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TREND ANALYSIS AND SPATIAL DISTRIBUTION OF MONSOON PRECIPITATION OVER BANGLADESH DURING 1951-2012

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ABSTRACT

In this study monthly rainfall data for 12 stations over Bangladesh for the period 1951-2012 are used to investigate and understand the inter-annual variability of the summer monsoon rainfall. Monthly, seasonal, and annual spatial rainfall patterns, and the spatial patterns of variability, are presented. Rainfall was found decreasing in the months of June, July and August but it was increasing in September. The trend of the country averaged monsoon rainfall was slightly decreasing during this period. Large spatial variation of the rate of change of monsoon rainfall was found over Bangladesh. The analysis of the decadal mean monsoon rainfall shows that the decades 1951-1960, 1961-1970 and 1981-1990 were wet i.e. rainfall was above normal and the decades 1971-1980, 1991-2000 and 2001-2010 were dry i.e. rainfall was below normal.

Keywords: *Rainfall trends, Variability, Monsoon*

1. INTRODUCTION

Monsoon, meaning season, is the wind system over Indian sub-continent and adjoining oceanic regions that blows from the southwest in half the year and from the northeast during the other half. The seasonal reversal of the wind direction occurring in May brings copious moisture from the warm waters of the tropical ocean to the Indian continent through southwesterlies. Most of the annual rainfall in Bangladesh occurs from June to September (Figure 1) during what is referred to as the summer monsoon or southwest monsoon. According to Bangladesh Meteorological Department (BMD) more than 71 % of the total annual rainfall (Figure 2) occurs in this season with peak in the month of July. In addition to year-to-year variability, there is also large spatial and intra-seasonal variability of the summer monsoon rainfall in Bangladesh. The primary reason for this variability is that the rainfall is associated either with the oscillation of the monsoon trough over northern India and adjoining Bangladesh or with the monsoon depressions that form over the North Bay and move over land. Tropical depressions and storms form in the Bay of Bengal during the season and generally move northwestwards over India and sometimes cross Bangladesh coasts. Storms, however, do not attain hurricane intensity in this season.

Both home and abroad, a number of studies have been conducted to examine the patterns and trend of rainfall based on daily, monthly, seasonal and yearly rainfall data. Gregory (1956) has examined the Regional variations in the trend of annual rainfall over the British Isles for the period 1881-1950 and he has found that annual rainfall values have fluctuated considerably over the years and also that these fluctuations varied from one part of Britain to another. He has noted the major implications of the regional variations in annual rainfall trends.

Some earlier studies have shown that the rainfall of Bangladesh has been increasing during the recent decades (Ahasan *et al.,* 2010; Karmakar *et al.,* 2000). Rahman *et al.* (1997) used trend analysis to study the changes in monsoon rainfall of Bangladesh and found no significant change.

The study by Nahrin *et al.* (1997) reported the existence of temporal oscillations with timescales of 2-3 years, 4-7 years and around 20 years. The variability of rainfall (>22 mm/day) for summer season has been studied by (Mannan and Karmakar, 2008). An analysis on summer monsoon rainfall over Bangladesh has been done by Ahasan *et al.* (2008). Kripalani *et al.* (1996) found that although the monsoon season rainfall over India and Bangladesh as a whole shows no relationship, the rainfall variations over Bangladesh show a significant relationship with rainfall variations over north-east India. Wahiduzzaman (2012) investigated the variability and trends of summer monsoon rainfall over Bangladesh and its relation with ENSO (El Nino Southern Oscillation). Roy (2013) studied the trend of monsoon rainfall over northeastern part of Bangladesh and found that monsoon rainfall over Sylhet has decreased.

The onset and withdrawal dates of summer monsoon in Bangladesh vary from year to year. The summer monsoon generally begins over southeastern part of Bangladesh by late May or early June and withdraws by the middle of October. A detailed work on onset and withdrawal dates of summer monsoon over Bangladesh has been done by Ahmed and Karmakar (1993). As per their study, the mean

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onset dates of summer monsoon in Bangladesh in the extreme south-eastern coastal part and in the extreme north-western part are 2 June and 15 June respectively.

