

Climatic potential for crop production at some stations in arid zone of India

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(Received 17 March 1981)

सार — पश्चिमी राजस्थान और गुजरात का सटा हुआ भाग भारत के शुष्क क्षेत्र के अन्तर्गत आते हैं। वर्षा और वाष्पोत्सर्जन विभव का विशेष संदर्भ देते हुए इस क्षेत्र की जलवायु के लक्षणों का विवेचन किया गया है। इस शोध पत्र में अल्पावधि वर्षा विश्लेषण, नमी उपलब्धता सूचकांक और आकलित मृदा नमी पर खासतौर पर जोर दिया गया है। शुष्क क्षेत्र के तीन स्टेशनों, अर्धशुष्क क्षेत्र के एक स्टेशन और अन्तर-मध्यम प्रकार के दो स्टेशनों के लिए अभिकलन किए गए हैं। संभावित विभिन्न स्तरों पर अपूर्ण गामा बंटन को लगाकर साप्ताहिक न्यूनतम वर्षा को अभिकलित किया गया है। इस प्रकार 30% और 50% संभाव्यता वाले स्तरों के मानों की साप्ताहिक औसत वर्षा के मानों से तुलना की गई है और विभव वाष्पोत्सर्जन को अभिकलित किया गया है। 50% संभाव्यता वाले स्तर पर न्यूनतम आश्वासित वर्षा को आधार मानकर साप्ताहिक नमी उपलब्धता सूचकांक को अभिकलित किया गया है। जल संतुलन तकनीक से साप्ताहिक मृदा नमी को अभिकलित किया गया है। इन कारकों के आधार पर संभावित फसल बढ़कर सत्र को दर्शाया गया है।

ABSTRACT. West Rajasthan and adjoining part of Gujarat come under the arid zone of India. The climatic features of this area with particular reference to rainfall and potential evapotranspiration are described. The main emphasis, in the paper has been given on short period rainfall analysis, moisture availability index and estimated soil moisture. Computations have been made for three stations in the arid zone, one station in semi-arid zone and two stations of intermediate type. By fitting Incomplete Gamma Distribution, weekly minimum assured rainfall has been computed at different probability levels. The values so obtained for 30% and 50% probability levels have been compared with the weekly rainfall average and the computed potential evapotranspiration. The weekly moisture availability index has been computed on the basis of minimum assured rainfall at 50% probability level. Weekly soil moisture has been estimated by water balance technique. On the basis of these factors, possible crop growing season has been indicated.

1. Introduction

A large portion of west Rajasthan and adjoining Gujarat comes under arid zone. In this region rainfall is low, variability is high and evaporation is more. The region enjoys little benefit of irrigation and suffers from twin problems of low production and instability. The cultivation is in general poor and precarious. Certain parts have better soil and some tracts are comparatively productive. In spite of these difficulties, some dry land crops are produced in this region, particularly at places where the soil condition is better and rainfall marginally meets the water demands of the crops.

In this paper week by week climatic parameters have been examined for six stations. Of these, Jodhpur, Bikaner and Jaisalmer belong to the arid zone, Udaipur in semi-arid zone, Sikar and Bhuj are in the border of semi-arid and arid.

An accurate evaluation of weekly rainfall adequacies and deficits on the basis of potential water demand provides a scientific basis for agricultural planning. Therefore, the minimum weekly assured rainfall at different probability levels has

been computed and compared with the potential evapotranspiration.

2. Data

Six stations chosen for study have daily rainfall data for about 70 years. These daily data have been converted into weekly form. By fitting Incomplete Gamma Distribution to the weekly rainfall total minimum assured rainfall has been computed at different probability levels. The weekly potential evapotranspiration (PE) has been obtained by interpolation from the monthly PE values computed by Rao *et al.* (1971) using Penman's formula.

