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Assessment of Trends and Variability of Post-Monsoon Rainfall for Some Selected Districts of Gangetic West Bengal, India

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ABSTRACT

Trends of Indian rainfall have been extensively studied by many researchers but the subject still remains complicated due to its high spatio-temporal variability. The post-monsoon season is a period of transition between the south-west monsoon (June-September) and the dry cool winter season (December-February). It broadly coincides with two months namely October and November. Harvesting of kharif crops entirely depends on the nature and characteristics of post monsoon weather. In the present study, an attempt has been made to identify the trend and variability of post-monsoon rainfall by analyzing monthly rainfall data of these two months (October and November) from 1961 to 2010 of some selected districts of Gangetic West Bengal where rainfall is the prime factor for the successful growth of agriculture.

Introduction:

Changing pattern of post-monsoon rainfall is rapidly emerging as one of the most serious global problems affecting many sectors in the world particularly the agricultural activities of the country. It is considered to be one of the most serious threats to sustainable development, food security, economic activities and natural resource conservation etc.

West Bengal is predominantly an agrarian State. The State is characterized by diverse natural resources and varied climatic conditions which provide a congenial situation for cultivation of a wide range of crops.

Farmers are aware about the weather and its variability and it has great impact on crop production (**Baweja 2011**). Rainfall events of any region will be understood by the annual, seasonal and monthly rainfall analysis (**Swetha 2015**).

A number of studies have been carried out for the assessment of trend (**Chakraborty and Das 2016; Lacombe and McCartney 2014; Longobardi and Villani 2009; Merabtene et al. 2016; Mukherjee 2017; Nouaceur and Mursrescu 2016; Wani et al. 2017**) and variability of rainfall (**Baweja 2011; Hossain et al. 2014; Shisanya et al. 2011**) using both parametric and non-parametric method (Mann-Kendall test). So, keeping the above points in view, in the present study an attempt has been made to identify the trend and variability of post-monsoon rainfall of some selected districts of Gangetic West Bengal.

2. Materials and methods

For the present study, monthly rainfall data of six selected districts of Gangetic West Bengal namely North 24 Parganas, Nadia, Murshidabad, Hooghly, Howrah and Bardhaman have been collected from Agricultural Meteorology Division of the State Agriculture Department, Government of West Bengal and Indian water-portal website (http://archive.indiawaterportal.org/metdata). The data was analyzed on monthly basis and statistical parameters

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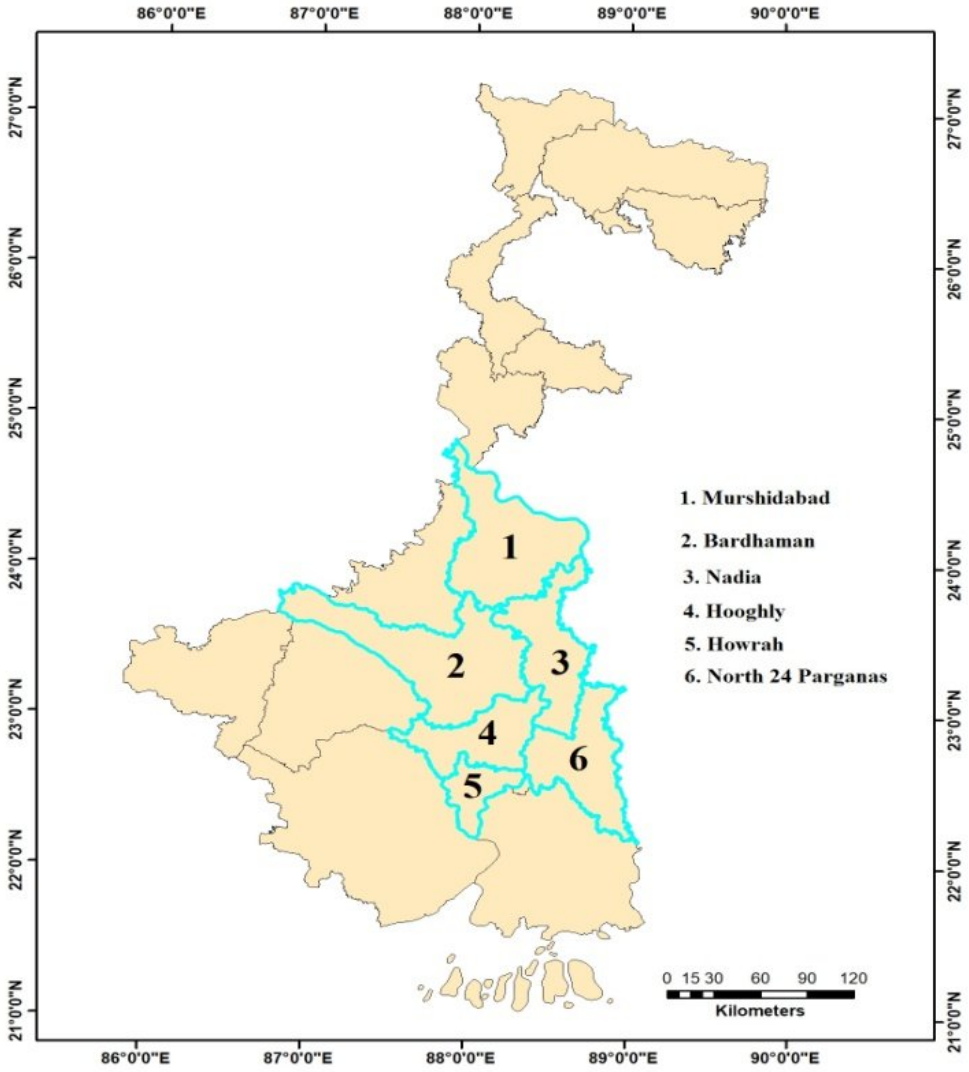


