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Analysis of rainfall over Nasik district

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ABSTRACT. The study of rainfall patterns over Satara, Pune and Ahmednagar districts indicated a definite variation in the distrbution of rainfall even within a district. Hence, an attempt has been made in this paper to study in detail the distribution of rainfall over Nasik district. The daily normal rainfall and daily actual rainfall have been analysed and it has been found that during the months of July and August the district can be distinctly differentiated into two regions which have different rainfall patterns. The comparative study of wind over Bombay in relation to increase in rainfall over the western talukas suggested that the strengthening of westerlies at 850 mb over Bombay cause increase in rainfall over the western part of the district while the rainfall distribution in the eastern part under similar conditions does not show any marked increase.

1. Introduction

In the Farmers' Weather Bulletins issued at present by the different Regional Meteorological Centres of India Meteorological Department, district has been considered as a smallest possible unit for which a single common weather forecast can be issued. Regional Meteorological Centre, Bombay issues Farmers' Weather Bulletins for all the districts of Maharashtra except Vidarbha. These bulletins have been useful for the farmer in the various agricultural operations. However, the study of rainfall over Nasik district (Rao and Prasad, 1976) pointed out the influence of orography on the rainfall distribution in the district. The study of rainfall distribution of Satara district by Mukherjee *et al.* (1979) and the study of rainfall characteristics in Pune and Ahmednagar districts by the authors (accepted in Mausam) also confirms the possible inhomogeneity of rainfall even within a district in Madhya Maharashtra. Hence, an attempt is made in this paper to critically examine the variations in the intensity and distribution of rainfall over the different areas in Nasik district so as to precisely understand the rainfall distribution in the different talukas of the district.

2. Physical features

Nasik district lies between Lat. 19 deg. 31′N and 20 deg. 52′N and Long. 73 deg. 16′E and 74 deg. 56′E with an area of 15,582 km^2 or 6015 sq. miles (Fig. 1). The western half of the district is a hilly area in the Western Ghats with elevation ranging from 600 m to 900 m. The eastern half is comparatively plain with elevation ranging from 300 m to 600 m. The general direction of the mountain range is from west to east. Table 1 gives the geographical co-ordinates of the stations and their heights above mean sea level. The stations, Igatpuri, Trimbak and Peint are on the Western Ghats while the remaining stations are on the lee side of the Western Ghats.

3. Data

Nasik district consists of 13 talukas. The daily rainfall for the period 1901 to 1950 were utilised to calculate the daily normal rainfall for the stations Igatpuri, Trimbak, Peint Sinnar, Nasik, Dindori, Kalwan, Chandor, Niphad, Yeola, Satana, Malegaon and Nandgaon. These daily rainfall normals were then used to study the various aspects of pentad and daily rainfall distribution in the different stations of the district.

4. Analysis and results

The study has been processed in the following steps :

(i) Monthly rainfall
(*ii*) Pentad rainfall
(*iii*) Daily rainfall
  (a) Study of daily normal rainfall
  (b) Study of daily actual rainfall from 1958-1970.

4.1 *Monthly rainfall*

The average monthly, seasonal and annual rainfall (in mm) and the number of rainy days for the months of June, July, August and September are given in Table 2. The seasonal rainfall is highest at Igatpuri of the order of 3161 mm and is the least at Satana which gets rainfall of about 385 mm. It is seen that all the stations do not have maximum rainfall in the same month, the stations Igatpuri, Trimbak, Peint, Nasik and Dindori get maximum rainfall

