Changing Behavior of Cyclone in Bangladesh and its Risk Assessment for Adaptation

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<u>Keywords</u>

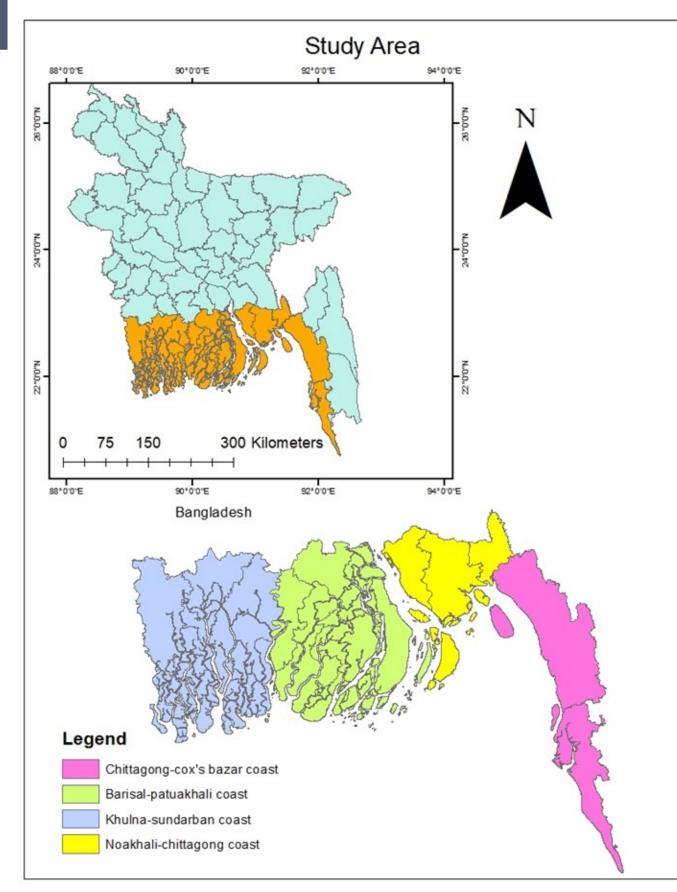
Tropical cyclones Sea surface temperature Impacts of cyclones Risk assessment

Abstract

Tropical cyclone (TC) is one of the most crucial topics not only for the natural loss but also for physical and economical loss of any country. The Bay of Bengal (BoB) generates number of tropical cyclones in each year. Bangladesh also experiences a number of cyclones. The surface temperature of the sea and air temperature is observed from NOAA high resolution satellite image. The Sea Surface Temperature (SST) of about 27°C and its higher is one of the prerequisite conditions for formation of a TC. But SST has increased by 1.2°C since last 40 years. It can be settled that both the Air Temperature and SST are increasing over the years. This rise in temperature of the BoB contributes to the occurrence of TC. Among the whole coastal zone of Bangladesh, the Chittagong-Cox's Bazar coast and Barisal-Patuakhali coast are more vulnerable than the other parts. About 35 million people of Bangladesh are living in the TC exposed area. Most of the TC are associated with storm surges and heavy rainfall, which add up to the damages and complications in the risky area in addition to high winds. It also includes flash flood, salt water intrusion, and loss of lands. In case of vulnerability and risk, it is noticed that Bangladesh is hit by Severe TC (Category-5) at least one in every 10 years, where the wind speed crosses 220 Km/hr. The huge amount of rainfall and storm surge result in floods, which increase the severity of this hazard. By this time Government takes steps to reduce the damages of the coastal area. Also, the analysis of behavior of the track and damage of Severe TC indicates that the whole coastal zone stays at risk at different times of the year. With proper analysis and measures, the damages caused by TC can be reduced. The management system of TC risk is not sufficient. The study shows that the TC has significant impact of high winds, rainfall and storm surge. Accordingly, it has the impact on all relevant objects on the society in addition to human loss and damage. Though it has the main influence on the coastal areas but rainfall associated with TC has significant impact on all over Bangladesh. The impacts are dependent on the behavior, landfall time and landfall area. The impact has been divided into three classes- low, medium and high. The classified impacts are varying from TC to TC, but high impact is observed more times over southwestern part of Bangladesh. It also influences the vegetation of the coastal part. Proper measurements should be taken to reduce risk of vulnerable areas of TC in Bangladesh

Study area

The study area of this research is typically the coastal zone of Bangladesh. The area lies within the tropical zone between 21-23° N and 89-93° E. The country has 710km long coast line runs parallel to the Bay of Bengal. In this study coastal zone has been divided into four areas. According to the coastal zone policy (CZPo, 2005) of the Government of Bangladesh, among 64 districts 19 districts are on this coastal zone.