Fig. 1 : Location Map of the Study Area

like standard deviation, co-efficient of variability (CV) were determined. Statistical techniques viz. moving average and semi average methods have been used to investigate the sequential change of rainfall trend over the time period of 50 years (1961-2010) during post-monsoon. Slope of rainfall has been computed to estimate the annual increase and decrease of rainfall. The annual rainfall anomaly index (RAI) has been calculated from the precipitation data to show the frequency and intensity of dry and wet years during post-monsoon season in the study area. The method of RAI was discussed by Rodrigues (2017) to analyze the frequency and intensity of the dry and rainy years for the Salgado Basin of Brazil.

RAI constitutes the following equation:

[(current monthly/yearly rainfall – monthly/yearly average rainfall of the historical series) / (average of the ten highest monthly/yearly rainfall of the historical series – average of the ten lowest monthly/ yearly rainfall of the historical series)]. Drought (dry year) is represented in terms of (–) numbers; for example, 0 to –2 is dry; –2 to –4 is very dry and below –4 is extremely dry. Wet condition is shown in terms of (+) numbers;

for example, 0 to +2 is humid, +2 to +4 is very humid and above +4 is extremely humid.

3. Results and discussion

3.1 Variability of rainfall

Variablity of annual rainfall can be analyzed by the the co-efficient of variation of annual rainfall (CV values). One of the most important features of post-monsoon rainfall is its inter annual variability. The present study investigates the trends and fluctuations of post-monsoon rainfall over Gangetic alluvial zone of West Bengal. For this purpose, co-efficient of variation (CV) and standard deviation (SD) of monthly and annual rainfall were calculated. Table 1 and 2 clearly show the mean monthly and seasonal rainfall with their standard deviation and coefficient of variation.

Inter annual variability of rainfall during post-monsoon has been expressed in the inter annual time series plotes for the period 1961-2010. The average post-monsoon rainfall of the study area was found to be 70.1 mm which ranges from 8.83 mm in the month of November (lowest) over Bardhaman to 155.4 mm in the month of October (highest) over Howrah with standard deviation (SD) of 45.17 mm and coefficient of variability (CV) of 84%. CV of rainfall of these two post-monsoon months (October and November) are found to be 52.67 and 116.33% over North 24 Parganas, 56.63 and 107.61% over Nadia, 50.05 and 104.13% over Murshidabad, 55.86 and 101.78% over Bardhaman, 57.61 and 126.47% over Hooghly and 57.6 and 116.38% over Howrah district.

