551.578.1 : 551.577.23(547.1)

RELATIONSHIP BETWEEN RAINY DAYS, MEAN DAILY INTENSITY AND SEASONAL RAINFALL IN MAHARASHTRA

1. The amount of rainfall received over an area is an important factor in assessing the amount of water available to meet the various demands of agriculture, industry, irrigation, generation of hydroelectricity and other human activities. The distribution of rainfall in time and space is, therefore, an important factor in the national economy.

Ananthakrishnan and Soman (1989) studied the association between cumulated percentage rain amount and cumulated percentage number of rainy days for 15 Indian stations representing a wide variety of rainfall regimes, utilizing the data for the period 1901-1980. They found that there is no universal normalised rainfall curve which can represent all rainfall regimes as suggested in some of the earlier studies. This work has been further extended by Soman and Krishna Kumar (1990) by using the data of 365 Indian stations for 80 years (1901-1980). The rainfall data relate to the southwest monsoon season June to September (122 days) which accounts for the major part of the annual rainfall over most parts of the country.

There are limitations in using monthly rainfall totals in studies of rainfall climatology as well as in hydrological and agricultural investigations. Two relatively simple parameters, which are closely associated with rainfall distribution and provide a better picture of tropical rainfall conditions than the seasonal total alone, are number of rainy days and mean daily rainfall intensity. A number of studies of these two elements have been carried out for various parts of the world, including their relationship with rainfall totals.

Relationship between monthly/seasonal rainfall, rainy days and mean daily intensity can be examined in two ways : (*i*) in spatial terms, and (*ii*) in temporal terms. Jackson (1986) has made a study of the general relationships between monthly rainfall, number of rainy days and mean daily intensity using a range of tropical data. He defined a rainy day with threshold value of rainfall of 0.3 mm for 18 stations, 0.1 mm for 7 stations and 1.0 mm for 3 stations. In the Indian region he has used the data of Bombay, Calcutta, Minicoy and Pune for which the threshold value of 0.3 mm is considered. This does not conform to the definition given by India Met. Dep. of a rainy day, where the threshold value is 2.5 mm. In the present study the relationship has been worked out for the seasonal rainfall, number of rainy days and mean daily intensity for Maharashtra region for the monsoon period.

2. Normal rainfall values and number of rainy days of 26 districts distributed in the four sub-divisions of Maharashtra as contained in *Climate of Maharashtra State* (India Met. Dep. 1971) have been utilised. These values are based on the daily data for the period 1901 to 1950. The sub-divisions, districts, and the normal values of rainfall and number of rainy days are given in Table 1. The analysis is limited to the monsoon period, *i. e.*, from June to September as the State gets the major part of annual rainfall during the southwest monsoon period. Konkan and Vidarbha receive 87% of annual total during this period. Madhya Maharashtra and Marathwada get 83% of the annual rain during the monsoon. A rainy day is counted when the rainfall is 2.5 mm or more. Mean daily rainfall intensity (MDI) is obtained by dividing the average seasonal total rainfall (*T*) by the average number of Rainy Days (RD).