Methodology & Data Collection

The following data has been collected for analysis under this study:

- Meteorological data: Rainfall, temperature, relative humidity,
- wind speed, evaporation data;
- Historical data collection;
- Sea surface temperature data;
- Cyclone tracking path data;
- Population and household structure data

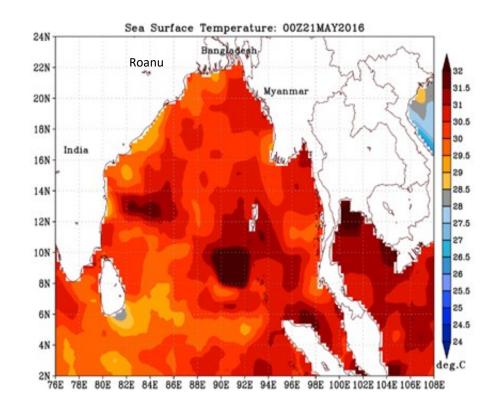
For this research meteorological data was collected from Bangladesh Meteorological Department (BMD), past history of cyclone data collected from SAARC Meteorological research center (SMRC) BMD, Indian Meteorological Department (IMD), sea surface temperature and air temperature data were collected from

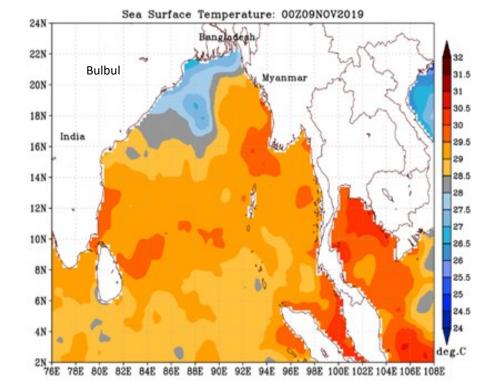


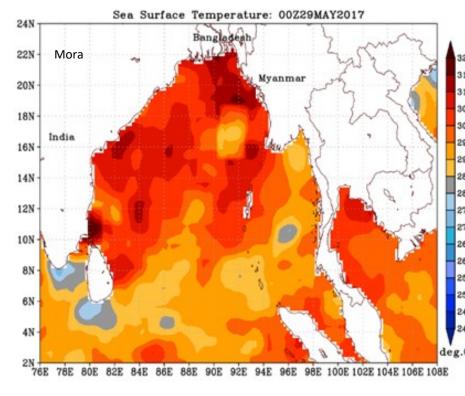


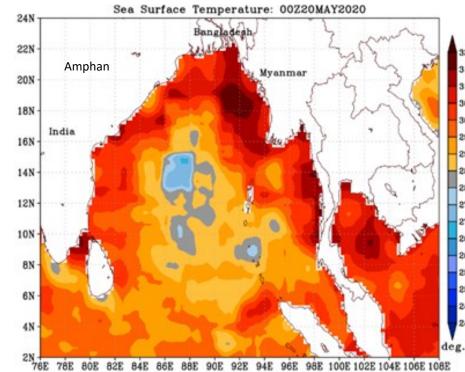


Contribution of Sea surface temperature during cyclogenesis: emperature variation has been observed the most in those time. Because of the variation, low pressure area is created on the sea which leads to the formation of cyclone. The condition of sea surface temperature during the cyclones of recent years have been shown:









