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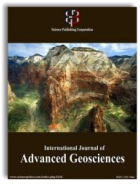

Analysis of changes in climatological condition: a perspective from Barguna district of Bangladesh

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Abstract

This study investigated the long-term changes in climatological condition, such as temperature, rainfall, humidity, storms, and tidal surge and flooding in Barguna district of Bangladesh. The BMD (Bangladesh Meteorological Department) data were used for temperature, rainfall, and humidity. The data for storms have been collected from secondary sources i.e. various journals, website and various records. This study applied the time series statistical test to examine the long-term changes in climatological condition, such as temperatures (1970-2015), rainfall (1975-2013), humidity (1975-2013), and storms (1987-2007). A parametric technique of trend analysis was used in this study for its inclusive use and simplicity. Data screening and filling missing values were also done before the analyses. The analyses of measured temperature indices that the annual average maximum and minimum mean temperature has increased 1.16°C and 0.56°C respectively at the end of 2015 since 1982 indicating that the weather has been becoming hotter. The analysis of the last 30 years rainfall data of Barguna was compared with national total annual rainfall and no significant change observed. The number of wetter days has been increasing over the time and more rainfall has been happening within small time. There is also a significant change in relative humidity. A total of thirty-five depressions, storms and cyclones hit Barguna district during the last 130 years among which hard hit severe cyclones have occurred in 1935, 1965, 1970 and the most recent cyclone SIDR in 2007 was notable. The study found that storm surge level and surge induced coastal flooding reached from the outfall of Baleshwar River up to 50 km upstream at Morrelganj with high surge level. Therefore, this study will provide a condensed view in further studies in advanced statistical modeling in combination with future scenario analysis for micro and macro scale climate variable changes in Bangladesh.

Keywords: *Climatological Condition; Barguna District; Bangladesh.*

1. Introduction

Bangladesh is a hotspot for geophysical and climatic hazards and is relatively ranked very high in terms of vulnerability to climate change. High temperatures, heavy rainfall, and seasonal variation are the unique characteristics that discriminate the climate of Bangladesh from that of other tropical regions (Hossain et al. 2014). The changes of climatic variables largely depend on physical and climatic settings of the area and the magnitude, duration, and consecutiveness of the hazards or change itself. The data on long-term climatic trends is scare and inadequate in Bangladesh. The parameter coverage in terms of the number of climatic variables, the temporal coverage in terms of annual, seasonal, monthly, 10-days, etc., and the analytical soundness are often inadequate and not representative of the entire country (CDMP 2013). No information is available at the community level which is at union or lower level. It is worthwhile to mention, as climate change is a slow on-set event, collecting climate change related information requires longer time frame; often years, even decades (CDMP 2014). The analysis of the data and subsequent generation of climate and trend maps at micro level would provide important information on specific geographical areas and time periods of concerns due to climate variables change. It is necessary to fill in this information and knowledge gap in order to devise appropriate policy and strategic measures and plan of action. A deeper understanding of the characteristics and distribution of climatic patterns will support water management, agricultural development, and disaster management and plan in Bangladesh in the context of national climate change (Rafiuddin et al. 2017, Mannan et al. 2016). A more in-depth knowledge of the climatic variability focusing on the seasonal, decadal and spatial aspects in this Barguna district area is essential for effective climate change adaptation planning. Therefore, the objective of this study is to analyze the long-term changes in climatological condition in Barguna district of Bangladesh.

2. Materials and methods

2.1. Description of the study area

The Barguna district is located in the southern part of Bangladesh and is situated between the Patuakhali and Khulna district. It is a flat land area full of rivers and estuarine creeks, having regular low and high tides. The notable rivers in Barguna district include Paira, Bishkhali, Khakdon, and the Baleshwar. The Bay of Bengal is positioned the southern boundary of this district. The total area of the district is around 1,831.31 km^2 of which 399.74 km^2 is riverine and 97.18 km^2 is under forest. The district is situated on the Ganges tidal floodplain and the land type is medium to high. The district is highly susceptible to storms and tidal flooding. The population density is around 2069/km^2. The total slum area is about 2.5 acre comprising around 180 numbers of households (District Statistics 2011).