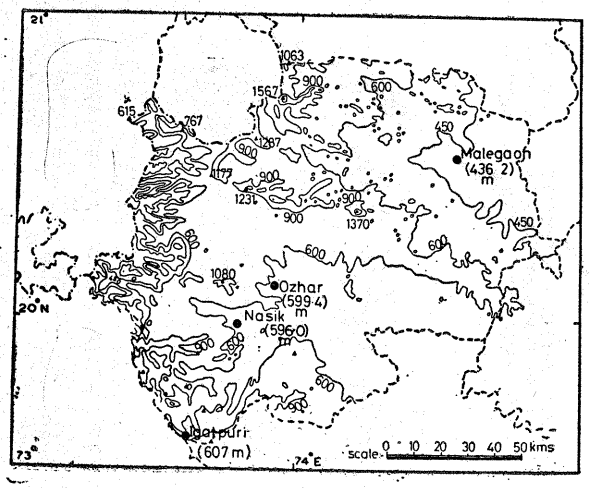

Fig. 1. Contour map of Nasik district (Figs. in bracket indicate height above msl)

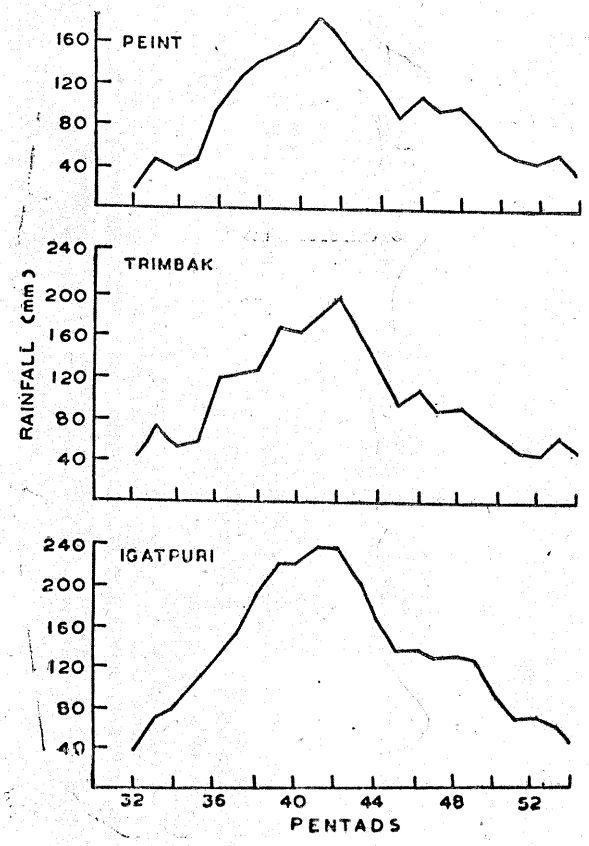

Fig. 2. Pentad rainfall of Gr. I stations in Nasik district

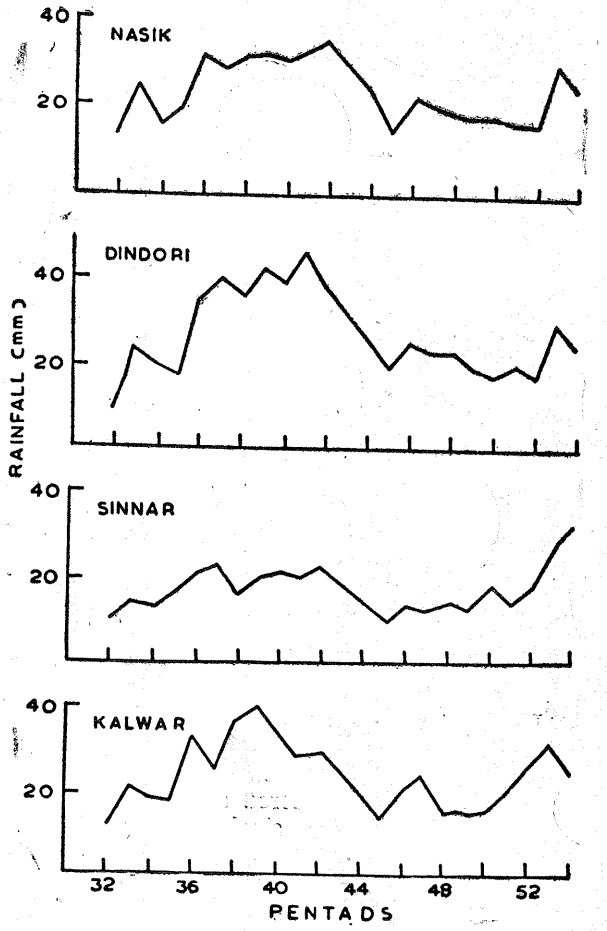

Fig. 3. Pentad rainfall of Gr. II stations in Nasik district

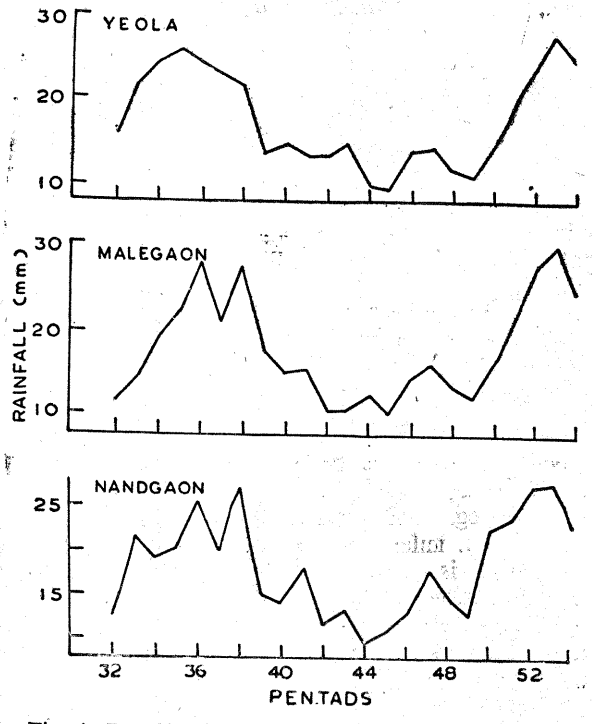

Fig. 4. Pentad rainfall of Gr. III stations in Nasik district

TABLE 1

Location of the stations in Nasik district

Stations	Lat. (N)	Long. (E)	Height (a.m.s.l.) (m)
Peint	20° 15′	73° 30′	518
Trimbak	19° 57′	73° 32′	549
Igatpuri	19° 43′	73° 35′	607
Nasik	20° 00′	73° 47′	596
Dindori	20° 12′	73° 50′	—
Pimpalgaon	20° 10′	73° 59′	—
Sinnar	19° 51′	74° 00′	—
Kalwan	20° 30′	74° 02′	—
Niphad	20° 05′	74° 07′	—
Satana	20° 36′	74° 12′	—
Chandor	20° 20′	74° 15′	—
Yeola	20° 03′	74° 29′	—
Malegaon	20° 33′	74° 32′	437
Nandgaon	20° 19′	74° 40′	—

in the month of July, while the stations Sinnar, Niphad, Kalwan, Chandor, Nandgaon, Pimpalgaon, Satana, Malegaon and Yeola show double maxima of rainfall in the months of July and September, the maximum in the month of September being generally higher than the rainfall maximum in the month of July. It is seen in general that the western parts of the district get maximum rainfall in July while the stations to the east get maximum rainfall in September and that the rainfall decreases from Western talukas to the Eastern talukas. Analysis of number of rainy days shows that the entire district has maximum number of rainy days in the month of July, except for the northeast plain stations Malegaon and Nandgaon where the number of rainy days are more in the month of September. This preliminary study indicated a definite variation in rainfall distribution within the district. Hence, the pentad rainfall characteristics of the different stations in the district were studied.

