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Characteristics of short period rainfall in Gujarat

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ABSTRACT. Weekly rainfall of 30-70 years for one station in each of fifteen districts in the dry land tract of Gujarat State has been studied. The assured amounts of rainfall that may be expected to be exceeded in 30 and 50 per cent of the years are shown. The distribution of dry and wet weeks during the monsoon season has been examined. In general number of wet weeks varies from two to twelve in each year during the monsoon season and the remaining are dry weeks. The average number of wet weeks increases as we proceed from west to east. The mean length of a wet spell also increases from two weeks at Bhuj to three weeks at Dohad. Mean length of a dry spell in monsoon varies from three to two weeks.

1. Introduction

Nearly the whole of Gujarat State lies in the dry farming tract of northwest India. The average annual rainfall in the different districts varies from 32 cm in Kutch to 100 cm in Panchmahals except for the southernmost district of Surat where it exceeds 150 cm. The area is characterised by generally low agricultural productivity and high instability. Irrigated area accounts for only about 10 per cent of the area under the plough and in Saurashtra this is less than 5 per cent. Rainfed crops like jowar, maize, pulses, groundnut and cotton form the bulk of the crop in the State. Good yield depends on well distributed rain. The probability of rainfall on a weekly basis, and the distribution of length of wet and dry spells in the State have been studied and are discussed in this paper. It is felt that such a study of the short period rainfall is the first step for delineating the Gujarat State into homogeneous rainfall zones. The result of this study when super imposed on soil and its depth will throw some light for revising the existing cropping pattern and economic practices for drylands so as to optimise the yield.

2. Data

Rainfall data available for standard weeks for 30-70 years have been used in this analysis. One station where a departmental observatory is situated in each district in the dry farming tract where the annual rainfall is less than 100 cm has been selected for the study. In the absence of sufficiently long period of data of a departmental observatory a suitabble State raingauge station with rainfall information available for a large number of years has been selected.

3. Annual and seasonal rainfall distribution

The distribution of annual rainfall for the State is given in Fig. 1. Except the southernmost parts of the State which gets more than 150 cm rainfall, the average annual rainfall of the major portion of the State is less than 100 cm. The entire Saurashtra and Kutch with an exception of Junagadh area gets less than 65 cm of rainfall. As little rain as 30 cm is recorded in the northwest corner of Kutch. Rao *et al.* (1972) made a detailed study of frequency distribution of Indian rainfall of 500 stations for a sixty year period, and concluded that the annual rainfall is more or less normally distributed. Fig. 1 also gives coefficient of variation (C.V.) of annual rainfall in Gujarat. It is seen that C.V. varies from 30 to 70 per cent in general. For rainfall less than 50 cm, C.V. is higher than 30 per cent. Fig. 2 shows the frequency distribution of annual rainfall at a typical station, Ahmedabad. The frequency curve is clearly seen to be the normal bell shaped curve. By and large, most of the rainfall in a year occurs during the southwest monsoon season (June to September). The C.V. of seasonal rainfall is similar to that of the annual rainfall. Neither the annual nor the seasonal rainfall distribution show skewness (Rao *et al.* 1972).

3.1. *Contribution to annual rainfall by daily values*

From an analysis of the distribution of 24 hr rainfall in different ranges at two stations, Ahmedabad (1893 to 1970) and Rajkot (1901 to 1970) it appears that 50 per cent of rainy days get amount less than 10 mm rainfall. It is further observed that 60 per cent of the annual rain is contributed by 25 per cent of the rainy days with more than 25 mm daily rainfall. That is to say, the rainfall at these stations is contributed by a small number of days of 'moderate rain' and a large number of occasions of 'light rain'.

