

Spread of drought in Rajasthan during the 1987 south-west monsoon

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सार – वर्ष 1987 के दौरान राजस्थान में दक्षिणी-पश्चिमी मानसून के अभाव के कारण इस क्षेत्र के अधिकांश भागों में एक बार फिर व्यापक रूप से भीषण सूखा पड़ा। पंद्रह वर्षों की अवधि (1981-95) के दौरान भीषण सूखे के वर्ष में कृषि उत्पादन में विशेषकर शुष्क क्षेत्रों के उत्पादन में काफी कमी आई है। जल संतुलन का निर्धारण करने के लिए पेनमेन-मोन्टीयथ विधि द्वारा वाष्पन-वाष्पोत्सर्जन के साप्ताहिक निर्देश मानों का आकलन किया गया है। फतेहपुर को छोड़कर, जहाँ सामान्य सूखा वर्ष था, इस शोध-पत्र में विवेचित सभी स्थानों के लिए 1987 का वर्ष भीषण अथवा अत्याधिक सूखे वाला वर्ष पाया गया। 1987 के भीषण सूखा वर्ष के दौरान राजस्थान में सूखा पड़ने और उसके प्रभाव क्षेत्र के अध्ययन से यह पता चला है कि 26वें सप्ताह के दौरान सूखे की स्थितियाँ पहले दक्षिणी क्षेत्र (बाँसवाड़ा) में बनी, 27वें और 28वें सप्ताह के दौरान दक्षिणी-पश्चिमी दिशा (जोधपुर और पाली) सूखा में पड़ा और 39वें सप्ताह में उत्तर-पूर्वी दिशा (फतेहपुर) की ओर बढ़ने के साथ यह समाप्त हो गया।

ABSTRACT. The failure of south-west monsoon over the Rajasthan state during 1987, has once again resulted in wide spread drought in most part of state. Agricultural production especially, in dryland tracts has considerably decreased, during the year of worst drought during 15 years period (1981-95). Weekly reference evapotranspiration values were estimate by Penman Montheith method for determination of water balance. The year 1987 found to be severe or disastrous drought year at all the stations studied except at Fatehpur where it was a moderate drought year. Studies on the incidence and spread of drought over Rajasthan during the severe drought year 1987, revealed that drought condition originated first in southern region (Banswara) during the 26th week, spread in south-west direction (Jodhpur and Pali) during the 27th & 28th weeks and dissipated in a north-east direction movement (Fatehpur) in 39th week.

Key words – Drought, Rajasthan, SW Monsoon.

1. Introduction

In any climatic province incidences of drought are a consequence of failure of seasonal rains. The subcontinent of India is highly dominated by the southwest monsoon, which varies in space and time. Failure of seasonal rains triggers moisture depletion on which magnitude and intensity of drought depend. In Rajasthan, agriculture is primarily rain depend. Every year its fat oscillates with the quantity, onset, progress and spatial distribution of rainfall. Thus, failure of monsoon in an area, where more than two-third of the area under cultivation is rainfed and where irrigation system is largely poor and in sufficient, often creates fall in employment, food, fodder and drinking water for both men and cattle. Due to geographical situation and climatic conditions, drought is almost prevailing in some parts of Rajasthan like an uninvited guest. In Marwar area of Rajasthan, people generally expected drought one year in every three years and one famine year in every eight years (Gahlot, 1937).

Drought is not a direct result of the shortage of rainfall alone but is something related to the soil and water need of a place. Hence, any drought analysis, which is based on the rainfall criteria alone, is inadequate to explain drought conditions properly. Thornthwaite and Mather (1955) also felt that drought does not begin when rain ceases but rather only when plant roots can no longer obtain moisture in the needed amount. Thus agricultural drought is a situation when the rainfall and soil moisture are inadequate to meet the water requirement of crops for their healthy growth and maturity.