The present study focuses on the spatial and intra-seasonal variability and trends of summer monsoon rainfall in more details over Bangladesh by using available long period dataset 1951-2012.

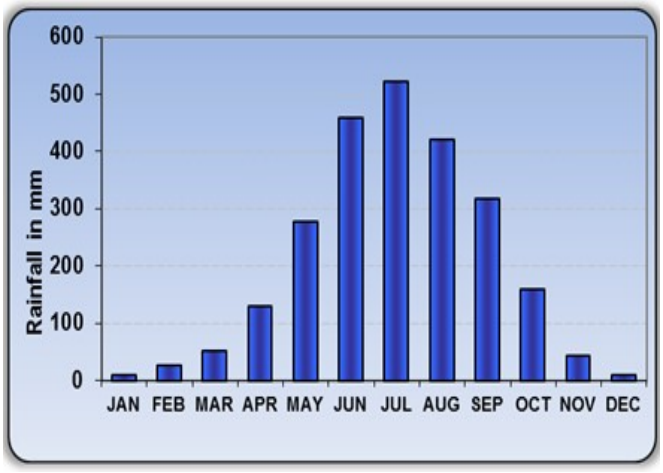

Figure 1: Monthly distribution of rainfall in Bangladesh (source: BMD)

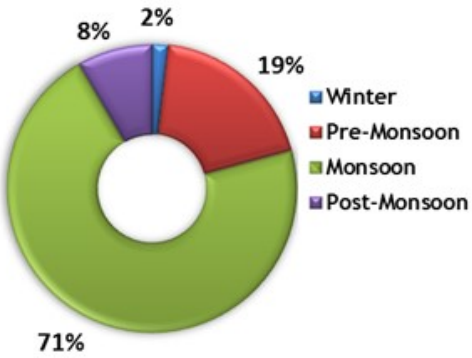

Figure 2: Seasonal Distribution of Rainfall over Bangladesh (source: BMD)

2. DATA USED

In this study the observed daily and monthly rainfall data of 12 selected rain gauge stations (Figure 3) of Bangladesh during the period 1951-2012 (62 years) were collected from the Bangladesh Meteorological Department (BMD). The stations are selected on the basis of availability of maximum data length and data accuracy. There were some missing data that were filled up by 30 years average. For filling up missing data WinSurfer software was used by using Kriging method. The monthly and seasonal rainfall data are constructed on the basis of the daily rainfall data.

In this study for data query Office Access version 10 has been used, for calculation and making graph MS-Excel version 10 has been used. For spatial analysis WinSurfer version 10 has been used.

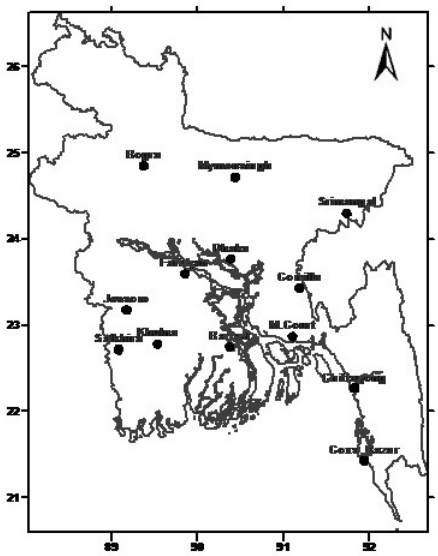

Figure 3: Location of selected rain gauge stations of BMD

3. RESULTS AND DISCUSSION

3.1 Variability and Trends of summer monsoon rainfall

Trend means the general tendency of the data to increase or decrease during a long period of time. Trend analysis of rainfall in the months of June, July, August, September and monsoon season during the period 1951-2012 are shown in figures 4-8 and are discussed in this section.

