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Frequency of wet and dry spells at five stations in Rajasthan

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ABSTRACT. Frequencies of wet and dry spells at five stations in Rajasthan (Bikaner, Jodhpur, Ajmer, Jaipur and Udaipur) for the southwest monsoon period are studied. The study is based on the daily rainfall data of these stations from 1891 to 1919. It is seen that frequencies of rain spells of less than 5 days are common and those greater than 10 days are extremely rare. Frequencies of dry spells of less than 5 days are common for all the five stations. Frequencies of dry spells greater than 15 days are also common at Bikaner, Jodhpur and Ajmer but are less frequent (20 per cent of the total days) at Jaipur and Udaipur. Intercorrelation coefficients among the stations for all dry spells of two days and more are found to be significant for Bikaner-Jodhpur, Bikaner-Ajmer and Jodhpur-Ajmer and Jaipur-Udaipur.

1. Introduction

Like the greater part of India, the southwest monsoon period from June to September, is the main source of rain in Rajasthan. While there have been studies of the nature and distribution of rainfall during SW monsoon period in this State, the picture was incomplete without a study of the frequencies of dry and wet spells. Raman and Krishnan (1960) have studied wet and dry spells at five stations on the west coast of India. In the present paper a similar study has been made for five stations — Bikaner, Jodhpur, Ajmer, Jaipur and Udaipur in Rajasthan. They are so situated that taken together they may be considered to generally represent the rainfall distribution during SW monsoon period in Rajasthan. Fig. 1 shows the positions of these five stations. If Ajmer may approximately be considered as central station in the above group of five stations, Bikaner, Udaipur, Jaipur and Jodhpur approximately lie in NW, SSW, ENE and W directions respectively.

The study has been made of the daily rainfall data of 1891 to 1919 for the monsoon season June to September. For the purpose of the present study, a day is classified as a rainy day if 0·01″ or more of rain has occurred during 08 A.M. to 08 A.M. of following day. Tables 1 and 2 give the average, maximum and minimum amount of rainfall and number of rainy days during each of the southwest monsoon months June, July, August and September and also for June to September as a whole. The tables are self-explanatory and mainly intended to give a general average picture of the rainfall of the area during the period of study.

2. Frequency distribution of wet spells

A day (8 A.M. to 8 A.M.) receiving 0·01″ or more of rain is classified as a wet day. A wet spell is considered to be a wet day or days which are preceded and followed by at least a day or more of dry days. In the case of a rainspell beginning in a particular month and continuing in the following month, it is assumed for the present study that the spell is broken on the last day of the previous month and a fresh spell is started in the next month beginning with the first day in following month. It is realised that when the sequences are considered for individual months, a few spells of larger duration would get split in shorter ones, in this process. A check of the daily data, however, shows that this does not affect much the arid stations—Bikaner and Jodhpur.

Wet spells upto ten days are tabulated as individual spells but spells exceeding 10 days are tabulated in groups of 11 to 15, 16 to 20, 21 to 25 and greater than 25 for the sake of simplicity. Table 3 gives the frequency of wet spells for the southwest monsoon period as a whole for all the five stations.

The frequencies of wet spells of shorter durations ($\leqslant$5 days) are most frequent at all the stations. Spells of duration greater than 10 days are very rare. In Bikaner and Jodhpur such spells have not been recorded during the period of study. For Ajmer and Jaipur, however, it is one in July and September and 1 and 3 respectively in August for these two stations. For the southwest monsoon period the frequency for spells $>$ 10 days is two for both the stations. The longest wet spell in any month (during 1891 to 1919) for Bikaner is 8 days in the month of August in 1908 and 1917. At Jodhpur it is 9 days in August 1897. Ajmer has recorded a wet spell of 17 days in July 1897. Udaipur has had the longest wet spell of 19 days in August 1908.

3. Expected frequency

In order to get an idea of the effect of persistence, the number of runs of different durations expected only on chance are worked out. The method followed for the present study is the same as that used by Jorgensen (1949).

