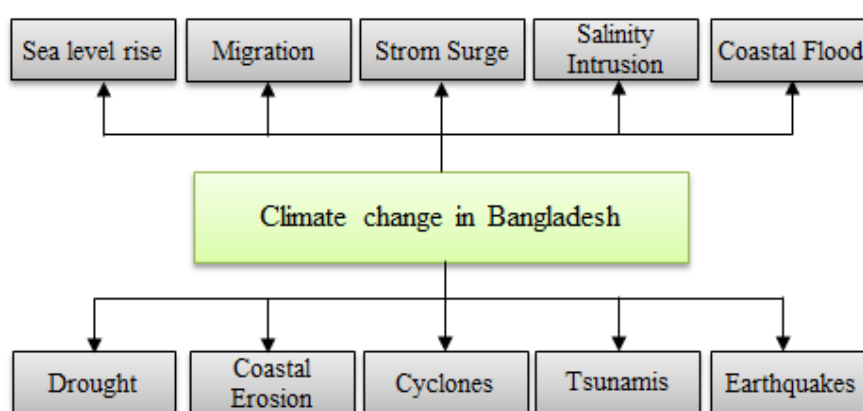
Different regions of coastal zones have been affected by sea level rises, floods, and erosions (M. A. Rahman and Rahman 2015). As the sea level rises in the country, the impacts and challenges of the coastal zone have been highly negative. The consequences have affected the lives and human health of the people in this area (Mallick and Vogt 2015). The infrastructural development was necessary for this zone. But, the government cannot easily develop the infrastructure and resource planning for the coastal areas.

VULNERABILITY OF THE COASTAL AREA

Naturally, the coastal area of the country is more vulnerable than the other areas (Azevedo de Almeida and Mostafavi 2016). Bangladesh has experienced the vulnerability of its coastal regions due to the interface of the Himalayas to the north and the Bay of Bengal to the south (M. N. Islam et al. 2016). Flat topography, the monsoon climate of the country and the multiplicity of rivers have created the vulnerability of the lands in the coastal areas (Matin, Hasan, and Ahmad 2020). The environment and climate of the country and coastal morphology develop factors supporting natural hazards with more negative impacts in the area (Sarker et al. 2016). In the meantime, the vulnerability of the coastal areas affects the social and economic development of the people (Quader, Agrawal, and Kervyn 2017).

There are different issues involved in the coastal zone that have been affecting infrastructural development and transportation of areas in Bangladesh (Ahmed, Nahiduzzaman, and Hasan 2018). Riverbank erosion and its consequences from the delicate landmass have literally affected the land and the situation. The coastal areas could not ignore the impacts of the heavy rivers dis-charge water in the land as well (Howe et al. 2013). Different coastal zones in Bangladesh have been dealing with sea level rises with the impacts on their locations, facilities and people (M. A. Rahman and Rahman 2015). These zones have been vulnerable to the growing sea level in the country. When the coastal zones deal with the sea level rises (Matin, Hasan, and Ahmad 2020), the authority needs to identify the level of vulnerability and the reasons behind the issues in the society (M. A. Rahman and Rahman 2015).

Figure 3: Major Hazard in the Coastal Areas of Bangladesh



Climate changes introduced lots of hazards in the country such as Floods, coastal storms, cyclone, rising sea levels, salinization, and coastal degradation are all common occurrences. (Ahmed, Nahiduzzaman, and Hasan 2018) showing in Figure 3. The people from rural areas are migrating from their locations and coastal zones of Bangladesh resulting in the creation of environmental problems with the urbanization in the cities (M. N. Islam et al. 2016). Hence, infrastructural development has been necessary for the coastal zone in the country. In Bangladesh, coastal urban areas have consisted of Chittagong, Barisal, and Khulna along with the 74 municipalities (M. A. Rahman and Rahman 2015). After the liberation war and modernization, the expansion of the urban areas has occurred due to the growth of the population (Gobbett, Nidumolu, and Crimp 2020). However, the urban facilities have been available in each area that has the taste of the urbanization.

