RESEARCH REVIEW JOURNALS
Volume-1
Issue-12
December-2016

ISSN: 2455-3085 (Online)
RESEARCH REVIEW International Journal of Multidisciplinary
www.rrjournals.com

Spatio-Temporal Variability and Trends of Rainfall by South-West Monsoon over North Bengal Region

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ARTICLE DETAILS

Article History
Received: 20 November 2016
Accepted: 29 November 2016
Published Online: 05 December 2016

Keywords
spatio-temporal, Rainfall, GIS, Monsoon

ABSTRACT

The study is an attempt to investigate the spatio-temporal variations and trends in the occurrences of rainfall due to south-west monsoon over different districts of North Bengal. The spatial variation of rainfall is very distinct in all the districts which also indicate different landuse practices in the area. Past 50 years record of rainfall indicate a dramatic change in the rainfall pattern over this region which shows a change in its intensity and frequency. The area is characterised by three important seasons, namely Pre -Monsoon Period (March-May), Monsoon Period (June-September), and Post Monsoon Period (October-December). Statistical techniques like coefficient of variation and regression slopes have been used to show the variability of rainfall pattern. For better understanding, the results are then incorporated in GIS based maps to show the asymmetry in the rainfall distribution pattern in the region. These observations of changing occurrences of weather events demonstrate regional climate change.

Introduction

Spatio-temporal variability refers to the variation in areal and chronological order of rainfall and this long term data indicates the trend of rainfall due to south-west monsoon. In present day scenario, change in the rainfall pattern can be easily recognized from past rainfall records. The area receives heavy shower during June-September, however sometimes the amount of rainfall increases because of the gambling of monsoon and leads to flood like condition. A combination of factors believed to be responsible for the dramatic changes in seasonal and inter-annual variation of rainfall. Sometimes the Sub-Himalayan West Bengal experiences sudden rainfall in Post monsoon period, due to some local disturbances. The data show a declining trend in the intensity and duration of rainfall in present era. Intra seasonal and seasonally persisting patterns of summer monsoon rainfall was studied by Krishnamurti and Sukla (2005) which visualizes that the monsoonal rainfall over India consists of intra seasonal oscillations on different time scales fluctuating about seasonally persisting components. The other researcher Kawemura (2005) also noticed startling changes in the ISM pattern of rainfall.

Study Area

The entire region of North Bengal is considered to be the area of study. The area extends from Darjiling district in the north to Maldah in the south and in the eastern side it extends up to Koch Bihar and newly formed Alipurduar district. It is comprised of seven districts, i.e. Darjeeling, Jalpaiguri, Uttar Dinajpur, Dakshin Dinajpur, Maldah, Koch Bihar and Alipurduar. Among these Alipurduar is newly formed district, which was separated from Jalpaiguri district in the year of 2014, so, we are unable to get required data to interpret the rainfall pattern of this district.

Objectives

1) To find out the spatial and temporal distribution in annual rainfall pattern in last few decades.

2) Detect the changes in the rainfall characteristics in recent years (1992-2016) in comparison to past years (1967-1991).

Materials and Methods

Monthly rainfall data has been collected from IMD (India Meteorological Organization) for last 50 years and divided it into two segments (25 years each) i.e. from 1967 to 1991 and 1992 to 2010 and those each section into three groups, namely, pre monsoon, monsoon and post monsoon. The rate of missing data were very less, though all those has been handled with care by the computation of average. A significant homogeneity test has been done to check the non-homogeneity parameter in between hills and plains. SPSS and Excel 2007 have been used to do statistical calculations and representation of the output. All the statistical calculation and its diagrammatic representation have been done with the help of MS Excel and SPSS. Rather than this, we have taken the help of Global Mapper and QGiS to plot the maps.