TABLE 1

Average and extremes of rainfall in inches (1891-1919)

Stations	Average					Maximum					Minimum				
	Jun	Jul	Aug	Sep	Jun to Sep	Jun	Jul	Aug	Sep	Jun to Sep	Jun	Jul	Aug	Sep	Jun to Sep
Bikaner	1·12	2·76	3·66	1·77	9·21	5·81	7·57	11·46	7·74	19·23	0	0	0	0	1·06
Jodhpur	1·25	3·77	4·11	2·70	11·83	5·74	12·60	12·32	12·44	35·36	0	0	0	0	1·11
Ajmer	2·14	5·81	4·30	2·66	14·91	5·70	19·31	16·70	7·49	34·40	0	0	0	0	2·74
Jaipur	1·90	7·34	7·35	3·49	20·06	6·96	17·51	21·83	14·37	45·35	0	0·4	0	0	3·68
Udaipur	3·44	6·96	6·94	4·43	21·78	13·57	14·30	14·76	13·93	39·10	0	1·02	0·51	0	7·97

TABLE 2

Rainy days (days with rainfall $\geqslant$ 0.01" during 24 hours from 08 A.M. to 08 A.M.)

Stations	Average					Maximum					Minimum				
	Jun	Jul	Aug	Sep	Jun to Sep	Jun	Jul	Aug	Sep	Jun to Sep	Jun	Jul	Aug	Sep	Jun to Sep
Bikaner	3·0	6·0	7·0	3·0	19·0	6	16	19	16	44	0	0	0	0	4
Jodhpur	2·5	6·7	6·5	3·5	19·2	7	15	15	15	28	0	0	0	0	2
Ajmer	4·2	10·0	10·0	5·3	29·5	11	20	20	15	48	0	0	0	0	9
Jaipur	6·0	14·0	14·0	8·0	42·0	13	23	27	25	80	0	4	0	0	18
Udaipur	8·0	14·0	16·0	9·0	47·0	18	29	25	21	69	0	1	4	0	18

TABLE 3

Frequency of wet spells during SW monsoon (1891—1919)

Days	Bikaner		Jodhpur		Ajmer		Jaipur		Udaipur	
	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected
1	204	393·5	183	397·2	194	495·3	221	533·3	183	520·1
2	76	61·0	78	62·4	77	125·2	98	178·4	94	201·5
3	31	9·4	35	8·9	46	28·9	55	60·3	74	77·8
4	16	1·5	15	1·5	23	6·9	35	19·9	36	29·8
5	3		2		17	1·7	20	6·9	27	11·6
6	2		2		4		17	2·3	17	4·5
7	0		3		7		11	0·8	20	1·7
8	2		0		2		7		7	0·7
9	0		1		4		4		6	
10	0		0		2		4		4	
11–15	0		0		2		6		7	
16–20	0		0		1		1		1	
>20	Nil		Nil		Nil		Nil		Nil	
Total	334		219		379		478		476	

TABLE 4

Number of wet days in each month and in the season as a whole and probability p on chance

Stations	Jun	Jul	Aug	Sep	Jun to Sep	p
Bikaner	92	169	192	98	551	·156
Jodhpur	74	101	189	194	558	·158
Ajmer	122	291	291	155	859	·243
Jaipur	172	401	411	222	1206	·341
Udaipur	231	420	455	270	1376	·389

The probability of rain occurring on chance on any one day p = (No. of rainy days)/(Total No. of days), p for each station for the SW monsoon period and number of rainy days in each month and also for the whole season are given in Table 4. The expected frequencies of runs of rainy days of different lengths are calculated from Cochran's (1938) formula and are given in Table 3.

If $f_{r,m}$ is the frequency of runs of length r wet days out of m trials having p as the probability of occurrence during the unit period, $q = 1 - p$ and $1 \leqslant r < (m-1)$,

$$f_{r,m} = 2p^r q + p^r q^2 \ (m-r-1) \qquad (1)$$

$m = 122$ days for the southwest monsoon period.

