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Drought spells over north-central India during the 1979 southwest monsoon

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सार — वर्ष 1979 के ग्रीष्मकालीन मानसून के दौरान उत्तर-मध्य भारत में व्यापक अनावृष्टि के दौर सामने आए । इस शोधपत्र में थोर्नथवाइट और मेथर (1955) की लेखांकन की प्रक्रिया का अनुसरण करते हुए उक्त क्षेत्र के प्रतिनिधि स्टेशनों में अल्पावधि जल संतुलन परअनावृष्टिके प्रभाव का अध्ययन करने का प्रयास किया गया है । अनावृष्टि के दौरों की तीव्रता एवं अवधि को अंकित एवं वर्गीकृत करने कलिए संचयी विचलन प्रविधि का उपयोग किया गया है ।

ABSTRACT. Widespread drought spells were observed over north-central India during the 1979 summer monsoon. An attempt has been made in the present paper to study the impact of drought conditions on the short period water balances of representative stations in the region, following the bookkeeping procedure of Thornthwaite and Mather (1955). Cumulative deviation techniques have been used to delineate and categorise the intensity and duration of drought spells.

1. Introduction

It is now fairly well established that climate in its natural or steady state is rarely found while what is more frequently experienced is its variation. One of the most important consequences of this variation is the imbalance in the water budget which is delicately balanced between water supply (precipitation) and water demand (evapotranspiration). Agricultural production is strongly geared to the water budget which is determined by precipitation and evapotranspiration. Other conditions being normal, agricultural production can be maximised only when adequate quantities of water are available at the appropriate time for the uninhibited growth and development of crops.

In a country like India, where droughts are as severe as they are frequent, it is essential to know the water requirements of individual regions and the extent to which the water supply by precipitation is not able to meet these requirements. According to the water balance approach, drought is a situation in which the amount of water needed for maximum evapotranspiration exceeds the amount obtainable from precipitation and the soil moisture reserve. Subrahmanyam and Subramaniam (1964) and others have applied water balance concepts of Thornthwaite (1948) and Thornthwaite and Mather (1955) for climatic studies of droughts in India.

Sastri and Malakar (1981) attempted a climatological analysis of the 1979 drought conditions over northwest India by computing departures of aridity indices (I_a) for the year from the climatic normal values. Their study was on a monthly basis and restricted itself to the incidence, spread and dissipation of the drought over the region as a whole. However, wide fluctuation in the water balances are possible within a period of a month at individual stations in a region. Hence, a more useful study would be to analyse the frequency and intensity of droughts on a smaller time scale for individual stations by critically examining their impact on local water balances.

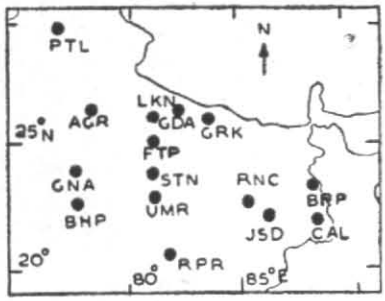

Fig. 1. Location of representative stations

2. Methodology

In this study of the wide spread drought over large parts of India during the monsoon (June-September) season in 1979, 5-day (standard pentads) rainfall and mean temperature data were used to compute water balances of fifteen representative stations (Fig. 1) in the States of Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar, West Bengal and Punjab from the twenty fifth pentad (1-5 May) to the sixty seventh pentad (27 Nov-1 Dec) so that the antecedant (pre-monsoon) and subsequent (post-monsoon) eco-climatic conditions may also be studied. All the important water balance parameters (actual evapotranspiration, soil moisture storage, water deficit and water surplus) have been derived using the book-keeping procedure (Thornthwaite 1978 and Thornthwaite and Mather 1955) and periods and magnitudes of water deficits were identified.

The intensity of a drought spell is as important as its duration in as much as both of them together determine the ultimate effect of water shortage on the economic situation (Subrahmanyam and Sastry 1969). Following the techniques of cumulative deviations, the deviation of 5-day water deficiencies (rather than rainfall departures) from the climatic normals were taken and expressed as ratios of normal annual water need (PE) in units of thousandths. These units were cumulated from an arbitrary origin (zero) and plotted against pentads, as was done by Foley (1957) for Australia using monthly rainfall deviations. The core period of the drought is then indicated by the steepest rise of the mass curve, the gradient of which gives the severity index of the drought during the period under question (Subrahmanyam 1967). The intensity of a drought is categorized as below :

Severity index	*Category of drought*	
0–10	Moderate	(M)
10–15	Large	(L)
15–20	Severe	(S)
>20	Disastrous	(D)

3. Results and discussions

Before the onset of the monsoon, rainfall was low over all the stations studied. The monsoon advanced into Gangetic West Bengal, Orissa and Bihar around 23 June, but was generally weak till the first week of July. Around 10 July, it advanced into western Uttar Pradesh and West Bengal. Around 15 July, the monsoon trough shifted to the foothills of the Himalayas, causing weak monsoon conditions over the country. However, it revived when a southward shift of the trough took place between 21 & 24 July.

