J. Environ. Sci. & Natural Resources, 7(2): 141-149, 2014 ISSN 1999-7361

Analysis of Variability in Rainfall Patterns in Greater Rajshahi Division using GIS

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Abstract

The study entitled 'Analysis of Changes in Rainfall Patterns in Rajshahi Division using GIS' is an experimental climatological research. The main objectives of the study is to examine the long-term changes in rainfall patterns of Rajshahi Division. Secondary data of rainfall distribution have been collected from Bangladesh Meteorological Department (BMD), Dhaka. The study has analysed monthly, seasonal and annual rainfall distribution pattern from 1962 to 2007 of five selected weather stations namely Bogra, Dinajpur, Ishurdi, Rajshahi and Rangpur. For convenience of analysis, the data has been divided into two halves of time period as 1962-1984 and 1985-2007. Based on GIS, the study gifts the spatial analysis of rainfall patten using Thiessen Polygon Method, Isohytal and Hytograph Method and Percentage Method. It has been found that there is evidence of annual rainfall change with an increasing pattern in Bogra, Dinajpur, Rajshahi and Rangpur. In these four stations, the changing pattern in Rangpur is the highest. Downward shift of annual rainfall shows a decreasing pattern in Ishurdi. The descending order of monthly and seasonal rainfall pattern for Ishurdi, Rajshahi and Rangpur has been found as July > June > September >August > October > April > March > February > November > December. Although Bogra and Dinajpur have contained this trend in the same order from July to March, anomalies pattern has been found for last four months. The seasonal variation of rainfall has been established as Monsoon > Pre – Monsoon > Post Monsoon > Winter for all those five stations. Evaluating the rainfall contour lines, it has been found that the rainfall annually varies from 1542.1 mm to 2235.8 mm in Rajshahi Division. The average number of rainy days in this region mostly varies from 86 to 112 days per year.

Key words: GIS, Rainfall, Rajshahi

Introduction

The climate of Rajshahi Division is generally marked with a typically tropical monsoon climate characterized by high temperature, heavy rainfall, often excessive humidity, and fairly marked seasonal variations (Islam and Neelim, 2010). In terms of rainfall, a variation within 10 percent in a year is marked as normal which exhibit a mild economic impact while a variation greater than 10 percent may exhibit an adverse impact to the economy and normal life style of the people (Sivasami, 2000). Likewise other part of the Bangladesh, the economy of Rajshahi Division is also largely dependent on rain-fed agriculture. So, the changes of rainfall pattern may largely impact the agricultural economy of the region. Therefore, it is essential to find out whether there are changes in rainfall patterns or not, so that information can be used for adjusting the planning and management of irrigation project, supplying drinking water, planning of fishery extension department and other water resources related issues and movements. Based on the above mentioned rationale and statement, the study has been conducted with the following specific objectives: 1. Evaluation of long-term changes in rainfall (maximum, minimum and average) at Rajshahi Division; 2. Assessment of annual, seasonal (monsoon, pre-monsoon, post-monsoon, winter, dry season and critical period) and monthly trends of rainfall (maximum, minimum and average) at Rajshahi Division.

Materials and Methods

Secondary data of daily rainfall (in mm) for the time period of 1962-2007 has been collected from five selected weather stations (e.g. Bogra, Dinajpur, Ishurdi, Rajshahi and Rangpur) of Rajshahsi (Figure: 01) which have been being maintained by Bangladesh Meteorological Department (BMD, 2007). For convenience of analysis and to obtain a comparative pattern of rainfall variation, the available rainfall data (1962-2007) have been divided into two halves of time period as 1962-1984 and 1985-2007. Other information, images and base maps have been collected from various sources i.e. books, journals, websites and official records. Quantitative techniques like Mean, Median, Mode, Percentage, Frequency, Standard Deviation (SD), Sample Variance, Kurtosis, Skewness, Range, Sum, Moving Average (5-years) and Co-efficient of variance (COV) have been used in data analysis to obtain a contented tabular & graphical presentation. Thiessen polygon method and Isohyetal Map Method have been adopted for spatial analysis. The results have been presented in the maps by using ArcGIS.