The trend of rainfall in the months of June, July and August (Figures 4, 5 & 6) are found decreasing but increasing trend found in the month of September (Figure 7). Rainfall is decreasing by 0.16 mm/year, 0.03mm/year and 0.10mm/year in the months of June, July and August respectively. But in the month of September rainfall has increasing trend at the rate of 0.14mm/year.

The time series of monsoon season rainfall over Bangladesh for the period 1951-2012 is presented in Figure 8. The long-term mean of the monsoon season rainfall over Bangladesh for the period 1951-2012 is 1602 mm (about 13 mm/day), and the standard deviation for this period is 206 mm (about 1.7 mm/day) or about 13% of the long-term mean. The time series of mean monsoon season rainfall shows considerable year-to-year variation with quite a few years having substantial above normal and below normal rainfall.

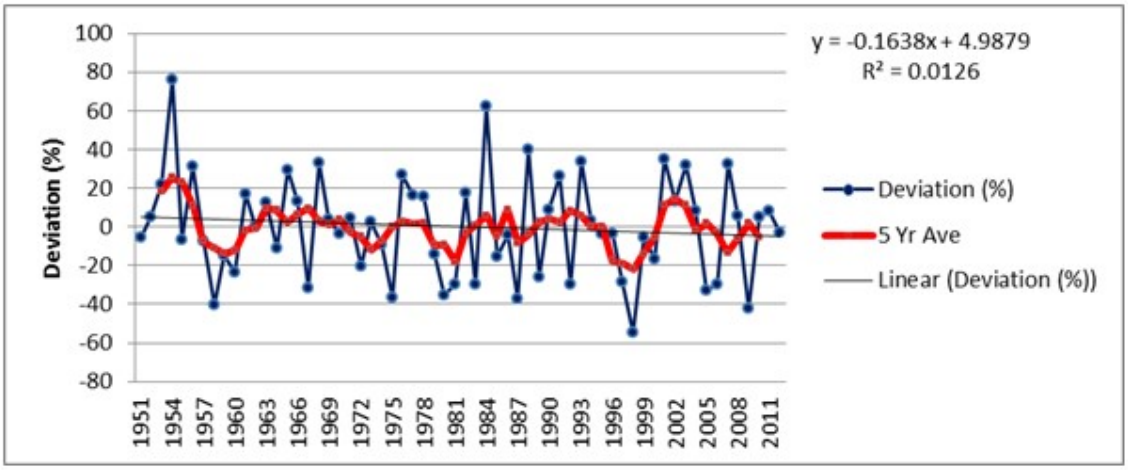

Figure 4: Variability of rainfall and linear trend analysis in June over Bangladesh during the period 1951-2012

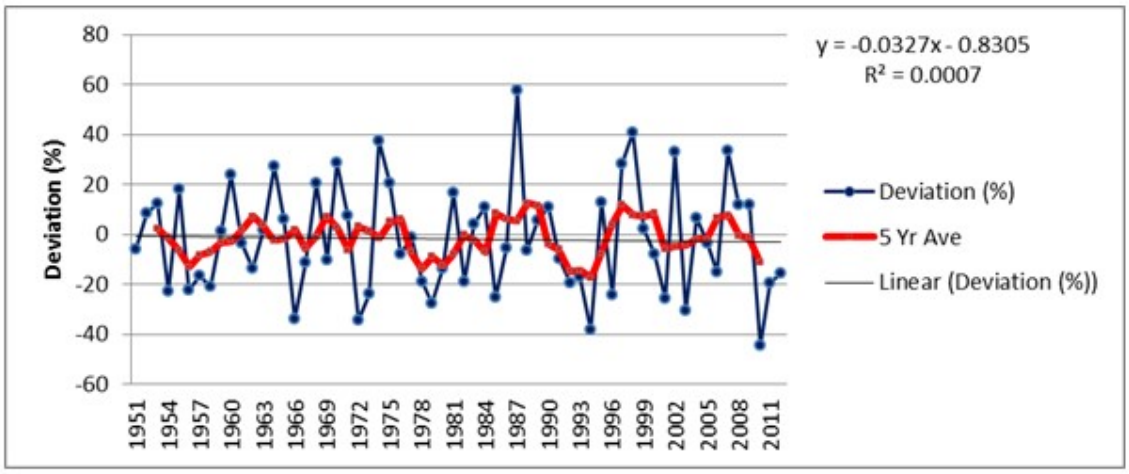

Figure 5: Variability of rainfall and linear trend analysis in July over Bangladesh during the period 1951-2012