Droughts, which are more frequent in arid and semiarid regions, seem to follow a pattern giving the hope that possibilities exist for their prediction. Drought have an origin and spread as well as decay (Linsley *et al.*, 1959). Prediction of drought by spread approach has been well tested and recommended by earlier workers. (Subrahmanyam and Sastri, 1971, Malini, 1981, Sastri and Malaker, 1981 and Ram Mohan *et al.*, 1984). In this

paper spread of drought approach has been used for the prediction drought during severe drought year 1987.

2. Methodology

The area comes under the study is the whole of Rajasthan state, which is the largest state of India with the geographical area of 34,224 thousand hectares. It represents 10.41 per cent area of the country. The state is situated in north-western part of India between 23° 30' and 30° 12' N latitude and 69°30' and 78°17' E longitude. The shape of Rajasthan state resembles an irregular rhombus with the north south diagonal about 784 km and the east-west diagonal about 850 km. In the present study meteorological and soil data from eight different stations (Fig. 1) representing each agro-climatic zone for a period of 15 years (1981-95) were collected.

Reference evapotranspiration (ET_o) was computed by Penman-Monteith method as suggested by Allen *et al.* (1998). The method overcomes the short comings of the FAO-24 Penman method and provides values that more consistent with actual crop water use data worldwide Allen *et al.* (1998) gave the following equation for estimation of reference evapotranspiration.

$$ET_o = \frac{0.408\Delta (R_n - G) + \gamma(900/T + 273) \times U_2 (e_a - e_d)}{\Delta + \gamma(1 + 0.34U_2)} \quad (1)$$

Where,

ET_o = reference evapotranspiration (mm day⁻¹),

R_n = net radiation (mjm⁻² d⁻¹) = R_{ns}-R_{nl},

R_{ns} = net short wave radiation (mjm⁻² d⁻¹),

R_{nl} = net long wave radiation (mjm⁻² d⁻¹),

T = mean daily air temperature (°C),

Δ = psychrometric constant (vapour) (k Pa °C⁻¹),

γ = slope of the saturation vapour pressure at temperature T (kPa),

e_a = saturation vapour pressure at dew point T (kPa),

e_d = saturation vapour pressure at dew point (kPa),

U₂ = average daily wind speed at 2 m height (ms⁻¹).

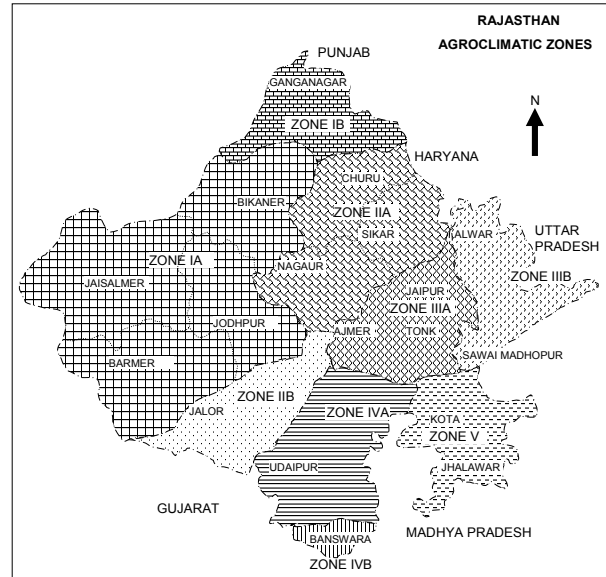


Fig. 1. Agroclimatic zones of Rajasthan

$$U_2 = \frac{U_z l_n \frac{Z_2 - d}{Z_{om}}}{l_n \frac{Z_n - d}{Z_{om}}} \quad (2)$$

U_z = mean wind speed measurement at height Z (ms⁻¹),

Z_n = height of wind speed measurement (m),

Z₂ = standard height of wind speed measurement (m) 2 m,

d = zero plane displacement of wind profile (m) = 0.08 m,

Z_{om} = roughness parameter momentum (m) = 0.015 m.

The weekly soil water balance was computed following the procedure introduced by Thornthwaite and Mather (1955). Drought was evaluated in terms of drought intensity for all the station under study by following the criteria proposed by Subrahmanyam and Sastri (1969) :

Departure of aridity index from the median	Drought intensity
< ½ 6	Moderate
½ 6 to 6	Large
6 to 2 6	Severe
> 2 6	Disastrous

Where, 6 is standard deviation of aridity index.

