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Precipitation Events Controlling Flood and Drought – a measure on probability of rainfall occurrences in West Bengal

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A B S T R A C T

The nature of precipitation largely affects the flood/drought condition of an area. It varies significantly in spatial dimension and West Bengal is no exception. The districts, like Purulia and Bankura suffer from water scarcity, while the districts like Murshidabad, Malda, and Nadia are mostly flood prone and flood-affected. This contradiction in rainfall distribution modifies the pattern of livelihood and economic activities of both of these regions. The current study explores the probability of rainfall occurrence in the four major weather stations of West Bengal (Darjeeling, Purulia, Berhampore, and Uluberia). By computing the probability of rainfall occurrence, the return period of a particular amount of rainfall in a particular station also has been estimated. The prediction for each station for the occurrence of maximum and minimum rainfall shows the chances of occurring drought/flood condition at that station characterizing the weather of that particular region of West Bengal. The current study is important for predicting the future precipitation scenario as well as the flood/drought condition of West Bengal as a whole as well as of its different regions with a view to formulate models for agriculture and landuse planning.

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Introduction

The state of West Bengal experiences varying climatic conditions in different parts/regions of it. Thus, while a region experiences flood, the other experiences drought. By computing the probability of precipitation event, the region with varying probability of rainfall occurrence can be identified, from which the nature of drought/flood condition can be predicted beforehand. In the present analysis, for the sake of convenience alone, West Bengal has been divided into four cardinal regions and four major stations, one each from a region has been selected as — (1) Darjeeling (27° 03′N, 88° 18′ E) for northern region, (2) Purulia (23°17′N, 86°24′E) for western region, (3) Berhampore (24° 02′N, 88°27′E) for eastern region, and (4) Uluberia (22°28′N, 88°06′E) for southern region.

Methodology and Database

Probability of extreme precipitation in a particular area can give an idea of future occurrence of a particular event. For this a large database with precipitation figures of 55 years for the four stations of Darjeeling, Purulia and Berhampore has been prepared to compute the probability and return period of monthly precipitation amounts. However, for Uluberia due to non-availability, the database spans for a period of 35 years. The data has been collected from the Indian Meteorological Department, New Delhi.

At the outset, each of the monthly rainfall value for 55 years for each particular station and for each month has been ranked. Then the probability of each rank has been calculated by applying the following formula –

$$Fa = 100 (2n - 1)/2y$$

where, n = rank of the particular precipitation,

y = total number of events.

Return Period = 100 / Fa

For each station, the monthly extreme precipitation values have been used for comparison. Comparison has also been made between and among the different regions/ parts of West Bengal.

Analysis

Probability of Rainfall at Darjeeling

The northern part of West Bengal generally experiences the lowest rainfall in winter season (November, December, January, February and March) (Fig.1). The extreme events are more significant in the monsoon months (like June, July and August). At Darjeeling, the months of October, November, December, January and February have maximum probability of zero rainfall occurrence; however, December has the maximum chances of getting zero rainfall, and also the lowest rainfall occurrence in a whole year. These zero rainfalls, on an average have a return period of 1 year.

On the other hand, the highest probability of rainfall in the months of March, April, May, June, July, August and September have the maximum probability of rainfall above zero, but it also differs with different concentration levels at Darjeeling. April has the maximum probability of 14.9 mm rainfall with 1 year of return period; it implies that this amount of rainfall is the bare minimum that will occur in a year. In May, the amount has been computed as 50.5mm with 98.96% probability with the same 1 year return period. For June the minimum rainfall is 150.6 mm with 98.98% probability and 1 year of return period. July shows 208.1 mm as the highest probability of rainfall with 98.94% probability with 1 year of return period. August has a slightly decreased figure of 156.6mm rainfall with 98.91% probability of occurrence and 1 year of return period. As winter begins, the rainfall figure declines. In September, it is 51.0 mm with 98.91% probability and 1 year return period.