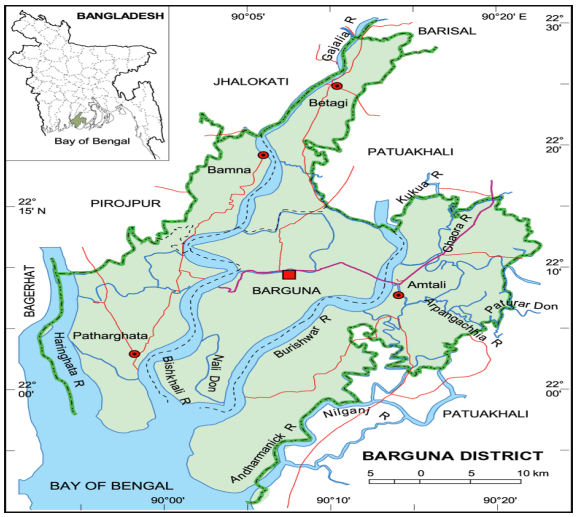

Fig. 1: Study Area Map Showing Barguna District of Bangladesh

2.2. Research Methods

The data of daily temperature for the time period of 1970-2015, data of daily rainfall for the time period of 1975-2013 and data of daily humidity (1975-2013) have been collected from Patuakhali weather station which has been being maintained by Bangladesh Meteorological Department (BMD 2016). The data for storms have been collected from secondary sources i.e. various journals, website and various records for the time period of (1887-2007). Other information, images, and maps have been collected from websites and various records. This study applied time series statistical test to observe the long-term changes in climatic variables. A trend analysis method was used in this study for its extensive use and simplicity. Data screening and filling missing values were also done before the analyses. The analysis of trends for temperature, rainfall, humidity, and storms was carried out by using the Statistical Package for Social Sciences (SPSS) and Microsoft Excel software.

3. Results and discussion

3.1. Temperature

The regression analysis of past 40 years temperature data of Patuakhali weather station approximately 45 km away from the Barguna district illustrated that the yearly average maximum and minimum mean temperature has increased 1.16 (°C) (r^2 = 0.55) and 0.56 (°C) (no significant correlation) respectively at the end of 2015 (Figure 2). These revealed that the weather has been becoming hotter. The projected mean maximum temperature in the area in 2030 will be 31.71°C which was 1.61°C higher than the base year (1973). The projected temperature up to 2080 in Barguna area is presented in Table 1.

Table 1: The Temperature Variability Analysis of Barguna District since 1973 and Projection to 2080

Year	Maximum Temperature (°C)		Minimum Temperature (°C)	
	Annual Mean	Increment	Annual Mean	Increment
1973	30.10	Base Year	22.30	Base Year
2016	31.26	1.16	22.86	0.56
2030	31.71	1.61	22.86	0.56
2050	32.35	2.25	22.87	0.57
2080	33.31	3.21	22.89	0.59

The monthly maximum mean temperature was plotted for every 10 years since 1973 and presented in Figure 3. The figure indicated that as the years are passing the area of high temperature in the graph (Figure 3) has been increasing over the mean maximum temperature of the respective year indicating that the number of hot days has been increasing since 1973.

