

Study of frequency of wet and dry spells over Nasik district

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(Received 17 May 1984)

सारा — दक्षिण-पश्चिम मानसून की अवधि में नासिक जिले के दिन्दोरी, पेयन्त, चन्दोर, येओला, कल्वान, सिन्नर, सतना तथा नासिक आदि 8 स्टेशनों पर आर्द्र तथा शुष्क दौरों की आवृत्तियों का अध्ययन किया गया है। यह अध्ययन इन स्टेशनों पर 1921 से 1970 तक 50 वर्ष के दैनिक वर्षा आंकड़ों पर आधारित है। ऐसा देखा गया है कि पांच दिन या उससे कम दिन तक वर्षा के दौरों की आवृत्ति कम हुई है। यही सादृश्य शुष्क दौरों की आवृत्ति के विषय में पाया जाता है। सभी स्टेशनों पर आर्द्र और नम दौरों के लिये दृढ़ता का प्रभाव, विभिन्न अवधियों के दौर, जिनकी केवल प्राकृतिक रूप से आशा होती है, भी अभिकलित किए गए हैं। आवृत्तियों पर पर्वतों के आकार का प्रभाव भी बली-भांति परिलक्षित होता है। पहाड़ी के पवनान्निमुख ओर निम्न आर्द्र दौर-अधिक होते हैं तथा वर्षा छाया क्षेत्र में शुष्क दौर अधिक होते हैं।

ABSTRACT. Frequencies of wet and dry spells at eight stations Dindori, Peint, Chandor, Yeola, Kalwan, Sinnar, Satana and Nasik in Nasik district for the southwest monsoon period are studied. The study is based on the daily rainfall data of the stations for 50 years from 1921 to 1970. It is seen that the frequencies of rain spells of less than five days are common and high for all stations and there is a general decrease in the frequencies for spells more than five days. The same analogy is noticed in dry spells also. The effect of persistence, the number of runs of different durations expected only on chance are also worked out for both wet and dry spells for all the stations. The effect of orography on the frequencies is very well reflected, lower wet spells being more on the windward side of the hills and higher dry spells in the rain shadow region.

1. Introduction

The southwest monsoon is the main season which provides rainfall for almost entire country and the economy of the country is mainly dependent on the rainfall of this season. Studies on the various aspects of rainfall for various districts/states have been undertaken by various workers. Among them, the frequency distribution of wet and dry spells over various places/districts are also noteworthy. Raman and Krishnan (1960) have studied the wet & dry spells at five stations on west coast of India. Gupta (1966) studied the frequency of wet & dry spells at five stations in Rajasthan. Manohar *et al.* (1978) studied the wet spells and persistence of daily rainfall in Raichur. Chowdhury (1979) analysed the dry spell and probabilities in Maharashtra and confirmed that hard core of drought is located over Ahmednagar district in Maharashtra and fitted a theoretical distribution to the dry spells. Mukherjee *et al.* (1979, 1980 & 1980) have studied the seasonal, monthly and pentad of daily rainfall over Satana district, central Madhya Maharashtra and also over Nasik district. Choudhury (1981) studied the probability concept of wet & dry

spells of six stations over Bihar while Kamte (1981) studied the persistence in sequences of wet and dry pentads over Bombay.

In the present paper, a similar study for wet as well as dry spells for eight stations in Nasik district, Dindori, Peint, Chandor, Yeola, Kalwan, Sinnar, Satana and Nasik is undertaken. The stations are so situated that if taken together they may be considered to represent rainfall distribution during S.W. monsoon period in Nasik district. Nasik district lies between Lat. $19^{\circ}31'N$ & $20^{\circ}52'N$ & Long. $73^{\circ}16'E$ and $74^{\circ}50'E$ with an area of 15582 km^2 or 6015 sq. miles . The western-half of the district is a hilly area in the Western Ghats with an elevation ranging from 600 to 900 m. The eastern-half is comparatively plain with an elevation ranging from 300 m to 600 m. The general direction of the mountain range is north-south on the west, with a lone range running west to east almost in the middle of the district.