TABLE 1

Normal rainfall values and deviations — Maharashtra State

District	Normal rainfall		Deviation		
	Total rainfall (*T*) (mm)	Rainy days (RD)	Mean daily rainfall intensity (MDI = *T*/RD)	RD& *T* (mm)	MDI& *T* (mm/ day & mm)
Madhya Maharashtra					
Ahmednagar	443.9	26.9	16.5	—5.4	2.4
Dhulia	596.0	37.0	16.1	1.1	—0.8
Jalgaon	642.7	38.0	16.9	0.9	—0.7
Kolhapur	1649.9	60.2	27.4	—0.9	0.9
Nasik	911.2	43.5	26.9	0	0
Pune	996.7	43.4	23.0	—2.1	1.3
Sangli	473.5	34.9	13.6	1.9	—1.1
Satara	445.1	31.7	14.0	—0.6	—0.1
Sholapur	431.1	26.6	16.2	—5.4	2.3
Marathwada					
Aurangabad	600.5	37.2	16.1	1.2	—0.8
Bir	620.5	34.1	18.2	—2.4	0.9
Nanded	786.2	39.2	20.1	—1.3	0.6
Osmanabad	732.9	40.3	18.2	1.1	—0.6
Parbhani	765.1	37.2	20.6	—2.7	1.3
Konkan					
Greater Bombay	1802.9	71.2	25.3	6.5	—2.1
Colaba	2871.2	86.4	33.2	—3.8	1.5
Ratnagiri	2960.9	89.1	33.2	—3.3	1.3
Thane	2164.1	77.5	27.9	4.1	—1.2
Vidarbha					
Akola	692.2	39.6	17.5	1.4	—0.8
Amraoti	747.4	40.1	18.6	0.5	—0.4
Bhandara	1318.3	52.7	25.0	—0.5	0.6
Buldhana	669.1	38.1	17.6	0.4	—0.3
Chandrapur	1265.0	53.5	23.7	1.4	—0.3
Nagpur	1001.1	48.1	20.9	2.4	—0.9
Wardha	943.4	45.5	20.7	1.3	—0.5
Yeotmal	750.3	44.0	17.1	4.4	—1.9
Standard error				2.79	1.169

3. Several polynomials as given in Table 2 between the seasonal total (*T*), rainy days (RD) and mean daily rainfall intensity (MDI) are examined.

The variable *Y* is the number of rainy days or mean daily rainfall intensity and *X* is the seasonal rainfall total. The constants *A* and *B* are worked out for the two sets of relationships, *i. e.*, (*i*) between rainy days and total rainfall, and (*ii*) between mean daily rainfall intensity and total rainfall.