4.2 *Pentad rainfall*

The pentad rainfall pattern of the stations are given in Figs. 2, 3 and 4. It is observed from the pentad rainfall pattern that these stations can be grouped under 3 categories having similar rainfall characteristics. The pentad rainfall behaviour of these 3 group of stations are summarised below :

Group I :

The stations Peint, Igatpuri and Trimbak which are on the Western Ghats. The pentad rainfall gradually increases from 32nd - 42nd pentad and starts decreasing in the subsequent pentad with singal maximum during 42nd pentad.

Group II :

The stations Dindori, Nasik, Kalwan and Sinnar which are to the leeward side of the Western Ghats:

(i) It is noticed that the pentad rainfall increases from 32nd-33rd pentad and decreases from 34-35th pentad.

(*ii*) There is sharp increase in pentad rainfall during 36th - 41/42nd pentad, reaching maximum at 41st/42nd pentad for all the stations except Kalwan where the pentad rainfall reaches maximum during 39th pentad.

(*iii*) The pentad rainfall decreases from 42nd to 52nd pentad with slight increase during 45th - 48th pentad.

(*iv*) The pentad rainfall increases from 52nd to 53rd pentad and reaches maximum at 53rd pentad, then there is decreasing trend of pentad rainfall from 54th pentad onwards.

Group III :

The stations Malegaon, Nandgaon,, Satana, Yeola, Chandor and Niphad to the central and eastern part of the district :

(*i*) The pentad rainfall increases from 32nd-36th pentad and reaches maximum during 36th pentad.

(*ii*) There is decreasing trend of pentad rainfall from 37th to 45th pentad reaching minimum during 45/46th pentad.

(*iii*) The pentad rainfall steeply increases from 46th/47th to 53rd pentad and maximum is observed at 53rd pentad. Then the pentad rainfall decreases in the subsequent pentads. The maximum during 53rd pentad is higher than the maximum during the 36th pentad.

The examination of the pentad rainfall characteristic of these 3 group of stations shows that the stations in group I exhibit single maximum during 42nd pentad. This maximum occurs in association with the onset of monsoon and its subsequent strengthening during July along the west coast. Group II and Group III stations show double maxima in 36th/41st pentad and 53rd pentad.

We find from the above pentad rainfall analysis that the rainfall pattern is different for the 3 groups of stations. The stations in the same group have more or less similiar rainfall behaviour. The 1st maximum is occuring in Group I and Group II stations in the initial phase of the monsoon while maximum pentad rainfall occurs in Group III stations at the last phase of monsoon. Next step in the study is the analysis of daily rainfall for these stations.

TABLE 2

Average monsoon rainfall and number of rainy days

(Nasik district)

	Jun		Jul		Aug		Sept		Rainfall	
	Rain-fall (mm)	No. of rainy days	Rain-fall (mm)	No. of rainy days	Rain-fall (mm)	No. of rainy days	Rain-fall (mm)	No. of rainy days	Seasonal (mm)	Annual (mm)
Peint	271.9	12.0	977.2	27.0	658.3	26.4	313.6	15.8	2221.0	2351.2
Trimbak	294.7	13.2	1016.2	27.6	658.8	26.7	313.2	16.5	2282.9	2456.9
Igatpuri	463.8	16.5	1334.3	28.9	921.0	27.9	441.8	19.4	3160.9	3341.6
Nasik	118.7	7.1	201.9	14.0	127.1	10.0	126.9	7.2	574.6	697.6
Dindori	116.9	7.3	241.7	17.3	148.3	13.7	130.3	7.9	637.2	753.3
Pimpalgaon	118.3	6.5	166.1	11.3	100.5	7·6	128.7	7.1	513.6	629.6
Sinnar	86.6	5.8	128.8	10.6	85.3	8.1	137.4	7.2	438.1	556.7
Kalwan	119.4	6.8	200.4	12.9	119.4	9.3	134.3	7.2	537.5	692.0
Niphad	99.6	6.0	119.3	10.0	83.9	6.9	131.3	7.4	434.1	548.6
Satana	99.3	6.3	100.2	7.7	67.7	4.9	118.2	7.0	385.4	477.2
Chandor	118.3	7.1	150.7	12.8	98.0	9.1	149.6	8.1	516.6	645.0
Yeola	124.8	6.5	103.8	8.6	76.9	5.8	135.3	7.5	440.8	555.3
Malegaon	110.5	6.2	115.1	7.7	73.7	5.1	141.9	8.1	444.3	544.3
Nandgaon	121.0	6.7	105.1	7.4	82.6	6.0	160.3	9.0	469.0	584.7