The study has been made of the daily rainfall data for the period 1921-1970 for the monsoon season June to September. For the purpose of this study, a day is

TABLE 1

Average and extremes of rainfall in cm (1921-1970)

Station	Average					Maximum					Minimum				
	Jun	Jul	Aug	Sep	Jun to Sep	Jun	Jul	Aug	Sep	Jun to Sep	Jun	Jul	Aug	Sep	Jun to Sep
Satana	10.19	9.57	7.71	12.42	39.90	26.01	19.05	26.29	37.21	75.92	0.00	1.27	0.00	0.00	5.53
Sinnar	8.52	15.42	9.83	14.84	48.63	22.42	32.03	27.99	39.24	93.87	0.07	3.45	0.00	0.00	21.15
Kalwan	11.29	20.61	13.48	14.64	60.01	30.40	66.70	59.46	44.34	153.69	0.00	4.47	0.86	0.76	23.03
Chandor	11.47	15.69	11.12	14.36	52.65	28.83	31.59	32.49	50.82	103.27	0.43	3.84	2.48	0.97	23.10
Dindori	10.88	24.63	15.91	13.85	65.28	29.76	64.56	35.00	41.73	109.75	0.00	7.69	4.15	2.31	35.07
Peint	24.34	99.43	65.93	37.81	228.05	71.27	209.49	155.42	108.58	306.78	0.99	43.71	19.02	4.87	101.68
Yeola	11.88	10.90	8.23	12.96	43.98	40.41	31.15	22.71	35.02	72.18	0.25	1.95	1.27	0.95	000.0
Nasik	9.92	19.30	12.49	12.68	54.27	32.15	38.64	43.07	42.62	119.55	0.00	4.36	0.96	0.96	27.43

TABLE 2

Rainy days (days with rainfall > 0.01) during 24 hours from 0830 to 0830 IST

Station	Average					Maximum					Minimum				
	Jun	Jul	Aug	Sep	Jun to Sep	Jun	Jul	Aug	Sep	Jun to Sep	Jun	Jul	Aug	Sep	Jun to Sep
Satana	8.3	13.9	10.3	10.1	42.7	22	27	24	20	70	0	2	0	0	5
Sinnar	8.4	20.0	18.4	11.0	57.8	25	30	28	22	82	1	11	0	0	21
Kalwan	9.4	20.9	18.7	11.9	60.9	20	30	27	21	80	0	9	7	1	35
Chandor	9.6	21.5	19.7	12.8	63.6	22	29	29	23	83	1	12	9	3	37
Dindori	11.0	27.1	25.8	15.6	79.5	24	31	31	26	94	0	17	14	7	64
Peint	14.9	29.5	24.0	19.8	88.2	28	31	31	30	109	4	23	21	3	71
Yeola	9.3	15.5	13.5	10.9	49.2	20	23	23	21	67	2	8	4	3	31
Nasik	9.9	23.9	22.1	13.7	69.4	23	31	31	24	90	0	9	9	2	40

classified as a rainy day if 0.01" or more of rain has occurred during 24 hours period ending at 0830 IST on the day. Tables 1 & 2 give the average maximum and minimum amount of rainfall and number of rainy days during each of the S.W. monsoon months, viz., June-September as a whole. The tables are self explanatory and mainly intended to give a general average picture of rainfall in the area during the period under study.

It is realised that when the sequences are considered for individual months, a few spells of longer duration would get split themselves in to shorter ones during the process as a consequence of the definition of the spells. Wet spells up to 10 days are tabulated as individual spells but spells exceeding 10 days are indicated as a single cumulative figure. Table 3 gives frequency of wet spells for S.W. monsoon period as a whole for all eight stations.

2. 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 same as that used by Jorgensen (1949).

The probability of rain occurring on chance on any one day $p = \text{Number of rainy days} / \text{Total no. of days in the period concerned}$, p for each station for the S.W. monsoon period and the number of rainy days in each month and also for the whole season are given in Table 4. The expected frequency of runs of rainy days of different lengths are calculated from Cochran's (1938) formula and are given in Table 3.

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

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

where,

$$m = 122 \text{ (June + July + August + September)}$$

$$r = \text{Number of days (1, 2, 3 etc.)}$$

3. Frequency distribution of wet spells

Tables 3 & 5 give the frequency distribution values for wet and dry spells.

