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Comparative analysis of rainfall pattern over different time frames in Howrah district of West Bengal, India

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ABSTRACT

Modern agriculture has growing concern over the climatological impacts specially on the rainfall. Rainfall pattern and its distribution have great effect on the economics of our country and specially to the areas where rainfed agriculture is the major source of income for the farming community. In view of this analysis of rainfall data for Howrah district of West Bengal under the hot moist sub-humid agro-ecological sub-region is carried out for three equal period of time distributed over 42 years (1970-2011). The analysis of the rainfall data are made with respect to the distribution of rainfall over different seasons (pre-monsoon, monsoon and post-monsoon), assessment of the drought, normal and surplus years and months and probability analysis of the drought, normal and surplus months. The data revealed that there is decreasing trend in rainfall and increase in the number of drought months over the last 14 years under study. The drought periods are generally concentrated in between November to March whereas the normal to surplus periods are from April to October irrespective of the period under study.

Key words: Rainfall pattern, Drought.

INTRODUCTION

Rainfall is one of the most important and at the same time one of the most difficult meteorological/hydrological parameters on which the economy of India depends. There has been increasing operational demand for daily/monthly rainfall analysis for a wide range of applications extending from the real time monitoring and prediction of flood events, climate analysis (Janowiak and Arkin, 1991), climate diagnostic study (Arkin and Xie, 1994), model verification (Gates, 1992) and global energy and water budget studies (WMO, 1993).

Howrah district, located in between the river Hooghly and Roopnarayan, is the smallest agricultural district of West Bengal with variety of agro-ecological situations ranging from new alluvial to old alluvial as well as coastal and saline situation. Historically, the name of the district ‘Howrah’ is derived from the word ‘haor’ which means a marsh or swampy depression filled with water in the rains. Therefore, traditionally this region has records of receiving high rainfall. Frequency of flood occurrences at the blocks of Amta-I, II and Udaynaraypur is 9 out of 10. Rainfed agriculture is generally practiced in majority of the district area.

Detailed knowledge of rainfall pattern helps in planning crop calendar and designing of different storage structures (Ray *et al*., 1987) to meet out irrigation requirement during drought periods. Analysis on long term rainfall data with estimation meteorological droughts for this region is lacking. Keeping in view this background, rainfall analysis for 3 different periods of time is carried out in this study in order to get an idea about the changes in magnitude and frequency of meteorological drought in this region which will help in planning the cropping pattern.

MATERIALS AND METHODS

Howrah, the smallest district in west Bengal is situated in the hot moist sub-humid agro-ecological sub-region. It is located in between 22º12'30" and 22º46'55" north latitude and 88º22'10" and 87º50'45" east longitude. Hemmed in between the river Hooghly (Bhagirathi) on the east and the Roopnarayan on the west and intersected by the Damodar, the Howrah district consists of a flat alluvial plain.

Monthly rainfall data of 42 years (1970-2011) were collected from the Regional meteorological Centre, Kolkata and the entire period was divided into 3 equal periods of (1970-1983), (1984-1997) and (1998-2011) for comparative analysis. The drought, normal and surplus months and years and their limits were worked out as suggested by Sharma *et. al.* (1979) using the following criteria.

The years were classified as drought years when they received rainfall less than Y-S. Surplus years were classified as the rainfall occurring more than Y+S and normal in between Y-S and Y+S; where ‘Y’ stands for mean annual rainfall and ‘S’ is standard deviation of yearly rainfall. The months were categorized under drought month when they received rainfall less than M/2. Surplus months were defined as the rainfall occurring more than 2M and normal in between M/2 and 2M, where ‘M’ represents the mean monthly rainfall.

The numbers of drought, normal and surplus months were listed in descending order of magnitude and probability analysis had been carried out using Weibull’s formula:

$$P=M/N + 1$$

Where, P is probability of the particular drought, normal and surplus month, M is the rank number starting with one as highest and N is the total number of years for which the data are available.

RESULTS AND DISCUSSION

Monthly rainfall analysis including its distribution patterns and probability of occurrences of drought, normal and surplus months were evaluated for 3 different periods of time-

A) RAINFALL ANALYSIS FOR THE PERIOD FROM 1970 TO 1983

Yearly rainfall analysis indicated that the mean annual rainfall of Howrah for the period from 1970 to 1983 was 1636 mm with the standard deviation of 453 mm. The rainfall characteristics (Table 1) were moderately consistent in nature depicted by the co-efficient of variation value (27.71 %). Further, it was found that all the years were normal years receiving annual rainfall in between 818.1 and 3272.4 mm.

Monthly rainfall analysis (Table 7 & 8) indicated that this district received more than 75 percent of annual rainfall during the monsoon period (June to September). August is the wettest month with an average of 387.1 mm rainfall and it covered 32.55 % of the monsoon rainfall for the period under study.

It is also very much clear from the data that chances of highest rainfall during the month of July was expected as there had no drought month in July for the entire period of 14 years. Month of January was the driest month with a mean annual rainfall of 6.7 mm having 9 drought months within the period under study. But, the highest number of drought months (10) was found in December having the highest value of co-efficient of variation (159.11) which supported the erratic pattern of rainfall during this month.