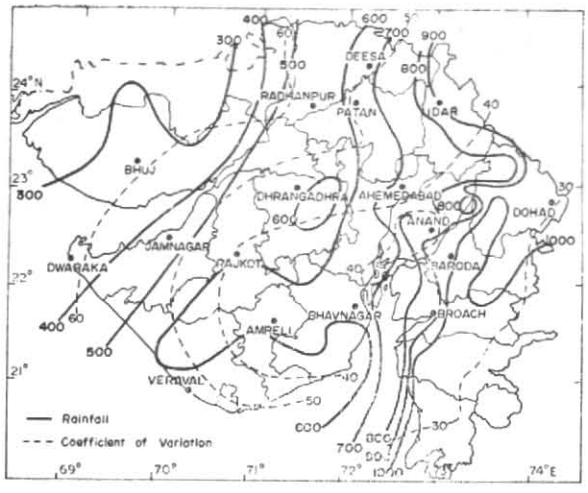

Fig. 1. Annual normal rainfall (mm) and coefficient of variation (per cent)

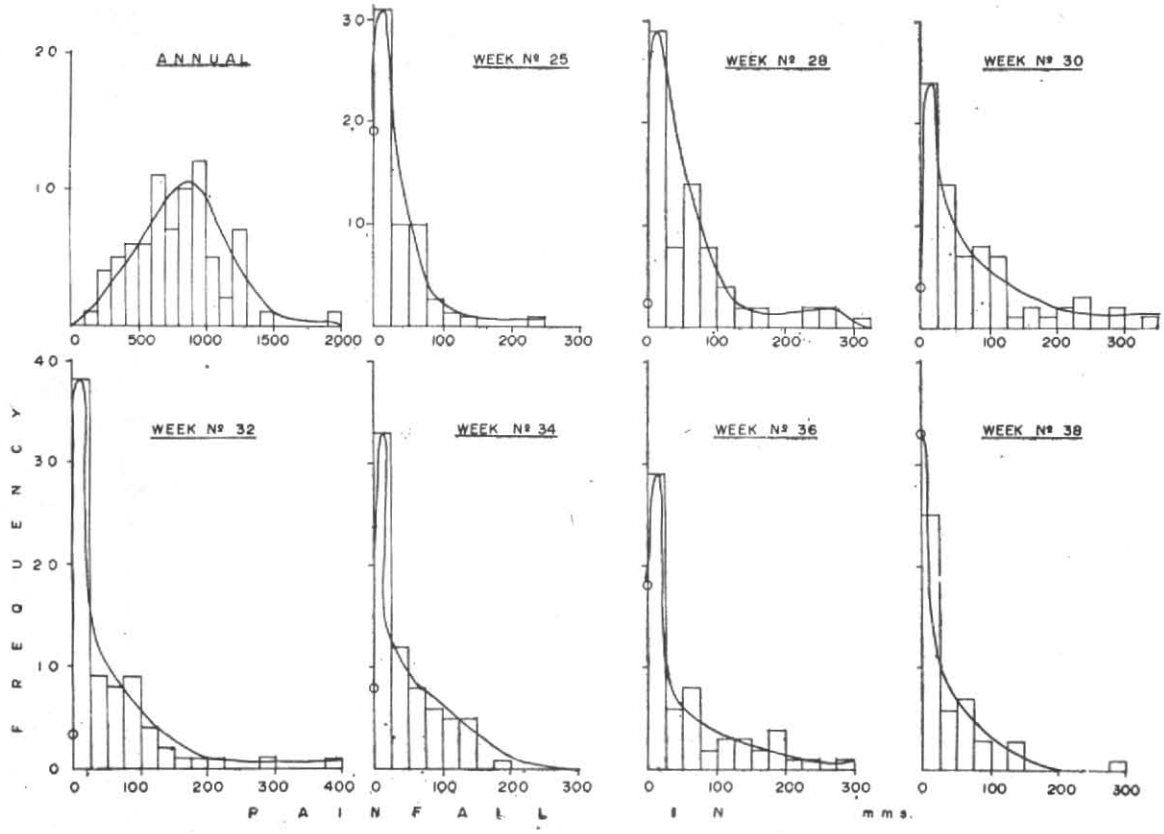

Fig. 2. Frequency of rainfall

4. Short period rainfall

In respect of short duration crops (80 to 110 days) which are increasingly being introduced, seasonal and monthly rainfall information may not be very much useful for the agriculturist. Several short periods such as 5, 7 and 10 days have been used in different countries for the analysis of rainfall. The distribution of weekly rainfall is seen to be highly erratic with respect to space and time. In a rainfed area with limited monsoon rainfall, distribution of rainfall from week to week is very important for the proper development of the crop. Hence, knowledge of the weekly assured amounts of rainfall and the probabilities of dry weeks within the monsoon period will be useful for successful planning and selecting the suitable varieties of various Kharif crops that will ensure a steady return to the agriculturist.