Rainfall Characteristics Analysis

Precipitation Concentration Index

To observe the characteristics of rainfall PCI has been analysed followed by the formula provided by Oliver (1980). It is an effective indicator which shows the seasonal and temporal distribution changes in the pattern of precipitation. Several authors have recently examined precipitation variability in Argentina. Compagnucci and Vargas (1998) and Compagnucci (2000) used PCA to explore spatial patterns of daily synoptic pressure fields over Argentina, Chile and Antarctica for winters between 1972 and 1983. It is an effective indicator which shows the seasonal and temporal distribution changes in the pattern of precipitation. Here monthly data for fifty years of each district in North Bengal has been taken into consideration for the calculation of average annual monthly mean to calculate precipitation concentration index. The more PCI value indicates more water logging condition and rain fed agriculture. PCI is also very helpful in water resource management. The formula is,

$$\mathbf{PCI}_j = \mathbf{100}\frac{\sum_{i=1}^{12} \mathbf{p}_{ij}^2}{\mathbf{P}_j^2}$$

Where, PCI_j is the Precipitation Concentration Index for year *j*, expressed as percent, P_{ij} is the precipitation of month *i* in the year *j*; and P_j is the annual precipitation in the year *j*.

Trend Analysis

There are numerous techniques for the determination of rainfall trend. In the current study we have used, parametric test, three year moving average technique (Sneyears, 1992, Salinger *et al.,* 1995) and linear regression to plot the data of temporal as well as spatial distribution of rainfall. Trend and linear regression (Gregory, 1978; Lanzante, 1996) analysis will be useful for further evaluation of future rainfall trend and water resource management planning.

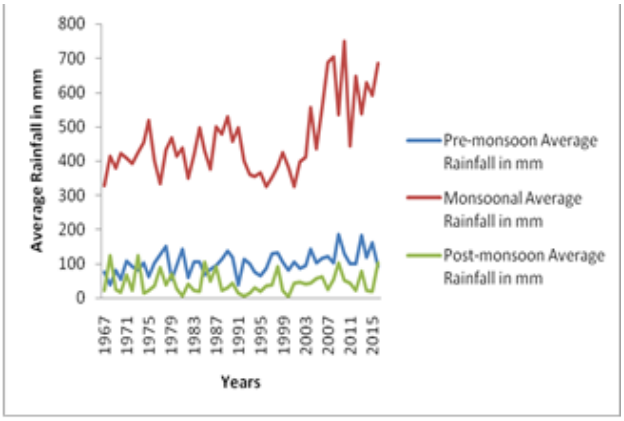
Result and Analysis

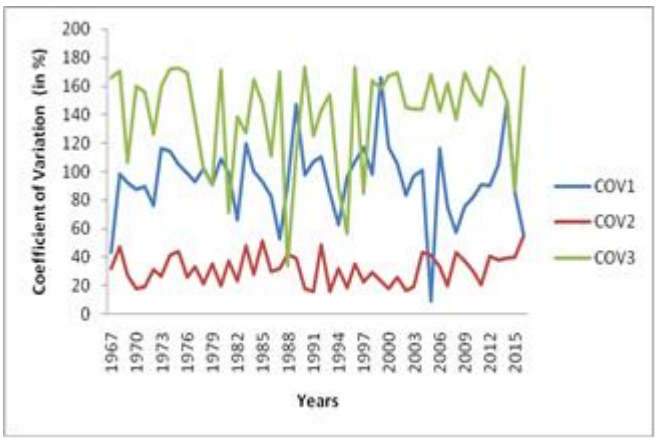
North Bengal is comprised of seven districts. Rainfall distribution and characteristics are more or less similar here. Hills and forest regions receives maximum amount of rainfall frequently than plain areas. From the above calculation we can visualize the average rainfall distribution pattern in six districts. It is indicating the spatial and temporal variation of rainfall. All the districts has similar kind of rainfall pattern during monsoon period for four months(June, July, august and September) and rainfall is less frequent in post and pre monsoon period. In the mountainous region elevation, forest cover, and drainage network condition is better than plain areas. This is the reason for regular and more frequent rainfall distribution pattern in these three (Darjiling, Jalpaiguri and Koch Bihar) districts. Among these six districts highest average rainfall is found in Jalpaiguri district (221.48mm.) and lowest is in Maldah district (111.6 mm), based on the 50 years data during pre and post monsoon period. Darjiling is the second highest district which receives great amount of rainfall but water scarcity still prevails there. Generally temperature has increased in recent years than before and rainfall frequency with intensity has decreased.