The expected frequency of one day wet spell is much greater than that observed, for all the stations. The expected frequency for two days of rain spell is fairly close to the observed two days spell for Jodhpur and Bikaner but is very much out for Ajmer, Jaipur and Udaipur. As the calculated values in the present study differ considerably from the observed, the formula does not appear suitable, although this has been used in a number of investigations (Raman 1960 etc). This subject needs further examination.

4. Frequency distribution of dry spells

The observed frequencies of runs of dry spells of two days or more for the southwest monsoon period for all the five stations are given in Table 5. The average yearly number of such spells is 10·4 for Bikaner, 10·5 for Jodhpur, 10·8 for Ajmer, 11·1 for Jaipur and 11·6 for Udaipur. The averages are nearly the same for all the stations. It is observed that there were individual months in some of the years when all the days were dry. In Table 6 is given the frequency of the number of years of dry spells lasting a full month. For example, for Bikaner there was one year in June, two each in July and August and four in September. All the stations excepting in June and July have during this period of 1891 to 1919 experienced dry spells lasting a complete month. It is, however, interesting to see that in Udaipur the spells have occurred only in June and not in any of the succeeding monsoon months.

Fig. 1. Situation of the five stations under study

The frequency of dry spells of different durations for all the five stations is diagramatically represented in Fig. 2. It may be seen that the most common among the dry spell is that of 2 days at all the stations. Dry spells > 15 days are also not very uncommon at Bikaner (20·2 per cent), Jodhpur (20·8 per cent) and Ajmer (12·5 per cent) but are comparatively less frequent in the case of Jaipur (6·2 per cent) and Udaipur (4·5 per cent).

The frequencies of runs of dry days expected on chance are also worked out using equation (1) and are given in Table 5. The probability p, number of dry days for each month and for the season as a whole are given in Table 7. It is seen that the expected frequencies on chance up to seven days are invariably greater than the observed for all the stations. It would appear that except for Ajmer, the more a station is dry the greater is the duration of dry spell at which an agreement between expected and observed frequencies can be seen.

5. Intercorrelation coefficient

Using the yearly frequencies of dry spells of two days or more, correlation coefficients (C.Cs.) are worked out among the different stations. The C.Cs. are given in Table 8 and their test of significance are indicated by asterisk. Three of the C.Cs. are significant at 1 per cent level and one at 5 per cent level. While some association is thus suggested among Bikaner, Jodhpur and Ajmer, the degree of association is, however, not high.

