SPATIO-TEMPORAL CHARACTERISTICS OF RAINFALL AND TEMPERATURE IN BANGLADESH

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ABSTRACT
This study deals with some available rainfall and temperature data for 31 stations of Bangladesh. Data for rainfall and temperature are collected during 1971 to 2012 time periods. Data of number of plantation and industries are also collected from the respective organizations. Annual rainfall, highest maximum and minimum annual temperatures have been analyzed by least square method. From the analysis it is found that, during study period the maximum rainfall occurred at Teknaf. On the other hand, minimum rainfall is found at Rajshahi. In most of the cases, the temperature of northern part is generally higher than the southern part of the country. From present study it has observed that the number of tree plantation was insufficient to reduce climatic degradation in Rajshahi region. Because of increasing the number of industries in Rajshahi, Dhaka, Khulna and Chittagong divisions, climatic parameters changed intensely in the following regions in last 14 years rather than the first and second 14 years which consequences the vulnerable threat to our modern civilization.

Keywords: climatic change; climatic data; least square method; regression equation; contour map

INTRODUCTION
Climate in a narrow sense is usually as the 'average weather', or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time.Climatic variability refers to variations in the mean state and other climate statistics (standard deviations, the occurrences of extremes, etc.) on all temporal and spatial scales beyond those of individual weather events (Ahmed, A.U. 2006). Climate change in Bangladesh is an extremely crucial issue and according to National Geographic, Bangladesh ranks first as the nation most vulnerable to the impacts of climate change in the coming decades. The main objectives of this study are as follows:

i) To study the spatio-temporal characteristics of annual rainfall in Bangladesh.
ii) To study the spatio-temporal characteristics of highest maximum and lowest minimum annual temperature.
iii) To find the effect of plantation and industrialization on different climatic parameters.

METHODOLOGY
Rainfall, temperature (1971-2012) data were divided into three periods, used for different analysis to perform this study at different stations. Less industrialization period is taken as first period (1971-1984), moderate industrialization period is taken as second period (1985-1998) and modern industrialization period is taken as third period (1999-2012). The daily rainfall, temperature (maximum, minimum), data were collected from the Bangladesh Meteorological Department (BMD) at 31 stations of Bangladesh for 42 years (1971-2012).

Plantation data of different years is collected from Barind Multipurpose Development Authority (BMDA) for Rajshahi division. Number of industries of different years is collected from Bangladesh Small & Cottage Industries Corporation (BSCIC) for Rajshahi, Dhaka, Khulna and Chittagong division.

To analysis the data of climatic parameters the least square method has been used where the regression equations show the variations of annual rainfall and temperature with time (Garg, S. K., 1976). This resulting curve is called a regression line of Y on X, since Y is estimated from X.

Mathematically, Y = mX + C (Shamsuddin S. 2009)
where, C = constant, m = slope of regression line of Y on the X to the X axis and is called coefficient of regression of Y on X

ANALYSIS OF DATA

Annual rainfall at different stations has been analyzed from 1971-2012, 1971-1984, 1985-1998 and 1999-2012. There are about 186 graphs of 31 stations. Fig.1, Fig.2, Fig.3, Fig.4, Fig.5, Fig.6 shows the analysis of rainfall and temperature data of Rajshahi station.

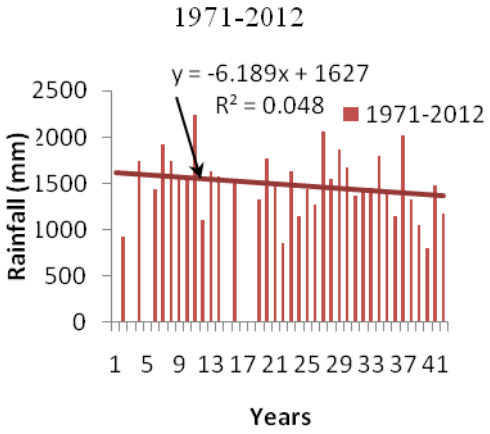

Fig.1: Variation of annual rainfall from 1971-2012 period at Rajshahi

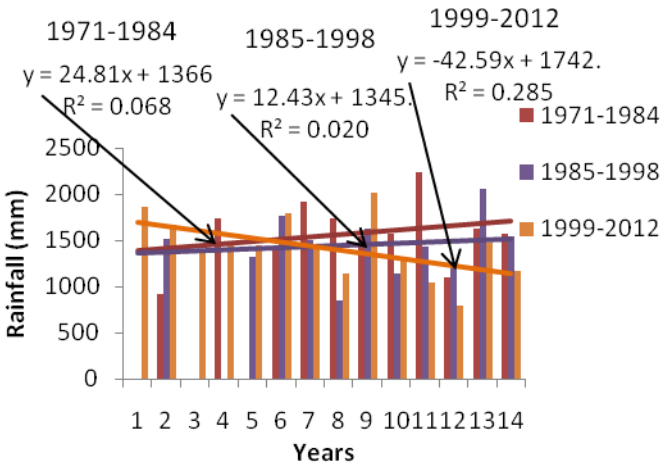

Fig. 2: Variation of annual rainfall from 1971-1984, 1985-1998, 1999-2012 period at Rajshahi