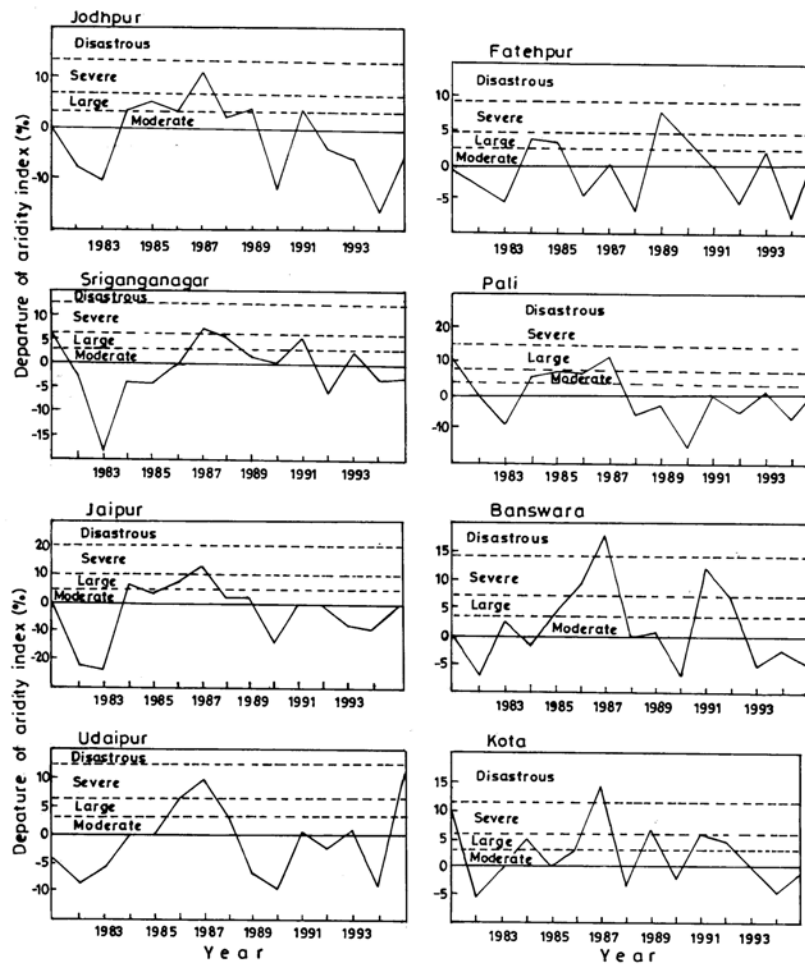


Fig. 2. March of yearly aridity index for different stations in Rajasthan (1981-95)

Departures of weekly water deficiency from the cumulative normal were taken and expressed as ratios of the normal water need in units of thousands. For depicting the spread of drought, the departure of actual weekly water deficiencies from normal values were calculated for all the stations and were expressed as a percent of water need (ETo) in unit of one thousand (these values are referred as “d”).

3. Results and discussion

3.1. Evaluation of drought

For the analytical study of drought with special reference to their intensity and frequency, the aridity index (Ia) has been used. Years of drought may easily be identified and the intensities can also be assessed. Fig. 2 show the march of the yearly aridity index at different stations. Taxonomy of drought has been made for different station in Rajasthan on the basis of their intensity by standard deviation technique. Drought years and their severities for different stations are given in Table 1.

It can be seen from Table 1 that according to drought classification (Subrahmanyam and Sastri, 1969), year 1987 was identified as a severe drought year at all the stations of the state. This of also inferred that the frequency of occurrence of drought of different intensities is 7 in all the stations under study except at Udaipur, where its frequency of occurrence is 6 out of 15 years. The percentage departure of aridity index from the median is higher at Banswara and Kota, which caused one disastrous drought year (1987).

