

Variability of various Climatic Factors at South West Coastal Regions in Bangladesh

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Abstract:

Climate change in coastal zones embodies potential additional stress on systems that are already under intense and growing pressure. Being one of the most vulnerable countries of climate change induced disasters; Bangladesh is facing some basic and major changes in its climatic behavior and weather pattern. The overall objective of this paper is to assess the present status, trends and anomaly of high intensity temperature, rainfall and humidity and gather information on the effect of climate change on South West Coastal region as Jessore (22°48'0"N, 89°20'0"E), Khulna (22°49'0"N, 89°33'0"E) and Satkhira (22°35'0"N, 89°08'0"E) in Bangladesh. A trend analysis over Jessore, Khulna during the last 44 years (1969-2012) and Satkhira districts during the last 27 years (1986-2012) shows an in Satkhira, highly decreasing (-0.0109) trend of total annual temperature (°C) was observed while in Khulna and Jessore was slightly increasing (0.011 and 0.0074) trend. The trend of rainfall (mm) was found decreasing (0.2401, -1.2515 and -0.7585) in all seasons of Jessore, Khulna and Satkhira district. There was focused slightly increasing trend (0.032,

0.002 and 0.1068) of humidity (%) except monsoon period in the study area over the last decade. The Anomalies of Annual average temperature (°C) were -0.0076, -0.0052 and 0.0149 in Jessore, Khulna and Satkhira respectively where satkhira exhibits the highest peak. Similarly, average anomaly of rainfall (mm) were 0.6374, 1.2012 and 2.0077 in Jessore, Khulna and Satkhira respectively where Satkhira exhibits the highest peak and the annual average anomaly of humidity (%) were 0.0076, 1.0606 and -1.1667 in Jessore, Khulna and Satkhira respectively where Khulna exhibits the highest peak. Both regional climate model and observed data show increasing trends of temperature, humidity and decreasing trends of rainfall. Hence, the climate change will impact on this coastal regions in Bangladesh.

Key words: Climatic Factors, South West Coastal Region, Status, Trends and Anomaly.

Introduction

Climate change is identified as an average weather condition of an area characterized by its own internal dynamics and by changing in external factors that affect climate (**Trewartha et al., 1980**). United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as the change resulting from long term direct and indirect activities that induces changes in the compared time which are much more than the natural change (**Daily Star, 2011**). The world's climate has always been changing between hotter and cooler periods due to various factors. Bangladesh is one of the most victimized countries of the world due to the Climate Change. Climate related change in coastal zones embodies potential additional stress on systems that are already under intense and growing pressure. In terms of the impact of climate change few places in the world will experience the range of effects and the severity of changes that will occur in Bangladesh, which will include: Average weather temperatures rising; more extreme hot and cold spells; rainfall and humidity being a lot of or sometimes less.

According to the fourth assessment report of IPCC the mean temperature of the earth has been increasing at a rate of 0.74 degree centigrade per century (**IPCC, 2007**). It is also found that climate change has profound impact on rainfall intensity and variability (**Wasimi, 2009**). Rainfall pattern will change due to global warming although the exact degree of change is not yet determined (**Linarce, 1992**). This study has been done to analysis the general status and trends of temperature, rainfall and humidity which can change adaptation quality upgrade in future.

Material and Methods

2.1- Study Areas

Geographically, Bangladesh is located in the tropical region (**FAO, 2011**). The study areas for the research is south western coastal region (Jessore, Khulna and Satkhira district) in Bangladesh. The Jessore district lies between 22°48'0" north latitudes and between 89°20'0" east longitudes. Maximum temperature of Jessore is 37.1°C, minimum temperature 11.2°C and annual rain fall 1537 mm. Khulna is located in south-western Bangladesh at 22°49'0"N, 89°33'0"E, on the banks of the Rupsha and Bhairab river. It covers a total area of 59.57 km² while the district itself is about 4394.46 km² (**BBS, 2001**). It lies south of Jessore and Narail, East of Satkhira, West of Bagerhat and North of the Bay of Bengal. It is part of the largest delta in the world. Khulna had an annual average temperature of 26.3°C (79.4°F) and monthly means varying between 12.4°C (54.3°F) in January and 34.3°C (93.7°F) in May. Annual average rainfall of Khulna is 1809.4 millimeters (71.2 in). Approximately 87% of the annual average rainfall occurs between May and October. Similarly, Satkhira district lies between 22°35'0"N latitudes and between 89°08'0"E longitudes. Satkhira district had an area of 3858.33 km², It is bordered to the north by Jessore District, on the south by the

Bay of Bengal, to the east by Khulna District, and to the west by 24 Pargana District of West Bengal, India. The annual average maximum temperature reached 35.5°C (95.9°F); and minimum temperature is 12.5°C (54.5°F). The annual rainfall is 1710 mm (67 inches). Tropical savanna climates had monthly mean temperature above 18°C (64°F) in every month of the year and typically a pronounced dry season, with the driest month having precipitation less than 60 mm (2.36 inches) of precipitation.