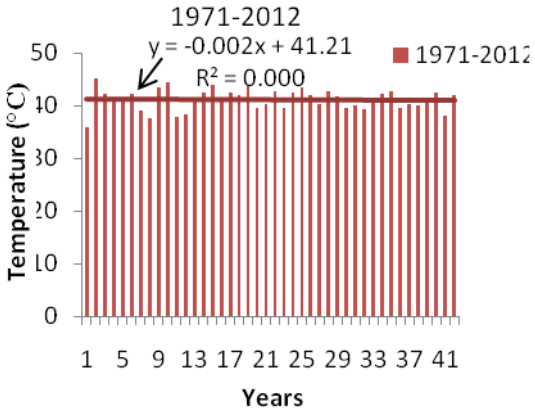

Fig.3: Variation of highest maximum annual temperature from 1971-2012 period at Rajshahi

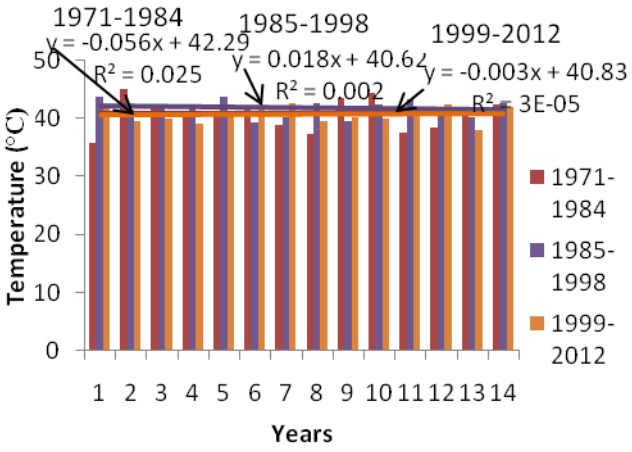

Fig.4: Variation of highest maximum annual temperature from 1971-1984, 1985-1998, 1999-2012 period at Rajshahi

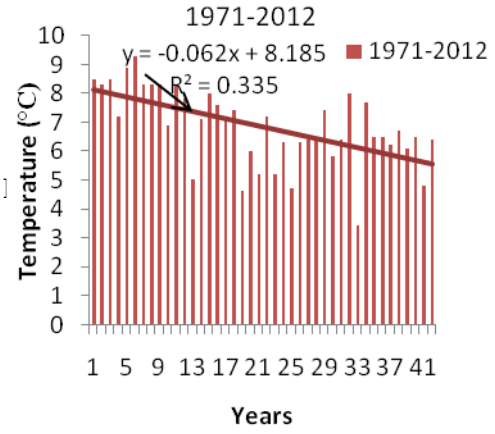

Fig.5: Variation of lowest minimum annual temperature from 1971-2012 period at Rajshahi

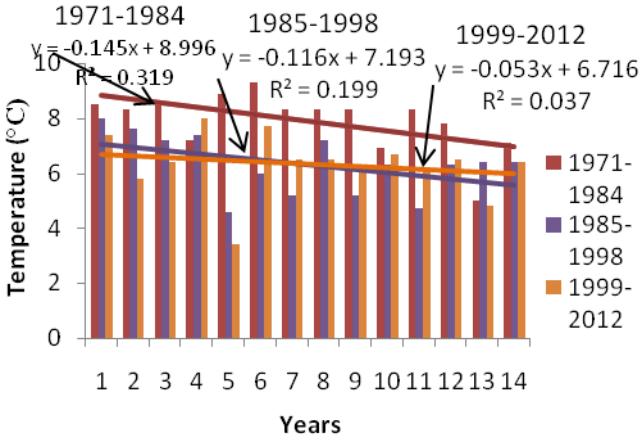

Fig.6: Variation of lowest minimum annual temperature from 1971-1984, 1985-1998, 1999-2012 period at Rajshahi

Fig.7, Fig.8, Fig.9, Fig.10, represents the number of industries of different years of Dhaka, Chittagong, Khulna and Rajshahi divisions.