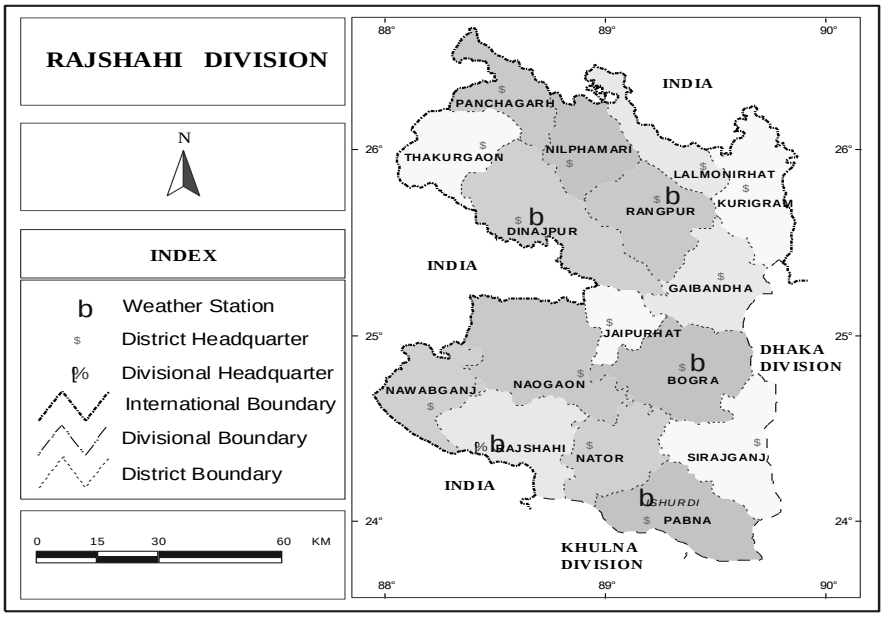

Fig.1. Five selected weather stations of greater Rajshahi Division, Bangladesh

Results and Discussion

Rainfall is the most dominant climatic element. The dry winter monsoon seldom carries any rain bearing clouds in Rajshahi Division. Most of the rainfall occurs in the summer monsoon season. It has been found that there is no typical trend in the rainfall variation in five selective weather stations in study areas. There are also mixed results of upwards and downwards shift in both seasonal and annual rainfall. Seasonal results are based on monthly analysis.

In context of monthly variation, for all of the five weather stations, July is the highest month of rainfall while December is the lowest one. For Ishurdi, Rajshahi and Rangpur the ranking order of highest rainfall months can be described as July > June > September >August > October > April > March > February > November > December (Figure 2, 3 and 4). Although Bogra and Dinajpur have contained this trend in the same order from July to March, anomalies pattern has been found for last four months. For Bogra and Dinajpur the order of highest rainfall month has been established as November > February > December > January and January > February > November > December respectively for the last four months (Figure 5 and 6).