4.1. *Distribution of weekly rainfall* — The normal rainfall of a week in the monsoon period is made up of a large number of occasions with little or no rain and a small number of moderate to heavy rainfall. The lowest rainfall in a week is zero but the highest rainfall in a week may be comparable to and may exceed the normal annual rainfall as can be seen from Table 1. Fig. 2 gives the frequency distribution of weekly rainfall for 7 typical weeks at Ahmedabad. It may be seen that the weekly rainfall frequency curve is highly skew. This is, because frequency of zero rain or small amounts is very high and that of large amounts is very small.

4.2. *Assured weekly rainfall* — Each week was considered as an independent unit. Weekly rainfall figures were further processed by high speed computer to fit the gamma distribution. The lowest amounts of rainfall at probabilities 10 per cent to 90 per cent were determined (Mooley 1973). The amounts of weekly rainfall that may be expected to be exceeded in 30 and 50 per cent of the years, for the four typical weeks 25, 29, 33 and 37 are shown in Figs. 3(a) and 3(b) respectively.

It is seen that the lowest assured amounts of rainfall at 30 per cent probability is more than 45 mm in the southeast part in the 25th week and it reduces to 15 mm at 50 per cent level. It tends to zero in Kutch area at 50 per cent.

In the 29th week rainfall decreases from Veraval to Bhuj and increases from Broach to Idar. Lowest assured rainfall at 30 per cent and 50 per cent probability is more than 90 and 50 mm respectively, in the 29th week at Sabarkantha and adjoining portions of Khaira and Panchamahal districts, and is less than 15 mm in the Kutch at 50 per cent level.

In the 33rd week it is more than 25 mm in Panchamahal and adjacent portions of Baroda, Khaira, Sabarkantha districts and is less than 5 mm in the western part. Rainfall at 30 per cent level is more than 15 mm throughout the State and exceeds 60 mm in NE portion.

The rainfall pattern in the 37th is similar to that in 25th week.

The lowest assured rainfall at 50 per cent probability is very little in October and November (weeks 40-48). However, with the soil moisture fairly high due to rainfall in preceding weeks

TABLE 1

Highest weekly rainfall

District	Station	Week	Year	Rainfall (highest) (mm)	Normal annual rainfall (mm)
Kutch	Bhuj*	28	1950	513	340
Jamnagar	Jamnagar*	28	1929	690	466
Junagad	Veraval*	31	1933	533	526
Rajkot	Rajkot*	28	1950	535	594
Surendranagar	Dhrangadhra	30	1927	924	508
Amreli	Amreli	25	1946	431	515
Banaskantha	Deesa*	30	1927	529	621
Mehsana	Patan	27	1956	370	618
Ahmedabad	Ahmedabad*	30	1927	1292	783
Bhavnagar	Bhavnagar*	26	1913	447	620
Sabarkantha	Idar	27	1908	564	974
Khaira	Anand	30	1927	1919	880
Baroda	Baroda*	27	1941	460	920
Broach	Broach*	21	1942	569	877
Panchmahal	Dohad*	31	1952	386	810

*India Meteorological Department Observatory

standing crops may complete their growth and maturity.

During the months December to March, isolated rainfall occurs generally in association with 'western disturbances', when these are either quite active or follow a track south of the normal. The contribution by dew (Raman *et al.* 1971) is appreciable being about 0·3 mm a week, compared to the seasonal rain. Even so, during this period the available precipitation is not sufficient for agricultural purposes.

The assured rainfall at 50 per cent level of probability is negligible in all districts in the weeks 14 to 22.

5. Analysis of wet and dry weeks

A week has been reckoned as a dry week if the rainfall recorded during the week is less than 18·0 mm. Otherwise, it has been counted as a wet week. A day is classified according to the IMD practice as rainy day if rainfall is 2·5 mm or more.