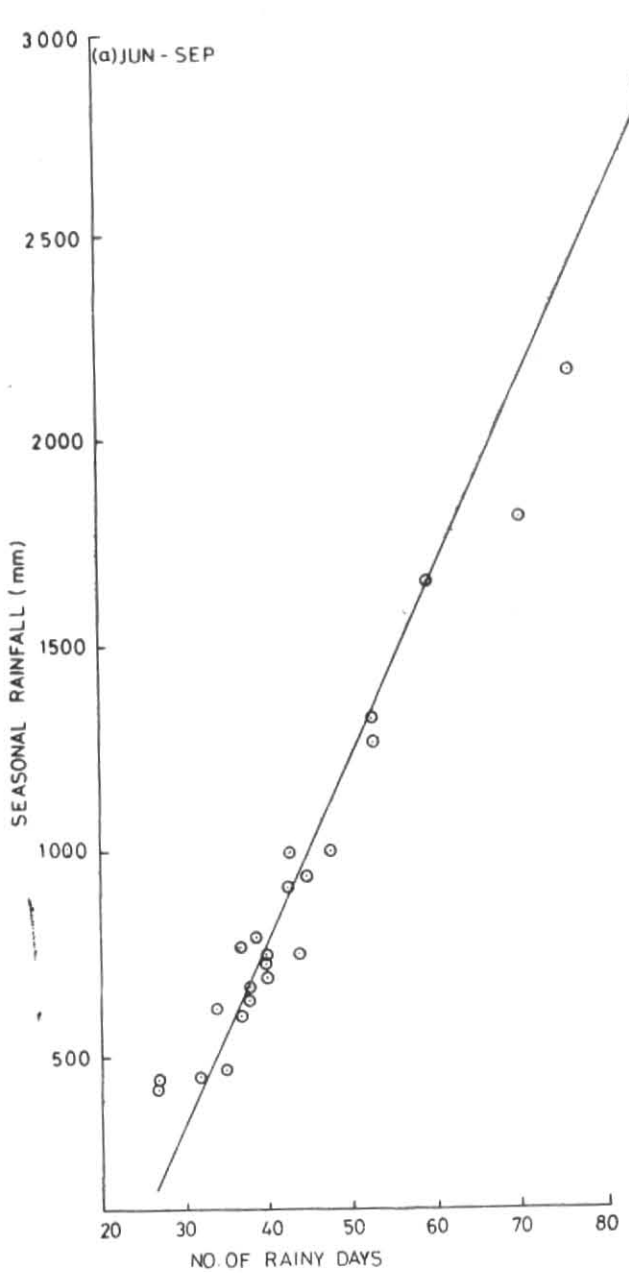

Fig. 1 (a). Seasonal rainfall and No. of rainy days in Maharashtra for Jun-Sep

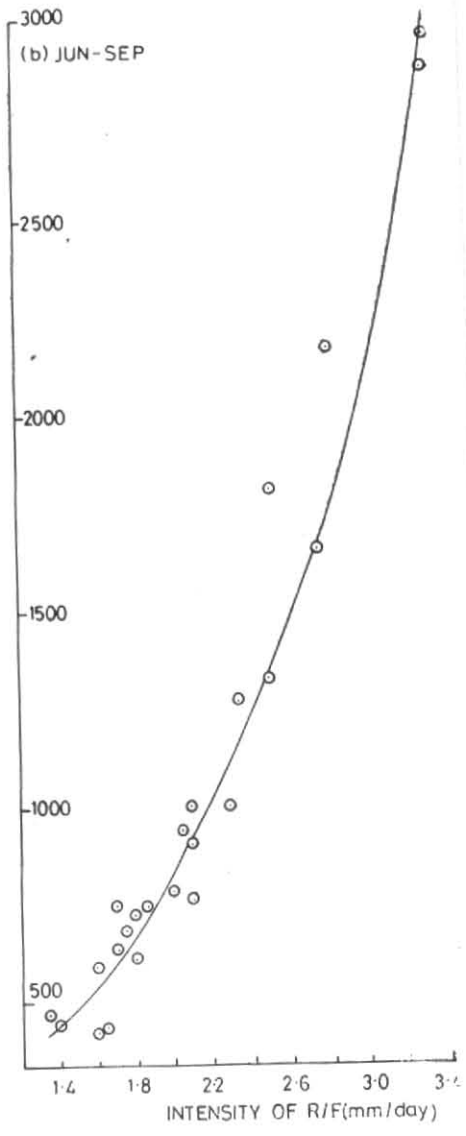

Fig. 1 (b). Seasonal rainfall and intensity of rainfall in Maharashtra for Jun-Sep

To assess the degree of relationship of the two parameters with rainfall, the R^2 value and the maximum deviation between the actual and the derived values which indicate the closeness of fit of the relationship of the parameters are worked out. Here R denotes correlation between the actual values of Y and those predicted by the polynomial. It is analogous to the multiple correlation coefficient and is known as correlation ratio (Yule and Kendall 1957).

4. Table 2 gives the values of the constants A, B and R^2 and the maximum deviation in respect of the relationships as mentioned in section 3, for the association of, (*i*) number of rainy days and total rainfall, and (*ii*) mean daily rainfall intensity and total rainfall respectively. The R^2 values for almost all the cases are highly significant and their difference are very small. Therefore, it is felt that the maximum deviation may provide some additional information indicating the goodness of fit.

Table 2 shows the highest value of R^2 (0.98) for the relation between rainy day and total rainfall in the form $Y=A+BX$. For mean daily rainfall intensity and total rainfall (Table 2) the maximum value of R^2 (0.95) is obtained for the relationship $Y=A+B \log X$. These relationships are shown in Figs. 1 (a & b). The R^2 value for the linear relationship between RD and T is greater than that for the logarithmic relation betweeh MDI and T, though the difference is not large. However, this indicates that the number of rainy days have better relationship with seasonal total than the mean daily rainfall intensity.