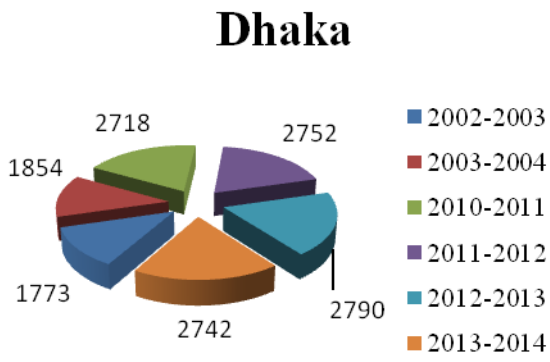

Fig.7 : No. of industries of Dhaka division for different years

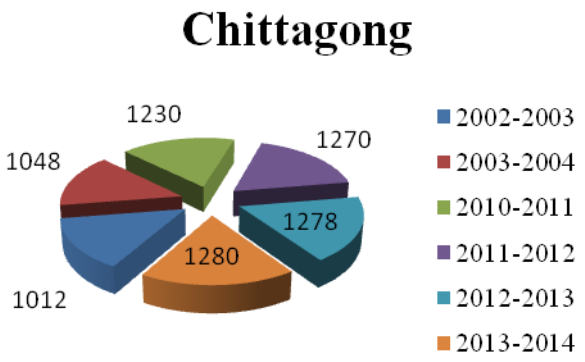

Fig.8 : No. of industries of Chittagong division for different years

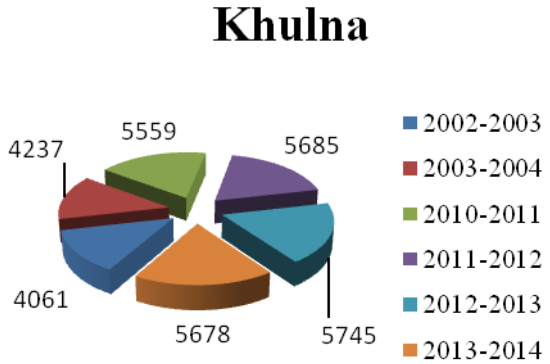

Fig.9 : No. of industries of Khulna division for different years

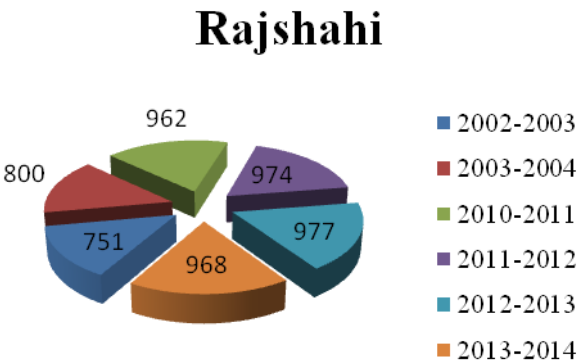

Fig.10 : No. of industries of Rajshahi division for different years

Fig.11, Fig.12, Fig.13 represents the number of existing trees of Rajshahi, Nawabganj and Naogaon regions.