2.2- Data collection and analyzing method

Secondary data is acquired from different meteorological stations such as Jessore and Khulna over a period of 44 years and Satkhira over 26 years.

- ❖ Maximum and Minimum Temperature (°C) - (Jessore and Khulna: 1969-2012) and (Satkhira: 1986-2012).
- ❖ Rainfall (mm) - (Jessore and Khulna: 1969-2012) and (Satkhira: 1986-2012).
- ❖ Humidity (%) - (Jessore and Khulna: 1969-2012) and (Satkhira: 1986-2012).

Annual data are obtained by averaging the monthly data for temperature and summation for the rainfall and humidity.

Linear equations are used for representing time series data.

The equations are as follows-

$$Y_e = a + bt$$

and

$$Y_e = Ae^{bt},$$

Where,

Y_e = dependent variables

a = intercept

b = Co-efficient

t = time series

It can be found by using the following formula -

$$R^2 = \frac{[\sum(x_i - \bar{x})(y_i - \bar{y})]^2}{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}$$

Where, x_i is the independent variable, \bar{x} is the average of the independent variable, y_i is the dependable variable and \bar{y} is the average of dependable variable. One way of testing significance of trends is calculating the Coefficient of determination, R^2 of the trend. Values of R^2 vary between 0 and 1. Highest correlation of the dataset could be found at 1 and it gradually reduces towards zero. Value less than 0.5 had been considered as less significant correlation (**Powell, 1994**).

Result and Discussion

3.1- Variability of Climatic Factors at South West Coastal Region (Jessore, Khulna (1969-2012) and Satkhira (1986-2012) in Bangladesh

Three climatic parameters such as 1) temperature ($^{\circ}\text{C}$), 2) rainfall (mm) and 3) humidity (%) were considered in the study. Bangladesh is located in the tropical monsoon region and its climate is characterized by high temperature, heavy rainfall, often excessive humidity, and fairly marked seasonal variations. The maximum, minimum and average temperature, rainfall and humidity of the selected region had been determined using historic available data from the South West coastal meteorological stations of Bangladesh. Data within last 44 years (1969-2012) from Jessore, Khulna and 27 years (1986-2012) from Satkhira was used to determine monthly average temperature, rainfall and humidity in Bangladesh.

3.1.1- Variability of Temperature ($^{\circ}\text{C}$)

3.1.1.1- Monthly and Annual Average of Maximum and Minimum Temperature ($^{\circ}\text{C}$)

In general Bangladesh is a high temperate country for her geological location. Table 1 shows monthly distribution of the average of maximum, minimum and annual distribution of temperature. Monthly maximum data had shown highest 35.2°C, 35.7°C and 35.6°C during April and lowest 10.3°C, 11.7°C and 11.4°C during January in Jessore, Khulna and Satkhira respectively. Similarly, annual average temperature had shown the highest value 27.3°C, 27.7°C and 27.4°C during 2010, 2000 and 2005 and the lowest value 21.0°C, 24.4°C and 22.5°C during 2009, 1994 and 2009 in Jessore, Khulna and Satkhira respectively. The country profile of Bangladesh state that the relatively cooler and drier winter extends from November to March, when temperatures range from 8 °C to 15°C, and minimum temperatures can fall below 5 °C in the north, though frost is extremely the temperatures fall gradually throughout November and December, and in the last week of December in 4°C at Jessore.

3.1.2- Variability of Rainfall (mm)

3.1.2.1- Monthly and Annual Average of Rainfall (mm)

Monthly maximum rainfall had shown highest 334.97 mm, 379.32 mm and 406.72 mm during June and lowest 12.74 mm, 4.96 mm and 10.78 mm during December in Jessore, Khulna and Satkhira respectively. Same as, annual average rainfall had shown the highest value 210.24 mm during 1970, 251.18 mm during 1982 and 296 mm during 1990 and lowest value 79.65 mm during 1972, 90 mm during 1992 and 96.75 mm during 1988 in Jessore, Khulna and Satkhira respectively (Table 1). Debnath (1995) et al. studied the rainfall characteristics and probabilistic rainfall extremes in Bangladesh during the post-monsoon and early winter season. Using monthly rainfall data of 21 stations of Bangladesh for the post- monsoon and early winter period (October-December) for 30 years (1961-1990), the probabilistic rainfall extremes for

three different time scales, namely (a) in 1 year out of 4 years, (b) in 1 year out of 10 years and (c) in 1 year out of 25 years had been computed. The mean rainfall decreases sharply from October to November and slowly from November to December. The gradients of mean monthly rainfall are maximum over the northeastern and south western parts of Bangladesh during these periods.