	PRE-MONSOON			MONSOON			POST-MONSOON		
District	**Average**	**SD**	**COV 1**	**Average**	**SD**	**COV 2**	**Average**	**SD**	**COV 3**
Darjiling	91.11	86.11	94.51	430.71	142.65	33.12	46.26	77.58	167.72
Jalpaiguri	115.72	108.6	93.85	479.49	155.62	32.45	54.78	100.65	182.65
Koch Bihar	115.77	107.3	92.69	430.98	151.65	35.18	52.34	85.02	162.42
Dakshin Dinajpur	64.13	58.83	91.74	292.13	109.07	37.34	42.71	62.31	145.87
Uttar Dinajpur	59.11	56.53	95.63	312.89	113.71	36.34	39.48	60.62	153.53
Maldah	49.38	44.72	90.56	275.35	103.45	37.57	38.57	55.57	143.82

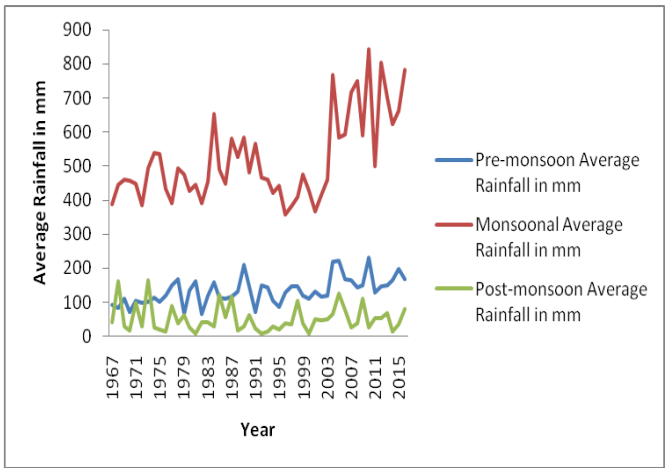
Distribution of Average Annual Rainfall and its Variability