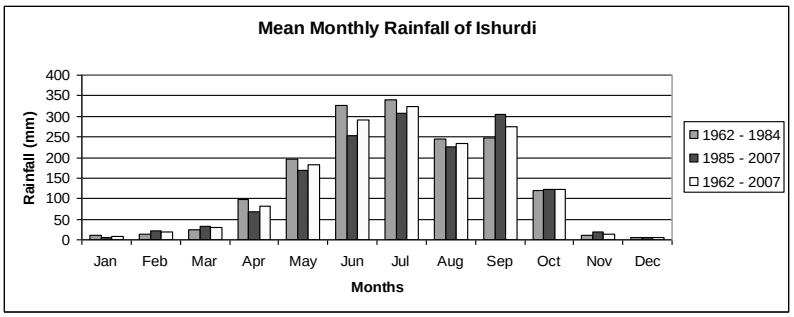

Fig.2. Mean Monthly Rainfall of Ishurdi

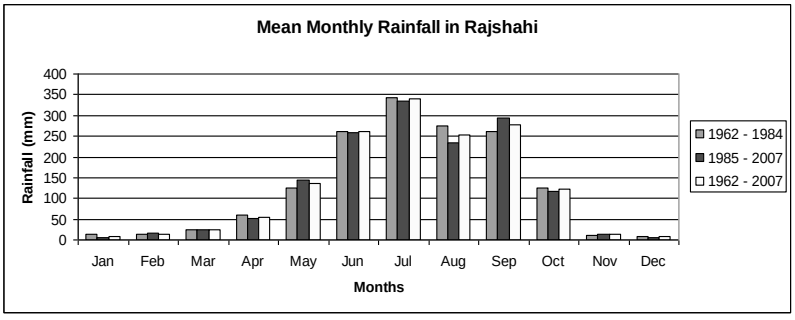

Fig.3. Mean Monthly Rainfall of Rajshahi

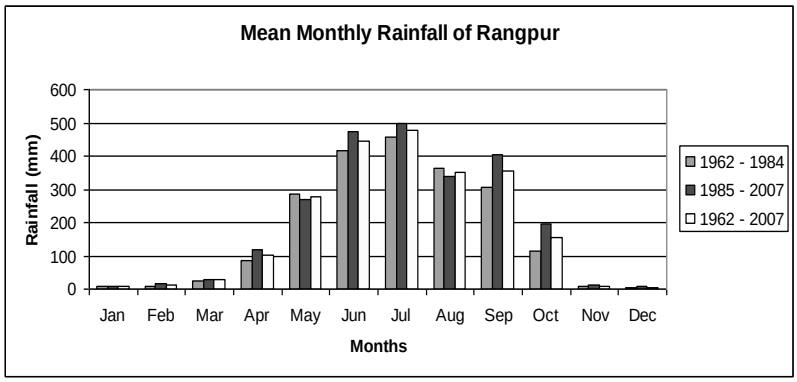

Fig.4. Mean Monthly Rainfall of Rangpur

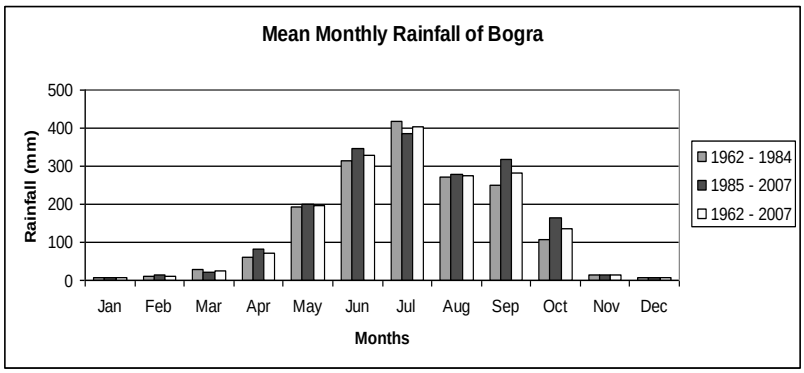

Fig.5. Mean Monthly Rainfall of Bogra

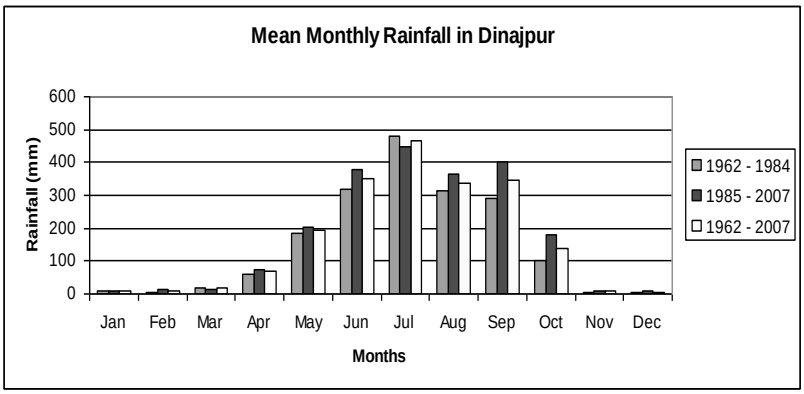

Fig.6. Mean Monthly Rainfall of Dinajpur

Considering seasonal variation for all those five stations, it has been found that monsoon is the highest season of rainfall while dry cool winter is the lowest one. Al most 70% of total rainfall of the year is being participated in the monsoon. Pre monsoon is the second highest season in rainfall occurrence (Figure 7, 8, 9, 10 and 11).