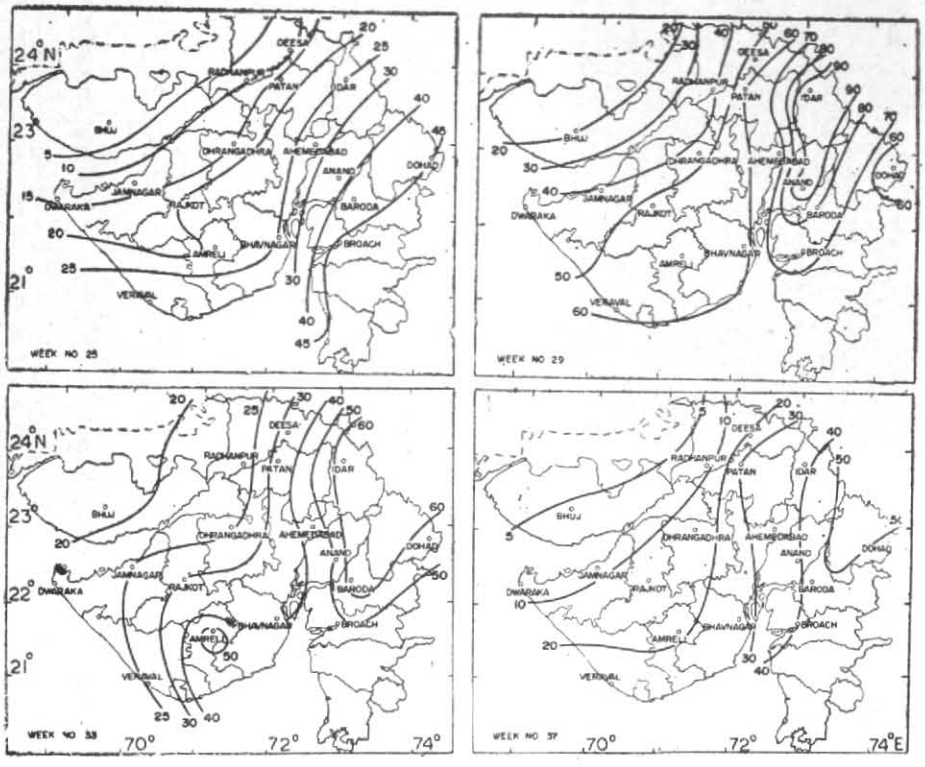

Fig. 3 (a). Lowest assured rainfall (mm) — 30 per cent probability

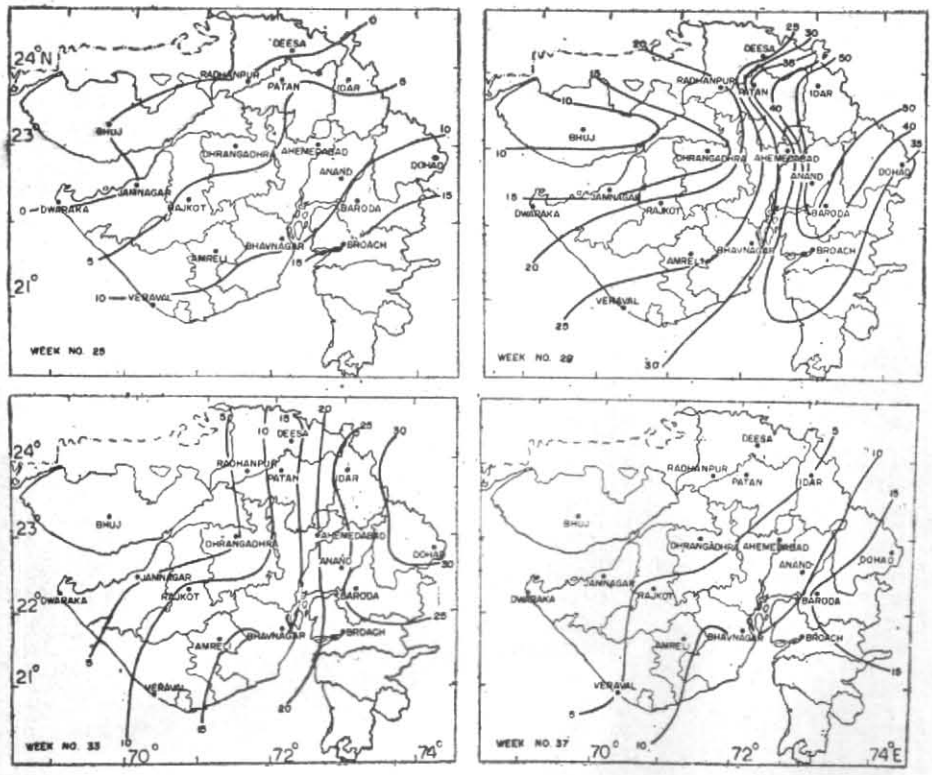

Fig. 3(b). Lowest assured rainfall (mm) — 50 per cent probability

TABLE 2

Percentage wetness of a week during monsoon

Station	weeks 23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
Bhuj	4	16	6	22	34	41	28	46	37	27	23	25	25	25	23	12	7
Jamnagar	12	18	21	38	45	44	38	44	29	26	27	32	27	29	18	11	11
Veraval	12	27	33	42	[58	51	51	56]	39	33	27	29	30	26	21	23	7
Rajkot	18	19	31	43	46	47	[51	60	53]	41	35	43	40	35	32	29	28
Dhrangadhra	12	23	27	46	47	[57]	47	[54]	46	37	34	32	34	31	19	21	19
Amreli	13	19	29	48	[61]	48	45	[55]	45	39	48	29	42	42	35	32	26
Deesa	6	18	21	24	[51	55	57	58	57]	42	31	40	48	43	33	15	12
Patan	9	16	44	47	[75	78	87	72	66	66]	47	[63]	44	47	44	25	19
Ahmedabad	13	30	34	[60	67	66	57	71	64	51]	49	47	44	41	42	33	17
Bhavnagar	11	31	40	47	[57	60	50	59	57]	34	41	39	43	[56]	33	29	20
Idar	9	33	33	[50]	46	[70	77	79	73	60	56	60	59]	42	40	33	19
Anand	18	29	43	[54	71	73	73	78	66	54]	49	[50	54	50]	40	41	18
Baroda	18	32	45	[58	71	82	76	66	68	58	53	50	53	50	53]	21	21
Broach	14	45	[50	64	76	74	70	61	68	53	50	50	53	51]	39	42	35
Dohad	11	35	43	[68	71	68	65	73	68	62	65	54	54	51]	46	49	22

Table 2 gives the percentage of wetness of the weeks from 23rd to 39th. Weeks with the percentages greater than 50 per cent are marked in the table.

The longest sequence of weeks with more than 50 per cent chance of being wet is twelve at Baroda from 26th to 37th and Broach from 25th to 36th week. Duration at Dohad and Anand is 11 weeks. It is 7 weeks at both Patan & Ahmedabad and 5 weeks at Deesa. At Dhrangadhra this period is of 2 weeks only. At Jamnagar and Bhuj there is not a single week that can be classified as wet even in 50 per cent level.