3. Method

Incomplete Gamma Distribution has been successfully applied by many workers to get probabilistic rainfall amount (Thom 1966), (Mooley 1973) and (Hargreaves 1974). Sarkar *et al.* (1977) have used this method to compute weekly rainfall at different risk levels for 87 districts under the Dry Farming Tracts of India. Biswas and Khambete (1977) have used this method for a similar detailed study for Maharashtra. The assured

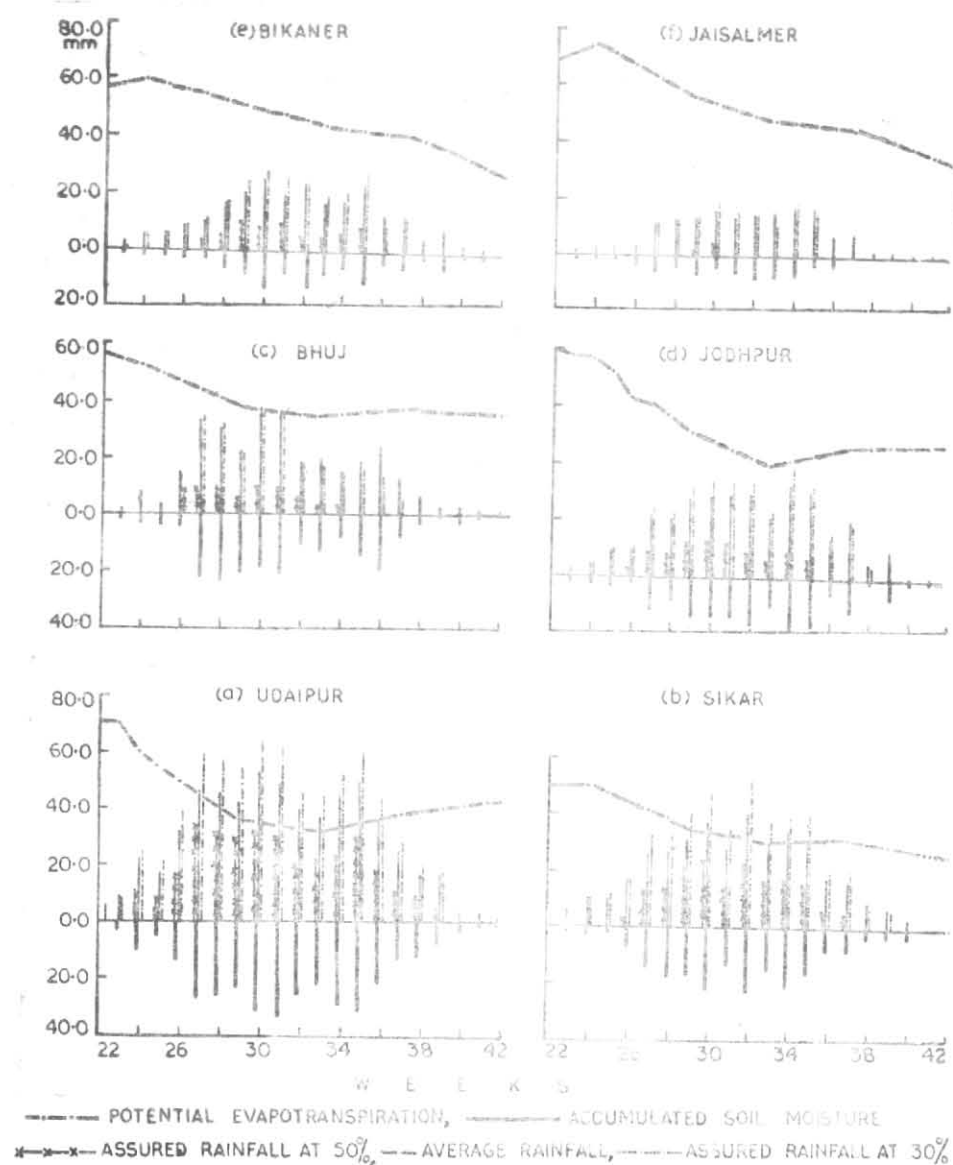


Fig. 1 (a-f). Weekly assured rainfall, P E and accumulated soil moisture

TABLE I

S. No.	Station	Lower		Rainfall (mm)							
		Lat. (°N)	Long. (°E)	Seasonal		Annual		Max. Year	Min. Year	Year	
				Mean	C.V.	Mean	C.V.				
1	Bhuj	23° 15'	69° 48'	323.5	71	353.2	70	1311.4	1959	21.8	1899
2	Jaisalmer	26° 54'	70° 55'	160.6	71	187.2	67	583.0	1944	0.0	1918
3	Bikaner	28° 00'	73° 18'	241.1	55	296.6	49	758.4	1917	52.6	1918
4	Jodhpur	26° 18'	73° 01'	325.7	54	364.6	54	1176.5	1917	37.9	1918
5	Sikar	27° 37'	75° 08'	380.0	40	444.4	35	864.4	1942	179.3	1918
6	Udaipur	24° 55'	73° 42'	593.2	31	650.9	30	1222.8	1917	266.7	1936

weekly rainfall values at 30% and 50% probability levels so computed have been compared with weekly rainfall normal and potential evapotranspiration (PE). Actual water requirement of crops depends on many factors. This will be a part of PE of the place which depends on the stage of the growth of the plants and in the fully vegetative stage it may exceed PE.

Weekly moisture availability index (MAI) which is defined as the ratio of assured rainfall to potential evapotranspiration has been estimated on the basis of assured rainfall at 30% and 50% probability levels. Hargreaves (1974) used the monthly MAI to demarcate northeast Brazil into different zones for agricultural production.

In this study it was assumed that rainfall at the 50% probability level is very deficient if it meets less than 30% of potential evapotranspiration requirements. This would mean that MAI from 0 to 0.3 would be classified very much deficient. Based on this consideration the following classification of climate was adopted for agricultural production in the same line as done by Hargreaves with monthly values.

