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STATISTICAL ANALYSIS OF RAINFALL OF MONSOON SEASON AND ITS VARIABILITY OVER BANGLADESH

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Abstract: This paper investigates the correlation and the coefficient of variation to find variability of rainfall during monsoon over Bangladesh from 1951 to 2000. Twenty nine stations have been considered in six divisions distributed all over Bangladesh in this study. Chittagong and Khulna have experienced the highest and lowest average rainfall respectively during the study period. The high and low stability of rainfall occur in Sylhet and Khulna divisions during the 50 years.

Keywords: Coefficient of variation, correlation, monsoon

Introduction

Climate is the most important phenomenon for life on the earth. It is not constant but changing continuously. Karmakar and Nessa (1997) observed that the mean annual temperature over Bangladesh have shows increasing trend especially after 1961-1970. Climate is one of the major controlling factors for the well being of the inhabitants of this world. Therefore, it is necessary to have concerted effort from all nations to assess the climate change aspects (Karmaker and Shrestha, 2000). On the basis of climate in Bangladesh there are two seasons namely dry season and rainy season. Dry season is termed is as winter and rainy season is divided into 1) pre-monsoon (March to May), 2) monsoon (June to September) and 3) post monsoon (October to November) (Das, 1995). Monsoon season is the most important for rainfall in and around Bangladesh and pre-monsoon and post monsoon seasons are important for severe cyclone formation in the Bay of Bengal (Hussain and Sultana, 1996). The effects of these cyclones are tremendous for Bangladeshi people. It is also observed that Rainfall during monsoon season accounts for 75–80% of the annual rainfall, which ranges from 1200 mm in the west-central part of the country to 3000 mm in the northeast and southeast. The main mechanism of the rainfall in Bangladesh during the summer monsoon season is provided by the tropical depressions, which are known as the monsoon depressions in the Bay of Bengal region. On an average, 4 to 5 such waves enter the Bay of Bengal per month, of which 2 to 3 intensify into monsoon depressions (Ramage, 1971; Barry and Chorley, 1997). Since monsoon season is most important for rainfall in and around Bangladesh, we tried to find out the statistical analysis for monsoon season rainfall and it's variability on the basis of metrological 29 stations all over Bangladesh during the period 1951-2000 i.e.50 years.

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Materials and Methods

Coefficient of Variation (C.V): Coefficient of variations is used in such problem when we want compare the variability two or more series.
Mathematically it is denoted as:

$$C.V = 100 \times \frac{\sigma}{\bar{x}},$$

where $\sigma = \text{standard deviation}$ and

$\bar{x} = \text{mean}$

The series for which the C.V is greater is said to be more variability or less consistent, less uniform or less stable or less homogeneous and on the other hand which C.V is less means just the opposite.

Correlation coefficient: Two variables linear correlation technique has been used in the study. The elementary principles of two variables linear correlation

$$Y_c = a + bX$$

This permitted us to make estimates of the value of the dependent variable from values of the independent variable. Next it was demonstrated that the total variation of the dependent variable was the sum of the explained variation and the variation which we had failed to explain by our hypothesis; that is, $\sum y^2 = \sum y_c^2 + \sum y_s^2$,

here, $\sum y_s{}^2 = \sum Y^2 - \bar{Y}\sum Y; \qquad \sum y_c^2 = \sum Y_c^2 - \bar{Y}\sum Y;$

In which $\sum Y_c^2 = a\sum Y + b\sum XY;$

Or, more simply $\sum y_c^2 = b\sum xy.$

Then the ratio $r^2 = \frac{\sum y_c^2}{\sum y^2}$ known as the coefficient of determination and its square root was called the coefficient of correlation.

t-distribution is used for the significance test-

$$t_{cal} = \frac{r}{\sqrt{\frac{(1-r^2)}{(n-2)}}}.$$

Where *r* is the correlation coefficient, *n* is the number of data and (*n-2*) is the degree of freedom.

Results

Distribution of correlation coefficients of Rainfall between the consecutive different months of monsoon season over Bangladesh:

*May-June***:** From the Fig. 1(a), we observe that the correlation coefficient of rainfall between May and June increases from Dinagpur region towards Jessore region and from Sundarbon to Hatiya. From the analysis data, we see that at Jessore and Hatiya, there is a high positive correlation between May & June which is significant at 99% level. The maximum positive and negative value of the correlation coefficient is observed at Jessore and Madaripur region and the values are 0.5 and -0.18 respectively.

June-July: From the Fig.1(b), the correlation coefficient of rainfall between June and July increases from Sylhet region towards Mymensing and Ishwardi region to west region. From the distribution pattern, we observe that at Rajshahi, Sylhet, Dhaka, Barisal, Khepupara, M.Court, Feni, Sandwaip and Madripur region the correlation coefficient is negative. From the analysis, we can say that there is negative correlation between June and July which is significant at 99% level.