The maximum probability of 50% in winter season also varies over the months. January has only 8.4mm of rainfall with 50% probability and it then goes on increasing till the month of July with the values as — 13.3mm (February), 34.6mm (March), 67.4mm (April), 154mm (May), 463.2mm (June), and 700.8mm (July). After this, it steadily decreases till the month of December with the values as — 523.0mm (August), 344.8mm (September), 55.0mm (October), to 1.6mm (November), and zero (December).

The lowest probability with a maximum amount and highest return period also varies between months. January has the lowest probability of 239.7 mm rainfall with 1.06% probability and 94 years return period; the next lowest is 117.4 mm with 3.19% probability and 31.31 years of return period which declines

rapidly. It then again increases from February to July with the values as – 65.0mm (February), 147.5mm (March), 200.8mm (April), 666.4mm (May), 1402.1mm (June), and 2260.3mm (July). After this, it steadily decreases till the month of December with the values as – 823.8mm (August), 801.2mm (September), 579.0mm (October), 142.0mm (November) and 19.5mm (December).

Probability of Rainfall at Purulia

At Purulia, located in the western part of West Bengal the nature of seasonal variation of rainfall occurrence is more or less same, although the intensity is different (Fig.2). The monsoon months have the highest seasonal rainfall concentration; however, there occurs no large variation between these months. The highest probability of rainfall is zero, that commonly occurs in the months of October, November, December, January, February, March, April and May with a 1 year of return period and above 90% of probability. The remaining months have minimum rainfall for every year, e.g., May rainfall is estimated at 4.3mm with 97.12% probability and 1 year of return period. For June, the figure is 43.4 with same probability and return period. For July it decreased to 37.2mm with 99% probability and 1 year of return period. For August it is 196.4mm with 97% probability and 1 year of return period. After this, it increased rapidly implying that the monsoon rainfall really increases in this part at a later period. In September it is 52.4 mm with 99% probability and 1 year of return period.

Probability above 50% also varies between months, signifying the fact that rainfall having 50% probability to occur in the next 100 years and which can return within an average of 2 year return period actually act differently in different months. From January to August it shows an increasing trend with the figures as — 9.6mm (January), 12.0mm (February), 13.6mm (March), 22.0mm (April), 51.5mm (May), 205.6mm (June), 282.1mm (July), and 282.8mm (August). After this, it starts decreasing from September to December, with the values as – 225.0mm (September), 63.2mm (October), 4.8mm (November), and zero (December) [having 37% probability but it is the maximum of this month].

Though the lowest probability of the extreme values having the highest return period are not very much significant, it accounts for the fact that this particular rainfall has occurred at that place at a time in past. The lowest probability of rainfall also varies between months. Rainfall with the highest return period increases from January to June, followed by a slight decrease, again increase till the month of September, and finally decrease. The values are — January (86.4mm) with a return period of 104 years , February (106.4mm) with a return period of 98 years, March (142.2mm) with a return period of 104 years, April (209.8mm) with a return period of 104 years, May (206.1mm) with a return period of 104 years, June (842.0mm) with a return period of 104 years. July and August have 573.6mm and 520mm respectively with a return period of 102 years. The value for September is 773.6mm, for October 352.2mm, for November 135mm and for December 88mm with a return period of 100 years.

Purulia experiences enough rainfall only in the month of August (above 196.4mm each year), but the remaining months have comparatively very less certain rainfall each year. The summer months usually experiences very less rainfall. May has zero rainfall with maximum probability and 51.5mm with 50% probability. Besides for the months of June, July, August and September plus the remaining seven months, rainfall estimated with 50% probability is only 50.0mm or below. October shows a slightly different condition with an estimated figure of

63.2mm rainfall. Thus, there is a positive chance of the region being drought-affected.