Coefficient of variabilty of rainfall exhibits a clear rising trend from 1961 to 2010 over Nadia, Murshidabad, Hooghly and Howrah districts which may limit the cultivation and harvesting of a wide range of kharif crops. Declining trend of CV (%) of post monsoon rainfall is found over North 24 Parganas and Bardhaman districts of Gangetic West Bengal.

Table 1. SD, CV and Trend of Rainfall in the Month of October (1961-2010)

District	Average Rainfall (mm)	Trend of Rainfall	SD	CV (%)
North 24 Parganas	154.23	Increasing	81.22	52.67
Nadia	110.65	Increasing	62.66	56.63
Murshidabad	107.10	Increasing	53.61	50.05
Bardhaman	103.46	Declining	57.79	55.86
Hooghly	126.13	Increasing	72.67	57.61
Howrah	155.40	Increasing	89.51	57.60

Table 2. SD, CV and Trend of Rainfall in the Month of November (1961-2010)

District	Average Rainfall (mm)	Trend of Rainfall	SD	CV (%)
North 24 Parganas	22.35	Increasing	26.00	116.33
Nadia	11.45	Increasing	12.32	107.61
Murshidabad	9.50	Declining	39.00	104.13
Bardhaman	8.83	Increasing	8.99	101.78
Hooghly	13.86	Increasing	17.53	126.47
Howrah	17.81	Declining	20.73	116.38

Table 3. Trend of CV (%) of Rainfall during Post-Monsoon (1961-2010)

District	Trend
North 24 Parganas	Declining
Nadia	Increasing
Murshidabad	Increasing
Bardhaman	Declining
Hooghly	Increasing
Howrah	Increasing