One of the most important features of the summer monsoon rainfall is its inter-annual variability. Inter-annual variability of monsoon rainfall was revealed in the inter-annual time series plots of the anomalies of All-Bangladesh monsoon rainfall for the period 1951-2012 as solid narrow line and the 5 year moving average as solid thick line (Figure 8). During the period 1951-2012, there have been 15 occasions when monsoon rainfall was deficient (below -10% of normal rainfall) and 15 occasions when the monsoon rainfall was excess (above

10% of normal rainfall) [Figure 8]. The trend analysis shows that the country averaged monsoon rainfall has slight decreasing trend (-0.057 mm/year).

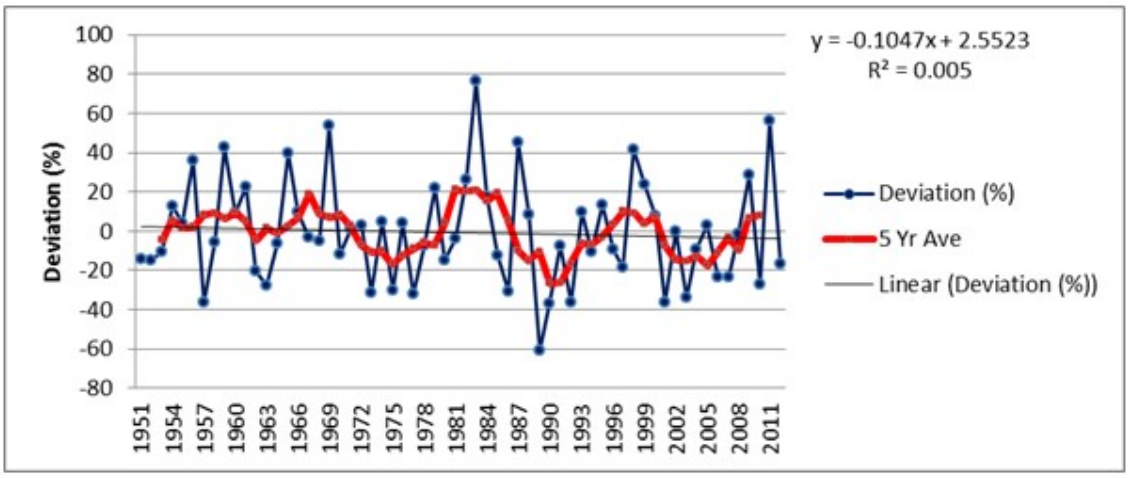

Figure 6: Variability of rainfall and linear trend analysis in August over Bangladesh during the period 1951-2012