5.1. *Distribution of wet spells* — The monsoon generally sets first in the southeastern districts and extends to the north and west. While receding, it withdraws first from the extreme west and later from the remaining districts to the east and south. The result is that as we proceed from west to the east the length of the wet period increases. The consecutive 2, 3, 4... wet weeks are counted as wet spells of length 2, 3 and 4 ... weeks respectively.

Table 3 gives the mean number of wet weeks per season and the mean length of run of a wet spell. Information about the mean number of rainy days is also given in the parenthesis. Percentage of occasions when wet spells of length 2, 3 ... weeks occurred during the monsoon are also given in the Table 3. It is seen that the mean number of wet weeks is only 4·6 per year at Bhuj which is the westernmost station; it is 10 weeks at Dohad. The mean number of rainy days per year also correspondingly increases from 15 to 41. Each wet week contains about 3 to 4 rainy days.

The mean length of the wet spell also increases from 1·6 at Bhuj to 2·5 at Dohad. The number of wet weeks and the mean length of the wet spell per monsoon increases as we proceed from west to east. The more scanty the rainfall less is the number of wet spells and shorter is their length.

5.2. *Distribution of dry spells* — During the period from 23rd to 39th week, an analysis of dry spells is also made. A sequence of dry weeks bounded by wet week on either side has been considered as dry spell of length 2, 3, 4... weeks according as the number of dry weeks in the sequence.

Table 4 contains information on the mean number of dry weeks for the season, percentage occasion of dry spells of 2, 3 ... weeks per season and the mean length of dry spells in weeks. The mean length of dry spell varies from 2·8 to 1·9 weeks. As we proceed from westernmost district Bhuj towards the east, the mean length of wet weeks increases and that of dry weeks decreases progressively.