OBJECTIVES

The research objectives of this paper are multifaceted. Firstly, it seeks to comprehensively analyze the impacts of sea-level rise on Bangladesh's coastal cities, with a particular emphasis on the vulnerabilities arising from their geographical positioning and limited community resources. Secondly, it aims to shed light on the profound and far-reaching consequences of escalating sea levels on these coastal cities, their communities, and society as a whole. Central to the research is the examination of how sea-level rise disrupts critical infrastructure development in the country, encompassing essential aspects of daily life such as access to clean water, sewerage systems, drainage, and reliable electricity and power supplies. Furthermore, the study endeavors to delve into the myriad challenges confronting coastal cities in Bangladesh, including but not limited to floods, salinity, earthquakes, cyclones, climate change, land-sliding, water-logging, and erosion. Ultimately, the research seeks to underline the urgency of addressing these challenges and highlights the need for resilient urban planning and adaptation strategies to secure the future of coastal city residents.

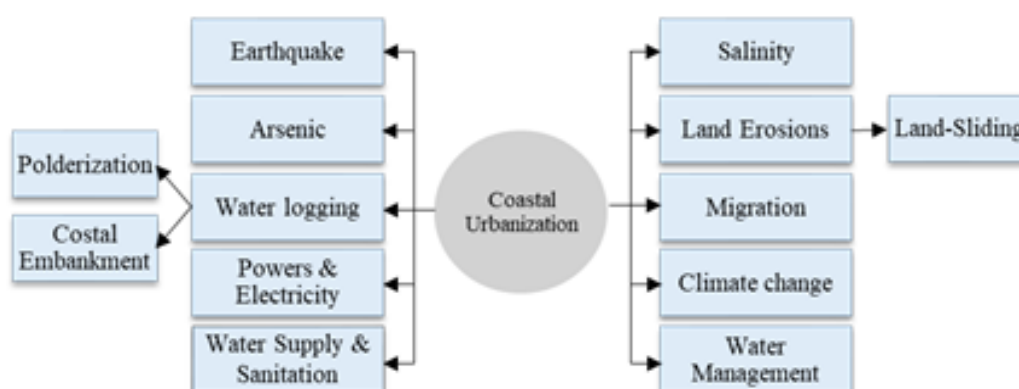
METHOD, MATERIALS

In this paper, secondary data collection and qualitative research approach have been selected. The information has been collected from various secondary sources such as journals related to sea level rises and infrastructure development in coastal areas, reports and case study on coastal areas of Bangladesh, paper reviewed journals and articles.

CHALLENGES OF COASTAL URBANIZATION

Coastal urbanization can come up with lots of challenges and risks for the government, people, and their assets (M. A. Rahman and Rahman 2015). The most challenges Urbanization are presented by Figure 4. Weak local governance can be one of the sources of risks for coastal urbanization. The authority should balance the linkup and cooperation among them (Sillmann et al. 2017). Ineffective coordination and communication between the Development Authority and the Government have been responsible for the majority of obstacles and limitations in infrastructure development for coastal regions and cities in Bangladesh. (Mallick and Vogt 2015). The entities involved in urban development or responsible for infrastructure improvements in cities rely significantly on the central government, which has impacted their ability to enhance facilities in coastal cities (Sarker et al. 2016). Meanwhile, climate change and the rising sea levels have intensified their detrimental effects on coastal towns and the progress of infrastructure development in these areas (Azevedo de Almeida and Mostafavi 2016). Consequently, the frequency and incidence of droughts, floods, and salinity intrusion have risen significantly, posing substantial risks to the availability of safe drinking water (M. N. Islam et al. 2016). This required the development of new water supplies for the people living in the area which have not been done in coastal zones of Bangladesh. Multiple vulnerabilities have been affecting coastal towns and cities are badly with climate change effects (Gobbett, Nidumolu, and Crimp 2020). The huge population contributed to the development of major challenges and the risks for the cities.