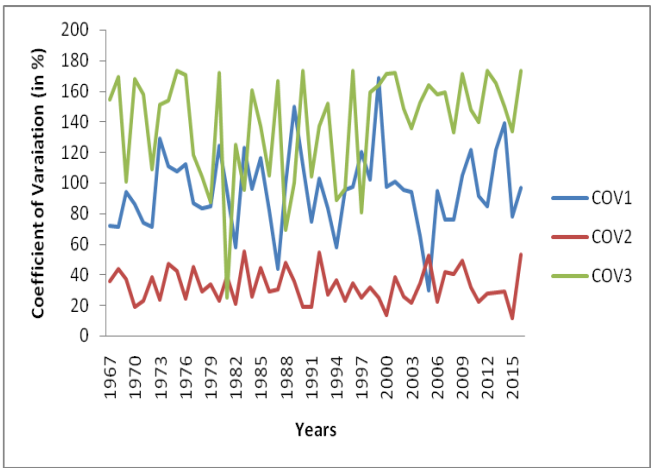
Darjiling District



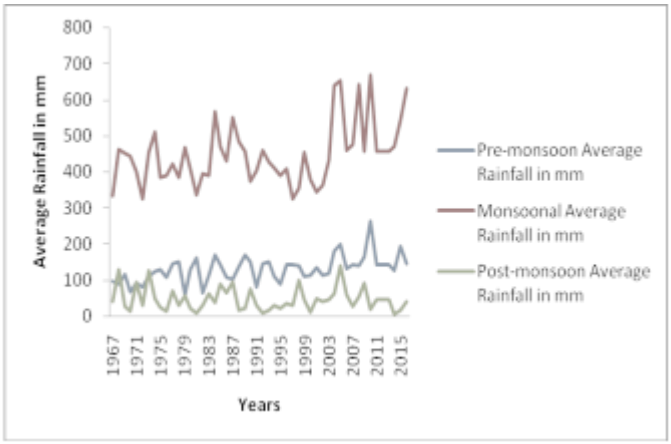


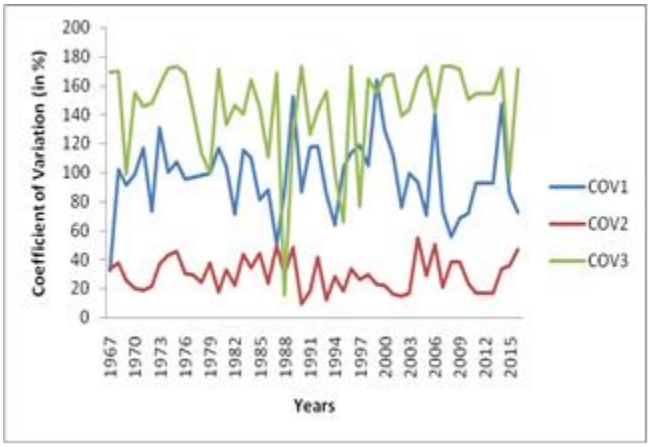
Jalpaiguri District



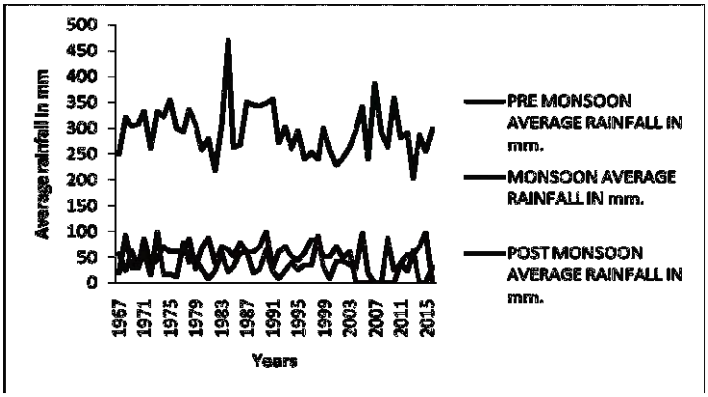


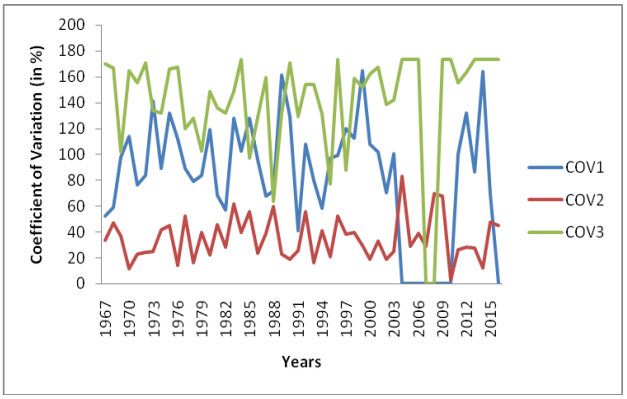
Koch Bihar District



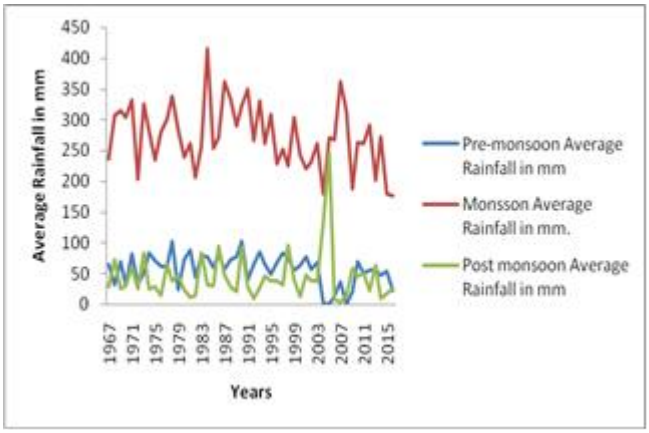


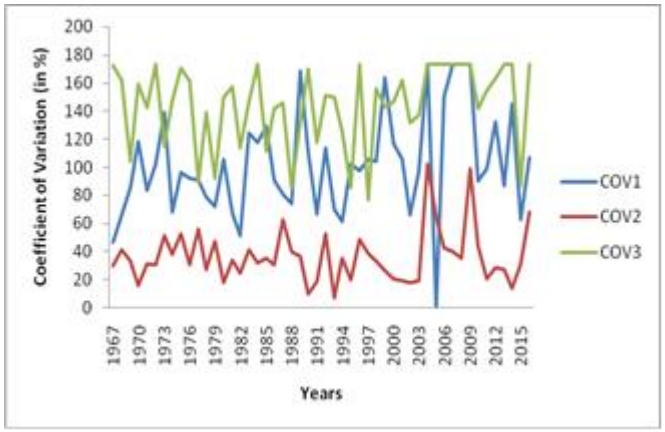
Uttar Dinajpur District



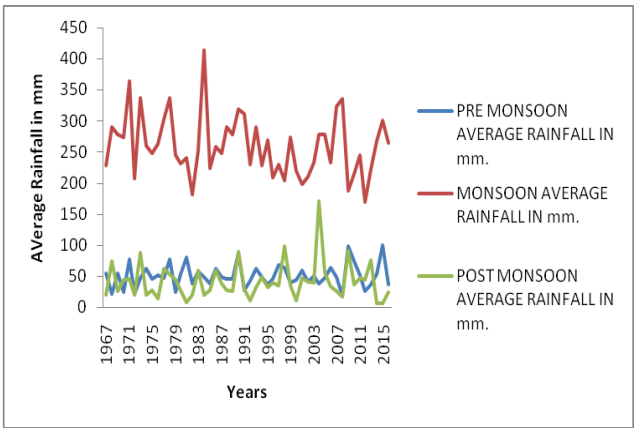