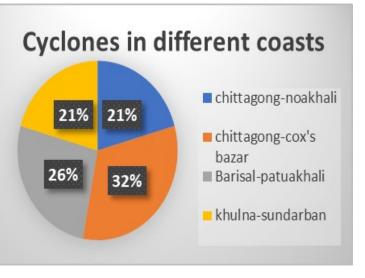
Storm surge impact: In this research Bangladesh coastal zone has been divided into four areas. These are as follows:

- Khulna- Sundarbans coast
- Barisal- Patuakhali- Noakhali coast
- Noakhali- Chittagong coast

. Chittagong- Cox's bazar coast

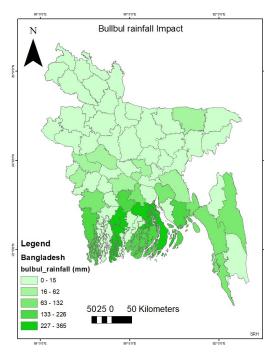
The pie chart shows the

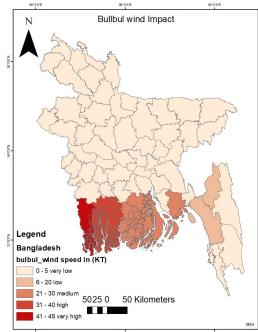
frequency of cyclone hits since 1960 to 2020.



Rainfall & wind Impact: The maps of the show the rainfall amount and wind speed during different cyclone. The rainfall during roanu varied from 140mm to 250mm. whereas the value is 120mm to 200 for Mora, 100mm to 160mm for Bulbul and 120mmto 200mm for Amphan.

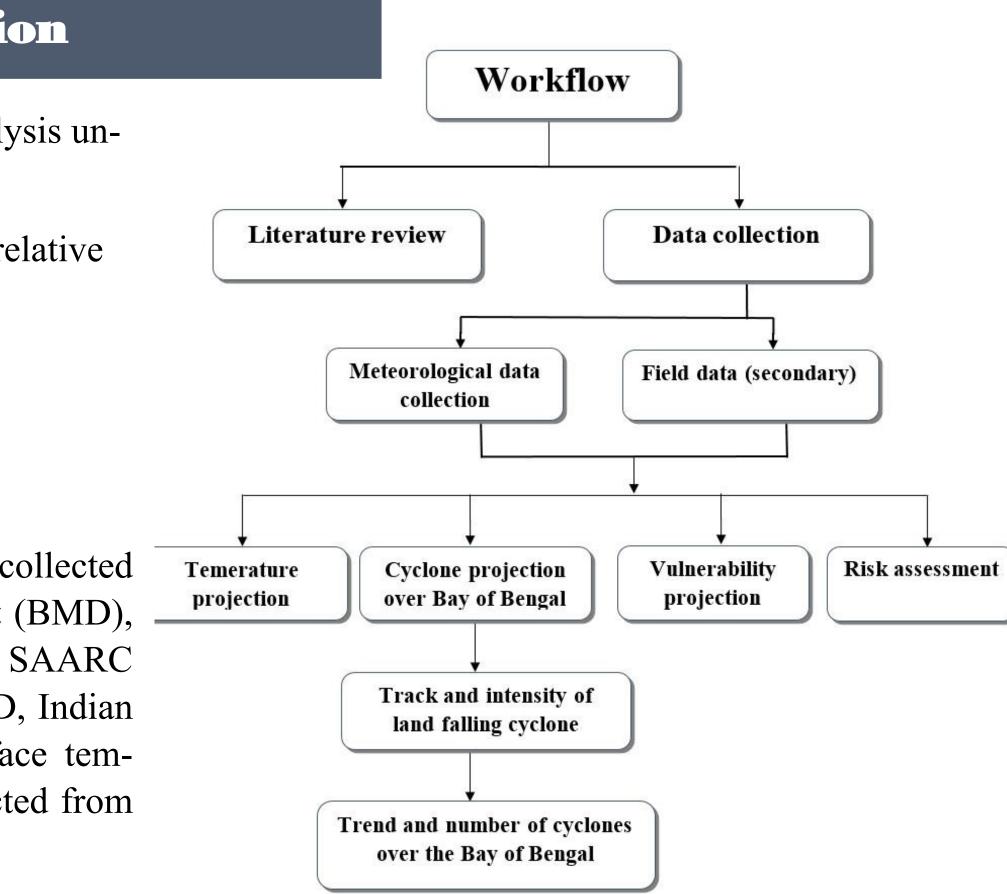
Wind speed varies from 120km/hr to 220km/hr. Highest wind speed recorded during Amphan which was 250km/hr.