Figure 4: An Overview of Coastal Urbanization



1. SALINITY

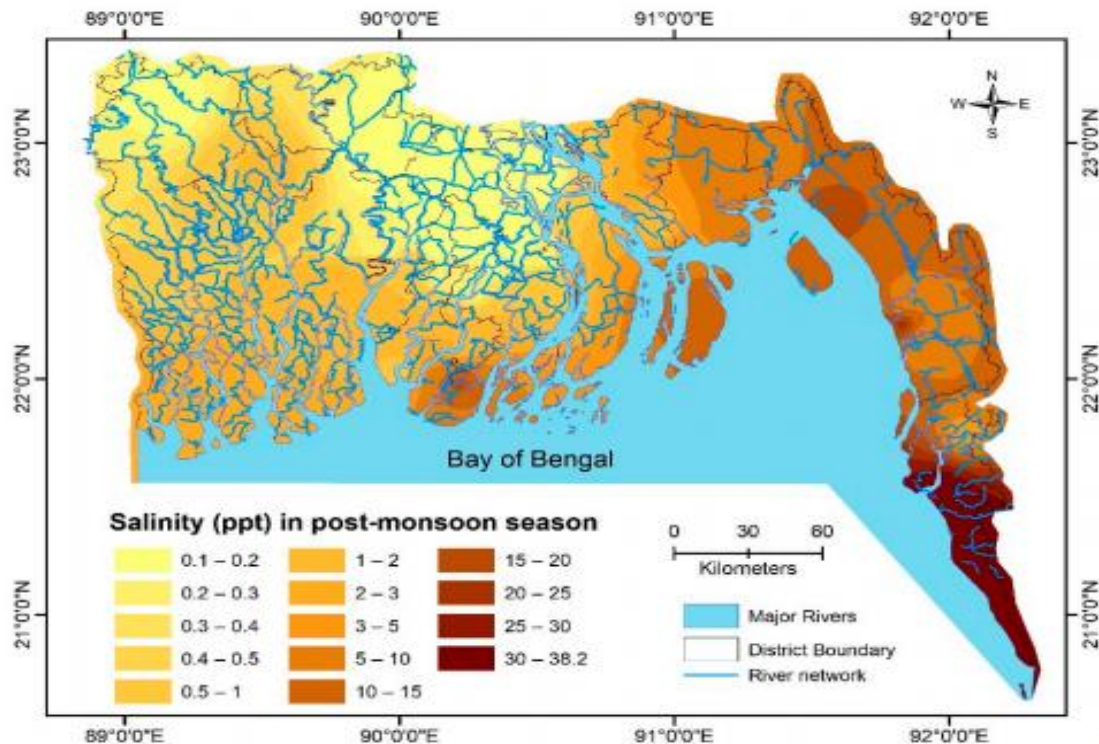
Under infrastructure and facilities, the cities are supposed to develop proper water and sewerage system (M. A. Rahman and Rahman 2015). But, in coastal areas, Water and soil salinity has been recognized as one of the common hazards where in the southwest region, the reduction in the dry season created surface water salinity (Bhuiyan and Dutta 2012).

Table 1: Coastal Towns affected by Salinity. *Source:* (S. N. Islam, Reinstädler, and Ferdaush 2017)).

Name of the City	City area (km ²)	Area affected by salinity (%)	Name of the City	City area (km ²)	Area affected by salinity (%)
Barguna	15.57	46	Botiaghata	8.30	69
Mathbaria	15.92	65	Dumuria	6.39	68
Pathorghata	18.31	68	Rupsha	2.30	45
Galachipa	9.60	72	Mongla	17.79	78
Kalapara	19.49	74	Paikgacha	2.12	81
Munchiganj	2.10	88	Bagherhat	15.36	65
Kaliganj	7.96	77	Morelganj	15.36	65
Ashasuni	6.81	85	Koira	10.06	81
Sathkhira	27.84				

In different areas and towns of the country under coastal zones, the impacts of salinity have been higher. Galachipa, Kalapara, Kaliganj, Munchiganj, Mongla, Paikgacha, Koira, and other towns have been affected by higher salinity (M. A. Rahman and Rahman 2015) (Table 1). The country should identify the areas having salinity for measuring and evaluating the level of risks and impacts on water and other facilities (Sarker et al. 2016).

Figure 5: The distribution of salinity in parts per thousand (ppt) during the post-monsoon season in the rivers and estuaries of Bangladesh's coastal regions. Source: Shammi, Mashura, et al., 2019



In Khulna city, Salinity has reached the water which affected the country's clean water supply for household and industrial usage. (Bhuiyan and Dutta 2012) which is shown in Figure 5. Some of the industries and factories have not been able to get fresh water due to the shortage in the dry season. In this situation, the infrastructure development could not raise the development of new industries for the country (Sarker et al. 2016). In some of the cities of Bangladesh, groundwater salinity has been found. In Noakhali, the groundwater salinity is high. Unfortunately, the climate change also contributed to the development of salinity in the coastal river with the shortage of fresh water for the people living in coastal areas (Matin, Hasan, and Ahmad 2020). In this situation, the government/authority should take higher steps for minimising the risk factor and impacts of the salinity in the fresh water supply for the community (Sifat and Saha 2019).

