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Trend of rainfall and temperature in different regions of Bangladesh during last five decades

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ABSTRACT

Time series of yearly and monthly rainfall, and monthly maximum and minimum temperatures at five stations covering different regions of Bangladesh were investigated for temporal and spatial trends. The study reveals no significant trend in annual rainfall. Significant decreasing trend of monthly rainfall during monsoon (wet season) at two stations and increasing trend during dry season at several stations are observed. Time series of monthly maximum and minimum temperatures appear to follow some trends, showing increase and decrease at two extremes, respectively. Time series of minimum temperature showed inconsistent trends throughout the year and also between stations.

Keywords: Rainfall variability, climate change, monsoon, agricultural practice, Bangladesh

Climate can be one of the biggest risk factors impacting on agricultural systems performance and management. In the long run, climatic change may show up as positive or negative trends in time series. Gradual build up of greenhouse gases is bringing about changes of global climate (IPCC, 2001; Marchand *et al.* , 1988; Gleick, 1987; Droogers, 2004). Due to this, hydrologists are also concerned about trends and shifts in time series of climatic parameters. With a warming trend, it is apprehended that monsoon rainfall may also increase (Marchand *et al.* , 1988; Warrick *et al.* , 1994). Such a likely increase in rainfall will have strategic implications in Bangladesh.

Agricultural practice in Bangladesh has developed over the centuries to accommodate and take advantage of monsoon rainfall. Any change in total rainfall or its pattern will disrupt current agricultural practices and alternate cropping pattern may be needed to accommodate such change. Therefore, it is important to investigate whether there has been any discernible change in the behavior of rainfall. Information on variability of monthly rainfall is required in many areas of water resource management and engineering design, selecting areas for profitable rainfed farming and developing possible means for rainwater harvesting during monsoon season (Schmidt *et al.*, 1997). It may also help in identification

of appropriate crops and cropping sequences that can match the water-availability duration and ensure increased and stabilized crop production (Shanker *et al.* 1992, Chang, 1981, Quadir *et al.* 2003). Irrigation water demands are particularly sensitive to changes in precipitation and temperature (Frederick and Major, 1997).

Recognizing the importance of assessing the behavior and pattern of rainfall and temperature, the main objectives of this study are to investigate the trend of: (i) yearly and monthly total rainfall, (ii) monthly maximum and minimum temperature over different regions of Bangladesh.

MATERIALS AND METHODS

Study area

Five meteorological stations, located in different representative regions (and agro-ecological zones) of the country, were selected for study. The stations were: Mymensingh (24 °43′ N, 90 ° 26′ E, and 19 m above Mean Sea Level (MSL)), Rangpur (25 °45′ N, 89 ° 15′ E, and 34 m above MSL), Rajshahi (24 ° 24′ N, 88 ° 48′ E), Khulna (22 °47′ N, 89 ° 32′ E.) and Chittagong (22 ° 16′ N, 91 ° 0′ E). The region 'Chittagong' is characterized by hilly (mountainous) area, and the region 'Khulna' is close to Bay of Bengal.

The climatic data (monthly maximum/ minimum temperature, and monthly total rainfall) from 1948 to 2001 were collected from Bangladesh Meteorological Department. Trends of yearly rainfall, monthly rainfall, monthly maximum temperature, and monthly minimum temperature were investigated by non-parametric as well regression (slope) method.

A: Non-parametric test

Trends were examined by 'Spearman's Rho' test (Conover, 1980). The advantage of the non-parametric test is that it does not depend on absolute values of data and is equally applicable for linear and non-linear trends. These tests are distribution free, i.e. they do not require any assumption to be made about population following normal or any other distribution. As the test uses relative values, missing data is not a problem.

The test statistic T of 'Spearman's Rho' test is given by:

$$T = \sum_{i=1}^{n} [R(X_i) - R(Y_i)]^2$$

where X_i is the value of rainfall (or temperature) corresponding to the year Y_i, $R(X_i)$ is the rank of rainfall (or temperature) X_i, and $R(Y_i)$ is the rank of the year Y_i. For n greater than 30, the quantiles of T is approximated by (Conover, 1980):

$$w_p \cong \frac{1}{6} n(n^2 - 1) + x_p \frac{1}{6} \frac{n(n^2 - 1)}{\sqrt{n - 1}}$$

where x_p is the pth quantile of a standard normal random variable. Upper quantile was estimated from the equation:

$$w_{1-p} = \frac{1}{3}n(n^2-1) - w_p$$

In all cases, the two tailed test was done at level $\pm = 0.05$.