Criteria	Classification
MAI more than 0.3 for (16-20) weeks	Wet dry
MAI more than 0.3 for (9-15) weeks	Semi arid
MAI more than 0.3 for less than 9 weeks	Arid
MAI is not even 0.3 in any week	Very arid

In addition, week by week soil moisture accumulation has also been estimated for these stations by water balance technique starting the calculation from the beginning of the monsoon.

4. Discussion

Table 1 gives normal, the highest and the lowest annual rainfall along with seasonal and annual variability of rainfall for the six stations. Among the arid zone stations, Jodhpur has the highest annual rainfall 364 mm while the lowest is 187 mm at Jaisalmer. Jaisalmer recorded zero rainfall in 1918. Variability of rainfall, both seasonal as well as annual, is highest at Jaisalmer. Bhuj is also having very high variability. The co-efficient of variation is not very high at Sikar. Among all these stations variation of rainfall, both annual and seasonal, is the lowest at Udaipur.

4.1. Assured rainfall

Fig. 1(a) & 1(b) depict the average weekly rainfall, assured rainfall amount at 30% and 50% probability levels and potential evapotranspiration (PE) for Udaipur and Sikar respectively.

TABLE 2
Moisture availability index (MAI)

S. No.	Station	Probability level (%)	Number of weeks exceed					
			.1	.2	.3	.4	.5	.9
1.	Udaipur	30	17	16	16	16	16	12
		50	16	14	13	11	10	6
2.	Sikar	30	16	14	12	11	11	7
		50	10	9	9	7	5	0
3.	Jodhpur	30	12	10	9	7	5	0
		50	5	2	1	—	—	—
4.	Bikaner	30	12	10	8	6	4	0
		50	8	2	1	—	—	—
5.	Bhuj	30	12	11	10	7	7	2
		50	6	3	2	1	—	—
6.	Jaisalmer	30	9	6	3	1	—	—
		50	—	—	—	—	—	—

It is seen that assured rainfall at 50% level is more than 12 mm at Udaipur from 26th to 36th week and at Sikar for 9 weeks from 27th to 35th week. Assured rainfall is above 20 mm once in three years for 16 weeks at Udaipur and 12 weeks at Sikar. Average rainfall and assured rainfall at 30% level are more than PE for 10 and 5 weeks at Udaipur and Sikar respectively.