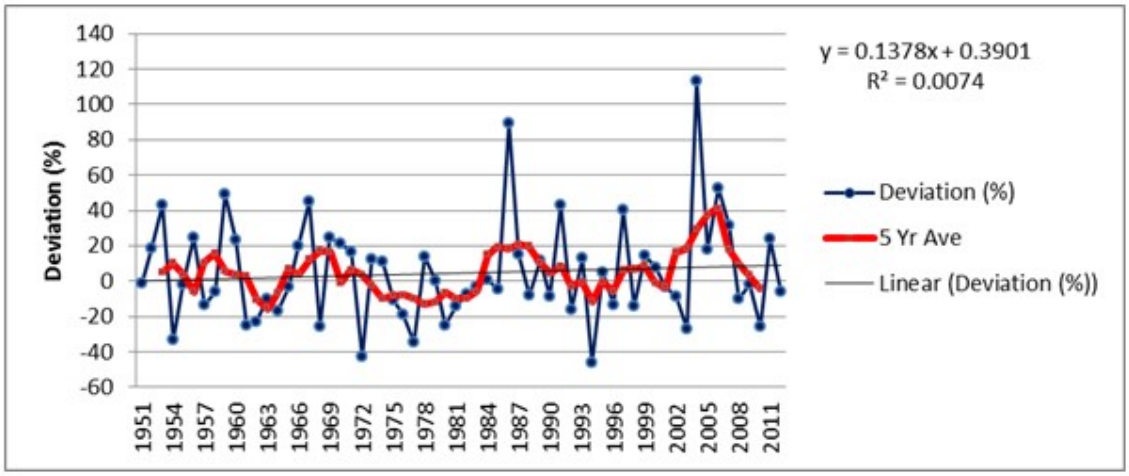

Figure 7: Variability of rainfall and linear trend analysis in September over Bangladesh during the period 1951-2012

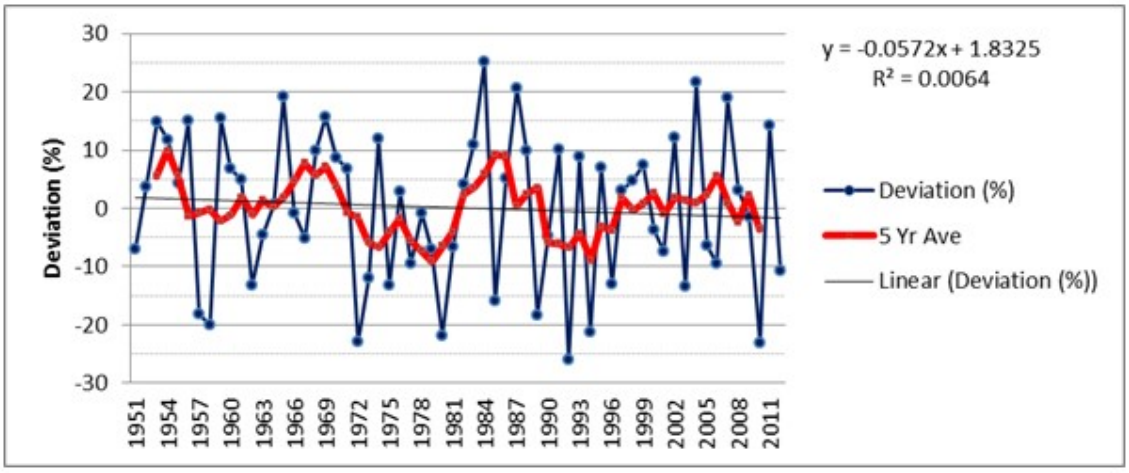

Figure 8: Variability of monsoon rainfall and linear trend analysis over Bangladesh during the period 1951-2012

3.2 Spatial distribution of summer monsoon rainfall

The spatial distribution of the variations of the monsoon rainfall over Bangladesh can be summarized by the map of the standard deviation of the monsoon rainfall anomalies (Figure 9) which shows that Comilla and Khulna region have large variability but Chittagong and Sylhet region have less. There is large spatial variation of rate of change of monsoon rainfall over Bangladesh. The highest decreasing rate of monsoon rainfall during 1951-2012 was found over Comilla region and the decreasing rate was -10.0 mm/year (Figure 10), and the highest increasing rate was found