TABLE 2

Polynomials between (*i*) Rainy Days (RD) and seasonal rainfall (*T*) (*ii*) Mean daily rainfall intensity (MDI) and seasonal rainfall (*T*)

Equation	Rainy days (RD) & seasonal rainfall (*T*)				Mean daily rainfall intensity (MDI) & seasonal rainfall (*T*)			
	A	*B*	R^2	Max. deviation	*A*	*B*	R^2	Max. Deviation
$Y=A+BX$	21.7222	0.0239	0.98	6.5	13.0532	.0073	0.92	6.8
$Y=Ae^{BX}$	28.0780	0.0004	0.93	13.0	14.4275	.0003	0.85	3.6
$Y=A+B/X$	79.4860	—25810.9800	0.79	18.3	13.0532	.0073	0.93	20.1
$Y=A+B \log X$	—157.4245	30.0542	0.95	11.1	—43.4130	9.4387	0.95	2.4
$Y=AX^B$	0.8645	0.5795	0.97	4.6	1.1616	0.4198	0.91	2.9
$Y=X/(A+BX)$	10.6650	0.0099	0.87	15.2	11.7225	0.0360	0.62	8.8

Y=MDI $X=T$ (mm)

TABLE 3

Deviation greater than standard errors

Relationship	Deviation				
	Positive		Negative		Zero
	Total	>S.E.	Total	>S.E.	
(*i*) RD and *T*	14	3	11	4	1
(*ii*) MDI and *T*	10	6	15	3	1

5. Residuals in terms of positive and negative deviations for individual districts are from the 'all data' equations since a general relationship is worked out for the State as a whole. The deviations obtained from the reationships between : (*i*) rainy day and total rainfall, and (*ii*) mean daily rainfall intensity and total rainfall, along with the standard errors are shown in Table 1. The sign of the residual reverses for several districts between the two relationships (Table 3). The number of districts having positive deviation greater than the standard error are more (6) for the relationship between MDI and *T* than those (3) in the case of RD and *T*. The maximum value of deviation is found in the case of RD and *T*. The patterns of the positive and negative deviations seem to be of interest. Such pattern may highlight differences and similarities between individual districts and regions.

5.1. Noticeable departures are seen in Madhya Maharashtra and Konkan sub-divisions. In Madhya Maharashtra, negative departures are almost twice the number of positive departures. Only for two districts Ahmednagar and Sholapur, these are exceeding the standard error. In Konkan, the number of districts having positive and negative deviations are the same and in each of them the magnitude of the deviation exceeds the standard error. The remaining two sub-divisions, *i.e.*, Marathwada and Vidarbha have deviations less than the standard error except for one district Yeotmal. In Vidarbha, the deviations are mostly positive. In Konkan the deviations are both positive and negative.

5.2. Out of 26 districts 9 have deviations greater than the standard error (6 are positive and 3 negative). In Madhya Maharashtra three districts have deviations greater than the standard error and these are all positive. In Marathwada only one district has significant deviation which is positive. In Konkan all the four districts have significant deviations with two positive and two negative. Vidarbha has only one district for which the deviation is greater than the standard error and it is negative.

The above conclusions expose a variety of patterns of sign of deviations in relation to geographic locations in the State.

6. Number of rainy days have a better relationship with rainfall total than does the mean daily rainfall intensity. The former has linear relationship and the latter shows a logarithmic relationship. The geographic locations seem to have an influence in the relationship. The dominance of either positive or negative deviations at many districts indicate basic differences in the two simple rainfall parameters between individual districts. The present study is a preliminary one for the State as a whole and for the seasonal rainfall. It is clear from the study that one single relationship for each of the two parameters with seasonal rainfall does not hold good for different types of rainfall regimes. The study is, therefore, being extended in greater detail subregionwise and also monthwise later.

7. The authors acknowledge thanks to the Deputy Director General of Meteorology, Regional Meteorological Centre, Bombay who provided the facility to make this study.

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