Probability of Rainfall at Berhampore

In the eastern part of West Bengal, the scenario of rainfall occurrence is entirely different from the western and the northern part (Fig.3). Each year Berhampore is experiencing minimum rainfall lower than that of the northern and western parts. The nature of monthly variation of minimum rainfall is broadly similar to that in other parts of West Bengal. Usually the lowest rainfall occurs in the winter months, while the monsoon months have the largest amount.

The minimum rainfall with a maximum probability within 1 year of return period is zero for the months of November, December, January, February, March and April. June has the minimum rainfall of 35.4mm with 99% probability followed by a sharp increase with the advent of monsoon. In February it is only 31.8mm. In August, rainfall increased rapidly with a minimum of 119.2mm. For September, the figure is only 66.4mm that further decreases in October each year.

Rainfalls having 50% of probability in different months also differ between one another with an average return period of 2 years. These are the minimum amounts rainfall above which the area can experience rainfall with a return period of 1 to 2 years. Rainfalls are also the lowest in the winter months, i.e., November (2.2mm), December (zero), January (3.2mm), February (2.6mm), and March (8.6mm). It shows an increasing trend from April to July with the values as — April (28.4mm), May (104mm), June (204mm), and July (279.4mm) with a probability of 50%. This starts decreasing after July with the values as — 229.8mm (August), 228.9mm (September), and 102.3mm (October).

The rainfalls of minimum probability to occur in the future 100 years also show different pictures in different months. But it has been recorded only once in the past with a return period of 100 years and more. These values have lowest or negligible probability of 0.01%. The figures are — January (92mm), February (77.6mm), March (101.4mm), April (261.0mm), May (287.9mm), June (1106.6mm), July (784.5mm), August (572.3mm), September (599.0mm), October (422.7mm), November (70.0mm) and December (61.0mm). Thus, it increases from January to June with a slight dip in February and then steadily decreases till the month of December.

The period of July—September with highest rainfall at maximum probability may be identified as flood-prone; however, drought condition is not available in any of the remaining months (though 'zero' rainfall shows maximum probability), because during this period, much higher rainfall occurs at more than 60% probability, excepting some of the winter months.

Probability of Rainfall at Uluberia

Uluberia in the southern part of West Bengal experiences extensive rainfall in some of the months in a year (Fig.4). In general, monthly rainfall on an average is much less than that in the other parts of West Bengal. The probability of the lowest rainfall is the highest with a return period of 1 year. This highest probability above 98% has been recorded for the months of October, November, December, January, February and March. The remaining months do not experience much rainfall; it shows an increasing trend from April to September, e.g., April (2.6mm), May (4.1mm), June (20.6mm), July (126.0mm), August (71.0mm), and September (98.61mm).

Rainfall estimated at a probability of 50% with a return period of 2 years is maximum in the month of July (334.0mm), followed by 312.7mm in August, 235.8mm in September, 230.4mm in March, 103.9mm in October, 37.4mm in April, 19.0mm in March, 12.0mm in November, 10.8mm in February, 1.4mm in January and zero in

December. This implies that maximum rainfall can occur in the months of June, July, August, September triggering a flood condition, as the minimum rainfall with highest probability is also high during these months.

The highest rainfall experienced in the past years has a very little probability with a huge return period. All the months have these highest values with an average return period of 65 years. But the values are different in different months of a year. The highest is 1066.6 mm in the month of September, 741.1mm in August, 727.6mm in July, and 643.8mm in June, 451.8mm in October, 261mm in November, 233.7mm in April, 130.7mm in March, 109.8mm in December, 82.4mm in February and lastly 66.8mm in January. Thus there is no clear trend between months.

Thus, Uluberia is experiencing maximum rainfall in the months of June — September, that can be identified as flood-prone. But chances of drought is only little as even in winter months it is experiencing lower rainfall and the seasonal variation alone does not lead to flood condition; however, if it occurs during monsoon months, there will definitely be a prolonged drought condition in this region.