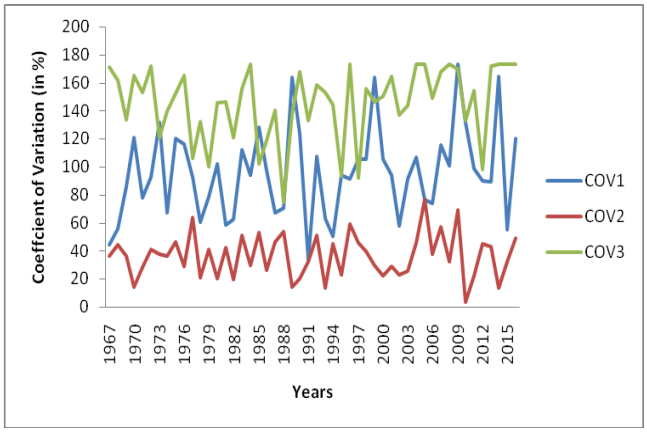
Dakshin Dinajpur District





Maldah District

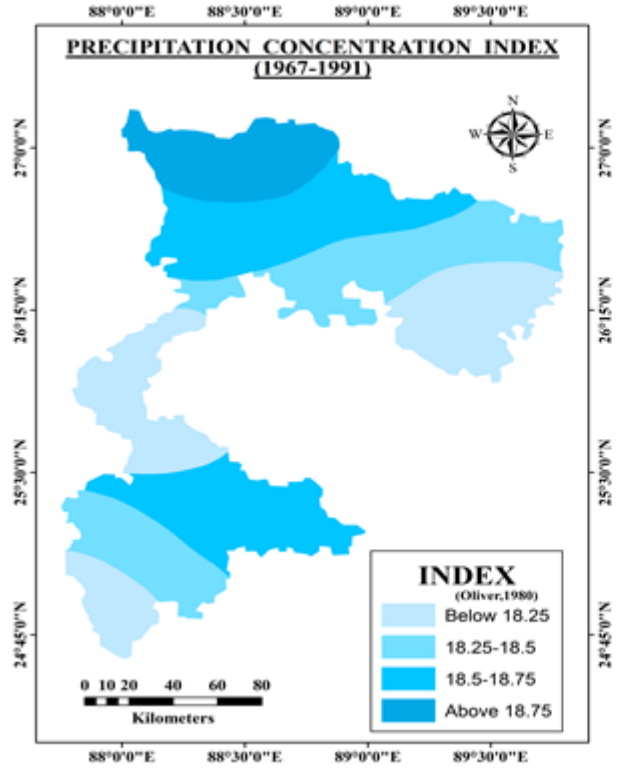


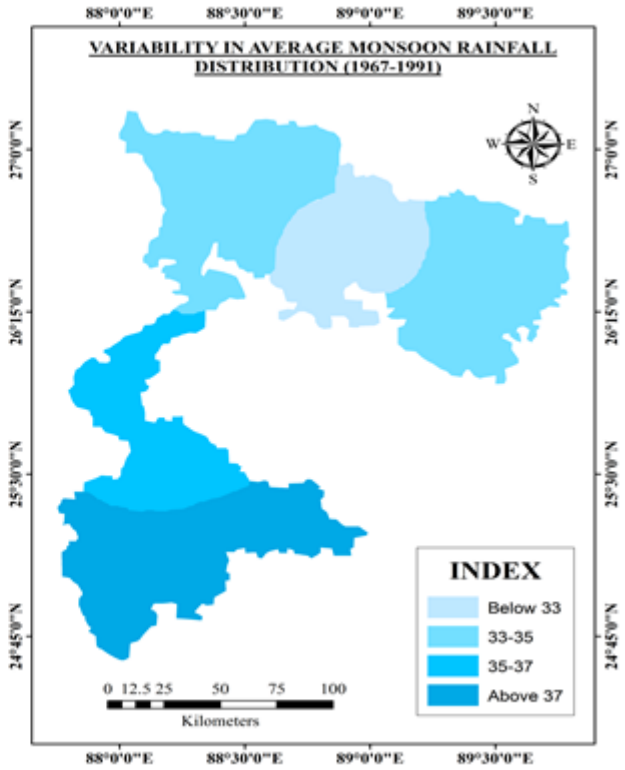


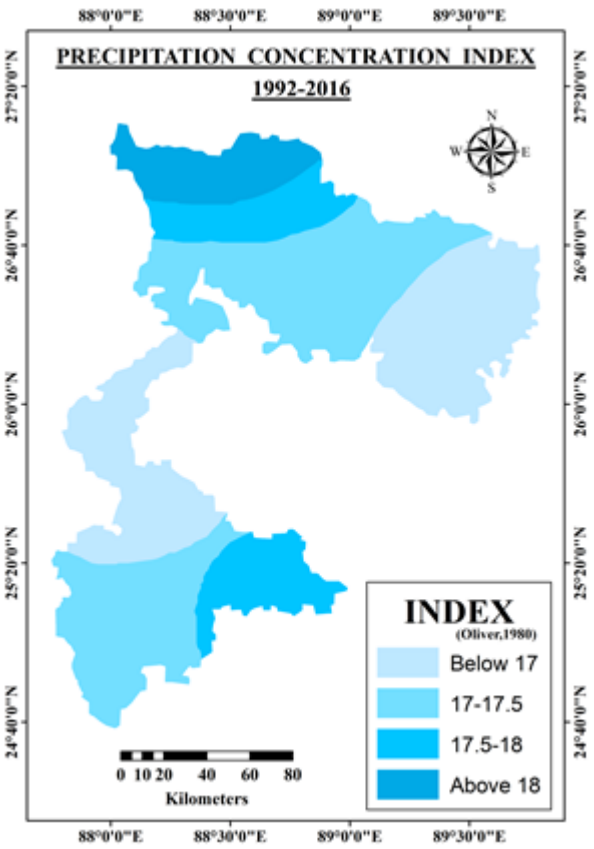
All the maps reveal high amount of variability during monsoonal time period as compare to pre monsoon and post monsoonal phase. The above represented diagrams are showing us the spatial changes of precipitation concentration in present twenty-five years as compare to the last twenty five years along with its changing pattern. Lower concentration shows the areas like Koch Bihar, Uttar Dinajpur, Maldah districts are less prone to water logging condition. Whereas Darjiling, Jalpaiguri and Dakshin Dinajpur are having higher concentration of PCI. But in recent time although the overall scenario remains same but areal extension has been changed dramatically. Maldah is receiving more PCI nowadays.