2. LAND EROSIONS

The authority of the coastal zones is required to be careful about more issues regarding sea level rises and impacts on the community and lives of the coastal zone (Sillmann et al. 2017). Coastal erosion and accretion are prevalent issues in Bangladesh's coastal area. The authorities have recognized that the embankment systems are creating significant and persistent issues in the coastal regions as well (M. N. Islam et al. 2016).

The poor embankment system and infrastructure of the coastal zone have exposed lots of interior lands. Also, the lands of the coastal zone are exposed to the country's vulnerability to cyclone surges and saltwater intrusion (Gobbett, Nidumolu, and Crimp 2020). In the coastal zone, river erosion can one of the greatest concerns for the authority, community, and society. River erosion has become a severe problem in a number of coastal cities and metropolitan areas and towns. Chandpur and Bhola have been experiencing river erosions in the country. The government must take measures to ensure proper planning and safeguarding of the coastal zone against river erosion. The lacking of comprehensive erosion control and lack of protection plan of Bangladesh has created more impacts on the land and resources of the coastal zone. Riverbank erosion of Padma and Jamuna has brought consequences on the land and infrastructure of the coastal zone (Matin, Hasan, and Ahmad 2020).

2.1. LAND-SLIDING

Coastal areas of Bangladesh are prone to landslides due to a combination of factors such as heavy rainfall, soil erosion, and unstable land conditions. The low-lying coastal area of Bangladesh is frequently affected by severe cyclones and storm surges, conditions that have the potential to initiate landslides. Landslides can occur in both hilly and flat areas. In hilly areas, the slopes can become unstable due to soil erosion caused by heavy rainfall, deforestation, and other environmental factors. In flat areas, landslides can occur due to the saturation of the soil with water, which causes the soil to become unstable and slide.

(Sillmann et al. 2017) To mitigate the impact of landslides, it is important to take preventive measures such as planting trees and vegetation to reduce soil erosion, controlling deforestation, and improving drainage systems to reduce the saturation of the soil with water. Furthermore, it is possible to set up early warning systems to notify residents in regions prone to landslides about imminent threats (Matin, Hasan, and Ahmad 2020), (Alam and Uddin 2013).

3. MIGRATION

The sea level rises in the country can contribute to the migration system of the country. In coastal zones, the sea level and impacts of sea level rises in Bangladesh have created migration for the people (Davis et al. 2018). The frequency of migration away from coastal regions has been high, leading to a rise in land prices and house rents compared to rural areas (Assaduzzaman et al. 2020). This has resulted in environmental pollution and degradation. Khulna and Barisal districts have seen the net-out migrations around 31 people per day (Sarker et al. 2016) (M. R. Islam et al. 2016). These elements are pushing people to accept the migration while creating major challenges and risks for the people (Figure 6 and Table 2).

Figure 6: Disaster induced human migration. Source: Rahman, Sowmen, and Mohammed Ataur Rahman, 2015

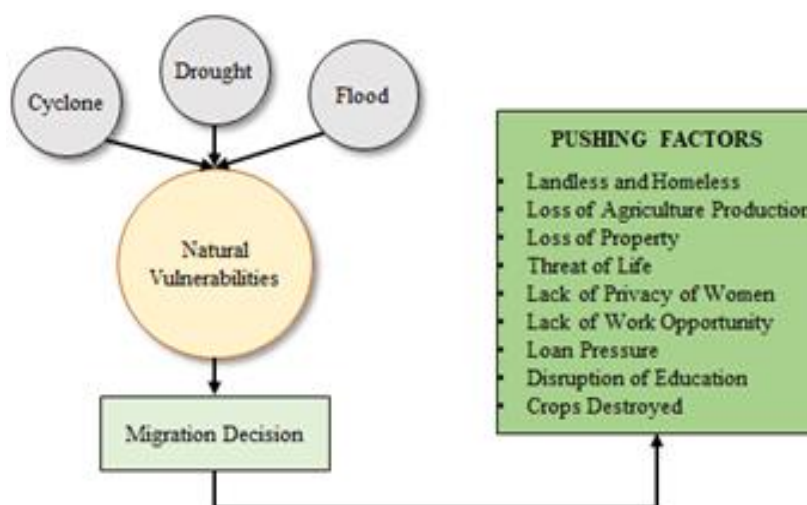


Table 2: A compilation of administrative districts known as "zilas" that face the greatest impact in various sea-level rise scenarios. These zilas are organized based on the estimated population displacement projected under the RCP 8.5 scenario by the year 2050. Source: (Davis et al. 2018)