Conclusion

The foregoing analysis brings out the following facts — (a) the northern region / part of West Bengal, known commonly as the North Bengal has a very high probability of highest precipitation during monsoon; this is much higher than any other region/part of the state, which can lead to frequent flash flood in the Himalayan region, (b) the western region/part of West Bengal, known commonly as *jungle mahal* has deficit moisture regime, which is acute even in the initial months of monsoon season; with highest probability the estimated rainfall amount is very less that can often be translated into drought scenario, (c) in the eastern region the occurrence of precipitation is more or less similar to Purulia excepting some months. But the problem of flood is a certainty more due to geomorphological reasons than others, e.g., reduced carrying capacity of rivers, etc., and (d) the southern 'region/part of West Bengal is the other region is more vulnerable to flood due to precipitation as it experiences excess rainfall with higher probability.

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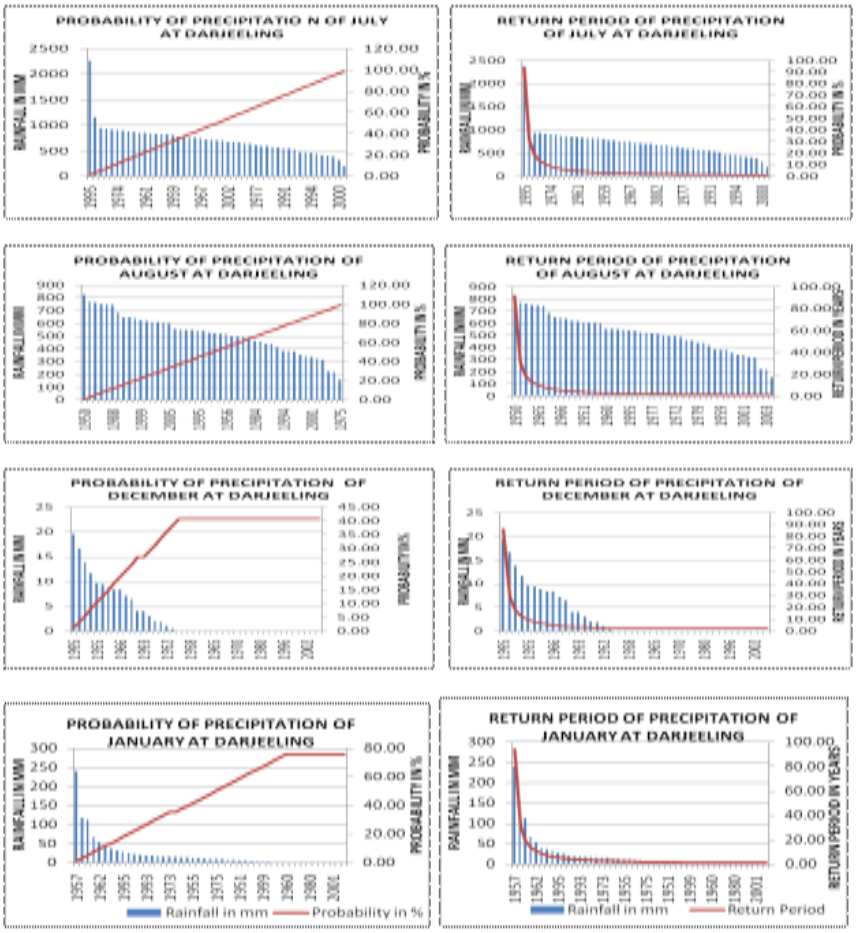

Fig. 1: Probability of Precipitation and Return Period in Summer and Winter months at Darjeeling.