3.1.3- Variability of Humidity (%)

3.1.3.1- Monthly and Annual Average of Humidity (%)

Monthly maximum humidity had shown in Table 1 where the highest value 334.97 mm, 379.32 mm and 406.72 mm during June and lowest value 12.74 mm, 4.96 mm and 10.78 mm during December in Jessore, Khulna and Satkhira respectively. Similarly, annual average humidity had shown the highest value 82.33 % during 1998, 82.41 % during 1977 and 82.25 % during 1998 and lowest rise of temperature of 73.58 % during 2000, 75.16 % during 2003 and 72 % during 1987 in Jessore, Khulna and Satkhira respectively.

Table 1- Monthly and Annual Maximum and Minimum Average Temperature (°C), Rainfall (mm) and Humidity (%) in Jessore, Khulna (1969-2012) and Satkhira (1986-2012)

Climatic Parameter	Region and Year	Annual and Monthly Average							
		Maximum		Minimum		Annual Average			
		Month	Highest	Month	Lowest	Year	Highest	Year	Lowest
Temperature (°C)	Jessore (1969-2012)	April	35.2	January	10.3	2010	27.3	2009	21
	Khulna (1969-2012)	April	35.7	January	11.7	2000	27.7	1994	24.4
	Satkhira (1986-2012)	April	35.6	January	11.4	2005	27.4	2009	22.5
Rainfall	Jessore	June	334.97	December	12.74	1970	210.24	1972	829.8

(mm)	(1969-2012)								
	Khulna (1969-2012)	June	379.32	December	4.96	1982	251.18	1992	825.14
	Satkhira (1986-2012)	June	406.72	December	10.78	1990	296	1988	833.4
Humidity (%)	Jessore (1969-2012)	August	88.59	March	70.75	1998	82.33	2000	73.58
	Khulna (1969-2012)	September	89.02	April	73.38	1977	82.41	2003	75.16
	Satkhira (1986-2012)	September	86.53	February	71.35	1998	82.25	1987	72

3.1.4- Regional Average of Climatic Factors

The different regional average of climatic factors in Bangladesh during 1969 to 2012 were shown in Table 4.1. The distribution of temperature (T) of different regions was

$${}^T\text{Khulna} > {}^T\text{Satkhira} > {}^T\text{Jessore}$$

The distribution of rainfall (R) of different regions was

$${}^R\text{Satkhira} > {}^R\text{Khulna} > {}^R\text{Jessore}$$

The distribution of humidity (H) of different regions was

$${}^H\text{Khulna} > {}^H\text{Jessore} > {}^H\text{Satkhira}$$

3.2- Trends of Annual Average Climatic Factors in Jessore, Khulna (1969-2012) and Satkhira (1986-2012)

3.2.1- Trends of Annual Average Temperature (°C)

Figure 1 shows the trends of annual average temperature (°C) was slightly variate from maximum or minimum temperature. Trend values were 0.0074, 0.011 and -0.0109 in Jessore, Khulna and Satkhira. Coefficient determination value (R^2) are 0.006, 0.029 in and 0.0077 found in Jessore, Khulna and Satkhira respectively where Khulna exhibits the highest value and the

curve of annual average temperature shows a slightly increasing trend from 1969 to 2012 at Jessore and Khulna but decreasing trend at Satkhira. From the period 1972 to 1981, there has been a periodic continuous decrease in the amount of temperature at Khulna and Jessore for the years 1988, 1989, 1992 and 1995 although this trend does not sustain further. The highest amount of rainfall has been recorded in the year 2001 at Khulna followed by the year 1973 with its second highest amount. Sharp decreasing temperature trend is recorded during the year 1977 and 2009 at Jessore and 2009 at Satkhira respectively. The temperature trend has an approximately stable trend during the years 1985 to 1988.