*July-August***:** From the Fig.1(c), the correlation coefficient of average rainfall between July and August increases from north side of the country at Rangpur towards Jessore, Khepupara

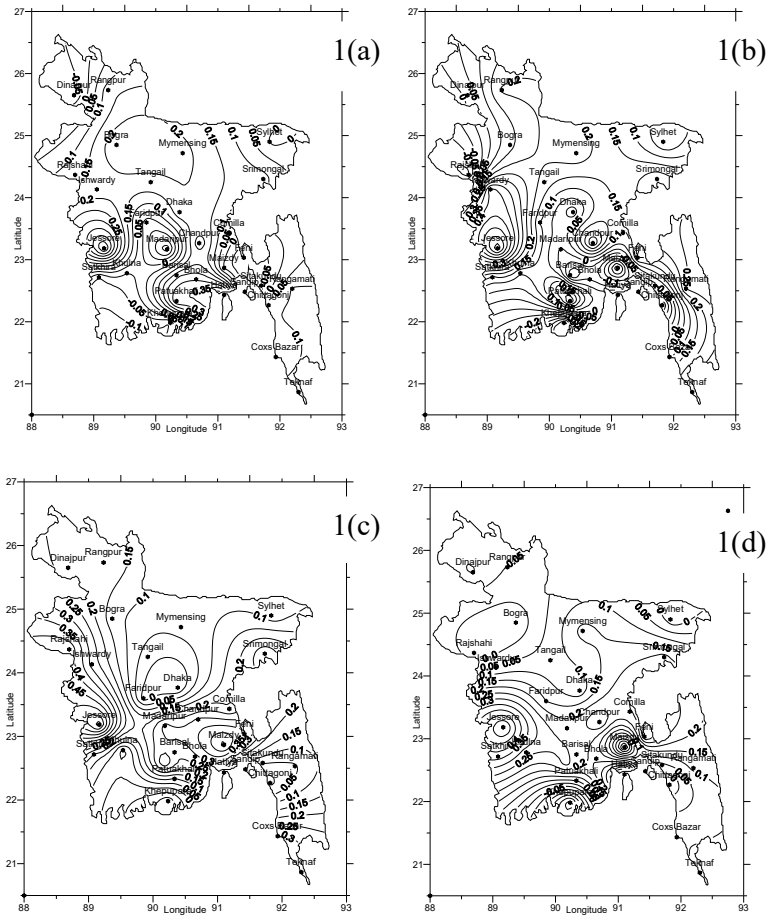

Fig. 1. Correlation coefficient of monthly mean rainfall of May with that of June (a), June with that of July (b), July with that of August (c) and August with that of September(d) using the data for the period 1951-2000 all over Bangladesh.

region to Feni region and also increases from Chittagong region to Teknaf region. From the analysis, we can say that the correlation coefficient is maximum positive of the country is observed at Rajshahi, Jessore and M.Court and which is significant at 99% level. The maximum positive and negative value of the CC is observed at Jessore and Khepupara region and the values are 0.6 and -0.14 respectively.

*August-September***:** From the Fig.1(d), the correlation coefficient of rainfall between August and September increases from Ishwardi region towards Jessore and from Cox's Bazar to Maizdy region. From the distribution pattern we observe that at Bogra, Rajshahi, Sylhet, Khepupara, M.Court, Sandwaip and Chittagong region the correlation coefficient is negative, there is negative correlation between August and September. The maximum positive and negative value of the correlation coefficient is observed at Hatiya and Khepupara region and the values are 0.6 and -0.33 respectively.

Discussion

Statistical analysis of the rainfall for the month of June from 1951-2000 over Bangladesh: The statistical analysis of the rainfall for the month of June is observed that Teknaf has the highest average of rainfall 955.46 mm. The highest and lowest C.V was observed at Jessore and Sylhet and the values were 140.40% and 33.00% respectively, *i.e*., the frequency of occurrence at Jessore has more variability and at Sylhet has less variability.

Statistical analysis of the rainfall for the month of July from 1951-2000 over Bangladesh: The statistical analysis of the rainfall for the month of July is observed that Teknaf has the highest mean rainfall 987.96 mm. The highest and lowest C.V was observed at Jessore and Madaripur and the value were 145.10% and 32.80% respectively *i.e*., the frequency of rainfall occurrence at Jessore has the more variability *i.e*., less consistency and at Madaripur has more consistency than other stations of Bangladesh.

Statistical analysis of the rainfall for the month of August from 1951-2000 over Bangladesh: The Statistical analysis of the rainfall for the month of August is obtained that the highest mean rainfall is 898.92 mm in Teknaf and the next highest mean is 698.86 mm in Cox's Bazar. The highest and lowest C.V was observed at Chandpur and Sylhet and the value were 132.30% and 33.00% respectively *i.e*., the frequency of rainfall occurrence at Chandpur has the more variability *i.e*., less consistency and at Sylhet has opposite.