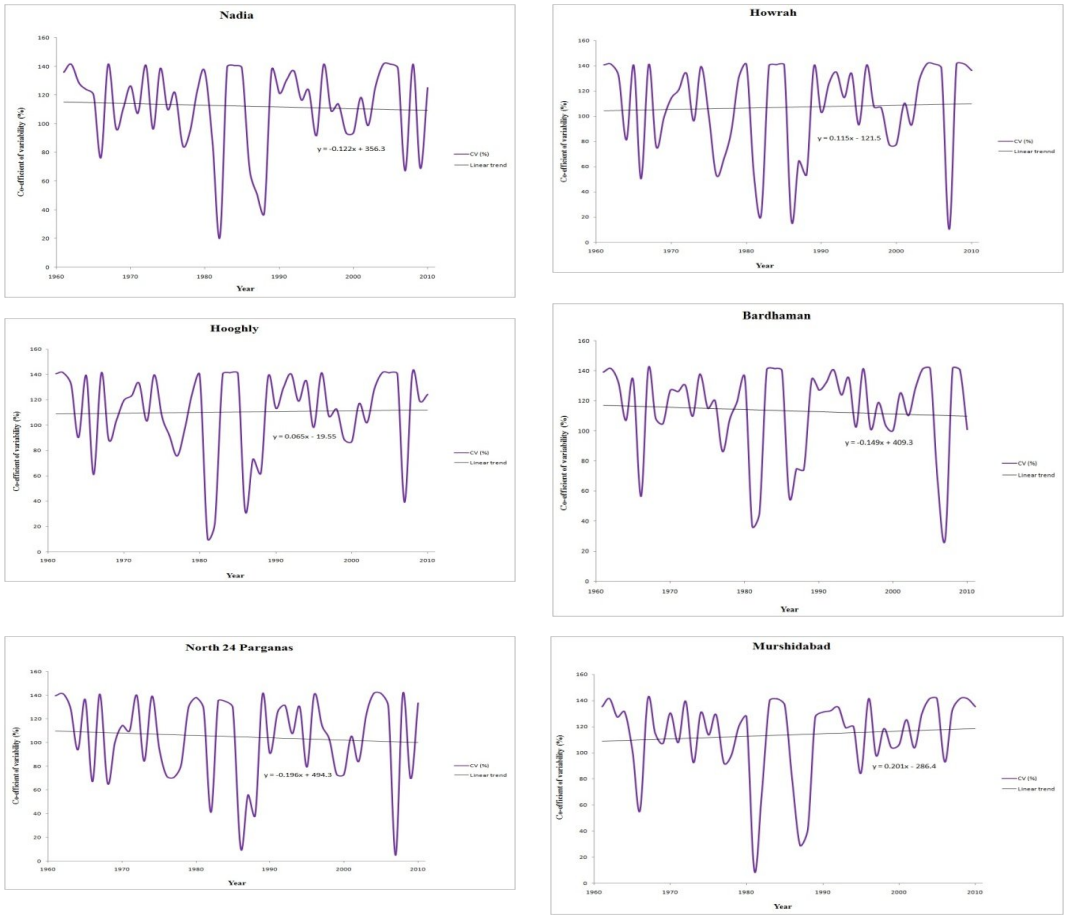


Fig. 2 : Trend of Co-efficient of Variability of Rainfall during Post-Monsoon (1961-2010)

3.2 Trend of Post-monsoon rainfall

Analysis of rainfall data of individual district revealed that all the studied districts of Gangetic West Bengal experience maximum amount of rainfall in October during post-monsoon season.

The linear trend of post-monsoon rainfall for the selected districts during the period 1961 to 2010 are represented in Figure 3 and 4. It is found that the post-monsoon rainfall shows highest increasing and decreasing trend over Howrah (0.85 mm/year) and Murshidabad (-0.07 mm/year) during October and November respectively.

Nearly all the studied districts of Gangetic West Bengal exhibit rising trend of post-monsoon rainfall in the month of October except Bardhaman where decreasing trend of post-monsoon rainfall at the rate of -0.01 mm/year is noticed. It is observed that the district Howrah shows highest increasing trend of 0.85 mm/year followed by Murshidabad (0.43 mm/year), North 24 Parganas (0.37 mm/year), Nadia (0.33 mm/year) and Hooghly (0.02 mm/year) in October. Post monsoon rainfall in the month of November shows increasing trend over North 24 Parganas, Nadia, Hooghly and Bardhaman and declining trend over Murshidabad and Howrah .

3.3 Rainfall anomaly Index

Classification of positive and negative severities in rainfall anomalies is done by Rainfall Anomaly Index (RAI) which was developed by Rooy (1965) (**Rodrigues 2017)** . From the rainfall data (1961-2010), the annual rainfall anomaly index has been calculated to show the frequency and intensity of dry and wet years during post-monsoon season in the study area. The positive values in figure 5 indicate wet years and the dry years are indicated by the negative values. During post-