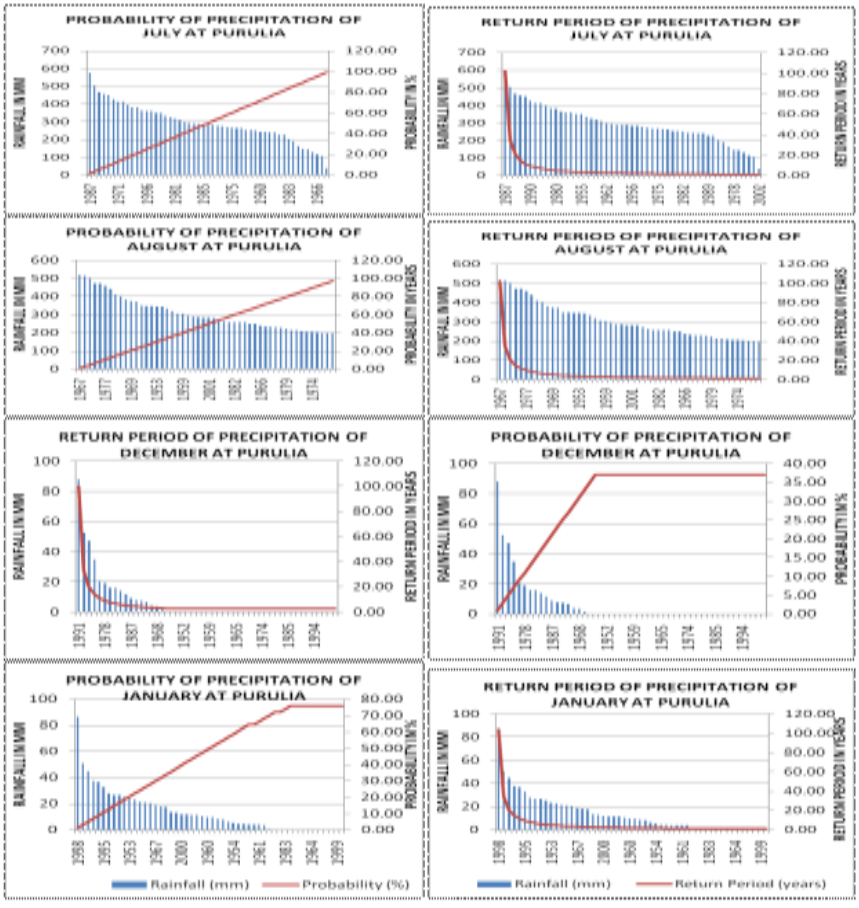

Fig. 2: Probability of Precipitation and Return Period in Summer and Winter months at Purulia.