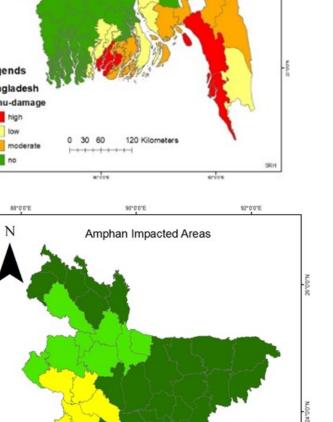


Risk assessment and Adaptation

Overall damage assessment of recent cyclones: The maps are created on the data of the wind impact, rainfall impact of the coastal area during and after the cyclone.

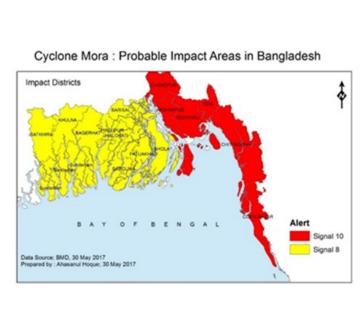


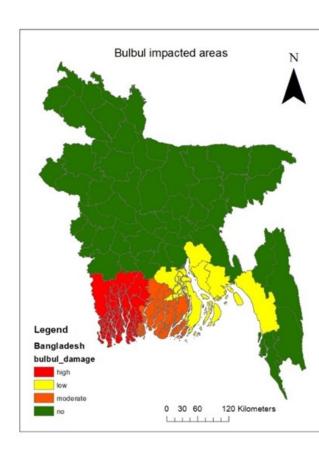
Roanu impacted area Legends no 0 30 60 120 Kilometers