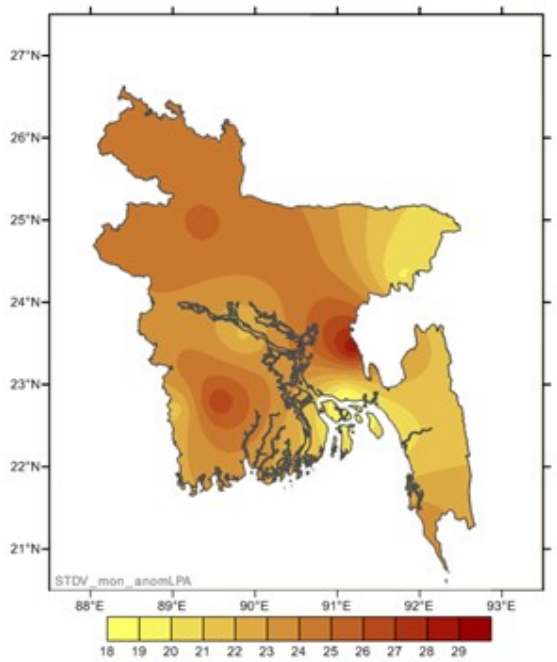

Figure 9: Standard deviation monsoon season rainfall anomalies over Bangladesh during the period 1951-2012

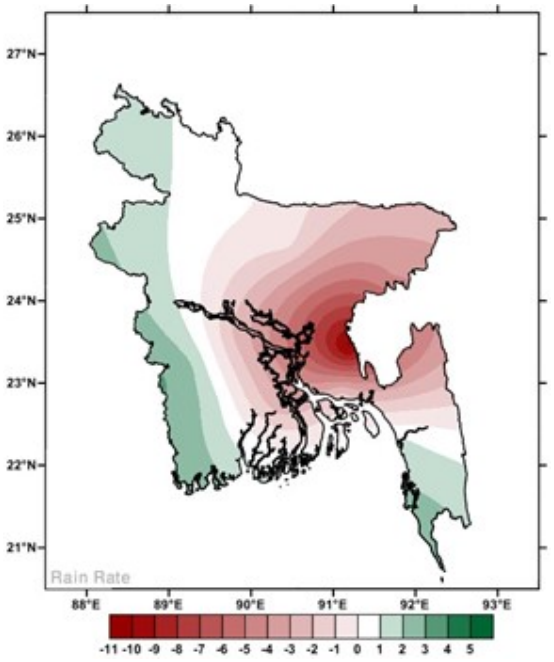

Figure 10: Spatial distribution of linear trend value of monsoon rainfall (mm) over Bangladesh during the period 1951-2012

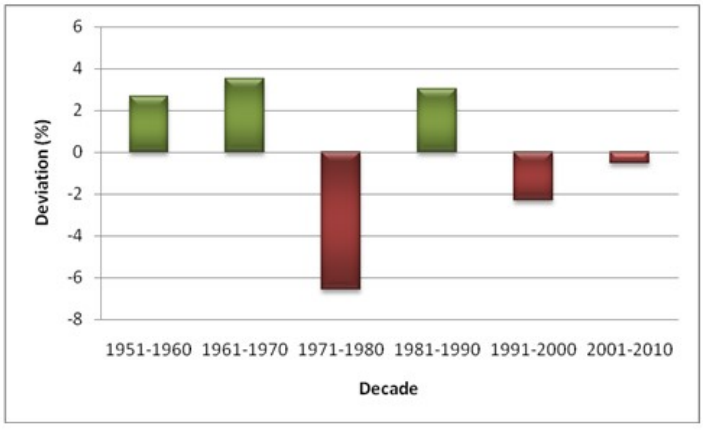

Figure 11: Deviation (%) of decadal mean rainfall

The mean monsoon rainfall over Bangladesh has been calculated for 30 selected stations using the data covering 1961-2010. The spatial distribution of these station-wise monsoon rainfall is high over the northeastern, southern and the southeastern parts; the latter experiences the highest monsoon rainfall (3200-3400 mm). This is due to enhanced activities of cyclonic disturbances and the first frequent impact of monsoon thrust over this region. The Arakan Mountains and the Mizo hills play an important role for increasing rainfall at Teknaf and Cox's Bazar area i.e. southeastern part of the country. The second highest monsoon rainfall occurs in the northeastern part of the country (2400-2600 mm). This is due to the trapping of the moisture laden monsoon

flow in the orographic convergence of the northern and eastern hill slopes. This is interesting to note that Sylhet is situated near Cherapunji of Shillong plateau which is one of the areas of the world with highest rainfall.