3.2.2- Trends of Annual Average Rainfall (mm)

Figure 2 describes the variation of total amount of rainfall annually for the period (1969-2012) at Jessore, Khulna and (1986-2012) at Satkhira. The Figure shows the rainfall variations in the curve gives interesting information. The curve shows a continuous decrease in annual rainfall from 1969 to 2012. From the period 1985 to 1996, there has been a periodic decrease in the amount of rainfall for the years 1970, 1989, 1992, 1993, 2001 and 2007 although this trend does not sustain further. The highest amount of rainfall has been recorded in the year 1991 at Satkhira district followed by the year 1974 and 1982 at Khulna with its second highest amount.

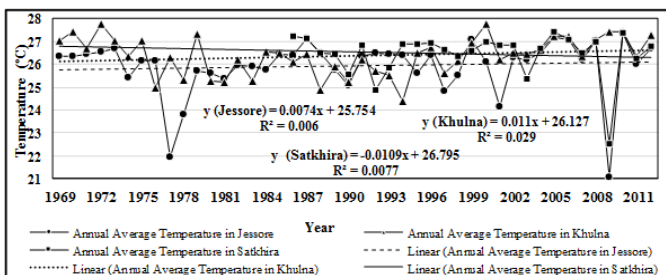


Figure 1- Trends of Annual Average Temperature (°C) in Jessore, Khulna (1969–2012) and Satkhira (1986-2012)

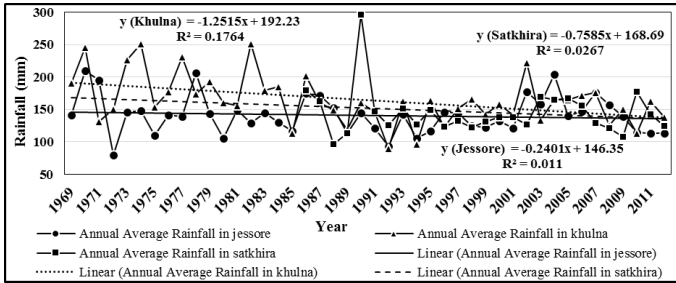


Figure 2- Trends of Annual Average Rainfall (mm) in Jessore, Khulna (1969–2012) and Satkhira (1986–2012)

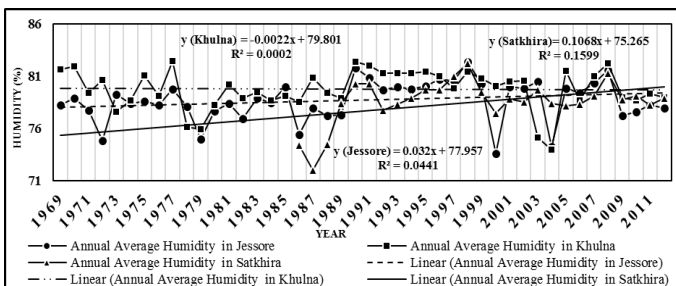


Figure 3- Trends of Annual Average Humidity (%) with 5 years Moving Average in Jessore, Khulna (1969–2012) and Satkhira (1986–2012)

The sharp increase and decrease in rainfall is recorded in the year 1993 followed by the year 1990 with its second highest amount. The sharp increase and decrease in rainfall is recorded during the year from 1969-1989 and 1993-2011 respectively. The rainfall has an approximately stable trend during the years 1990 to 1992. Figure 1 also shows generally decreasing trends of annual average rainfall (mm) vary -0.2401, -1.2515 and of -0.7585 in Jessore, Khulna and Satkhira. On the other hand, Coefficient determination value (R^2) are 0.011, 0.1764 in and 0.0267 found in Jessore, Khulna and Satkhira respectively where Khulna exhibits the highest value.

3.2.3- Trends of Annual Average Humidity (%)

Similarly, the trends of annual average humidity (%) vary 0.032, 0.002 and 0.1068 in Jessore, Khulna and Satkhira. Coefficient determination value (R^2) are 0.0441, 0.0002 and 0.1599 found in Jessore, Khulna and Satkhira respectively where Satkhira exhibits the lowest value at 1987 (Figure 3).

3.3- Anomaly of Annual average Climatic Parameters at Jessore, Khulna and Satkhira districts in Bangladesh during 1969-2012 and 1986-2012

3.3.1- Anomaly of Annual average Temperature ($^{\circ}\text{C}$)

Extremes in air temperature, both hot and cold, were associated with higher levels of human morbidity and mortality than seen within an intermediate or 'comfortable' range of temperatures. Annual average Temperature ($^{\circ}\text{C}$) Anomaly of Jessore, Khulna and Satkhira region had shown a synchronous variability throughout the time series. The Anomalies of Annual average Temperature ($^{\circ}\text{C}$) are -0.0076, -0.0052 and 0.0149 in Jessore, Khulna and Satkhira respectively where satkhira exhibits the highest peak (Figure 4).