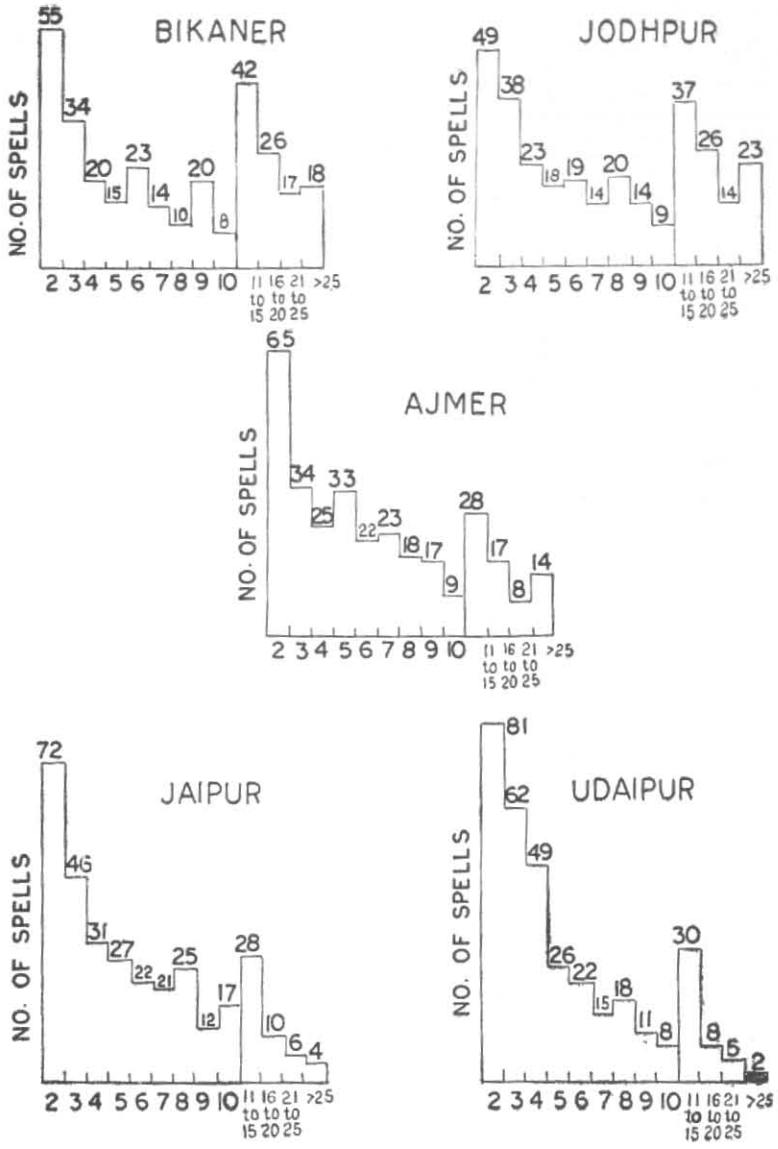

Fig. 2. Frequency of dry spells

TABLE 5

Frequency of dry spells during SW monsoon in 29 years (1891—1919)

Days	Bikaner		Jodhpur		Ajmer		Jaipur		Udaipur	
	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected
2	55	72·6	49	67·7	65	125·1	72	182·6	81	204·5
3	34	55·4	38	56·4	34	93·9	46	119·0	62	123·9
4	20	46·3	23	47·1	25	70·5	31	77·6	49	75·0
5	15	38·9	18	35·4	33	52·9	27	50·6	26	45·4
6	23	32·5	19	29·6	22	39·7	22	33·0	22	27·6
7	14	27·1	14	24·7	23	29·8	21	21·5	15	16·7
8	10	22·3	20	22·5	18	22·0	25	13·8	18	9·9
9	20	18·7	14	18·8	17	16·5	12	9·0	11	6·0
10	8	15·6	9	15·7	9	12·4	17	5·9	8	3·7
11–15	42		37		28		28		30	
16–20	26		26		17		10		8	
21–25	17		14		8		6		5	
>25	18		23		14		4		2	
Total	302		304		313		321		337	

TABLE 6

Frequency of years when dry spell lasted for a full month

Stations	Jun	Jul	Aug	Sep
Bikaner	1	2	2	4
Jodhpur	6	3	3	5
Ajmer	3	2	2	2
Jaipur	Nil	Nil	1	2
Udaipur	2	Nil	Nil	Nil

TABLE 7

Number of dry days in each month and for the season as a whole and the probability q on chance

Stations	Jun	Jul	Aug	Sep	Jun to Sep	$q=1-p$
Bikaner	778	730	707	772	2987	·844
Jodhpur	776	798	710	676	2980	·842
Ajmer	748	608	608	715	2679	·757
Jaipur	698	498	488	648	2332	·659
Udaipur	639	479	444	600	2162	·611

TABLE 8

Intercorrelation coefficients of all dry spell of 2 days and more

	Jodhpur	Ajmer	Jaipur	Udaipur
Bikaner	0·58**	0·58**	0·18	0·00
Jodhpur		0·48**	0·07	—0·17
Ajmer			0·11	0·13
Jaipur				0·40*

**Significant at 1 per cent also

*Significant at 5 per cent only

6. Concluding remarks

As already stated the results of this study are based on the data of earlier years. If there is no change in the meteorological behaviour with respect to rainfall during the recent years so that the earlier data may be considered to be a representative random sample then these results will provide a good picture of the actual situation. However, similar studies have already been taken in hand with the recent 30 years' data and the results thereof will be presented in a separate paper.

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