Statistical analysis of the rainfall for the month of September from 1951-2000 over Bangladesh: The statistical analysis of the rainfall for the month of September from 1951-2000 is observed that Sylhet has the highest average of rainfall 512.45 mm. The highest and lowest C.V was observed at Chandpur and Rangamati and the values were 183.40% and 38.30% respectively, *i.e*., the frequency of occurrence at Chandpur has less consistency and at Rangamati more consistency.

The statistical analysis of the rainfall for the month of June of monsoon season of different divisions over Bangladesh during 1951-2000: Sylhet (618.41 mm), Chittagong (576.73 mm), Barisal (447.37 mm), Dhaka (365.76 mm), Rajshahi (332.58 mm) and Khulna (217.25 mm).

From the data analysis, it is observed that Sylhet division was the highest mean rainfall (618.41 mm) and Khulna division was the lowest mean rainfall (217.25 mm). The highest and lowest C.V were observed at Khulna and Sylhet division and the values were 81.33% and 43.95% *i.e.,* the frequency of occurrence of rainfall at the division of Khulna was more variability, *i.e*., less consistency and the Sylhet division has the opposite of Khulna.

The statistical analysis of the rainfall for the month of July of monsoon season of different divisions over Bangladesh during 1951-2000: Chittagong (669.58 mm), Sylhet (555.84 mm), Barisal (460.63 mm), Dhaka (370.32 mm), Rajshahi (368.57 mm) and Khulna (237.43 mm).

Chittagong division shows the maximum mean rainfall of 669.58 mm and Khulna division shown the lowest mean rainfall (237.43 mm). The max and min C.V were observed at Khulna division and Rajshahi and the values are 82.70% and 48.72 % *i.e.,* the frequency of occurrence of rainfall at Khulna division has high variability, *i.e*., low stable and the Rajshahi division has the opposite Khulna.

The statistical analysis of the rainfall for the month of August of monsoon season of different divisions over Bangladesh during 1951-2000: Chittagong (537.52 mm), Sylhet (468.46 mm), Barisal (412.05 mm), Dhaka (306.00 mm), Rajshahi (303.66 mm) and Khulna (226.29 mm).

It is observed that Chittagong division experienced the highest average rainfall of 537.52 mm and Khulna division experienced the lowest mean rainfall. The difference between mean and median was shown at Khulna division. The highest and lowest C.V were observed at the division of Khulna and Sylhet and the values were 64.80% and 38.90% *i.e.,* the frequency of occurrence of rainfall at the division of Khulna has more variability, *i.e.,* less uniformity and the Sylhet division has the less variability, *i.e.,* high uniformity.

The statistical analysis of the rainfall for the month of September of monsoon season of different divisions over Bangladesh during 1951-2000: Sylhet (380.79 mm), Chittagong (307.12 mm), Barisal (305.13 mm), Rajshahi (267.91 mm), Dhaka (256.05 mm) and Khulna (222.61 mm).

We observed that Sylhet division hold the highest average rainfall of 380.79mm and Khulna hold the lowest mean rainfall of 222.61 mm. The highest and lowest C.V were observed at the division of Khulna and Sylhet and the values are 75.60% and 48.70% respectively *i.e.,* the frequency of occurrence of rainfall at the division of Khulna was more variability, *i.e*., less consistency and the Sylhet division was the opposite.

Statistical analysis of average rainfall of the monsoon season from 1951-2000 over Bangladesh: The average rainfall all over the monsoon season, we observed that Chittagong division has the highest average rainfall from 1951-2000 over Bangladesh. And the Sylhet division has the next value. Again Khulna division has the lowest rainfall all over the monsoon season from 1951-2000. Khulna division has the highest C.V and Sylhet division has the lowest C.V among the six divisions of Bangladesh all over the monsoon season from 1951-2000. So we can comment that the frequency of occurrence at Khulna division has more variability, *i.e*., less consistency and at Sylhet division has the opposite than other division of Bangladesh.

Conclusion

High degree correlation coefficients of rainfall between all the study months are seen at Jessore. Over the study period 1951-2000, *i.e.*, 50 years, for June, July, August and September, Sylhet and Cox's Bazar showed highest average rainfall respectively. Khulna has shown lowest average rainfall in this period for all consecutive months. The highest and lowest average rainfall has shown in Chittagong and Khulna division respectively for all over the monsoon season from 1951-2000, *i.e*., for 50 years. For the study periods, *i.e*., 1951-2000, the highest to lowest C.V's sequence according to divisions is as Khulna, Rajshahi, Chittagong, Dhaka, Barisal and Sylhet, *i.e*., Sylhet has shown the more stability of rainfall.

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