B: Regression test (Slope test)

Trend was also examined by testing the significance of slope of the linear regression line. For this purpose, climatic variables were plotted (Y-axis) against the relative year values (year rank, i.e. for 1948 to 2001, relative year values are 1 to 54). The slope of the plot represents the trend. The slope was then subjected to *t*-test for significance at 5 % level.

RESULTS AND DISCUSSION

Yearly rainfall trend

From non-parametric test (*Rho*-test), the trend of yearly rainfall is non-significant for all locations. From regression analysis, the slopes of regression line of yearly rainfall (Fig.1) are positive at two locations (Chittagong and Khulna) and negative at other 3 locations (Mymensingh, Rangpur and Rajshahi) but the slopes are not significant.

Monthly rainfall trend

From *Rho*-test, significant decreasing trends are observed at two stations (Mymensingh and Rangpur) during monsoon (June), while increasing trends during dry period (December, February) at three stations (Mymensingh, Rangpur and Khulna). From regression analysis, significant decreasing trends are apparent at two stations (Mymensingh and Rangpur) during monsoon (June), with non-significant trends during December. Significant increasing trend at one station (Chittagong) is observed (Fig.2.), but insignificant in *Rho*-test.

Monthly maximum temperature

From *Rho*-test, significant increasing trends of maximum temperature are observed during mid-monsoon to late monsoon (July - Oct.) at three stations (Khulna, Chittagong and Mymensingh) and significant decreasing trend during winter (Jan.) only at Khulna station. The regression test showed similar significant trends as that of the *Rho*-test. The pattern of slope for Mymensingh location is shown in Fig.3.

Monthly minimum temperature

From *Rho*-test, significant decreasing trends are found during winter (Dec.–Feb.) at several locations. A significant decreasing trend in May at two stations (Khulna and Chittagong), and increasing trend in June at one station (Mymensingh) are also noticed, which are inversely related with the monthly rainfall. A warming (increasing) trend in both maximum and minimum temperature is apparent at Chittagong. Minimum temperature trends are not consistent throughout the year (Fig. 4) and also between stations.