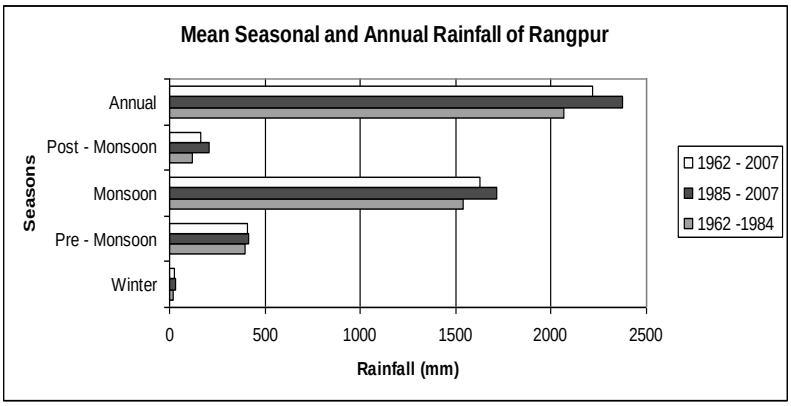

Fig.7. Mean Seasonal and Annual Rainfall (mm) of Rangpur

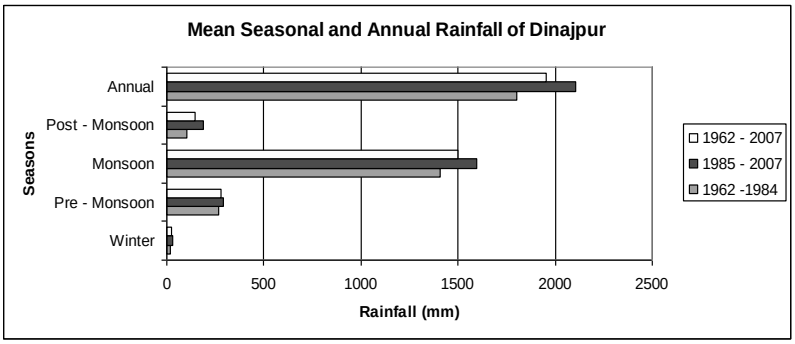

Fig.8. Mean Seasonal and Annual Rainfall (mm) of Dinajpur

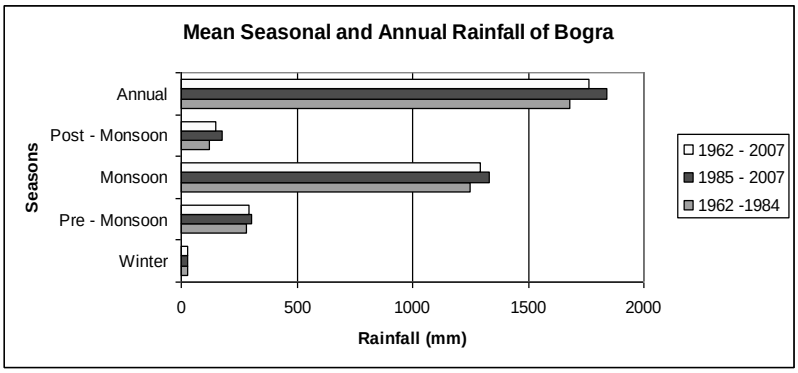

Fig.9. Mean Seasonal and Annual Rainfall (mm) of Bogra

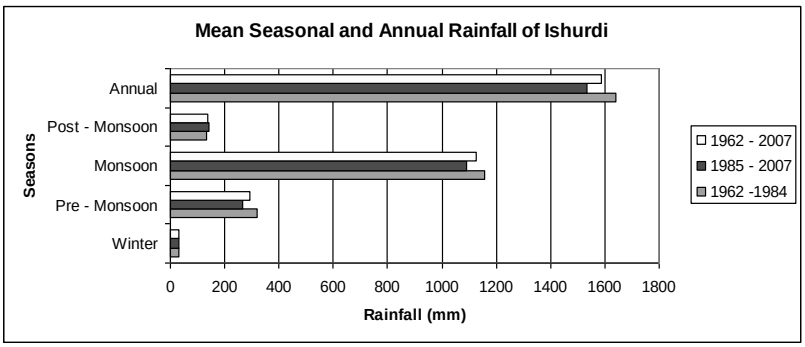

Fig.10. Mean Seasonal and Annual Rainfall (mm) of Ishurdi

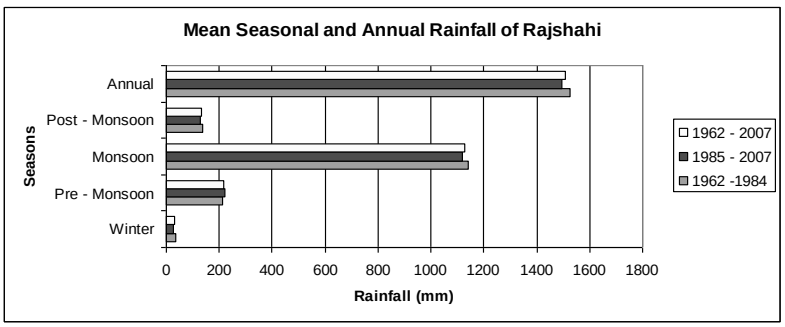

Fig.11. Mean Seasonal and Annual Rainfall (mm) of Rajshahi

Comparing the mean monthly, seasonal and annual rainfall variation between the two halves of time period 1962-1984 and 1985-2007, it has been found an increasing pattern in Rangpur, Dinajpur and Bogra while a decreasing pattern in Ishurdi and Rajshahi. The results have been interpreted by isohyetal maps by GIS (Figure: 12).

Evaluating the rainfall contour lines, it has been found that the rainfall annually varies from 1542.1 mm to 2235.8 mm in Rajshahi (Figure: 12). From July to September, when the monsoon established firmly, its south-eastern river basins of Jamuna, Tista and lower portion of Atrai and

Chalan Beel have been being flooded due to heavy rainfall.

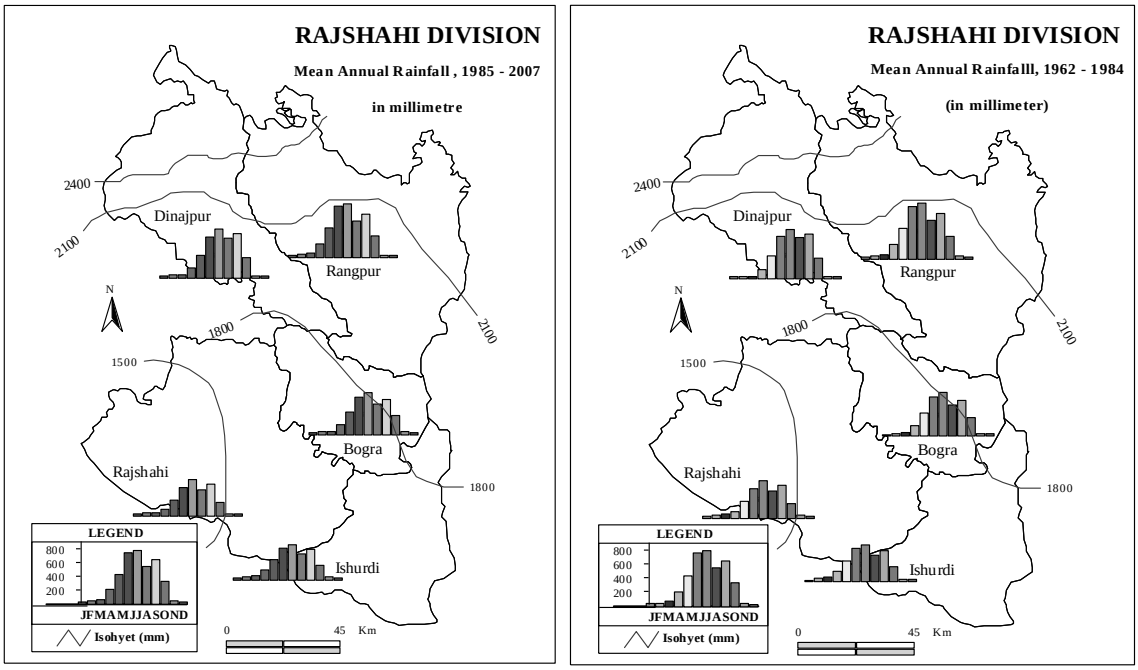

Fig.12. Isohyetal and hytograph map of Rajshahi Division for time series of 1962-1984 and 1985-2007

For both the time period of 1962-1984 and 1985-2007, the order of highest ranking rainy region has been established as Rangpur > Dinajpur > Bogra > Rajshahi > Ishurdi (Figure 13). Rangpur is the rainiest area in this region comprising 7556.2 and 7930.7 sq. km of rain zone within a total area of 34513 sq. km for the time period of 1962-1984 and 1985-2007 respectively. Ishurdi comprises about 5763.6 and 5208.2 sq. km of rain zone for 1962-1984 and 1985-2007 respectively being the lowest rainfall region in the Rajshahi Division.