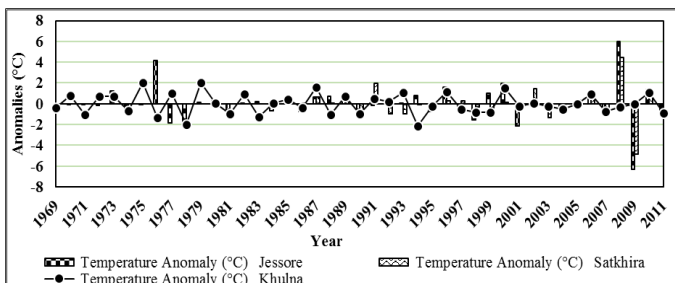


Figure 4- The Anomaly of Annual Average Temperature ($^{\circ}\text{C}$)

3.3.2- Anomaly of Annual Average Rainfall (mm)

Rainfall was liquid precipitation, it was the condensation of atmospheric water vapor into drops of water heavy enough to fall, often making it to the surface. Figure 5 showed the annual average anomaly of Rainfall (mm) are 0.6374, 1.2012 and

2.0077 in Jessore, Khulna and Satkhira respectively where Satkhira exhibits the highest peak.

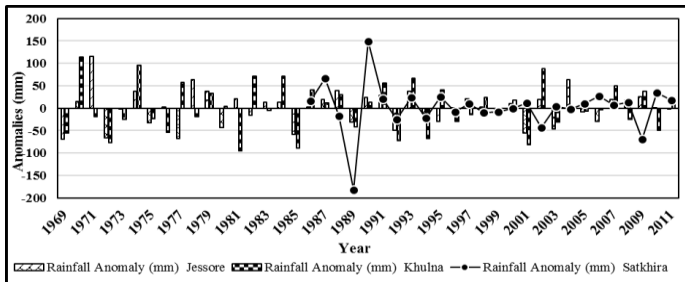


Figure 5- The Anomaly of Annual Average Rainfall (mm)

3.2.3- Anomaly of Annual Average Humidity (%)

Annual average humidity (%) anomaly of Jessore, Khulna and Satkhira region had shown a synchronous variability throughout the time series. Figure 6 showed the annual average anomaly of humidity (%) are 0.0076, 1.0606 and - 1.1667 in Jessore, Khulna and Satkhira respectively where Khulna exhibits the highest peak.

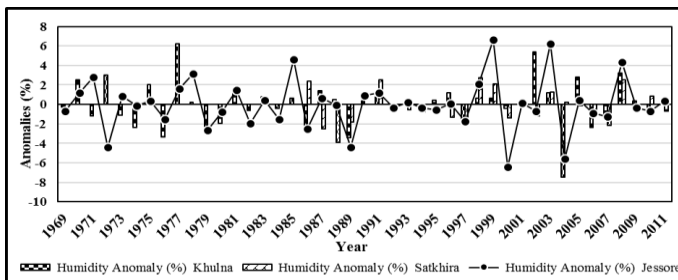


Figure 6- The Anomaly of Annual Average Humidity (%)

Conclusion

The study was based on long-term climatic data, regional climatic scenarios and impact analysis of different aspects of climate change on south west coastal regions. In case of maximum and minimum temperature (°C) was observed decreasing and increasing trend in Satkhira, it was also found

slightly increasing trend in both Jessore and Khulna. In Satkhira the trend of total annual temperature ($^{\circ}\text{C}$) was highly decreased (-0.0109) where as in Khulna and Jessore there was found a slightly increasing (0.011 and 0.0074) trend. Similarly, total annual rainfall (mm) was showing decreasing trend and total annual humidity (%) showing slightly increasing trend in Jessore, Khulna and Satkhira districts. The Anomalies of Annual average temperature ($^{\circ}\text{C}$) were -0.0076, -0.0052 and 0.0149 in Jessore, Khulna and Satkhira respectively where satkhira exhibits the highest peak. Similarly, average anomaly of rainfall (mm) were 0.6374, 1.2012 and 2.0077 in Jessore, Khulna and Satkhira respectively where Satkhira exhibits the highest peak and the annual average anomaly of humidity (%) were 0.0076, 1.0606 and -1.1667 in Jessore, Khulna and Satkhira respectively where Khulna exhibits the highest peak.

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