Legend impacted_areas

50 25 0 50 Kilometers

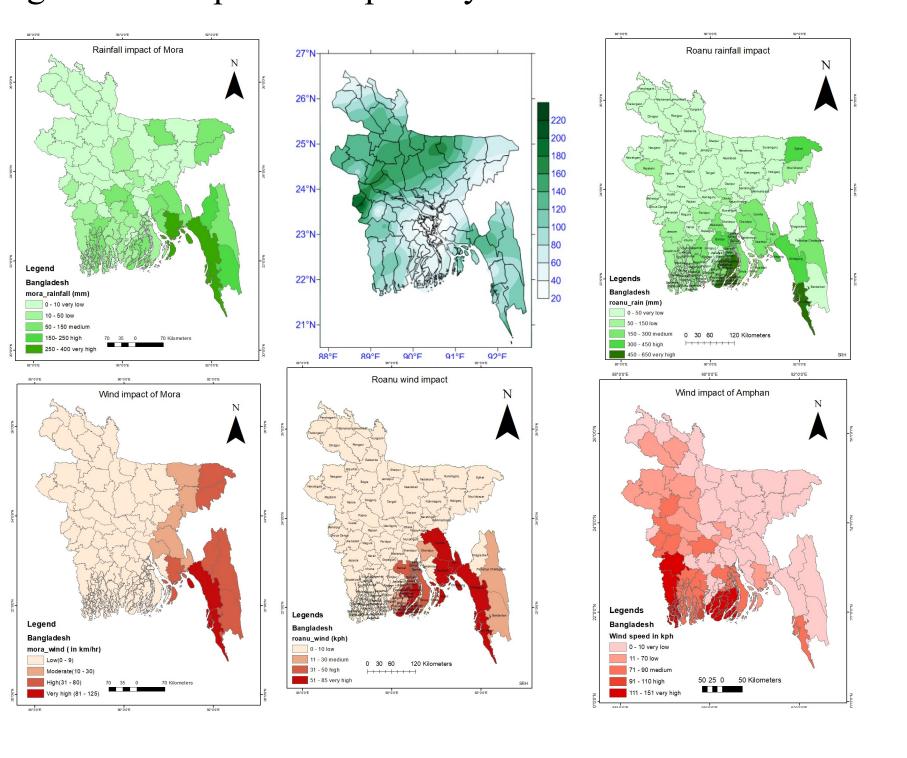




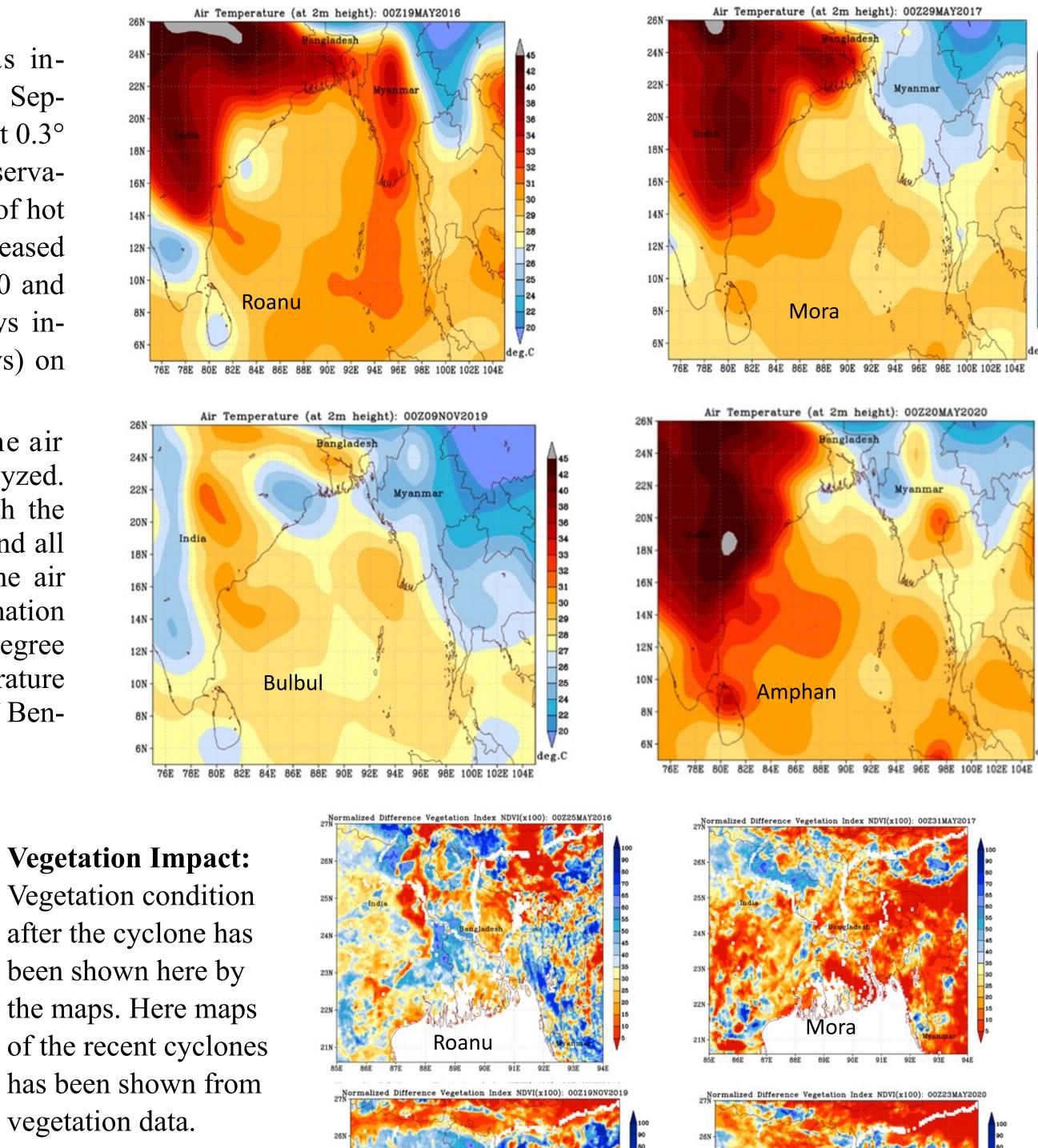
- Permanent dams and bridges need to be prepared for the Minimization of the inundation
- Sufficient Cyclone shelters are needed which can be used in the time of need. This needed for the 45 million people living in coastal region of Bangladesh
- Technical and financial support should be more effective in the era of digital world.