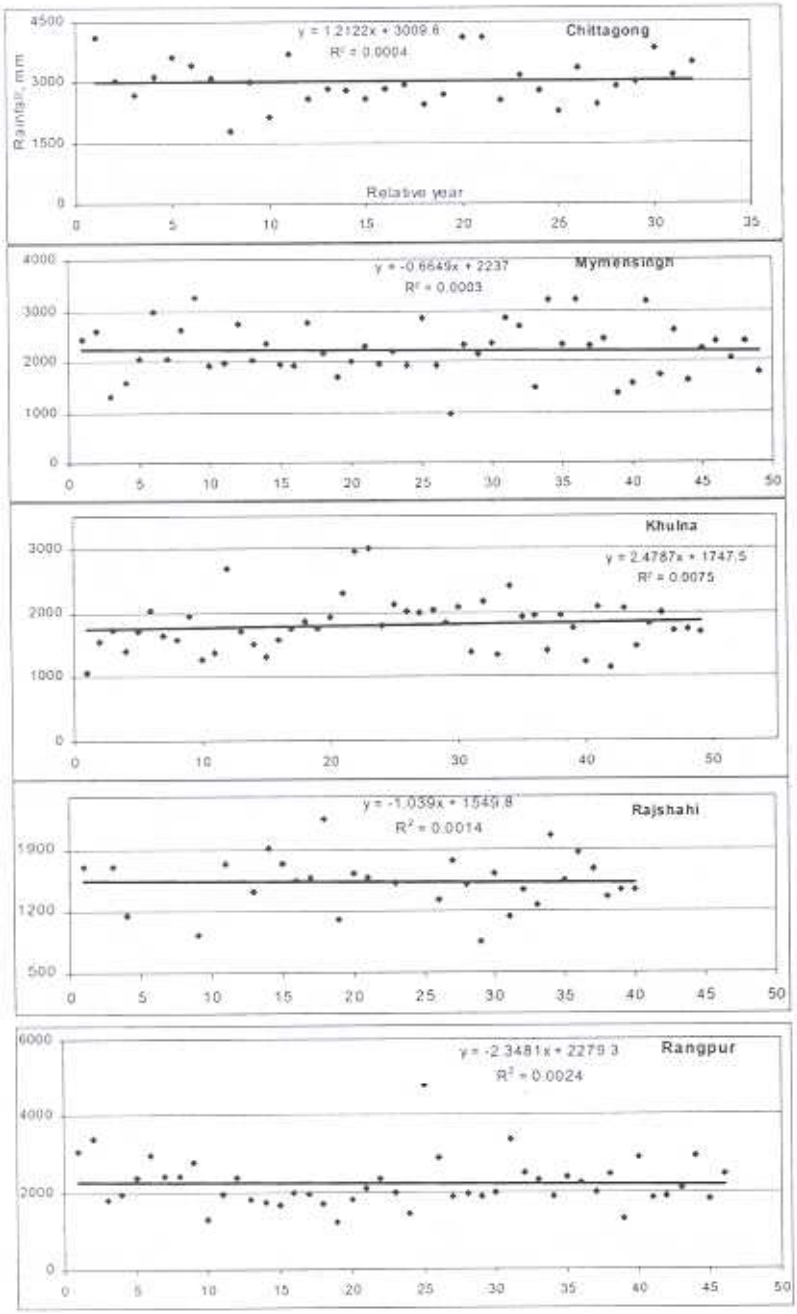

Fig.1: Trend of yearly rainfall of different stations

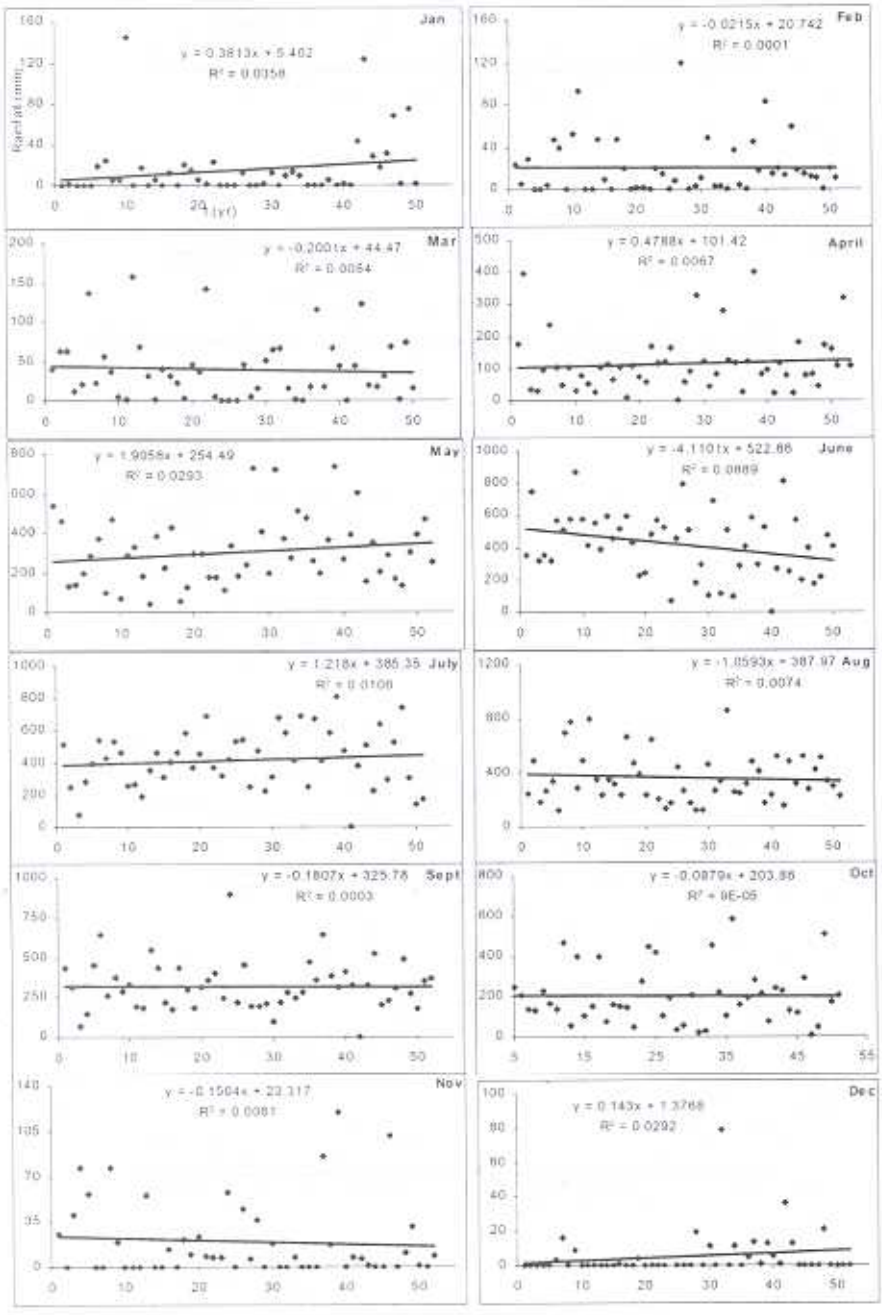

Fig.2 : Trend of monthly rainfall at Mymensingh

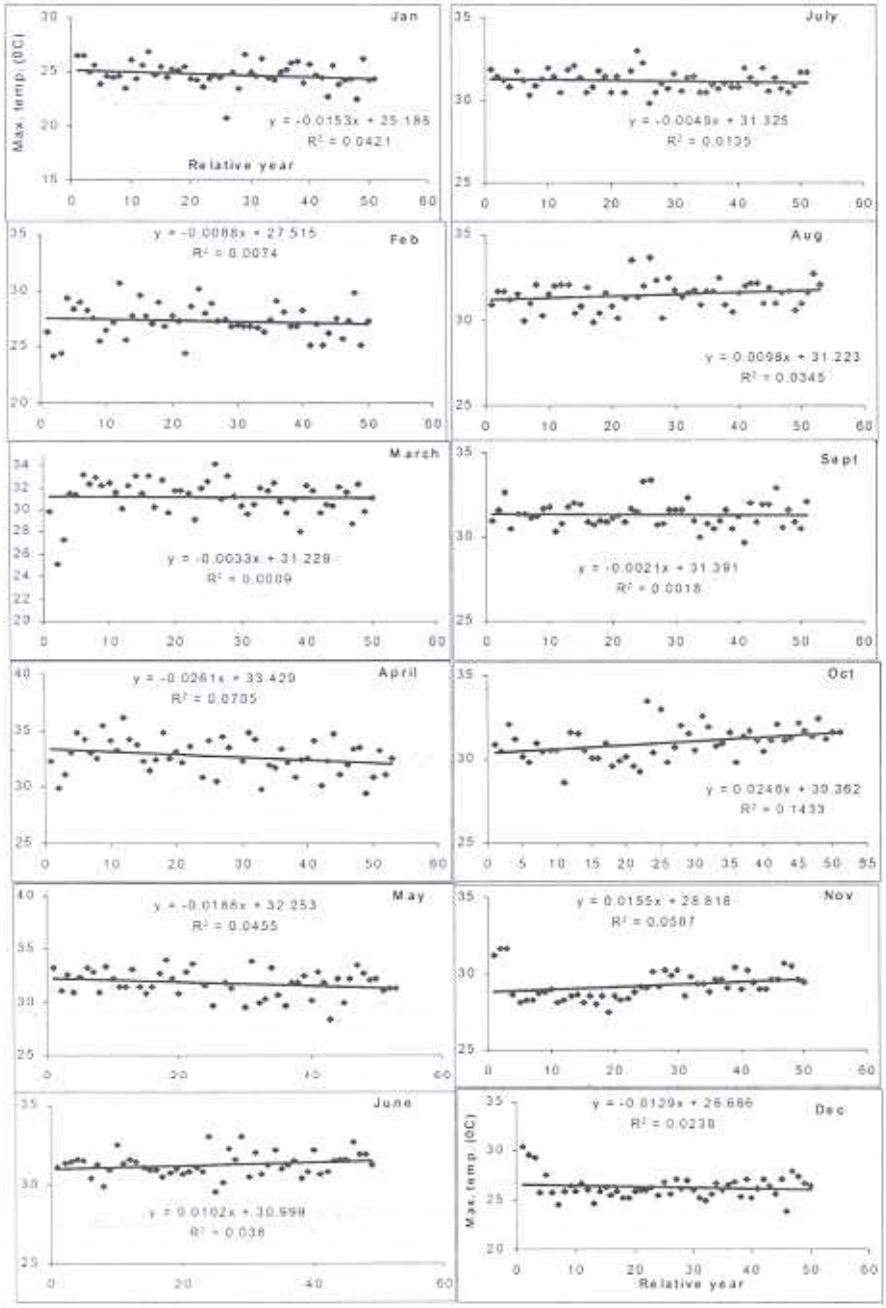

Fig.3: Trend of maximum temperature at Mymensingh