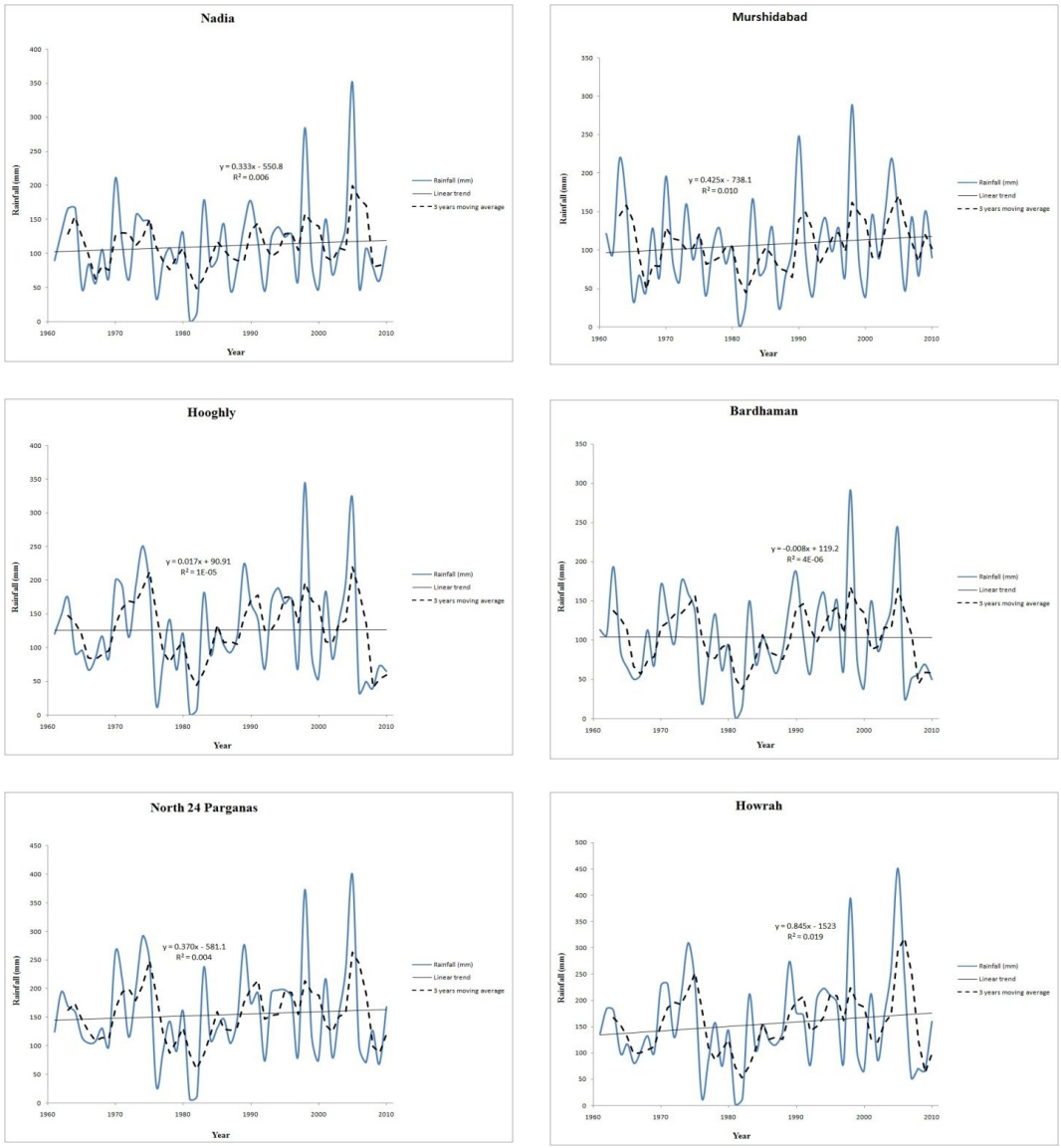


Fig. 3 : Trend of Rainfall in the Month of October (1961-2010)

monsoon, the study area experiences 26, 25, 27, 26, 26 and 27 years with negative RAI over North 24 Parganas, Nadia, Bardhaman, Hooghly, Howrah and Murshidabad respectively. In other words, Bardhaman, Hooghly, Murshidabad, North 24 Parganas experienced more years of drought (dry years) than the wet years (Table 4). In case of Howrah, the number of wet years exceeds the number of dry years and the number of dry and wet years is equal for the district Nadia.

Conclusion

Detailed knowledge of rainfall of an area is helpful for the planning of crop calendar. The present study has investigated the trends and variability of monthly and seasonal rainfall of some selected districts of Gangetic West Bengal from 1961 to 2010 . A large data set was used, consisting of two months namely October and November with the length of data series of 50 years.