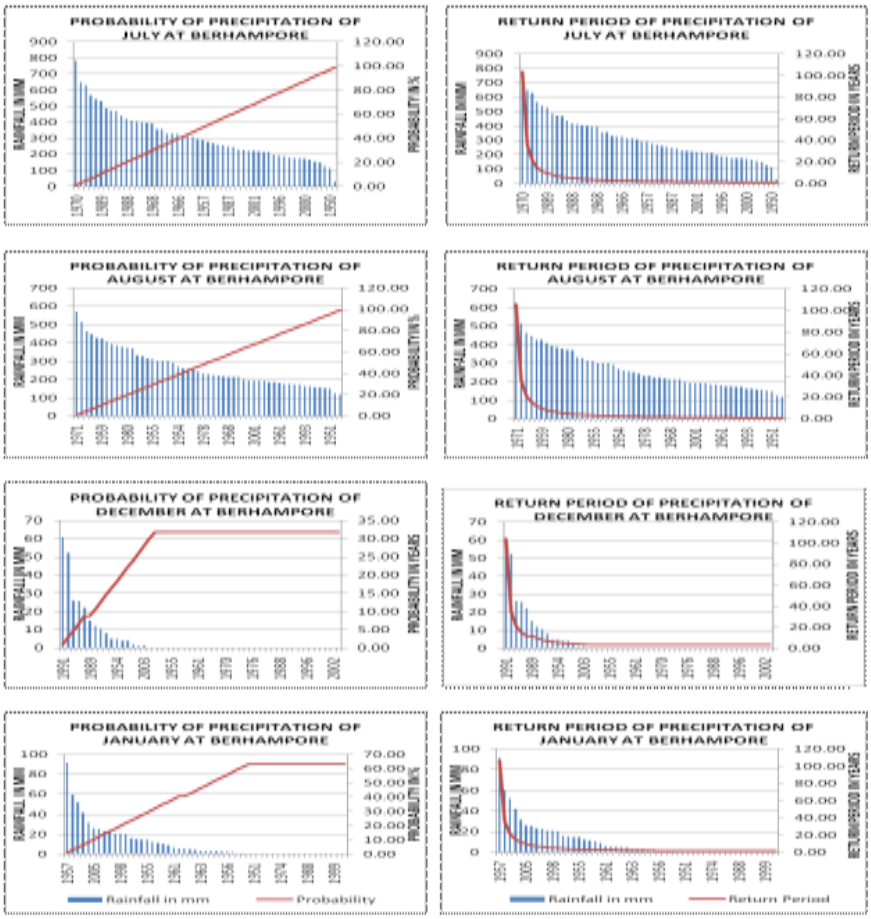

Fig. 3: Probability of Precipitation and Return Period in Summer and Winter months at Berhampore.

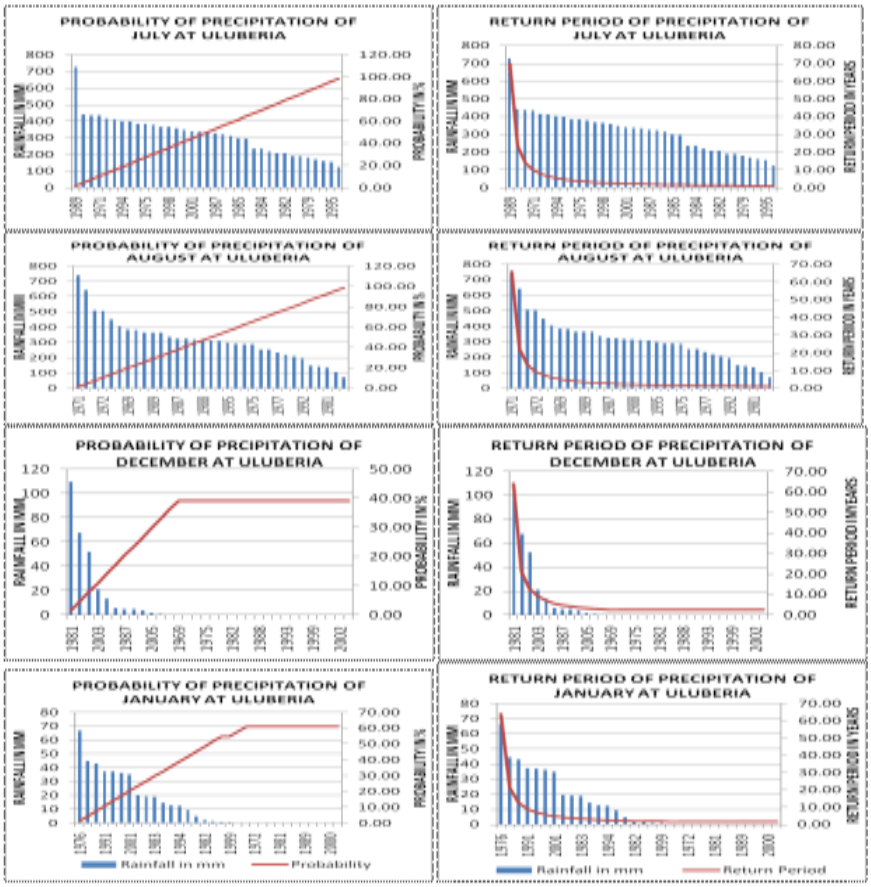

Fig. 4: Probability of Precipitation and Return Period in Summer and Winter months at Uluberia

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