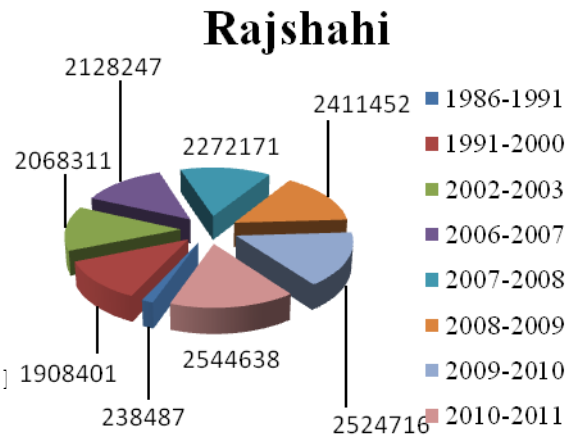

Fig.11: No. of existing trees of Rajshahi region for different years

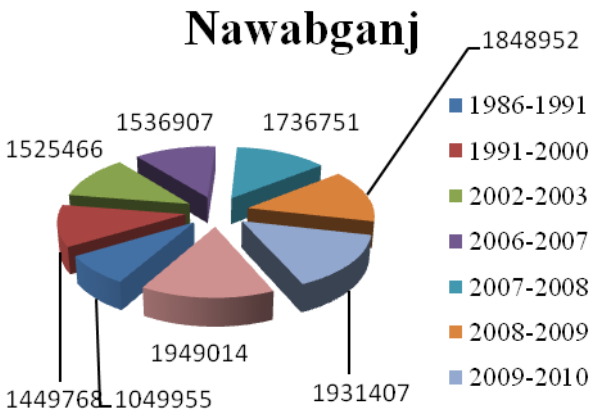

Fig.12 : No. of existing trees of Nawabganj for different years

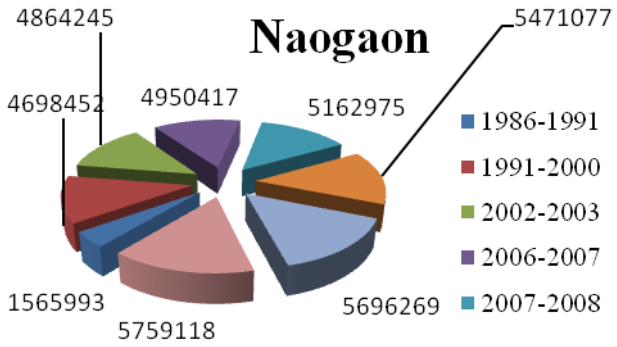

Fig.13 No. of existing trees of Naogaon region for different years

RESULTS & DISCUSSIONS

From the analysis it has been found that among 31 stations for annual rainfall, downward trend at 18 stations, rising trend at 10 stations and nearly constant trend at 3stations. For highest maximum annual temperature downward trend at 12 stations, rising trend at 8 stations and nearly constant trend at 11 stations and for lowest minimum annual temperature downward trend at 16 stations, rising trend at 6 stations and nearly constant trend at 9 stations. From the study it is found that among 31 stations rainfall rate is decreasing in most of the stations. Normally northern part is warmer than the southern part and from the contour map it has found that temperature is increasing from south to north. In the last 14 years number of industries has greatly increased in Bangladesh for this reason it has found from this study that climatic parameters have greatly changed in the last 14 years rather than the first and second 14 years. Table.1, 2, 3, shows the nature of trend of annual rainfall, highest maximum annual temperature and lowest minimum annual temperature of 6 stations among 31 stations for 42 years. It is also found that the trend of annual rainfall is decreasing for 42 years at Rajshahi. Trend of rainfall for first and second 14 years is increasing but for the last 14 years the trend is decreasing. Despite of large plantation the rainfall trend is decreasing. So may be plantation rate is not enough for this region as well as no. of industries has also increased in different divisions. From the total result different maps has drawn to show the overall climatic condition of Bangladesh in terms of rainfall and temperature. Contour maps of these parameters have also drawn (Ahmed, A.U. 2006). Fig, 14, Fig.15, Fig.16, Fig.17, Fig.18 and Fig.19 have represented them.

Table.1 Nature of trend of annual rainfall for 42 years at different stations

Name of stations	Rising Trend			Downward Trend			Nearly constant Trend	Average rate of decrease in Rainfall mm/year	Average rate of increase in Rainfall mm/year
	Start year	Finish year	Diff	Start year	Finish year	Diff			
Rajshahi	-	-	-	1621	1367	254	-	6	-
Bogra	-	-	-	1980	1622	358	-	8.5	-
Dinajpur	-	-	-	2116	1892	224	-	5	-
Rangpur	-	-	-	2801	1889	912	-	22	-
Ishurdi	-	-	-	1755	1346	409	-	10	-
Syedpur	-	-	-	-	-	-	Nearly constant	-	-

Table.2 Nature of trend of highest maximum annual temperature for 42 years at different stations

Name of stations	Rising Trend			Downward Trend			Nearly constant Trend	Mean highest maximum annual temperature
	Start year	Finish year	Diff	Start year	Finish year	Diff		
Rajshahi	-	-	-	-	-	-	Nearly constant	41
Bogra	-	-	-	-	-	-	Nearly constant	39
Dinajpur	-	-	-	-	-	-	Nearly constant	38.9
Rangpur	-	-	-	38.7	36.9	1.8	-	-
Ishurdi	-	-	-	-	-	-	Nearly constant	40.7
Syedpur	-	-	-	-	-	-	Nearly constant	38.3

Table.3 Nature of trend of lowest minimum annual temperature for 42 years at different stations