By the first week of August, active monsoon conditions were prevalent over the region, with a low pressure area over the northeast Bay. But around the second week of August, the monsoon trough again moved northward causing weak monsoon conditions over many States. Until the beginning of September 1979, break monsoon situation was evident and only around 4 September, did the monsoon revive again and become vigorous all over the country. Monsoon began withdrawing from the study area on the 23 September and by the first week of October had left the region.

The rainfall for the monsoon period as a whole was deficient by more than 20 per cent in many meteorological sub-divisions of Bihar, Madhya Pradesh, east Rajasthan, Uttar Pradesh. Punjab, Haryana and Delhi. Rainfall was normal in Gangetic West Bengal and Orissa.

3.1. *Impact of the monsoon on water balances*

The water balances of three stations — Raipur (East Madhya Pradesh and Orissa), Gorakhpur (Uttar Pradesh and north Bihar) and Bhopal (west Madhya Pradesh and east Rajasthan) representing the regions given within brackets are representing the regions given within brackets, are three regions exhibit similar water balance conditions.

Before the advent of the monsoon, all stations experienced large water deficits in all the pentads. But the onset was reflected immediately, by an increase in the precipitation and consequent soil moisture accretion after the needs of potential evapotranspiration were fully met (Fig. 2). Raipur, for example experienced large water deficits till the 35th pentad. Precipitation during this pentad and the next was 91 mm and 45 mm respectively; soil moisture accretion took place to the extent of 80 mm, which was partially (9 mm) used up during the 37th pentad. However, heavy rains due to a low pressure area over Orissa brought back the soil moisture to fairly satisfactory levels and water deficits were absent till the 45th pentad. Deficiencies were observed from the 46th pentad onwards when the break monsoon conditions were prevalent.