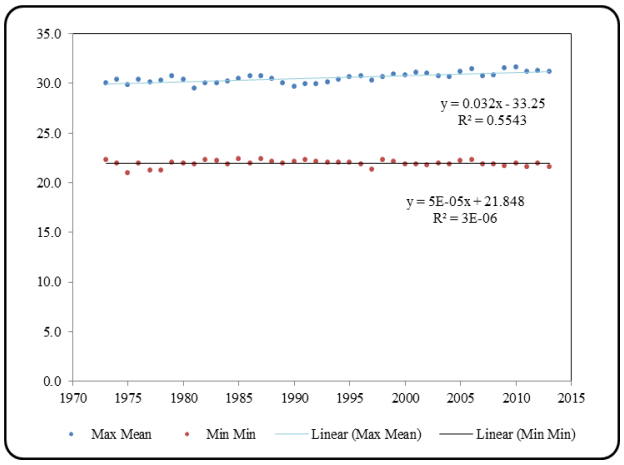

Fig. 2: Barguna District Mean Maximum and Minimum Temperature

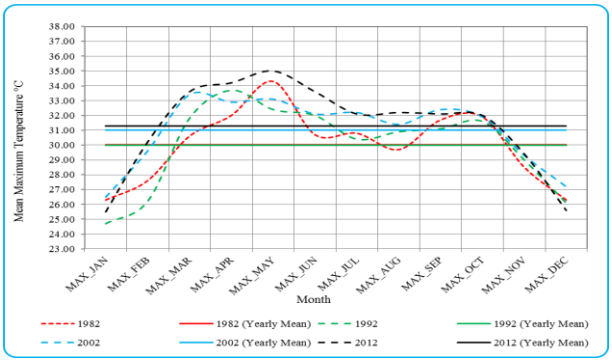

Fig. 3: The Mean Maximum Temperature Scenario of Barguna District Considering Last Three Decades

3.2. Rainfall

There was no significant change observed between the national (2472 mm) and Barguna (2486 mm) total annual rainfall in last 30 years (1982 to 2013). The decadal average of annual total rainfall trends and the seasonal patterns in different times of the year are presented in figure 4 and figure 5. The figure 4 illustrated that since 1975 the trend of the decadal average of annual rainfall in Barguna was sinusoidal in nature. That is in one decade the decadal average of annual rainfall is below the line of last 30 years average and the consecutive decadal average of total annual rainfall was above the last 30 years average rainfall. Figure 5 indicated

that there was no significant change in the decadal average of monthly total rainfall in winter, pre-monsoon and post monsoon in different decades. But the annual average rainfall in different decades indicated that the number of wetter days has been increasing over the time. Figure 5 also illustrated that as the time is passing since 1975 the yearly trend of monthly total rainfall curve's tip has been coming sharp indicating more rainfall in small time.