Out of these 14 years, the drought, normal and surplus months were 30.37, 57.73 and 11.90 percent respectively. So it can be inferred that in a year, expected number of drought, normal and surplus months might be 3.7, 6.9 and 1.4 months respectively. Probability distribution of drought, normal and surplus months in a year (Table 2) revealed that the maximum number of drought, normal and surplus months in a year were 8, 9 and 6 respectively. At maximum probability (0.933), there may be chances to get 3 normal months. The probability analysis also revealed that there was 2 drought months, 5 normal months with a probability of 0.733.

B) RAINFALL ANALYSIS FOR THE PERIOD FROM 1984 TO 1997

Critical analysis of the rainfall during this period showed that mean annual rainfall of Howrah district was 1732.2 mm with standard deviation of 352.2 mm (Table 3). The co-efficient of variation value of 20.39 % corroborated to the fact that rainfall characteristics was more or less consistent and all the 14 normal years received rainfall within the range of 864.1 to 3464.3 mm.

It had been found that more than 79% of the total annual rainfall was contributed by monsoon season whereas 11.9 % and 8.9 % were contributed by pre-monsoon (February to May) and post monsoon (October to January) respectively (Table 7). Out of the total monsoon rainfall during 1984 to 1997, July was observed to contribute maximum with 27.33 %, followed by August with 26.95 % (Table 8). Similar trend of monsoon rainfall i.e. highest contribution by the month of July was also found by Jat *et. al.* (2005). It had been observed from Table 3 that the months of May, June, July and August had chances of high rainfall as they had very low drought months which were only 1 to 2. December was recorded as the driest month within the entire period with a mean rainfall of only 1.9 mm and maximum number of drought months (9). Very high value of co-efficient of variation (227.06 %) showed lack of uniformity in rainfall pattern during this month. Similar trend for the December rainfall was also observed by Saha and Mishra, 2005 for Umiam district of Meghalaya.

The drought, normal and surplus months were 34.52, 52.38 and 13.10 percent respectively within 1984 to 1997. Therefore, expected number of drought, normal and surplus months might be 4.1, 6.3 and 1.6 months respectively. At minimum probability (0.067), there might be chances to get 8 drought months, 9 normal months and 3 surplus months. But, at the highest probability level of 0.933 there was a chance to get only 1 drought month (Table 4).

C) RAINFALL ANALYSIS FOR THE PERIOD FROM 1998 TO 2011

The latest period of data i.e. from 1998 to 2011 (Table 5) showed that mean annual rainfall and standard deviation was 1532.2 and 255.9 mm respectively maintaining a consistent nature of distribution through this time span which was reflected by the co-efficient of variation value of 15.40%. The difference between the annual dry and surplus limit was 2280.3 mm and all the years were normal.

The distribution patterns of rainfall in three different seasons were 13.7, 74.6 and 11.7 percent for pre-monsoon, monsoon and post-monsoon respectively (Table 7). The month of July had the highest contribution (30.40%), whereas the months of June, August and September had more or less comparable distribution to the monsoon rainfall (Table 8).

It was also very much clear that the chances of high rainfall during July to September were assured as they had the lowest drought month (Table 5). December was the driest month with a mean rainfall of only 3.8 mm having maximum number of drought months and highest co-efficient of variation value (204.89), which showed unevenness of the rainfall pattern for the month within the period under study.

Critical analysis of the rainfall data during 1998 to 2011 revealed that 38.1, 50.0 and 11.9 percent of the months were drought, normal and surplus respectively and therefore expected number of these months might be 4.6, 6 and 1.4 within a year. The month of December had the maximum contribution as far as drought months were concerned, accounted for 11 years out of 14 years followed by November, January, February, March and September. Probability distribution of drought, normal and surplus months in a year (Table 6) depicted that the maximum number of drought, normal and surplus months in a year were 8, 9 and 6 respectively. At maximum probability value of 0.933 there might be chances to get 2 drought months and 3 normal months.

D) COMPARISON OF RAINFALL PATTERN OVER THE THREE PERIODS UNDER STUDY

Rainfall pattern of Howrah district over the 42 years were critically compared within three equal period of distribution. It had been found that average and total rainfall was the least during the last 14 years (Table 9). But the mean rainfall during the drought year was highest while the same during the normal and surplus year was the minimum during the period from 1997 to 2011. It had also been observed that numbers of drought months were increased from a minimum of 51 during 1970-83 to a maximum of 64 during 1997-2011. Total deviation in rainfall during the drought and surplus years were also taken into account and it had been found that the negative deviation for the drought months was decreased considerably from (-) 352.1 mm during 1970-83 to (-) 284 mm between 1984 and 1997 and to only (-) 71.1 during 1997-2011. The amount of positive rainfall for the surplus years was also the least during the last period under study i.e. from 1997 to 2011. Increasing number of drought months along with decreasing rainfall during the last 14 years may be due to the effect of global warming during this time. Trenberth, 2011 in his study also indicated the direct influence of global warming on the precipitation pattern.

Percent distribution of monsoon rainfall revealed that rainfall during the months of June, July increased sharply and narrowly for September from the first 14 years (1970-1983) till the last 14 years (1997-2011). But, a completely reverse trend in case of August rainfall, where a very sharp decline to the monsoon rainfall contribution was observed over the three different periods in a decreasing trend from 1970-83 to 1998-2011 (Fig.1).

CONCLUSION

It can be concluded that the drought periods were generally concentrated in between November to March where as normal to surplus periods were from April to October. The surplus monsoon rainfall water may be used for irrigation by rainwater harvesting technology during drought periods. Increasing global temperature over the last two decades may be the cause of decrease in mean annual rainfall and increase in drought months over the last 14 years.

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