3.1. Wet spell

The average yearly number of such spells are also given in the Table 3. The lowest value 10.7 and highest value 20.5 are noticed for Peint and Yeola respectively. Table 3 shows that the wet spells of shorter duration

≤ 5 days are most frequent in all stations. The most common among them is that of 2 days. It may be noted that value is highest for Yeola $446 + 229 = 665$ while the lowest is noticed for Peint $122 + 66 = 188$. The figures for wet spells > 10 days are also not uncommon, the figures being lowest for Satana 6, Yeola 9 while the highest is noted for Peint 138. These differences in Peint and Satana/Yeola are due to their situation with respect to orography. Peint being on the windward side and Satana/Yeola on the lee of the Western Ghats. From Table 4, it may be seen that lowest probability of wet days is 0.348 against Satana while highest value 0.722 against Peint.

The expected values up to spells of 5 days are not agreeing with the observed values. However, there is some agreement above this spell and up to 10. The formula of Cochran does not fit in for these stations. This is in agreement with the conclusions of earlier authors Raman *et al.* (1960) & Gupta (1966) in respect of stations for west coast and Rajasthan district.

3.2. Dry spells

The observed frequencies are indicated in Table 5 for dry spells. As mentioned earlier for wet spells, the most common among them is for frequencies less than 2, the value being lowest 260 for Peint and highest 595 for Yeola. The average yearly number of such frequencies are also indicated in the Table. The lowest being 8.9 for Peint and highest value for Yeola (21.2) & Satana (18.9) are noticed.

The figures for dry spells > 10 days are also not uncommon. The figures being lowest for Peint (24) while the highest (81) is noted for Satana.

It may be noted that even though the observed and expected frequencies do not have any agreement up to spells of 5 days as noticed in wet spells, there is a fairly better agreement for subsequent spells. However, the applicability of Cochran's formula for tropics is to be investigated further.

Table 6 shows the frequency of number of years of dry spells lasting full month. For Satana, Dindori and Nasik there was only one year in June and for Kalwan there were two years while for Satana & Sinnar there was one year in August while for Satana & Sinnar the corresponding figures are 1 & 2 during September for the entire period of 1921-1970 when they remained dry during entire month. It is, however, interesting to note that during the entire period all the eight stations remained wet and received some rainfall during July. Also, it may be noticed that Chandor, Yeola & Peint had remained wet all these years.

TABLE 3

Frequency of wet spells — Southwest monsoon season (1921-1970)

Days	Dindori		Peint		Chandor		Yeola		Kalwan		Sinnar		Satana		Nasik	
	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.
1	215	476.4	122	363.4	320	825.0	446	868.4	328	697.6	322	778.4	408	891.9	263	662.4
2	116	308.9	66	260.1	154	338.4	229	346.9	163	360.4	159	366.5	216	307.9	147	372.5
3	88	199.4	37	186.4	86	190.6	131	138.8	94	186.3	82	172.7	100	106.3	95	209.5
4	44	128.9	41	133.8	61	94.6	73	55.5	67	96.2	61	81.4	64	36.7	62	118.0
5	29	83.4	22	95.9	38	46.9	51	22.2	41	49.7	32	38.3	37	12.7	51	66.3
6	32	53.9	26	68.7	37	23.3	25	8.9	26	25.7	39	18.1	23	4.4	43	37.3
7	25	34.8	17	49.2	28	11.5	21	3.5	23	13.3	27	8.5	13	1.5	23	21.0
8	18	22.5	21	35.5	17	5.7	10	1.4	25	6.9	20	4.0	7	0.5	20	11.8
9	15	14.6	12	25.3	20	2.8	4	0.6	21	3.5	17	1.9	6	0.2	17	6.6
10	15	9.4	10	18.1	15	0.7	6	0.2	14	1.8	11	0.9	5	0.1	15	3.7
>10	103		138		68		9		42		44		6		73	
No. of years	48		47		50		49		47		48		49		50	
Yearly average	14.6		10.7		16.9		20.5		17.9		16.8		18.6		16.2	

TABLE 4

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

Station	Jun	Jul	Aug	Sep	Jun to Sep.	'p'
Satana	407	680	503	496	2086	0.348
Sinnar	405	962	884	528	2779	0.475
Chandor	482	1073	983	642	3180	0.521
Kalwan	442	982	884	562	2870	0.500
Dindori	530	1302	1240	749	3821	0.652
Peint	693	1388	1128	931	4145	0.722
Yeola	454	760	662	535	2411	0.403
Nasik	493	1193	1103	675	3464	0.567

The probability q & number of dry days for each month and for season as a whole are given in Table 7. It may be noted that the lowest value of probability is 0.278 for Peint while the highest value 0.652 is noticed for Satana. The distribution of dry spells is also showing the effect of orography.