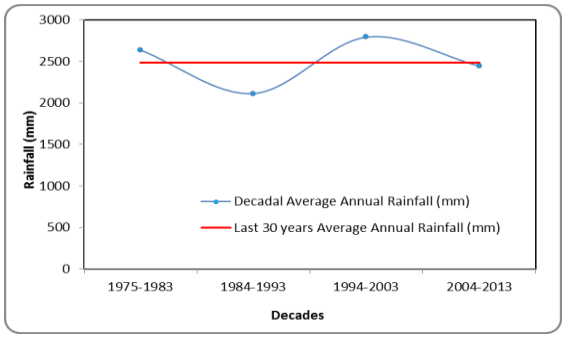

Fig. 4: The Rainfall Trend of Barguna District

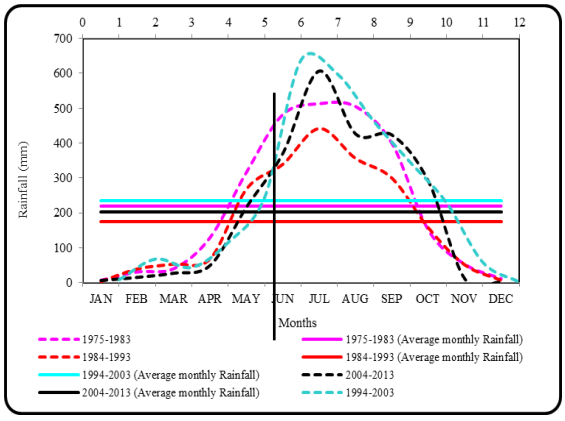

Fig. 5: The Rainfall Trend of Barguna District

3.3. Humidity

All Bangladesh annual normal relative humidity for a period of 30 years (1980-2009) is found to be 78.4%. (CDMP 2013). Such humidity was 77.1%, 75.9% and 76.9% during 1970-1999, 1960-1989 and 1950-19789, respectively. It thus seems that the annual normal humidity has increased gradually in Bangladesh since the 1960s (CDMP 2013). This study reveals that there is a significant change between national and Barguna average relative humidity in last 39 years (1975-2013). The maximum and minimum relative humidity status and average relative humidity trends in different times of the year are presented in figure 6 and figure 7. The long-term changes in humidity are marked by a rising trend in 1975-2013.

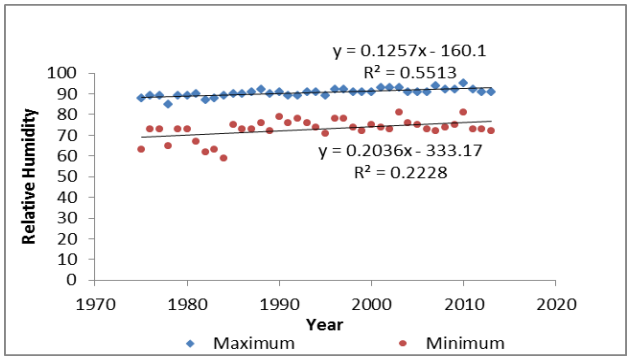

Fig. 6: Mean Maximum and Minimum Humidity Status of Barguna District

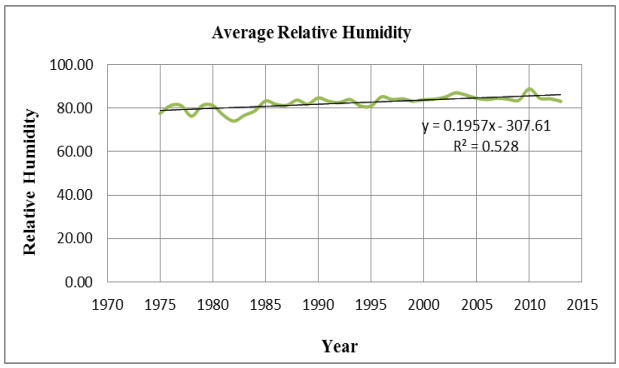

Fig. 7: The Humidity Trend of Barguna District

3.4. Storms

The Barguna district of Bangladesh is susceptible to cyclones and storm surges and subjected to severe damages frequently. The historical dataset (1877-2003) of landfalling storm track in Bangladesh developed applying the Global Tropical Cyclone Climatic Atlas (GTCCA) revealed that thirty-five depressions, storms, and cyclones hit Barguna district during the last 130 years (Tamima 2009). Along this Barguna was also affected by hard-hit severe cyclones during 1935, 1965, 1970 and the most recent cyclone in SIDR in 2007. The extent of damage caused by the last catastrophic cyclone SIDR, which swept through Bangladesh coast on 15 November 2007, was about $450 million. The total Patuakhali, Barguna, and Jhalokati districts were hit hard by the storm surge over 5 meters (16 ft). In Barguna district, 1335 people were died (44.5% of total casualties), 1119.89 sq. km area was annihilated (61.15% of total area), 60-70% of the crop was lost and 95,412 houses were fully and partially damaged (36.89 % of total).