Surface air temperature: Surface air temperature has increased since 1960, particularly June through August and September through November (rainy summer) seasons by about 0.3° C and 0.5°C, respectively [UNDP]. Daily temperature observations show significantly increasing trends in the frequency of hot days and hot nights. The average number of hot days increased by 26 per year (an additional 7.2% of days) between 1960 and 2003. From June through August, the number of hot days increased by 9.9 days per month (an additional 32% of days) on average. (USAID, 2015)

Contribution of Air Temperature at 2m height: Here the air temperature at 2m height from sea surface has been analyzed. The air temperature of the ocean area also increases with the SST. Due to global warming temperature rises with time and all of these triggers to the formation of severe cyclones. The air temperature at 2-meter height at the time of cyclone formation has been shown here. The temperature is higher than 27 degree Celsius of the sea surface and the air above it. This temperature is favorable for the cyclone formation. That's why Bay of Bengal is a hot spot for tropical cyclones.



Vegetation condition after the cyclone has been shown here by the maps. Here maps of the recent cyclones has been shown from vegetation data.

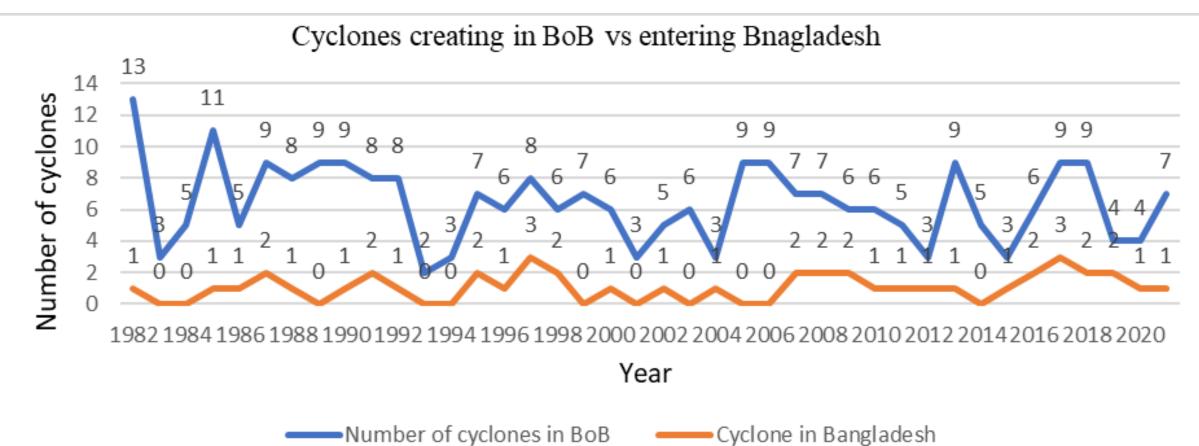


The graph (upper graph) shows the number of cyclones occurred in last 40 years which have made landfall in Bangladesh in comparison to neighboring country India. Though the graphs say that the percentage of cyclone hitting Bangladesh coast is relatively low but this country i not out of risk. The vulnerability of the coastal zone, sluggish development process and economical condition influence the risk of damages. Strict actions should be taken to save the coastal zone, specially concentrate on building proper dams and roads to lessen the structural and economical loss caused by this disaster.