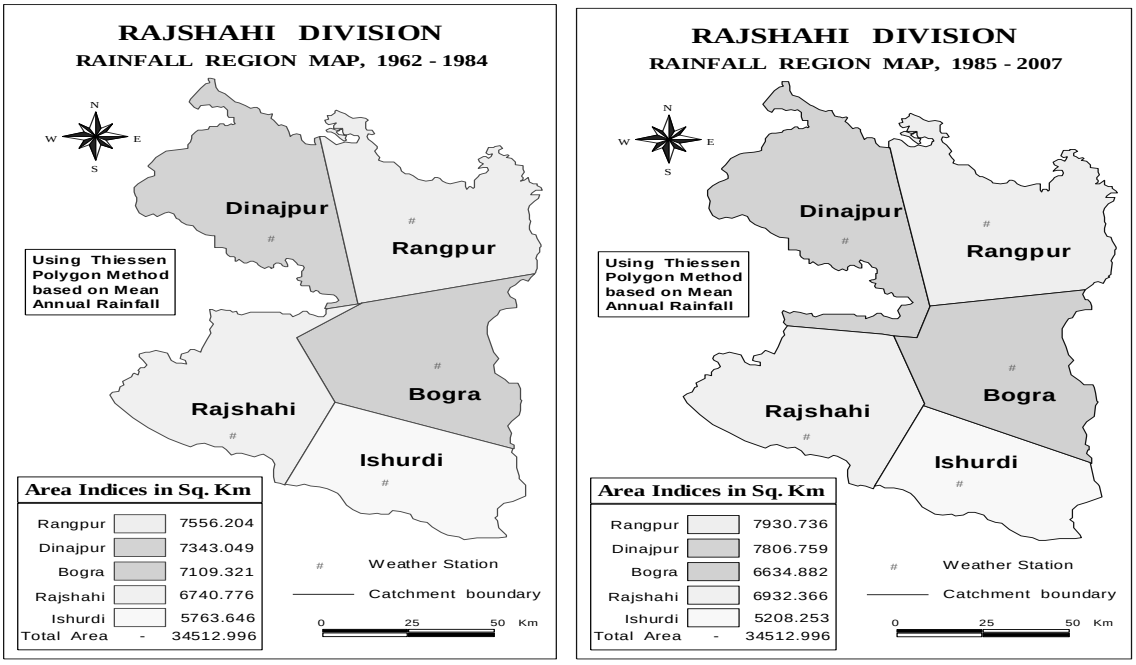

Fig. 13. Rainfall region map of Rajshahi Division for the time period of 1962-1984 and 1985-2007

Two maps of rainfall percentage have also been prepared on the basis of Thiessen Polygon Method. These maps have showed that monsoon is the highest season of rainfall while winter is least one in Rajshahi region. In monsoon it varies from 71% of rainfall in Ishurdi to 78% in Dinajpur for the time period of 1962-1984 while 71% in Ishurdi to 76% in Dinajpur for the time period of 1985-2007. In Bogra, the monsoon rainfall percentage has been decreased from 74% to 72% while its compared between the two halves of time period. A decreasing pattern has

also been established for monsoon rainfall percentage in Rangpur while it varies in a similar manner to Bogra. But the monsoon rainfall percentage has remained same in Rajshahi for both the halves of time period (Figure: 14).

However, in case of pre-monsoon rainfall, it has found an increasing trend for Rajshahi while the rest comprised a decreasing trend between the two halves of time period. Dinajpur, Bogra, Ishurdi and Rangpur has showed an increasing trend of post-monsoon rainfall percentage while Rajshahi comprised a decreasing trend. Therefore, it has been revealed that there is an inverse trend of pre and post monsoon rainfall percentage in Rajshahi Division. However, the winter rainfall percentage has remained almost same for the entire division comprising no variation between the two halves of time period (Figure 14).