District	State	RCP 8.5 2050 (0.30 m)				RCP 4.5 2100 (0.54 m)				1.5 m 2100			
		Popul	%	Km ²	%	Popul	%	Km ²	%	Popul	%	Km ²	%
Shariatpur	Dhaka	114642	6.9	208	16.0	95157	6.9	208	16.0	91321	6.6	222	17.1
Naray	Dhaka	112135	2.6	37	4.7	91972	2.6	37	4.7	128839	3.6	47	6.1
Angonj													
Munshigonj	Dhaka	108092	5.2	109	11.7	90627	5.2	109	11.7	82475	4.7	126	13.5
Barisal	Barisal	1058798	3.2	74	3.4	88766	3.4	75	3.4	150139	5.6	145	6.5
Chandpur	Chittagong	78403	2.4	115	7.5	63007	2.3	115	7.5	67105	2.4	118	7.7
khulna	Khulna	60958	1.8	33	0.8	51112	1.8	33	0.8	142969	5.3	88	2.6
Comilla	Chittagong	44689	0.7	26	0.9	36275	0.7	27	0.9	24696	0.5	27	0.9
Shatkhira	Khulna	37062	1.4	82	2.5	31075	1.3	82	2.5	108362	4.8	196	5.9
Pirojpur	Barisal	35573	2.4	35	2.9	29826	2.4	35	2.9	27389	2.2	39	3.2
Cox's Bazar	Chittagong	27782	0.8	16	0.8	23294	0.8	16	0.8	89838	3.5	45	2.1
% of total affected		81.8	...	86.6	...	81.7	...	86.6	...	61.7	...	54.3	...

4. CLIMATE CHANGE

The country's coastal areas have been grappling with the consequences of global warming and climate change (Sifat and Saha 2019). Climate change of the world is expected to increase the severity of the storms, cyclones, storm surges further inland, deforestation and other natural disasters causing higher damages to the country (Hart, Pitman, and Byun 2020) (Table 3). In coastal zones of Bangladesh have been dealing with damaging flood conditions. Khulna, Cox's Bazar, Chandpur and Barisal have been dealing with more risks and challenges developed from the climate changes involving floods, tidal waves, and cyclonic storms are becoming more increasing frequently (Brammer 2014). List the major cyclonic storms in 2008 to 2021 shows on Table 3.

Table 3: Major cyclone hits in Bangladesh.
Source: (Hossain and Mullick 2020; Rahaman and Esraz-Ul-Zannat 2021)

Date/Name	Wind speed (km/hour)	Daeth/Damaged
26-27 October 2008 (Cyclone Rashmi)	85	There were 15 deaths and thousands of damaged homes.
27–29 May 2009 (Cyclone Aila)	120	More than 150 individuals lost their lives, while two million residences were devastated, and three million acres of crops and cultivated areas were ruined.
16–17 May 2013 Cyclonic Mahasen	85	Throughout the nation, 17 individuals lost their lives, and almost 1.3 million were impacted. There were losses of over \$35.3 million to crops.
29 July 2015 Cyclone Komen	75	A total of 132 people were killed and approximately 510,000 houses were damaged as a result of the floods
21 May 2016 Cyclone Roanu	100	There were 26 deaths and 40,000 damaged homes.
29–31 May 2017 Cyclone Mora	110	At least 20,000 houses were damaged and 18 people were killed. Over 500,000 people moved out of coastal areas.
4 May 2019 Cyclone Fani	163	Approximately 63,000 ha (160,000 acres) of farmland were destroyed and 17 people were killed.
9 November 2019 Cyclones Matmo and Bulbul	224	An estimated 72,000 metric tons of crops were lost, worth \$31 million.
20 May 2020 Cyclone Amphan	154	A cyclone hit the nearby West Bengal region after making landfall.
26 May 2021 Cyclone Yaas	160	Numerous coastal structures and jetties suffered damage from the powerful tidal waves.