4.3 *Daily rainfall*

(a) *Normal rainfall*

The five-day moving averages of the daily rainfall normals for the 13 stations were calculated. The scatter diagrams were plotted for each pair of stations and the linear correlation coefficients were determined. The nature of correlation coefficients and the values of correlation coefficient for linear correlation for the month of June, July, August and September are given in Table 3. The nature of correlations are discussed below for the different months separately. The value of correlation coefficient greater than 0.5 were found to be significant at 1 per cent level.

June — All the 3 groups of stations have significantly positive correlation indicating that rainfall distribution is similar in the district.

July—Group I and Group II stations are positively correlated with each other and are negatively correlated with the stations in Group III. There exists significantly positive correlation between the Group III. The station Kalwan is not correlated with any of the stations.

August—The stations in Group I and II including Niphad and Chandor of Group III are positively correlated and are negatively/not correlated with the remaining stations of Group III. The stations in Group III are positively correlated except Niphad. The stations Chandor and Kalwan were found to be correlated with all the stations of Group I, II and III.

September—There exists high positive correlation among all the stations of Group II and III which are negatively/not correlated with stations in Group I. Group I stations are positively correlated with each other.

It is apparent from the study of daily normal rainfall that the distribution of rainfall is different in the various areas of the district. It is found that during the month of June the rainfall distribution is homogeneous, while during July a delineation line can be imagined through Sinnar and Kalwan running north-south, dividing the district into two regions consisting of Igatpuri, Peint, Trimbak, Nasik, Dindori, Kalwan and Sinnar to the western part and Nandgaon, Niphad, Chandor, Satana, Yeola and Melegaon to the eastern part of the district. This demarcating line as given in Fig. 5 is found to shift slightly to the east during August and thus includes Niphad and Chandor to the western region while Nandgaon, Satana, Malegaon and Yeola to the eastern region. In the month of September the entire district has similar rainfall distribution except Igatpur, Peint and Trimbak which are at the peak of the Western Ghats.