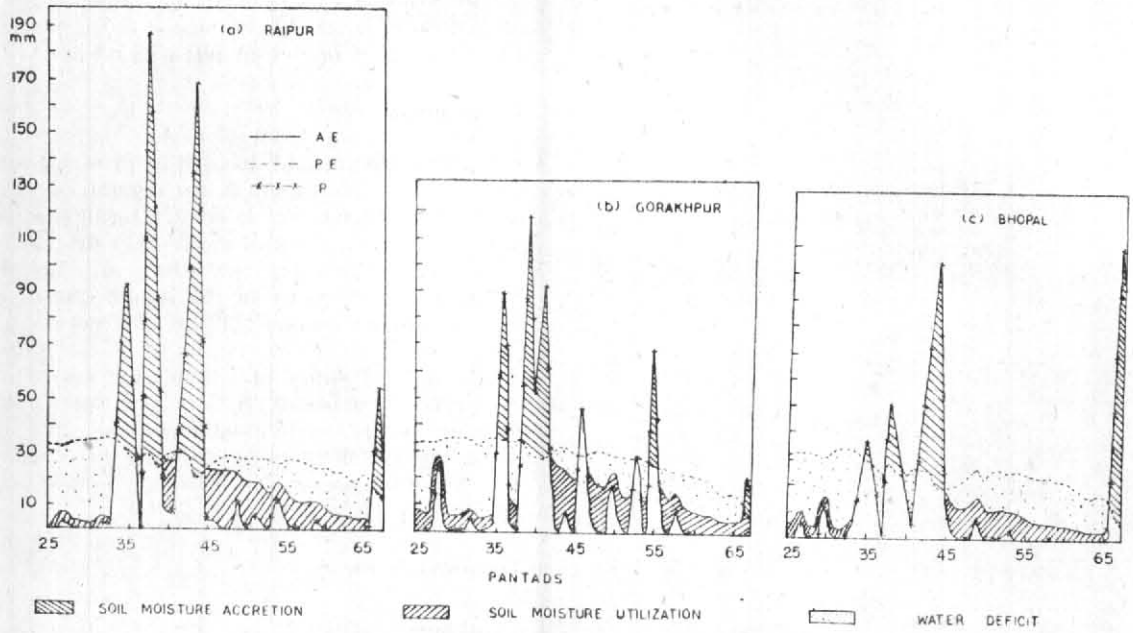

Fig. 2. Water balance during 1979 southwest monsoon

TABLE 1

Duration and severity indices of drought spells

S. No.	Station	Drought spell	Duration (days)	Severity index	Category
1	Calcutta	26 May–9 Jun	15	14.67	L
2	Fatehpur	30 Jun–9 Jul	10	15.28	S
		19 Aug–27 Sep	40	11.56	L
3	Gorakhpur	31 May–24 Jun	25	19.60	S
		30 Jun–9 Jul	10	8.07	M
4	Jamshedpur	31 May–9 Jun	10	20.17	D
		5 Jul–29 Jul	25	9.12	M
		13 Sep–26 Nov	75	6.67	M
5	Ranchi	16 May–9 Jul	55	12.29	L
6	Bhopal	31 May–19 Jun	20	18.48	S
		14 Aug–26 Nov	105	9.74	M
7	Lucknow	31 May–9 Jun	10	11.38	L
		15 Jun–9 Jul	25	8.77	M
		19 Aug–27 Sep	40	14.56	L
8	Guna	31 May–9 Jul	40	17.15	S
		14 Aug–16 Nov	95	19.44	S
9	Agra	4 Aug–2 Sep	60	16.55	S
10	Satna	8 Sep–26 Nov	80	12.03	L
11	Patiala	16 May–9 Jun	25	9.78	M
		15 Jun–19 Jul	35	11.80	L
		14 Aug–12 Sep	30	11.17	L
12	Umaria	31 May–24 Jun	25	17.00	S
		30 Jun–9 Jul	10	14.69	L
		19 Aug–26 Nov	100	9.09	M
13	Gonda	1 May–9 Jul	70	17.84	S
		13 Jul–28 Aug	30	15.17	S
		3 Sep–26 Nov	85	11.42	L
14	Berhampur	1 May–4 Jul	65	14.54	L
15	Raipur	1 May–14 Jun	45	17.94	S
		8 Oct–26 Nov	50	9.89	M

Gorakhpur, a station further north on the monsoon track, on the foothills of the Himalayas, exhibited soil moisture accretion for the first time in the season in the 36th pentad because the onset was around 28 June. Precipitation decreased the next pentad but the monsoon was again active between the 39th and 42nd pentads and soil moisture storage improved to 247 mm. Such a satisfactory soil moisture status continued till the end of the month when the monsoon trough shifted southwards. Rainfall decreased over this region and increased over central India and other parts of the country. But during the 46th pentad (14-18 August) there was a low over Uttar Pradesh and Bihar and hence rainfall was high (47 mm) over this station. Deficits existed during the rest of the season.

The water balance of Bhopal, a station in central India is now discussed with the onset of monsoon here in the 35th pentad, precipitation was greater than water need and there was a small increase in soil moisture storage. However, precipitation was low in the 37th pentad causing soil moisture depletion. However, the monsoon revived due to a depression in the north Bay and hence precipitation was heavy from the 38th pentad onwards. Soil moisture storage improved to 187 mm by the end of the 45th pentad. When break monsoon conditions set in from around 16 August, rainfall decreased and soil moisture depletion was observed. Even when monsoon revived over other regions, rainfall was very low over Bhopal till the end of November. Water deficits were high from the 46th pentad onwards.

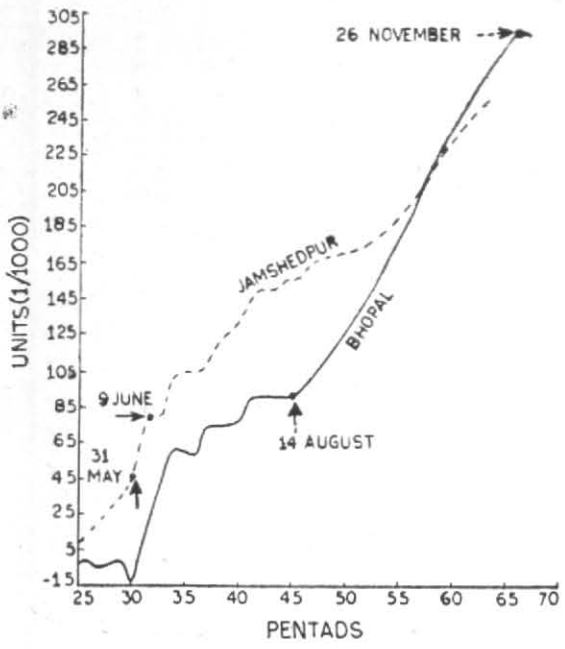

Fig. 3. Cumulative deviations of water defeciencies

3.2. *Intensities and duration of drought spells*

The study of the water balances of above three stations gives an idea of the duration and magnitudes of water deficits in the regions they represent. Absolute values of water deficits are, however, not sufficient to indicate the intensity of the drought spells and comparison with normal water deficits are essential. Drought is a relative term and can be regarded as the positive deviation of water deficiencies over normal. The cumulative deviation technique has been employed and the intensities and duration of all drought spells have been presented in Table 1.

All the stations had at least one drought spell of 10 days duration or more during the period of study. Almost all stations experienced drought conditions during the break monsoon period beginning from about 18 August 1979. Only stations in West Bengal and Orissa were exceptions to this.

The most intense drought (disastrous) was experienced at Jamshedpur between 31 May & 9 June (pentads 31 and 32) before the monsoon set in. Bhopal experienced the longest spell for any station from 14 August to 26 November (105 days) of moderate intensity (Fig. 3).

4. Conclusion

Ecologically, a mild drought of prolonged duration is more detrimental to vegetation than a short duration intense drought. During the study period, there were prolonged drought spells of large and severe categories which are capable of crippling the economy of the region due to their adverse impact on agricultural production.

The water balance procedure thus can be used to effectively delineate periods and intensities of droughts from a eco-climatic point of view. It is suggested that these techniques are more rational in delineating areas and periods of drought and categorising their severities.

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