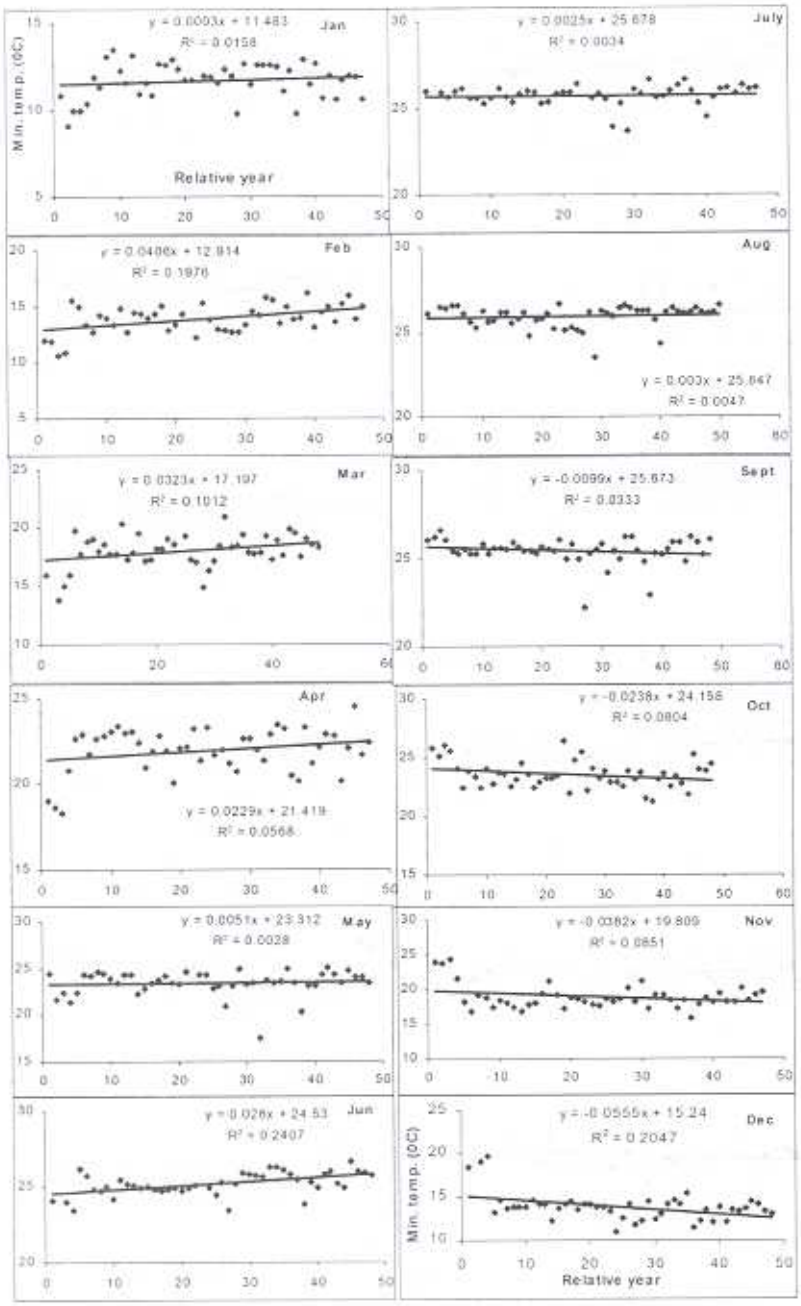

Fig.4 : Trend of minimum temperature at Mymensingh

CONCLUSION

There is no significant trend in yearly rainfall at different locations over 54 years. Monthly rainfall indicates a change in pattern of rainfall, although it is not significant in most cases. Monthly maximum and minimum temperatures show trend in time series, showing warming and cooling at two extremes, respectively. Uncertainties of relating temperature to rainfall are exhibited.

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