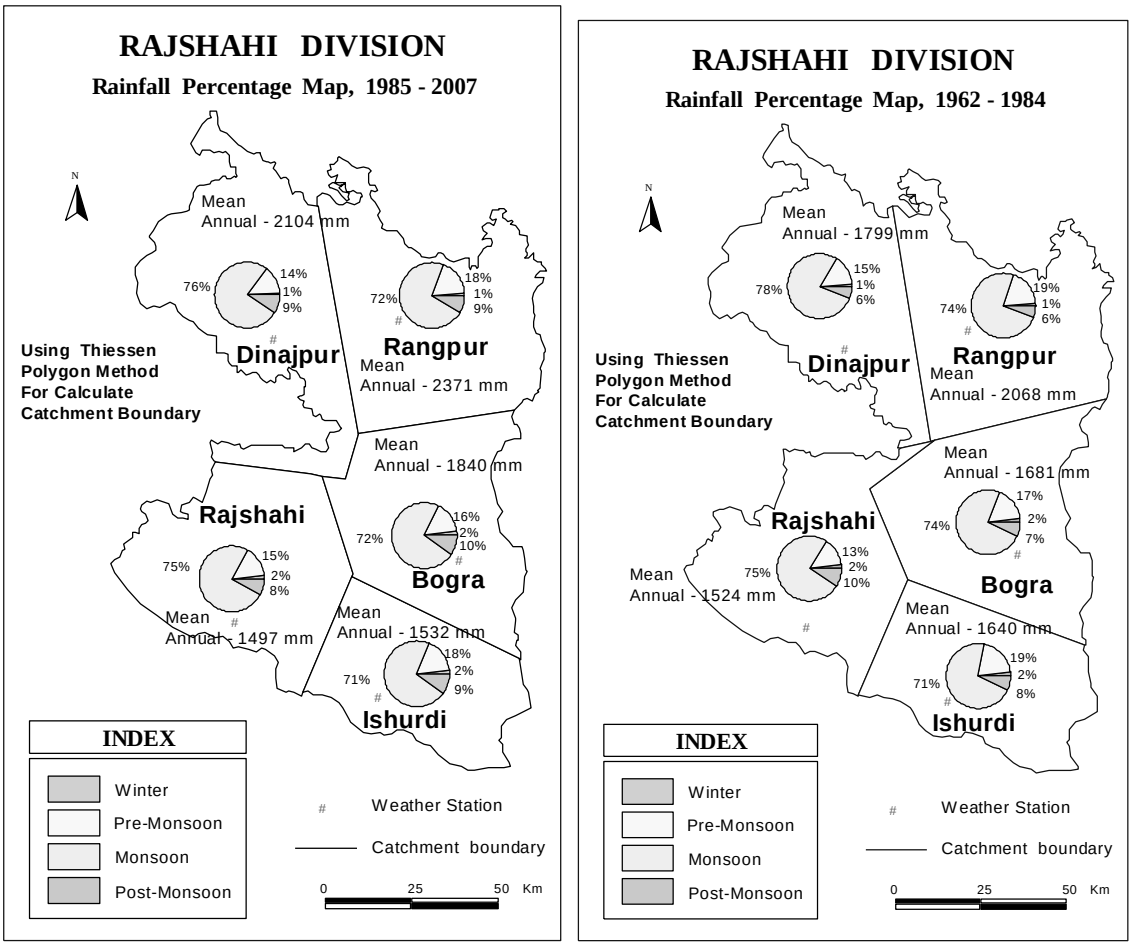

Fig. 14. Rainfall percentage map of Rajshahi Division for the time period of 1962-1984 and 1985-2007

The average number of rainy days in this region mostly varies from 86 to 112 days per year. Total number of rainy days analyses has revealed an increasing pattern of rainy days in the study area. In all seasons, rainy days have increased and it also maximally continued in monthly and annual pattern (Figure 15 and 16).