3.3 Deviation (%) of anomaly of decadal mean rainfall

The deviation (%) of the decadal mean rainfall from normal (1961-1990) shows that the decades 1951-1960, 1961-1970 and 1981-1990 were wet i.e. rainfall was above normal and the decades 1971-1980, 1991-2000 and 2001-2010 were dry i.e. rainfall was below normal. 1961-1970 decade was the wettest, during this decade rainfall was above normal by 3.5% and 1971-1980 was the driest and during this decade rainfall was below normal by 6.6% (Figure 11). This clearly indicates the multi-decadal scale of variability of the summer monsoon rainfall.

4. CONCLUSIONS

- The long-term mean of the monsoon rainfall over Bangladesh during the period of 1951-2012 is 1602 mm (about 13 mm/day) and the standard deviation for this period is 206 mm (about 1.7 mm/day).
- During the period 1951-2012, there have been 15 occasions when monsoon rainfall was deficient (below -10% of normal rainfall) and 15 occasions when the monsoon rainfall was excess (above 10% of normal rainfall).
- Trend of the country averaged monsoon rainfall has slight decreasing trend at the rate of (-0.057 mm/year). There is decreasing trend of rainfall in the months of June, July and August but it has increasing trend in the month of September. Standard deviation of the monsoon rainfall anomalies indicates large variability at Comilla and Khulna region have large variability but less variability at Chittagong and Sylhet region.
- There is large spatial variation of rate of change of monsoon rainfall over Bangladesh. The highest decreasing rate of rainfall is found over Comilla region and highest increasing rate is found over Khulna region.
- The decades 1961-1970 and 1981-1990 were wet and the decades 1971-1980, 1991-2000 and 2001-2010 were dry.

REFERENCES

Ahasan, M. N., Mannan Chowdhury, M. A., and Quadir, D. A., 2008. Few aspects of the flood disaster caused by heavy rainfall over Bangladesh, Proceedings of SAARC Seminar on Application of Weather and Climate Forecasts in the Socio-economic Development and Disaster Mitigation, 05-07 August, 2007, Dhaka, Bangladesh,79-94

Ahasan, M. N., Mannan Chowdhury, M. A., and Quadir, D. A., 2010. Variability and Trends of Summer Monsoon Rainfall over Bangladesh, Journal of Hydrology and Meteorology, 7, 1, 1-17

Ahmed, R. and Karmakar, S., 1993. Arrival and withdrawal dates of the summer monsoon in Bangladesh. Int. J. Climatol., 13, 727-740.

Gregory, G., 1956. Regional Variations in the Trends of Annual Rainfall Over the British Isles, Geographical Journal, 122, III, 346-353.

Karmakar S., and Shrestha M. L., 2000. Recent Climate Change in Bangladesh, SAARC Meteorological Research Centre (SMRC), Report No. 4. Dhaka.

Kripalani, R. H., inamdar, S., and Sontakke N. A., 1996. Rainfall variability over Bangladesh and Nepal: comparison and connections with features over India. Int. J. Climatol., 16, 689-703

Mannan, M. A., and Karmakar, S., 2008. Proceedings of SAARC Seminar on Application of Weather and Climate Forecasts in the Socio-economic Development and Disaster Mitigation, 05-07 August, 2007, Dhaka, Bangladesh, 95-115

Nahrin, Z., Munim, A. A., Begm, Q. N., and Quadir, D. A., 1997. Studies of periodicities of rainfall over Bangladesh, J. of Remote Sensing and Environment, 1, 43-54.

Rahman MR, Salehin M, Matsumoto J., 1997. Trends of monsoon rainfall pattern in Bangladesh. Bangladesh Journal of Water Resources 14–18: 121–138.

Roy, M., 2013. Time Series, Factors and Impacts Analysis of Rainfall in North-Eastern Part in Bangladesh, International Journal of Scientific and Research Publications, 3, 8.

Wahiduzzaman, Md., 2012. ENSO connection with monsoon rainfall over Bangladesh, Int. Journal of Applied Sciences and Engineering Research, 1, 2, 26-38.