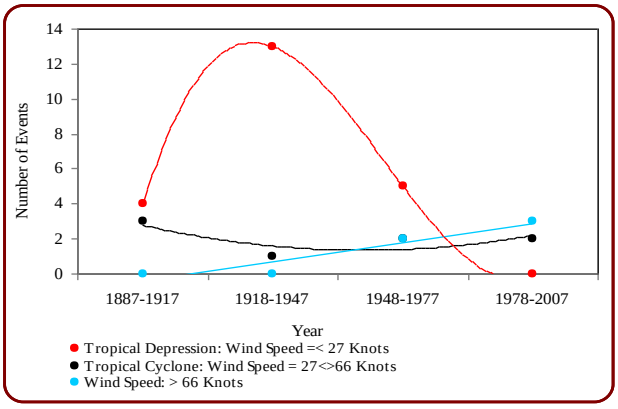

Fig. 8: The Historic Trends of Different Types of Extreme Weather Events

3.4. Tidal surge and flooding

The Barguna district is susceptible to tidal surges and flooding with a variable degree considering the distance from the ocean and the elevation. The elevation of the Barguna Pourashava is around 1m and it is 34.84 km distant from the coast. The surge level at different points of river Haringhata, Bishkali, and Burirshawr and at the confluence of the three rivers during severe cyclonic storm SIDR was compared with the previous cyclone in the district during 1970 and 2007 (Tamima 2009). The results showed that storm surge level and surge induced coastal flooding reached from the outfall of Baleshwar River up to 50 km upstream at Morrelganj with high surge level. The analysis also revealed that except two Upazila in Barguna district, the rest of the three Upazila were submerged by the storm surge due to the overtopping of the embankment. It is important to note that the height of the embankment is 5m along the three Upazila namely Patharghata, Amtali, Barguna Sadar and the Pourashava at a variable degree depending on the elevation and the surge height which varied form from 1

meter to 9.15 m. It needs to be noted that in general the high tide during summer rises up to 1.3 meters above the general ground level (Haque 2006). Embankments and Polders do not provide enough heights to prevent overtopping from cyclone storm surge. The embankment was built to protect the high tide water of 6 feet but not the tidal surge of 20 or 30 feet. That is why the embankment failed during SIDR and the whole area was inundated.

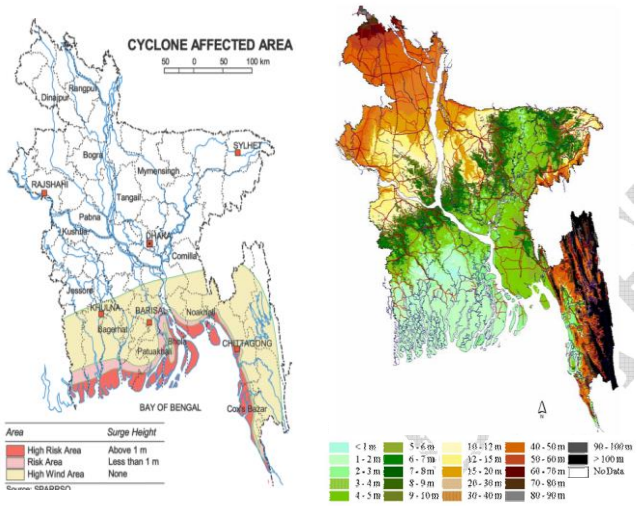

Fig. 9: Tidal Surge Map Left (SPARSO) and Elevation (Tight) Map of Bangladesh

4. Conclusions

The study has revealed that the annual average maximum and minimum mean temperature has increased 1.16°C of last 40 years. It is found that the weather has been becoming hotter. The expected mean maximum temperature will be raised 1.61°C in 2030 than the base year 1973. The study found that there was no substantial change observed between the national and Barguna total annual rainfall in last 30 years (1982 to 2013). The annual average rainfall in different decades showed that the number of wetter days has been increasing over the time. The durable changes in relative humidity are marked by a rising trend. The historical dataset of landfalling storm track in Bangladesh has revealed that thirty-five depressions, storms, and cyclones hit Barguna district during the last 130 years (1877 to 2003). The entire Barguna district was hithard by the storm surge over 5 meters (16 ft). The storm surge level and surge induced coastal flooding reached from the outfall of Baleshwar River up to 50 km upstream at Morrelganj with high surge level. This study is a very little but elementary work which will be helpful in future studies. This study will be supportive for future scenario analysis for microscale climate variables changes in Bangladesh.

Acknowledgement

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