TABLE 3

Nature of correlation between stations in Nasik district

	Peint	Trimbak	Igatpuri	Nasik	Dindori	Sinnar	Kalwan	Niphad	Satana	Chandor	Yeola	Malegaon	Nandgaon
						June							
Peint	1	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.8	0.7	0.7	0.8	0.8
Trimbak	0.9	1	0.8	0.9	0.9	0.7	0.9	0.7	0.7	—	0.5	—	0.8
Igatpuri	0.9	0.8	1	0.8	0.9	0.9	0.9	0.8	0.8	0.8	0.7	0.9	0.9
Nasik	0.9	0.9	0.8	1	0.9	0.8	0.9	0.8	0.7	0.7	0.7	0.7	0.9
Dindori	0.9	0.9	0.9	0.9	1	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.9
Sinnar	0.9	0.7	0.9	0.8	0.9	1	0.8	0.9	0.9	0.9	0.8	0.9	0.8
Kalwan	0.9	0.9	0.9	0.9	0.9	0.8	1	0.8	0.8	0.8	0.7	0.8	0.9
Niphad	0.8	0.7	0.8	0.8	0.9	0.9	0.8	1	0.8	0.9	0.8	0.8	0.8
Satana	0.8	0.7	0.7	0.7	0.9	0.9	0.8	0.8	1	0.8	0.8	0.8	0.8
Chandor	0.7	—	0.8	0.7	0.8	0.9	0.8	0.9	0.8	1	0.9	0.8	0.7
Yeola	0.7	0.5	0.7	0.7	0.8	0.8	0.7	0.8	0.8	0.9	1	0.7	0.8
Malegaon	0.8	—	0.9	0.7	0.8	0.9	0.8	0.8	0.8	0.8	0.7	1	0.8
Nandgaon	0.8	0.8	0.9	0.9	0.9	0.8	0.9	0.8	0.8	0.7	0.8	0.8	1
						July							
Peint	1	0.9	0.9	—	0.7	—	X		X	—0.7	—0.7	—0.7	—0.7
Trimbak	0.9	1	0.8	—	—	0.7	X				—0.7	—0.8	—0.9
Igatpuri	0.9	0.8	1	—	—	—	X			—0.8	—0.9	—0.9	—0.8
Nasik	—	—	—	1		0.8	X	X	X	X	X	X	X
Dindori	0.7	—	—	—	1	0.7	X		X	X	X		
Sinnar		0.7		0.8	0.7	1	X	X	X	X	X	X	—0.6
Kalwan	X	X	X	X	X	X	1	X	X	X	X	X	X
Niphad				X		X	X	1	—	—	0.7	0.7	0.8
Satana	X			X	X	X	X	—	1	0.7	—	0.7	—
Chandor	—0.7		—0.8	X	X	X	X	—	0.7	1	0.8	0.9	0.7
Yeola	—0.7	—0.7	—0.9	X	X	X	X	0.7	—	0.8	1	0.9	0.8
Malegaon	—0.7	—0.8	—0.9	X			X	0.7	0.7	0.9	0.9	1	0.9
Nandgaon	—0.7	—0.9	—0.8	X		—0.6	X	0.8	—	0.7	0.8	0.9	1
						August							
Peint	1	0.9	0.8	0.9	0.9	0.8	—	0.8	X	—	X	X	X
Trimbak	0.9	1	0.9	0.7	0.7	—	—	0.7	X	—	X	X	
Igatpuri	0.8	0.9	1	—	0.7				X		X	X	
Nasik	0.9	0.7		1	0.9	0.9	0.8	0.7	0.7	0.8	X	X	X
Dindori	0.9	0.7	0.7	0.9	1	0.8	0.7	0.7	X	0.7	X	X	
Sinnar	0.8	—	—	0.9	0.8	1	—	0.7	X	—	X	X	X
Kalwan	—	—	—	0.8	0.7	—	1		0.9	0.9	0.7	0.8	0.6
Niphad	0.8	0.7		0.7	0.7	0.7	—	1	X	—	X	X	X
Satana	X	X	X	0.7	X	X	0.9	X	L	0.9	0.7	0.9	0.7
Chandor	—	—	—	0.8	0.7	—	0.9	—	0.9	1	0.7	0.7	0.6
Yeola	X	X	X	X	X	X	0.7	X	0.7	0.7	1	0.5	0.6
Malegaon	X	X		X	X	X	0.8	X	0.9	0.7	0.5	1	0.8
Nandgaon	X			X	X	X	0.6	X	0.7	0.6	0.6	0.8	1
						September							
Peint	1	0.7	0.9	X	X		X		X	X			
Trimbak	0.7	1	0.7	X	X	X	X	X	X	X	X	X	X
Igatpuri	0.9	0.7	1			—0.7							X
Nasik	X	X		1	0.9	0.8	—	0.9	—	—	0.7	0.7	—
Dindori	X	X		0.9	1	0.7	0.7	0.9	0.7	0.7	0.8	0.7	—
Sinnar		X	—0.7	0.7	0.7	1	—	0.8	—	—	0.7	0.7	—
Kalwan	X	X		—	0.7	—	1	0.8	0.9	0.9	0.9	0.9	0.8
Niphad		X		0.9	0.9	0.8	0.7	—	—	—	0.8	0.8	—
Satana	X	X		—	0.7	—	0.9	—	1	0.9	0.8	0.9	0.7
Chandor	X	X		—	0.7	—	0.9	—	0.9	1	0.8	0.9	0.8
Yeola		X		0.7	0.8	0.7	0.9	0.8	0.8	0.8	1	0.9	0.8
Malegaon		X		0.7	0.7	0.7	0.9	0.8	0.9	0.9	0.9	1	0.7
Nandgaon		X	X	—	—	—	0.8		0.7	0.8	0.8	0.7	1