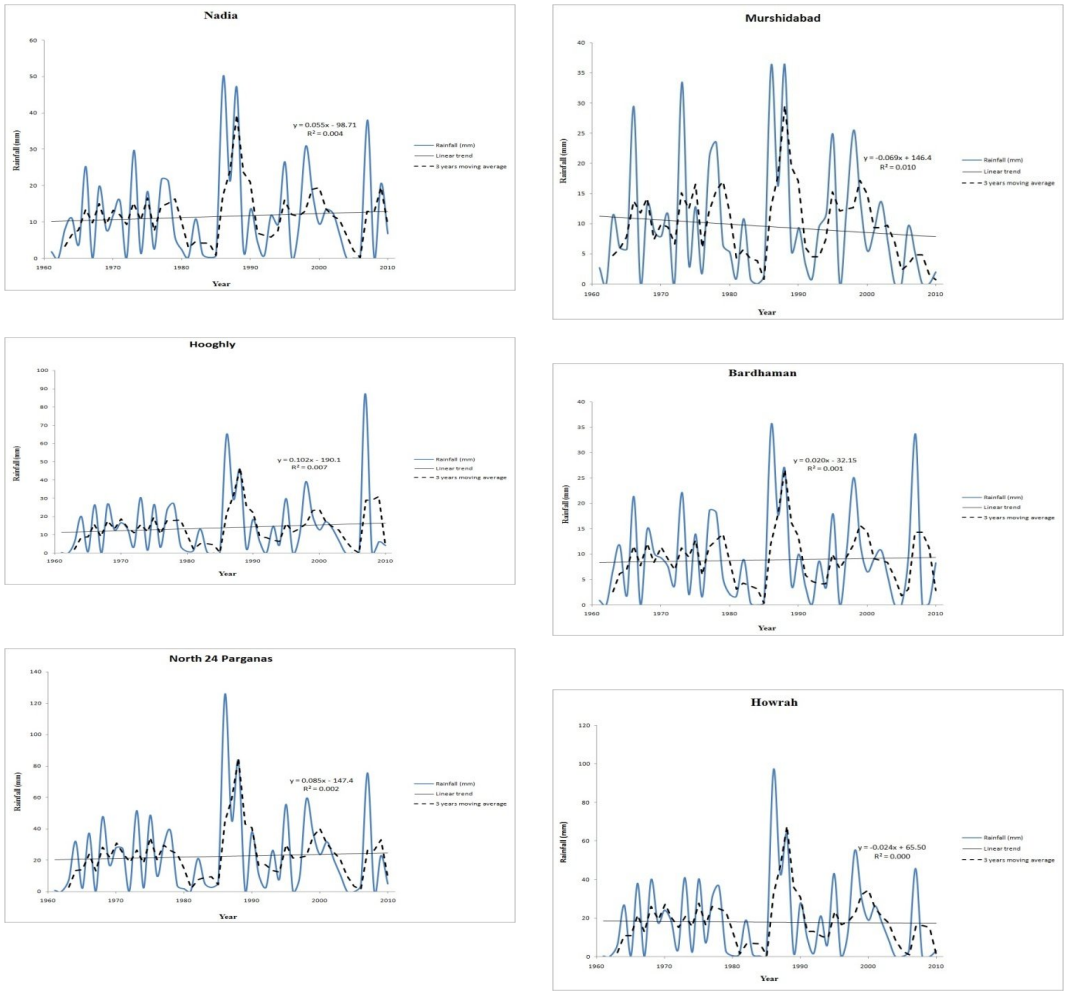
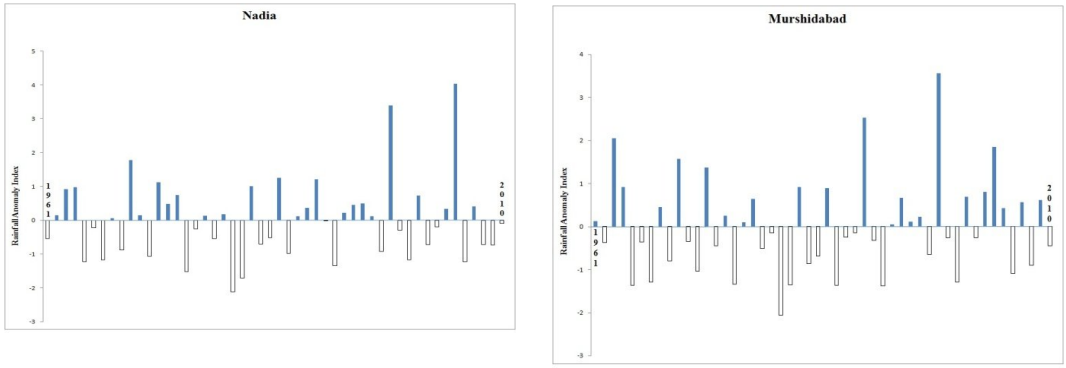


Fig. 4 : Trend of Rainfall in the Month of November (1961-2010)