No moderate drought year was experienced at Kota, whereas Jaipur experienced highest four moderate drought years. The frequency of occurrence of large drought years varied from zero at Udaipur to 5 at Jodhpur. It is also interesting to note that the year 1987 was either severe or disastrous drought year at all the stations except at Fatehpur where a moderate drought was experienced during 1987.

TABLE 1
Drought years and their severities during 1981-95

Station	Severity of drought				Total drought year
	Moderate	Large	Severe	Disastrous	
Jodhpur	1988	1984, 1985, 1986, 1989, 1991	1987	-	7
Sriganganagar	1989, 1990, 1993	1984, 1991	1981, 1987	-	7
Fatehpur	1987, 1993	1984, 1985, 1989, 1995	1989	-	7
Pali	1993, 1995	1984, 1985, 1986	1981, 1987	-	7
Jaipur	1981, 1985, 1988, 1989	1984, 1986	1987	-	7
Udaipur	1988, 1991, 1993	-	1986, 1987, 1995	-	6
Banswara	1983, 1989	1985, 1992	1986, 1991	1987	7
Kota	-	1984, 1986, 1992	1981, 1989, 1991	1987	7

3.2. Spread of drought

Drought, usually do not descend all of a sudden with out warning, but they are usually the result of cumination of a weather sequences that require extended periods of time to develop. Droughts have their origin and decay, it is of utmost importance to planners to have knowledge of the drought vulnerability, and pattern of spread of drought in a region. This can enable them to plan timely measures to combat the intensity of drought and to mitigate the drought effect, as the reasons, are known in advance once the drought spell begin. In Rajasthan, often one part or the other experiences localized drought. However, in some years the whole state experiences drought conditions. Studies revel that even in such years, the drought intensity and its time of occurrence varied from zone to zone. In order to project a pattern of drought spread in Rajasthan, the severe drought year 1987 was selected. Diagrams depicting the spread of drought based on the departures of actual weekly water deficiency from normal values to the ratio of annual water need and expressed in 1000 units are presented from 23rd to 39th week, during the main rainy season in the state (Fig. 3).

A perusal of Fig. 3 clearly indicates that the zone of maximum drought intensity changed both its intensity and location in different weeks indicating a sequential pattern of drought spread and decay over the state. There were no drought conditions until 25th week in Banswara region, which experiences moist sub-humid type of climate over the state in comparison to the regions experiencing semi-arid, arid and extremely arid type of climates. Also interesting is the fact that the lowest values of water deficiencies were observed in Jodhpur region which records the lowest annual rainfall. Thus during the year 1987, the water deficiency remained slightly pronounced in the southern region of Rajasthan except at Udaipur

region during 23rd and 26th week, *i.e.*, even before the monsoon onset, with elongation direction of the isolines in the south-west direction into the Pali and Jodhpur regions. By 27th week the drought conditions in Rajasthan not only intensified but once definite core of severe drought conditions in Rajasthan not only intensified by one definite core of severe drought can be identified in Pali. The isolines run south to north during this week also, with increase in the intensity of the drought over a major part of the state. However the decreasing gradient continued to be in north to south and also from south to south-west direction towards the Jodhpur and Pali regions during the 28th week and lowest intensity being recorded in the Jodhpur and Pali regions. Thus the drought which originated in Banswara region had intensified from moderate to large drought and Kota respectively by 28th week. Sriganganager, Jodhpur, Fatehpur and Udaipur region had experienced large drought conditions during this period.

The drought intensity in the Jaipur region had eased off by 29th week. During the 30th and 31th weeks drought spread all over the Rajasthan state and large drought conditions were experienced. Then the drought intensity had eased off in the Fatehpur region by 32nd to 34th weeks, in the Udaipur region by 32nd to 35th weeks and in the Banswara and Kota regions by 34th to 35th weeks. The lage drought intensity in the Jaipur region had also eased off by 35th weeks. By the 36th week, Banswara had lowest water deficiency and isolines run from east to south and also north east to south east in 37th week. By the 38th week Kota has experienced lowest water deficiency and isolines run from south to north of the state. By the 39th week the water deficiency with lesser intensity around Fatehpur while over the rest of the region the fraught core had merged with the seasonal drought (occurring with the rainless period after the withdrawal of the monsoon).