—=Positive nonlinear correlation, gaps are negative nonlinear correlation and X=no correlation.

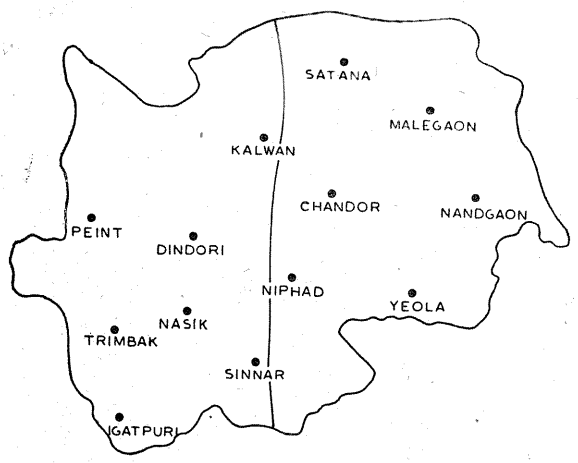

Fig. 5. Line of delineation in Nasik district

(b) *Actual rainfall*

The above results were verified in relation to the aactual rainfall for the period 1958 - 1970 excluding 1959, 1966 and 1967 (for which data were not available) to study the distribution and intensity of rainfall for the western and eastern regions separately.

It is well known that the rainfall increases over the Western Ghats with strengthening of westerlies during monsoon months. But due to positive correlations between Group I and Group II stations during July, it is supposed that this strengthening of westerlies may result in increase of rainfall in Group II stations also. Hence the rainfall of western region comprising of Group I and Group II stations were examined in relation to the strengthening of monsoon westerlies at 850 mb over Bombay. The daily average wind for 00 GMT and 12 GMT of the day for Bombay and average rainfall for Group I and Group II stations for the next day were analysed. The comparative study indicated that out of 256 observations of increased/decreased rainfall activity in the district, during 166 observations the strengthening of westerlies with wind speed more than 20 knots over Bombay increased the rainfall activity over the western part of the Nasik district while weakening of westerlies decreased the rainfall activity over the western region of the delineating line. It is also seen that during these 65 per cent of occasions when the increase or decrease of rainfall over the western region was observed, the eastern region showed an opposite trend confirming the negative correlations arrived at in the study of daily rainfall. In the remaining 35 per cent of cases the rainfall in the eastern region increased but the increase is seen to be one stage less both in intensity as well as spatial distribution as compared to the rainfall in western region. Thus rainfall amount and its spatial distribution in the western part of the district is in general higher than the rainfall amount and spatial distribution in the eastern part of the district under similar conditions.

5. Conclusion

The detailed study of the rainfall distribution over the Nasik district reveals that during the month of June the distribution of rainfall is homogeneous in the entire district while in the month of July and August the district can be distinctly diffentiated into 2 regions having different rainfall behaviour. During the month of September the rainfall distribution is uniform over the district except the Group I stations which are on the Western Ghats. The study of actual rainfall variation also suggested that the wind over Bombay can be utilised to forecast the rainfall over western part of the district and correlation arrived at also indicates that under the same conditions the eastern part can be given the rainfall forecast of lesser intensity and occurring at fewer stations. This may be very valuable to the forecaster.

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