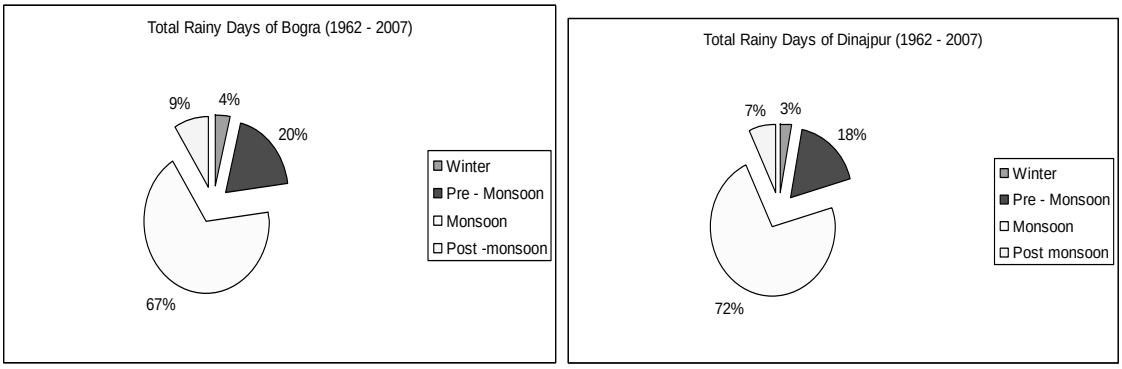

Fig.15. Percentages of Total Rainy Days in a year in Bogra and Dinajpur

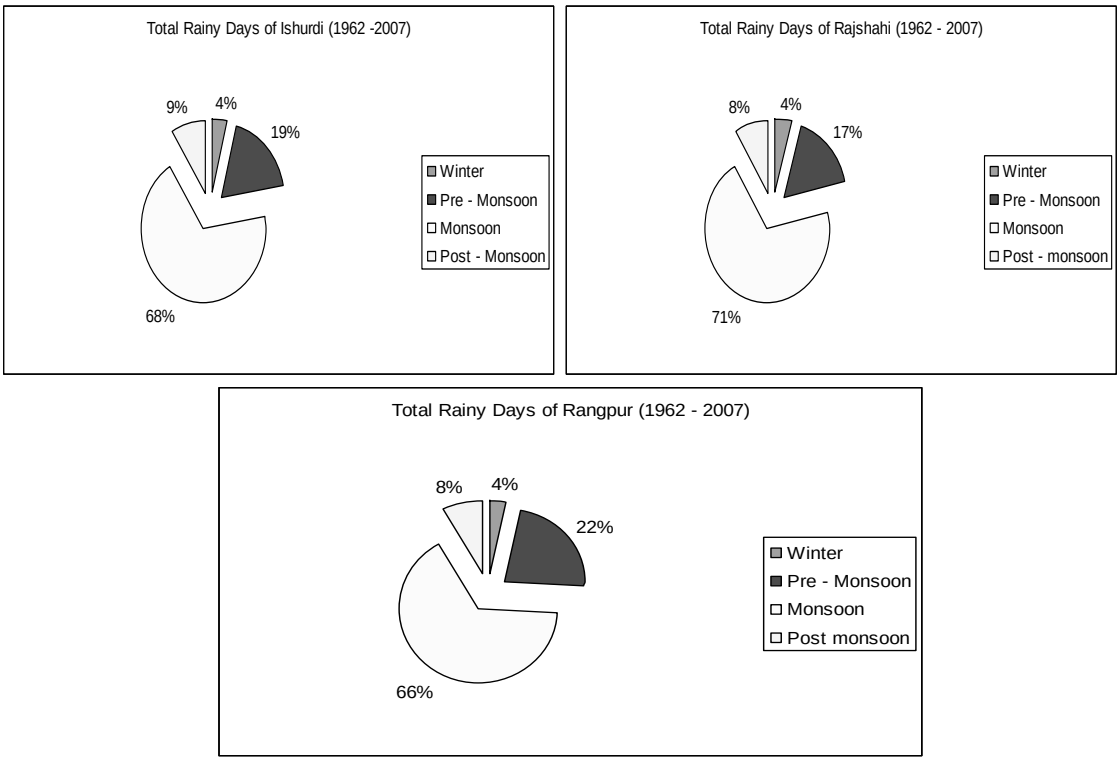

Fig. 16. Percentages of Total Rainy Days in a year in Ishurdi, Rajshahi and Rangpur

Finally, the annual time series trend of rainfall pattern has been illustrated that 1988, 2007, 1977, 1981, and 1989 comprised the highest rainfall year for Bogra, Dinajpur, Ishurdi, Rajshahi and Rangpur respectively. It has found an increasing pattern of annual rainfall in Bogra, Dinajpur, Rajshahi and Rangpur in the recent years while a decreasing pattern in Ishurdi (Figure 17, 18, 19, 20 and 21).