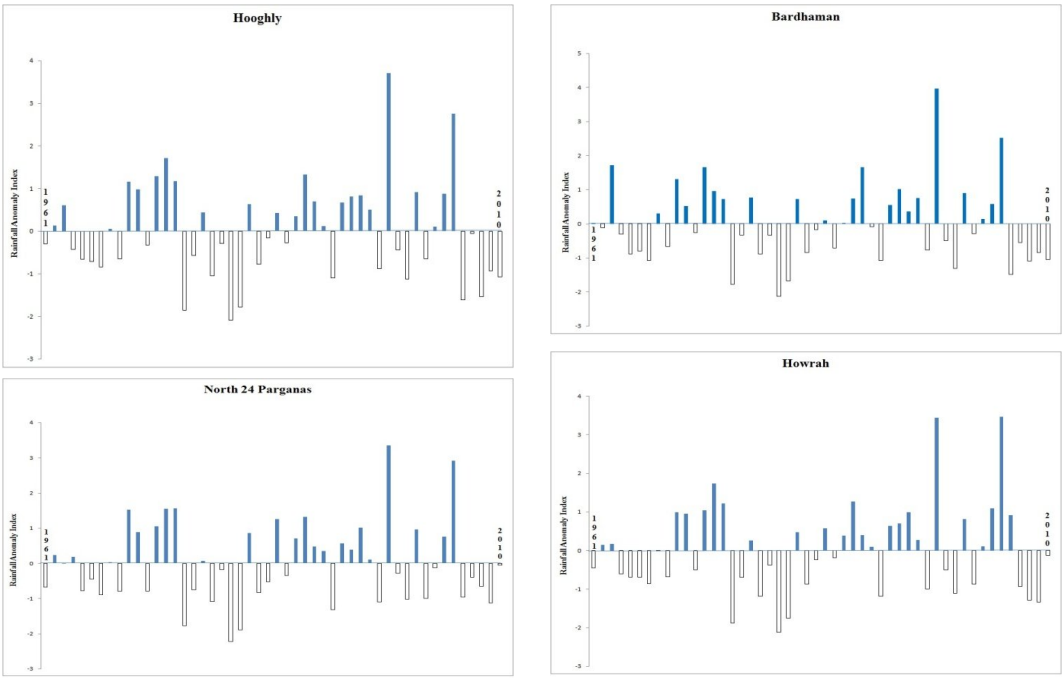


Fig. 5 : Rainfall Anomaly Index During Post-Monsoon (1961-2010)

Table 4. Rainfall Anomaly Index (RAI) for the Six Districts of Gangetic West Bengal

Districts	Rainfall Anomaly Index (RAI)	Total
Bardhaman	Positive	23
	Negative	27
Howrah	Positive	24
	Negative	26
Hooghly	Positive	24
	Negative	26
Murshidabad	Positive	23
	Negative	27
North 24 Parganas	Positive	24
	Negative	26
Nadia	Positive	25
	Negative	25

One of the most important feactures of the post-monsoon rainfall is its inter annual and spatial variability. The present study concluded that the studied districts of Gangetic West Bengal showed substantial changes in rainfall pattern during last 50 years i.e. from 1961 to 2010.

It was possible to observe a rising trend of post-monsoon rainfall over Murshidabad, North 24 Parganas, Nadia, Howrah and Hooghly in the months of October while declining trend of rainfall is noticed over Bardhaman in the same month. Districts North 24 Parganas, Nadia, Hooghly and Bardhaman exhibit rising trend of post-monsoon rainfall during November except Murshidabad and Howrah. While success of cultivation of rabi crops in the state during winter depend on favourable temperature regime and abundant sinshine, cultivation and harvesting of kharif crops entirely depend on the nature and characteristics of post-monsoon rainfall. The excessive rainfall during post monsoon particularly in October may produce severe yield loss. The increasing variability of post- monsoon rainfall over the study area may limit the cultivation of a wide rainge of kharif and rabi crops. Though the

study area receives considerable amount of rainfall during October (126 mm), but the number of years with negative RAI (dry years) exceed the years with postive RAI (wet years). With the frequent change of rainfall characteristics during post-monsoon, rescheduling of crop calendar is necessary utilizing normal weather requirement of crop and actual weather data for the synchronization of crop need and actual weather.

Acknowledgment

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