Fig. 1(c-e) gives the assured rainfall pattern of three stations, Bhuj, Jodhpur and Bikaner. It is seen that average rainfall and assured rainfall at 30% level at Bhuj are more or less equal to weekly PE for a few weeks only. At the other two stations PE is higher than weekly average and assured rainfall at 30% level.

Among these stations assured rainfall both in amount and duration is more or less same at Bhuj and Jodhpur and is of the order of 10 mm for about seven weeks once in two years. At 30% probability level assured rainfall at both the stations is of the order of 20 mm for 10 weeks. At Bikaner assured rainfall exceeds 10 mm for 2 weeks only at 50% level.

The assured rainfall at 50% probability could be computed only for two weeks at Jaisalmer, Fig. 1(f). The amount is more than 10 mm for eight weeks once in three years.

4.2. Moisture availability index

Table 2 gives the number of weeks when moisture availability index (MAI) exceeds 0.2, 0.3... 0.9 at 30% and 50% levels. At Udaipur MAI is more than 0.5 for 10 weeks at 50% level and it exceeds 0.3 for another 3 weeks. At 30% level MAI exceeds 0.5 for 16 weeks. At Sikar MAI is more than 0.5 and 0.3 for 5 and 9 weeks once in two years. At 30% level MAI is more than 0.5 and 0.3 for 11 and 12 weeks respectively. Thus the duration of water availability period is seen to differ significantly among the stations

in the same climatic zone. Crops upto growing period of 13-15 weeks at Udaipur and of 10-12 weeks at Sikar may be suited.

In arid zone MAI has not exceeded 0.5 at 50% level at any station even during the monsoon period, although it is more than 0.2 for 2-3 weeks at different stations. At 30% level MAI is more than 0.5 for 4-7 weeks and it exceeds 0.3 for 8-10 weeks at three stations, Jodhpur, Bikaner and Bhuj. Of these stations, water availability period is more at Bhuj than other two stations, Jodhpur and Bikaner. Although crop production without irrigation is highly speculative in arid zone, shorter duration rainfed crops about 8-10 weeks may be harvested once in three years.

At Jaisalmer MAI is not even 0.1 in any weeks at 50% level and it exceeds 0.2 for six weeks only once in three years. Rainfed crops are unsuitable in this region.

4.3. Soil moisture accumulation

Fig. 1(a-f) gives amount of average weekly soil moisture accumulation at different stations, calculated by the water balance technique. In this calculation accumulation in a particular week may be zero for a year and may be very high for another year. Average has been worked out taking all the values. Although averages figure hardly occur, it gives an idea how much water may be available to crops. Maximum moisture accumulation is at Udaipur and the lowest is at Jaisalmer 67 mm.

5. Conclusion

The present study has brought out some distinct features in climatic parameters, viz, rainfall (average as well as assured), soil moisture and moisture availability index for the six stations. It is seen that there are distinct variations in each parameter from one station to another in the same region. It, therefore, appears that classification based on rainfall alone is not adequate. A new classification on the basis of moisture availability index appears warranted. The classification and potential for agricultural production

as emerging from this study can be summarised as below :

Classification	Station	Description
Wet dry	—	No station in the region of study
Semi-arid	Udaipur & Sikar	Crops of growing period (12-14) weeks at Udaipur and (10-12) weeks at Sikar may be suited at 40% level
Arid	Jodhpur, Bikaner & Bhuj	Shorter duration crops may be harvested once in three years.
Very arid	Jaisalmer	Not fit for rainfed agriculture

It is believed that the proposed classification is an improvement upon the old classification. However, further work with a large number of stations is required to map out and demarcate the areas into various agroclimatic zones.

Acknowledgement

The authors are indebted to Shri R. P. Sarker, Deputy Director General of Meteorology (C & G) for going through the manuscript and constructive criticism. They are also thankful to Shri S. Venkataraman, Retired Director, Agrimet Division, Pune for his valuable suggestions. Thanks are due to the staff of D. F. R. Uni and Drawing Branch.

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