5. WASTE MANAGEMENT

Under infrastructure development, the authority is supposed to maintain solid waste management to manage the volume of wastes in the cities (Islam et al., 2016). In coastal zones, the lack of solid waste management affects the facilities for the cities. The authorities in Bangladesh's coastal areas have struggled to manage waste effectively, resulting in unclean and unhealthy living conditions in the city. In the meantime, the integrated solid waste management system citywide has not been implemented for the sake of the community and society (Afroz and Alam 2013).

6. EARTHQUAKE

The shreds of evidence showed that Earthquakes have a lower effect on coastal districts and cities in comparison to the rest of the world (Gobbett, Nidumolu, and Crimp 2020). In different countries, an earthquake can affect the lives of the people, community, resources, and strengths of the country. Compared to other coastal zones in the countries, in Bangladesh, several earthquake incidents took place in the area of the Chittagong. However, the government has not seen any bigger earthquake situations in coastal zones lately.

7. ARSENIC

Poor infrastructure development can bring more impacts to the community, society, and livelihood of the people (Sarker et al. 2016). Arsenic pollution is widespread along the country's coasts. In Bangladesh, many parts of the coastal zone have been dealing with arsenic. However, Satkhira, Barisal, Khulna, Gopalganj, Laxmipur, Chandpur, and Noakhali, have been dealing with the arsenic problem (S. Rahman and Rahman 2015). Even Khulna, Bagerhat and Satkhira, are experiencing pollution of groundwater with arsenic which has created concerns in the community. However, a small number of southeastern coastal communities have been under the consequences of arsenic (Matin, Hasan, and Ahmad 2020). 82 percent of the drinking water comes from the ground which can create a significant issue about arsenic and infrastructure development.

8. WATER LOGGING

In Bangladesh, the water logging has been increased due to sea level rising which collapsed the normal road transportation systems (M. A. Rahman and Rahman 2015). Even conventional

Figure 7: Water logging affected areas in coastal zone. Source: (Water and Board 2017)



vehicles such as rickshaws, vans, taxis, cars, and others cannot be easily used under the flood and collapsed roads in the coastal zones of Bangladesh (Pethick and Orford 2013). Unfortunately, coastal zones of the country have seen the contribution of the sea level and their impacts on the road where the people tend to use boats on the city roads (Matin, Hasan, and Ahmad 2020). One of the main reasons for this situation is the water-logging. This is particularly true in the areas of (Khulna–Jessore) and (Noakhali–Lakshmipur) in Bangladesh's southwest which is shown in Figure 7. (Matin, Hasan, and Ahmad 2020).

In different areas of coastal zones have dealt with water logging as a result of poor infrastructure management and rainfall (Sarker et al. 2016). In Bangladesh, as an area of the coastal zone, Noakhali town has been experiencing water logging for most of the monsoon season (Sifat and Saha 2019). In coastal zones and cities of Bangladesh, the infrastructure management has not been effective where the drainage infrastructure and sluice gates get choked (M. N. Islam et al. 2016). The authority needs to maintain proper decisions for the infrastructure development which contributes to the development of sewage system and sluice system of the coastal zone and areas (Gobbett, Nidumolu, and Crimp 2020). Also, even, water logging has been a major concerns for coastal zone of the country (Matin, Hasan, and Ahmad 2020). Abhaynagar, Keshabpur and Manirampur have large areas and the other cities in Jessore District, Khulna District, and Satkhira District have experienced water logging (Bhuiyan and Dutta 2012). These cities are permanently facing water logging due to different reasons. In the coastal zone of Bangladesh, Manirampur and Keshabpur Upazilas have been experiencing water logging of more than 85% of land (M. A. Rahman and Rahman 2015).

8.1. POLDERIZATION

Water logging problems in the coastal zone have been related to more issues and reasons in the country (Matin, Hasan, and Ahmad 2020). The adverse effects of the polders caused serious river drainage congestion in the coastal zone and water-logging problems in Bangladesh. Polders linked to the floodplain wetlands from the rivers which end up increasing and delivering more harmful impacts and disastrous consequences for the community and local communities (Sifat and Saha 2019). Basically, Systems of polders are considered as well as the first line of defense and shield for the community and the shore opposes sea level rising and tidal surges (M. N. Islam et al. 2016). With the damaged polder, livelihoods and the environment of the coastal cities have been affected. The authority and government need to work on effective infrastructure development with the polder system for managing the negative consequences of the floods, sea level rises, water logging and tidal surges (Gobbett, Nidumolu, and Crimp 2020) (Matin, Hasan, and Ahmad 2020).