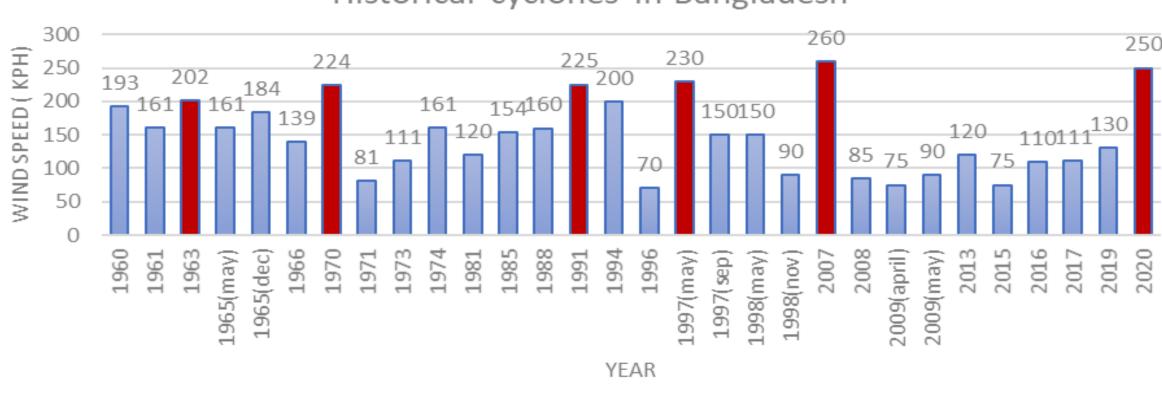
Looking at the history (Lower graph), it can be noticed that Bangladesh is hit by severe cyclone (category-5) at least ones in every 10 years where the wind speed crosses 220 kph. By The time government takes steps to control the long-term damages, another severe cyclone strikes in. The Bhola cyclone in 1970, Gorki cyclone in 1991, Sidr in 2007, Amphan in 2020 are the severe ones in last 50 years. Along with these small cyclones are striking the coast of the country every year. The damages caused by Sidr in 2007 have still not been compensated. After that, Cyclone Amphan (2020) has created a havoc in the coastal area specially in south west side.

Adaptation strategies and measures:

• Government and non-government measures taken by authority for the betterment of coastal population



Historical cyclones in Bangladesh



Affected sectors	Cyclone 1970	Cyclone 1991	Cyclone	Cyclone 2020
			2007	
Total affected people	4,700,000	89,23,250	10,721,707	10,000,000
Total damaged house	400,00	1,630,543	1,518,942	330,667
Total amount of dam-	450 million	1.8 billion	1.7 billion	131 Million USD
age	USD	USD	USD	
Wind speed	223km/hr.	225km/hr	240km/hr	240km/hr
Storm surge height (meter)	6-9 m	6-7.6	5-6	5
Cyclone category	3	4	4	5

Conclusion

From the information and assessment above, it can be said that the TC predominantly hit the southern part of the country and caused for damages. In recent years the impact of TC is observed over northern part of Bangladesh along with the coastal area. The analysis of population growth with cyclonic history shows that the Chittagong-Cox's bazar coast and Barisal-Patuakhali coast are much more vulnerable than other coastal areas. The number of coastal populations are growing. The roads, dams and the household structure are not resilience for the natural hazards. Along with the observation of the track paths, four recent cyclones Roanu, Mora, Bulbul, Amphan have been analyzed elaborately in this research and the observed total property loss is about 300 million dollars. The most common consequences of the TC are storm surge and flood which is responsible for land loss. Because of the loss of agricultural lands every year, required amounts of food cannot be produced each year, which leads to scarcity of food and need to export food from foreign countries that causes price hikes. A developing country like Bangladesh faces more difficulties to overcome this situation. According to IPCC and WMO, Bangladesh is one of the most vulnerable countries of the world. But it is possible to reduce the impacts of cyclones further in the coastal zone and decrease the risks. The existing disaster management system of the country has not been sufficient for a long time. Proper attention should be given on the preparation to face a cyclone rather than recovery after the cyclone. The study reveals that risk related to TC over the coastal area is very high and Bangladesh coast and adjoining other area will be under more threat of TC because both the Air Temperature and SST are increasing over the Bay Bengal. The risk over the coastal area is also dependent on the position and landfall of TC. The detected potential risk related to TC are human causalities, damage of housing and infrastructure, loss of agricultural production, damage of road infrastructure, damage of embankments, soil erosion and loss of biodiversity etc. So, proper and appropriate measurement are required to take on these aspects to reduce the loss related to TC.

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