TABLE 3

Wet spell during monsoon

Station	No. of years	Mean No. of wet weeks/ rainy days per year	Mean No. of wet weeks/ rainy days per monsoon	Mean percentage of occasions of wet spells during monsoon (length in weeks)						Mean length of run of wet weeks	No. of rainy days per wet week
				1	2	3	4	5	6 & above		
Bhuj	62	4·6/15·3	4·0/13·3	37	32	17	10	2	3	1·6	3·3
Jamnagar	64	5·3/20·5	4·8/19·0	35	24	15	10	11	4	1·7	3·9
Veraval	66	6·1/25·1	5·6/23·4	27	24	15	12	10	12	1·9	4·1
Rajkot	65	7·6/28·8	6·2/26·3	22	24	21	13	7	12	2·0	3·8
Dhrangadhra	60	6·3/24·2	5·5/22·2	30	22	15	14	6	11	1·8	3·8
Amreli	31	7·1/27·0	6·3/24·1	37	37	17	3	3	2	2·0	3·8
Deesa	67	6·5/27·7	5·9/25·6	19	22	17	12	14	16	2·1	4·3
Patan	41	7·0/27·6	6·3/25·7	24	28	10	8	17	12	1·9	3·9
Ahmedabad	65	7·9/36·7	7·6/34·1	16	18	18	16	10	22	2·3	4·6
Bhavnagar	61	7·7/29·7	6·6/26·8	21	23	17	12	10	17	2·0	3·8
Idar	70	9·2/41·2	8·7/38·5	12	14	14	14	7	38	2·9	4·4
Anand	66	9·2/38·4	8·0/36·0	15	14	18	7	11	34	2·5	4·1
Baroda	35	9·7/40·3	8·5/37·2	9	17	23	16	12	23	2·6	4·1
Broach	64	9·9/39·7	8·2/36·8	13	13	19	14	14	26	2·6	4·0
Dohad	40	9·8/40·9	8·5/36·9	10	18	18	19	9	27	2·5	4·2

TABLE 4

Dry spell during monsoon

Station	No. of years	Mean No. of dry weeks per monsoon	Mean percentage of occasions of dry spells during monsoon (length in weeks)						Mean length of dry spell in weeks
			1	2	3	4	5	6	
Bhuj	62	4·5	12	11	21	20	11	25	2·8
Jamnagar	64	5·4	10	18	25	9	15	23	2·8
Veraval	66	4·9	16	17	24	16	15	11	2·4
Rajkot	65	5·6	17	19	22	13	12	16	2·4
Dhrangadhra	60	5·3	18	15	22	15	11	19	2·4
Amereli	31	6·0	40	18	22	12	3	5	2·4
Deesa	67	4·3	18	17	25	15	7	18	2·4
Patan	41	5·1	19	25	25	12	7	12	2·2
Ahmedabad	65	4·6	27	26	17	12	5	13	1·9
Bhavnagar	61	5·3	21	19	21	14	8	17	2·2
Idar	70	3·8	28	26	11	15	11	8	1·9
Anand	66	4·6	23	27	15	16	7	11	2·0
Baroda	35	4·5	27	19	23	18	10	4	1·9
Broach	64	4·5	27	27	24	12	3	6	1·9
Dohad	40	4·7	26	29	22	2	11	11	1·9

6. Existing cropping patterns

About 20 per cent area all over Gujarat except few southern districts is covered by different types of groundnut, Cotton (about 16 per cent) is the second major crop of the State and is generally cultivated over middle Gujarat, Bhal and adjoining coastal areas and Saurashtra. Bajra and jowar are grown over at abut 14 per cent and 13 per cent areas respectively in north Gujarat, Saurashtra and west zone. Paddy and wheat play a minor role occupying less than 10 per cent area. Maize and oilseeds including till hardly cover 2 per cent area each.

Upland paddy and cotton which require more water may be reduced to give place to hybrid maize and bajra to boost up the production. Traditional wheat and groundnut may be replaced by short duration varieties. Specialised crops like cummin and ishbol may be included in crop rotation to suitable areas on the basis of the analysis.

7. Conclusion

The study attempts to provide information about the expectation of short period, *i.e.*, weekly rainfall. Result of this study when superimposed on the evaporation, type of the soil and its depth, can help demarcating the region into homogeneous soil-rainfall zone and may evolve a picture to suggest specific cropping pattern. The additional statistical information about the run of dry and wet spells may give useful information to plan the timing of various agricultural operations.

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