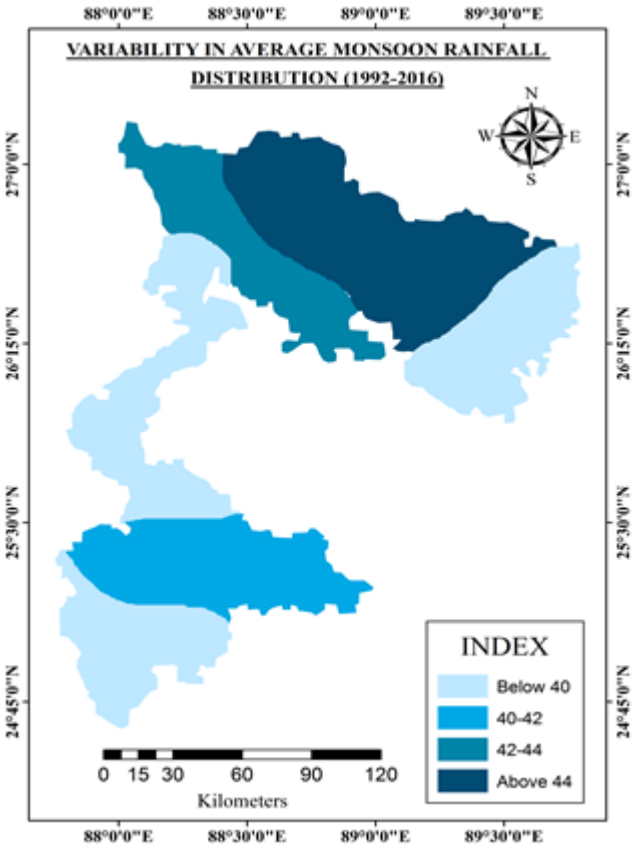
Each district is facing the changing precipitation pattern and so that the evapotranspiration rate is changing too. Mostly in pre monsoonal phase evapotranspiration is increasing with decreasing rainfall and in monsoonal phase its rate is going down. In case of Uttar Dinajpur the changing pattern is showing a dramatic change as compare to the other districts, which reveals that presently this region is receiving lesser amount of rainfall in pre monsoonal season and more evaporation than it used to receive earlier. Each district is showing different result in terms of showing future rainfall trend as comparing to its past trend. Darjiling, Jalpaiguri and Koch Bihar districts are showing an increase in future trend in all the monsoonal phase. Uttar Dinajpur is showing a decreasing trend in pre monsoonal phase but increasing trend

in post monsoonal phase. Maldah district is also showing a slightly declining trend in all the seasons as comparing to its past record. Dakshin Dinajpur is the only district showing an overall decreasing trend in overall monsoonal sessions. All the diagrams are represented below.









Conclusion

India is the country which receives 80% of the S-W monsoonal rainfall (Lal 2003, Jain and Kumar, 2012). So, the geo-hydrological picture of any region can be seen from rainfall condition (Mehrotra 1999). All the data and maps are revealing that each district is facing the problem of change in their climatic condition and drastic change can be found in the present years. The total amount of received rainfall (in mm.) has been declined in recent twenty-five years as well as the number of rainy days has been decreased significantly. In conclusion it may be said that variation in precipitation distribution pattern has direct impact on various aspects of social life, which may be positive or negative. Changing climate and rainfall distribution pattern is visible also. Water resource management is undoubtedly the most challenging job in regards with the local changes in climate and rainfall distribution pattern. Revitalizing the primitive practices along with advanced knowledge and water management skill on how to harvest rain water provides one way of coping with this problem. Before doing any interventions, a proper evaluation of the impact of climate change on water resources is necessary. Rising awareness among local people should also be a priority.

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