4. Conclusions

(i) There is fairly an equal distribution of wet and dry spells up to spells of 10 days.

(ii) The frequencies for spells up to 5 days for both wet and dry are quite high.

(iii) The observed frequencies and expected frequencies do not show any agreement up to spells of 4 to 5

TABLE 5

Frequency of dry spells — Southwest monsoon season (1921-1970)

Days	Dindori		Peint		Chandor		Yeola		Kalwan		Sinnar		Satana		Nasik	
	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.
1	289	873.6	181	836.0	318	825.0	399	605.0	342	754.8	303	708.9	300	486.2	334	860.0
2	127	301.6	79	230.4	147	338.4	196	358.3	160	358.4	156	369.2	175	314.5	141	369.3
3	78	104.1	48	63.5	103	190.6	116	212.2	78	170.4	90	192.3	105	203.4	66	158.6
4	39	35.9	25	17.5	79	94.6	84	125.7	75	80.9	70	100.1	60	131.4	58	68.1
5	25	12.4	13	4.8	44	46.9	57	74.4	41	38.4	49	53.1	75	85.1	28	29.3
6	24	4.3	16	1.3	22	23.3	38	44.1	27	18.3	26	27.2	36	55.0	33	12.6
7	18	1.5	13	0.37	29	11.5	27	26.1	19	8.7	29	14.1	33	35.5	25	5.4
8	13	0.51	10	0.10	19	5.7	29	15.5	30	4.1	21	7.5	21	23.0	29	2.3
9	9	0.18	6	0.03	15	2.8	19	9.2	13	2.0	13	3.8	24	14.9	9	1.0
10	7	0.06	8	0.01	11	0.66	14	5.4	10	0.9	11	2.0	17	9.6	12	0.4
>10	33		24		33		60		45		50		81		42	
No. of years		48		47		50		49		47		48		49		50
Yearly average		13.8		8.9		16.4		21.2		17.9		17.0		18.9		15.5

TABLE 6

Frequency of years when dry spells lasted for a full month

Station	Jun	Jul	Aug	Sep
Satana	1	--	1	1
Sinnar	--	--	1	2
Chandor	--	--	--	--
Kalwan	2	--	--	--
Dindori	1	--	--	--
Peint	--	--	--	--
Yeola	--	--	--	--
Nasik	1	--	--	--

TABLE 7

No. of dry days in each month and for the season as a whole and the probability q on chance

Station	Jun	Jul	Aug	Sep	Jun to Sep	$q=1-p$
Satana	1063	839	1016	974	3892	0.652
Sinnar	1035	526	604	912	3077	0.525
Chandor	1018	477	567	858	2920	0.479
Kalwan	968	475	573	848	2864	0.500
Dindori	910	186	248	691	2035	0.348
Peint	712	069	329	479	1589	0.278
Yeola	1016	759	857	935	3567	0.597
Nasik	1007	357	447	825	2636	0.433

days in both wet and dry spells but, however, it may be stated that there is fairly a better agreement noticed in dry spells. The Cochran's formula does not fit in for wet and dry spells. This is in agreement with the conclusion of earlier studies also.

(iv) All the eight stations had received rain and remained wet throughout July for the entire period 1921-70.

(v) The effect of orography is very well reflected in the frequencies of wet and dry spells, wet spells being more at the stations on the windward side of hills and dry spells at the stations in the rain shadow regions.

Acknowledgement

The authors express their thanks to Shri C.E.J. Daniel, R.D., Bombay for encouragement, Shri R.S.

Dube for the computational work and also Shri R.B. Daswani for typing the manuscript.

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