In coastal zones of Bangladesh, the amount of the polder systems has not been on the right point as 44 out of 123 coastal polders have been dealing with the risk of overtopping (Sifat and Saha 2019).

8.2. COASTAL EMBANKMENT

The Coastal Embankment Project (CEP), which elevated flood embankments in order to rescue agricultural fields between 1960 and 1980, started the degradation of the coastal ecosystem, as well to increase production of rice over the whole coastline region. There are 5017 kilometers of embankment in all were built along the coastline against the nature order of things.

9. POWER AND ELECTRICITY

The infrastructure development needs to focus on developing the power and electricity system of the country. In coastal zones, the household electricity connection in urban areas has been higher in some of the areas such as Feni, Chittagong, Jessore, Barisal, and Khulna. However, in some areas, the usages are low such as Bhola, Shariatpur, Cox's Bazar, and Narail. The provision of electricity in the coastal communities is frequently disrupted due to load management issues. This has a significant impact on both small and large organizations, as well as those involved in fish preservation, in coastal towns (Matin, Hasan, and Ahmad 2020). They use a higher level of power and electricity for the sake of their business. The coastal zones in Bangladesh have not seen proper management of infrastructure development regarding power and electricity supply.

10. WATER SUPPLY AND SANITATION

The authority needs to develop proper facilities for the community and society where water supply and sanitation are two of the facilities. For healthy living, the authority needs to maintain hygienic latrine facilities, water supply, and proper management of solid waste. At the same time, appropriate disposal of household waste, drainage system, Storm water and sewage need to be managed under the sanitation system (Afroz and Alam 2013). In the coastal zone, the lack of infrastructure development in Bangladesh affected the facilities and service for the people (Matin, Hasan, and Ahmad 2020). Most of the coastal towns/cities did not have proper facilities where in the coastal zone, the lack of a sewerage system affected the facilities for the people with the poor drainage system within low-lying areas (Brammer 2014). In the meantime, the government of the country has not focused on the proper drainage system of the industries as the untreated industrial effluent has been released to the river. The country cannot ignore the necessities of proper drainage and sewerage system for the community.

RECOMMENDATION

- a. The government should collaborate with both private and public sectors to promote environmental education and training for the public. At the same time, it is important for the people and the community to have a better understanding of the significance of sustainable use of coastal urban facilities, drinking water, and other natural resources in the area.
- b. The government and the organizations need to ensure community involvement and participation of the organizations in maintaining and protecting facilities of coastal zones and coastal urban drinking water quality. Also, the community and society should be supported for the resource development and management regarding infrastructure development.
- c. The authorities and organizations should promote the adoption of sustainable technologies for the utilization of facilities, resources, and sources of urban drinkable water. They should also extend desalination measures and rainwater harvesting to the local communities.
- d. The landscape management policy should be formulated for coastal cities, hilly and river-channeled ones. This can help the government to maintain and reduce the erosion, water logging and land-sliding of the coastal zones.
- e. The authorities in coastal zones need to develop and train up the capacity management for the local community groups, NGOs, stakeholders and local government. The coastal urban drinking water resource management activities need to be managed under the private and public sectors.
- f. Different policies and systems need to be developed for the government, authority and local community service organizations and host community. The policies development and formulation need to be managed for coastal zones.

CONCLUSION

In conclusion, the challenges posed by sea level rise and climate change in Bangladesh's coastal cities are multifaceted and profound. The research has shed light on the vulnerabilities inherent in these cities due to their geographical location, limited resources, and inadequate infrastructure. Sea level rise disrupts critical aspects of daily life, including water supply, sewerage systems, drainage, and power supply, exacerbating the hardships faced by coastal city residents. Additionally, a multitude of challenges, from floods and cyclones to salinity intrusion and land erosion, further compound the difficulties in sustaining these urban areas.

The paper highlights the crucial need for resilient urban planning and adaptation strategies to safeguard the future of coastal city residents. However, it is clear that weak local governance, poor coordination among authorities, and inadequate resource allocation have hindered infrastructure development in these vulnerable areas.

Moving forward, effective policies, strengthened coordination among stakeholders, and sustainable resource management are imperative to address the challenges of coastal urbanization in Bangladesh and build a resilient future for these communities.

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