Name of stations	Rising Trend			Downward Trend			Nearly constant Trend	Mean lowest minimum annual temperature
	Start year	Finish year	Diff	Start year	Finish year	Diff		
Rajshahi	-	-	-	8.1	5.6	2.5	-	-
Bogra	-	-	-	-	-	-	Nearly constant	7.8
Dinajpur	-	-	-	-	-	-	Nearly constant	
Rangpur	-	-	-	-	-	-	Nearly constant	7.5
Ishurdi	-	-	-	7.8	5.5	2.3	-	-
Syedpur	-	-	-	-	-	-	Nearly constant	7.1

Fig. 14 Map of annual rainfall trend at different stations

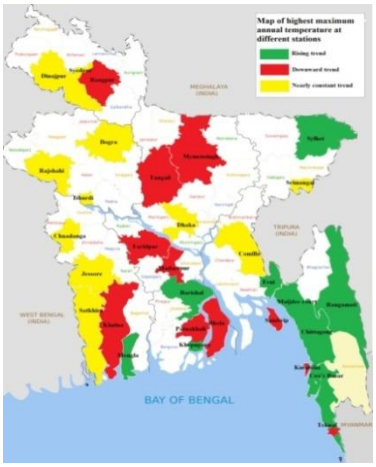

Fig. 15 Map of highest maximum annual temperature at different stations

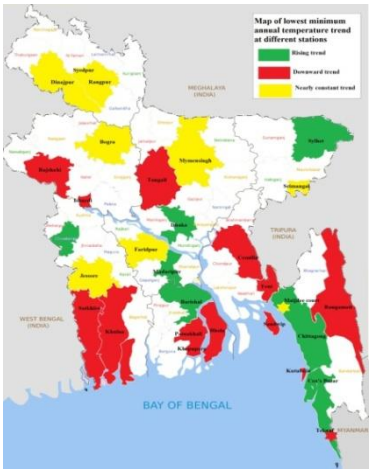

Fig 16 Map of lowest minimum annual temperature at different stations

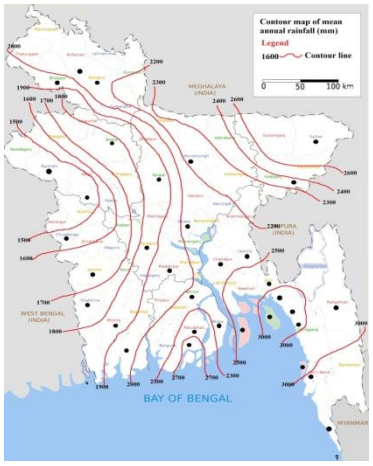

Fig.17. Contour map of mean annual rainfall

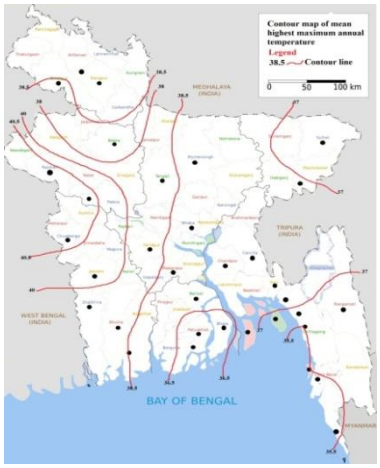

Fig.18. Contour map of mean highest maximum annual temperature

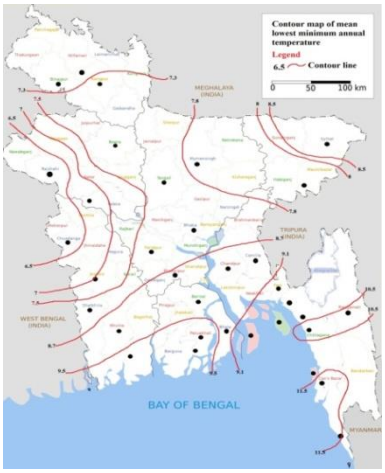

Fig19. Contour map of mean lowest minimum annual temperature

CONCLUSION

Trend of different climatic parameters mainly changed during last 14 years. Average annual rainfall (a.a.r.) varies from 1482 mm at Rajshahi to 4127 mm at Teknaf. The a.a.r. is large in the hilly area i.e. Teknaf, Chittagong, Sylhet, Srimongal and small in the north-western part of the country Highest mean minimum annual temperature varies from 5.9°C at Srimangal to 12°C at Cox's Bazar. Though Rajshahi is not an industrial area, number of industries is increasing day by day. Afforestation of this region seems not to be sufficient. This is one of the reasons of decreasing tendency of rainfall. Decreasing tendency of lowest temperature, increasing tendency of highest temperature have been found in this area. In general, characteristics of different climatic parameters which have impact on climatic degradation have been found in last 14 years period rather than the first and second 14 years periods which may be a vulnerable threat to our modern civilization.

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