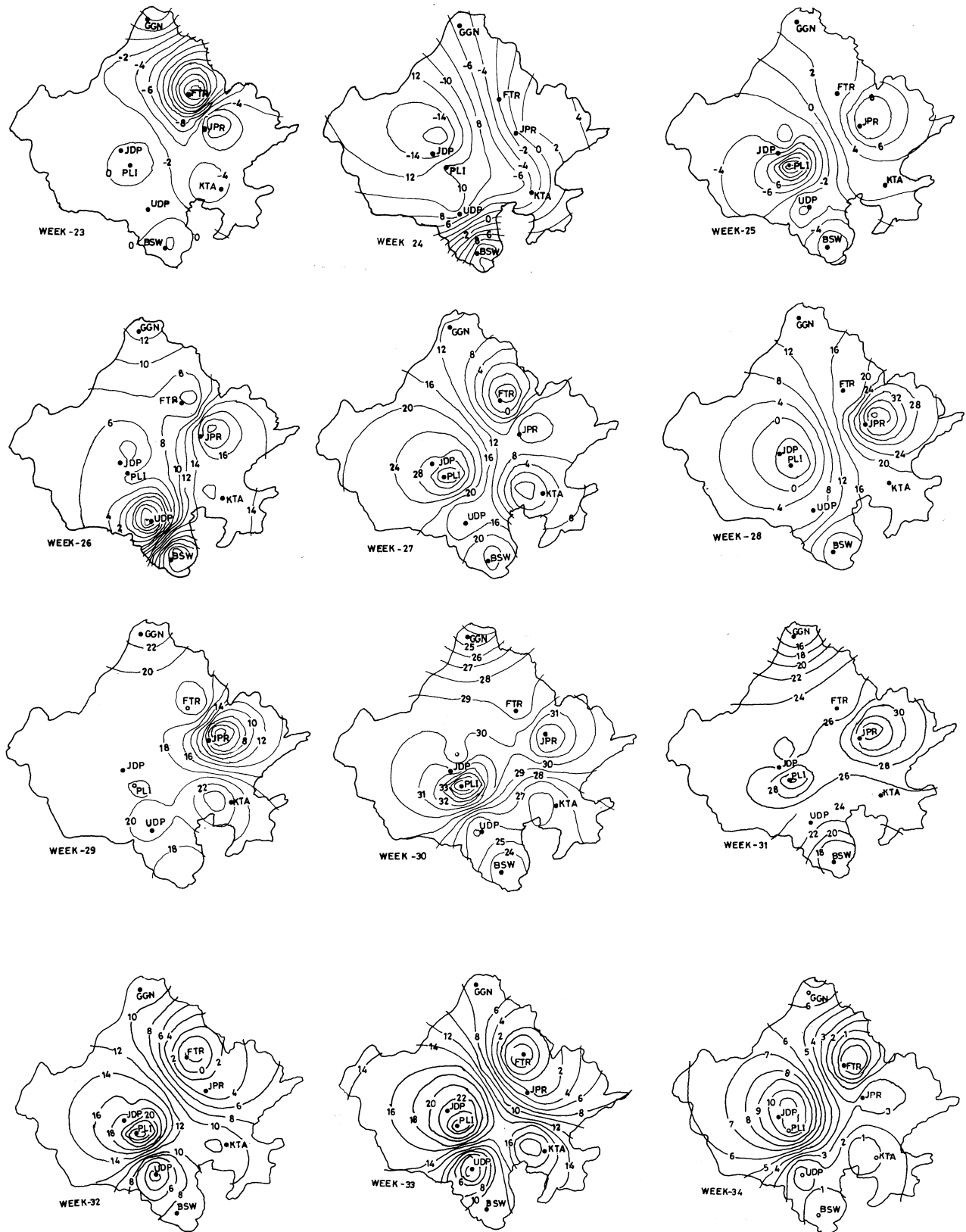


Fig. 3. Weekly variation in drought spread over Rajasthan during the year 1987

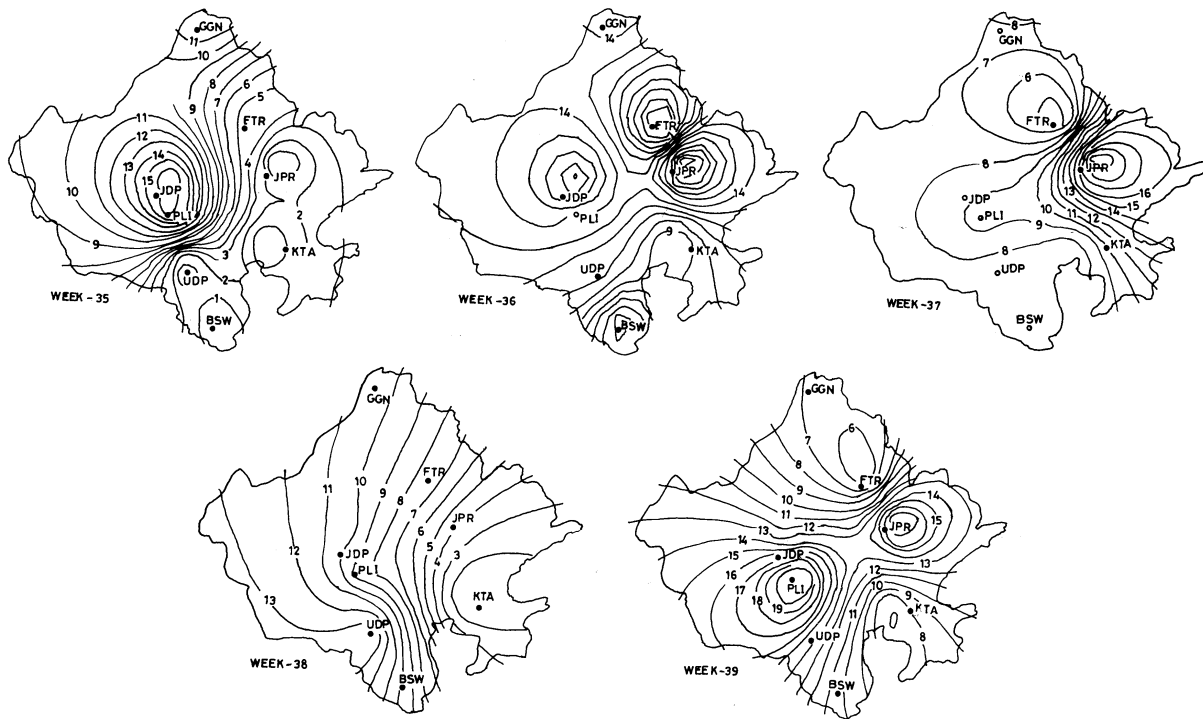


Fig. 3(Contd.). Weekly variation in drought spread over Rajasthan during the year 1987

Thus, it clearly indicates that the occurrence and spread of drought is not a sporadic event in Rajasthan state but it has a general tendency to originate in the southern region spread in southwesterly direction and dissipate with a northeasterly movement. The analysis thus clearly brings out two important facts, viz., the effect of drought is more discernable and occurs early in regions receiving comparatively higher rainfall than region of lower rainfall and secondly that they have an origin and follow a pattern of spread and decay. This type of analysis could be useful to pinpoint the origin and the gradual spread of drought into various regions of the state and would provide advance information to crop planners to mitigate the ill effects of such severe drought as well as minimizing the economic imbalances.

4. Conclusion

It can be concluded from the results of the present study that the year 1987 was found to be severe or disastrous drought year at all the stations except at Fatehpur, which experienced 1987 year as a moderate drought year. The occurrence and spread of drought was not found as a sporadic event in Rajasthan state but had a tendency to originate in southern region at Banswara from 26th week to spread in southwest direction in 27th-28th weeks and to dissipate with a northeastern movement in 39th week at Fatehpur.

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