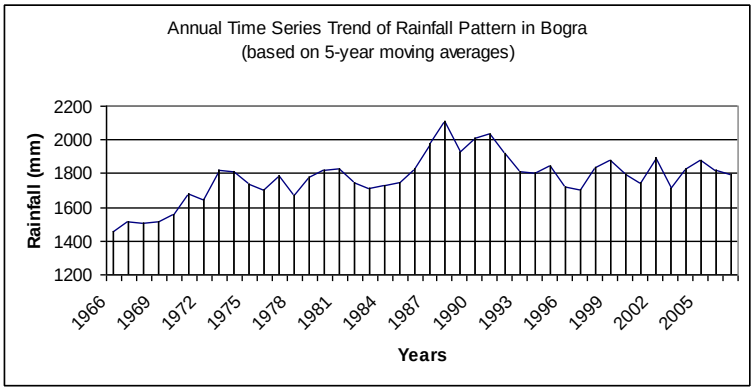

Fig. 17. Annual Time Series Trend of Rainfall Pattern in Bogra

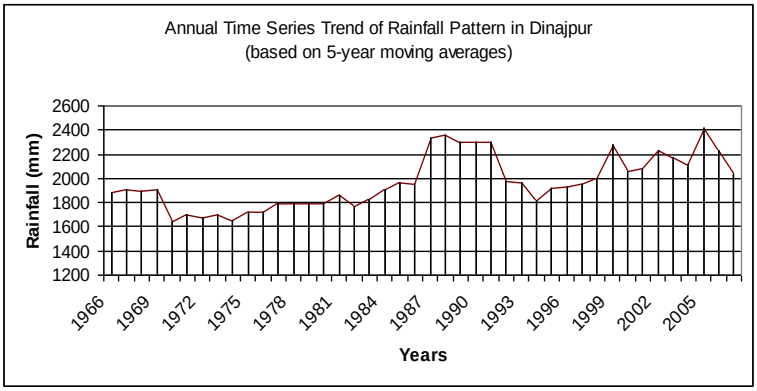

Fig. 18. Annual Time Series Trend of Rainfall Pattern in Dinajpur

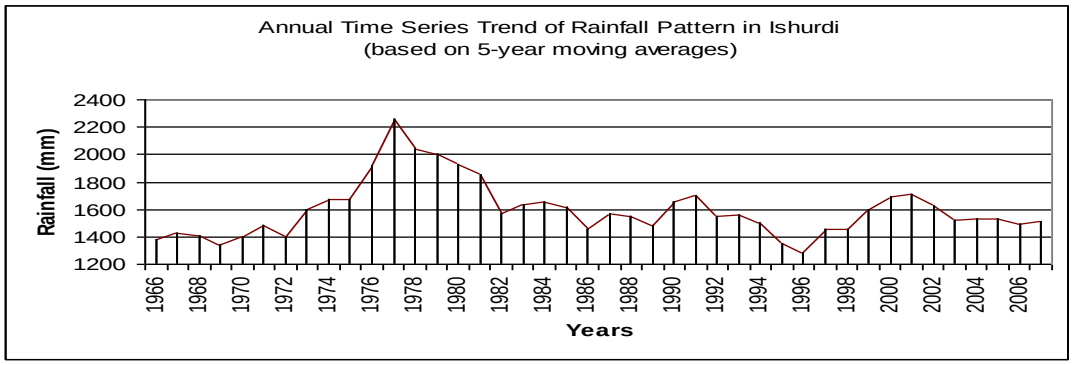

Fig. 19. Annual Time Series Trend of Rainfall Pattern in Ishurdi

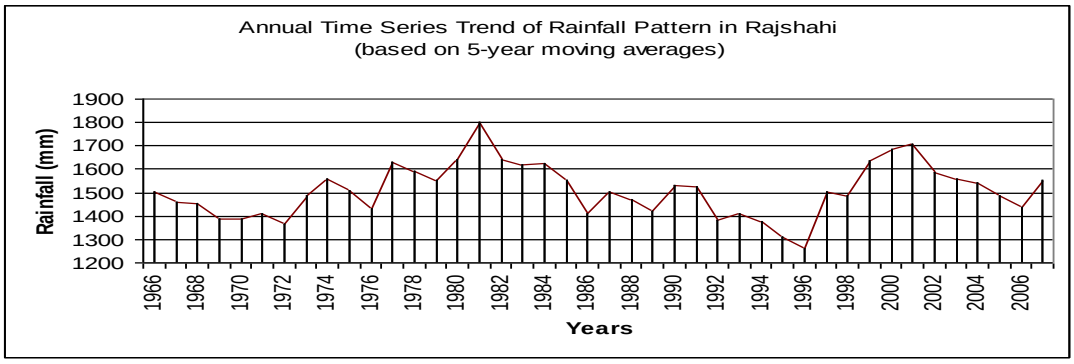

Fig. 20. Annual Time Series Trend of Rainfall Pattern in Rajshahi

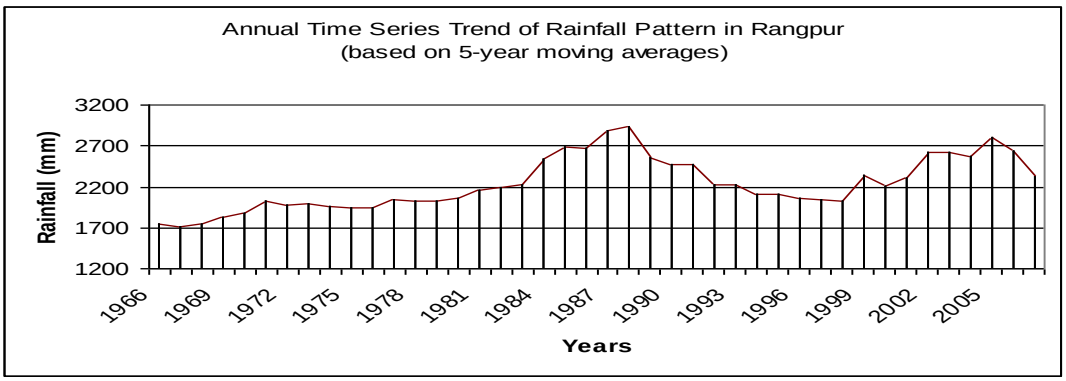

Fig. 21. Annual Time Series Trend of Rainfall Pattern in Rangpur

The study has revealed the following hypotheses for the rainfall pattern in Rajshahi division

There is evidence of annual rainfall change with an increasing pattern in Bogra, Dinajpur, Rajshahi and Rangpur. In these four stations, the changing pattern in Rangpur is the highest. Downward shift of annual rainfall shows a decreasing pattern in Ishurdi. The time period 1985-2007 shows mostly an increasing trend, which is being reversed during 1962 – 1984. In Rajshahi Division the mean annual and seasonal rainfall have increased in its northern portion and decreased in southern parts. Also the frequencies of rainy days pattern in every season for all of those five stations have increased. Results from the mean annual and seasonal rainfall and the moving average data are slightly different. Hence, periodic or cyclic of annual rainfall may exist and can partially be changed.

Rainfall distribution has showed an irregular changing pattern and the reasons for rainfall decreasing trend still have to be investigated.

Based on rainfall distribution of the time period of 1962-2007, the descending order of monthly and seasonal rainfall pattern in Rajshahi Division can be summarized as below:

Monthly rainfall pattern

a) Ishurdi, Rajshahi and Rangpur

July > June > September > August > October > April > March > February > November > January > December

b) Bogra

July > June > September > August > October > April > March > November > February > December > January

c) Dinajpur

July > June > September > August > October > April > March > January > February > November > December.

Seasonal rainfall pattern (for all stations)

Monsoon > Pre – Monsoon > Post Monsoon > Winter

Weather stations

Rangpur > Dinajpur > Bogra > Ishurdi > Rajshahi

From both the halves of time period, Rangpur has obtained highest area of catchments area and proves that it is the biggest rainfall region of Rajshahi Division. The study has been distinctly observed an increasing trend of catchments boundaries for Rangpur, Dinajpur and Rajshahi and a decreasing trend in Bogra and Ishurdi. Evaluating the rainfall contour lines, it has been found that the rainfall annually varies from 1542.1 mm to 2235.8 mm in Rajshahi Division. The average number of rainy days in this region mostly varies from 86 to 112 days per year.

Conclusions

The study has revealed that the changes in rainfall patterns in Rajshahi Division have been taken place over the years. It is found an increasing pattern in mean monthly, seasonal and annual rainfall in most of the region of Rajshahi Division. However, rainfall is a very important climatic factor for availability of water supply for rain fed cultivation, irrigation, storage in reservoirs for dry seasonal using purpose, water resource management and planning, navigation, fresh water fish cultivation, aquifer's recharging, and maintenance other water related issues and projects. This study is a very short but elementary work which will be helpful in future studies. The future studies should consider these changes in order to receive more accurate solutions of existing and new water related projects.

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