

# The density of reporting network necessary for proper appraisal of the occurrence of rainfall in small areas in different localities in India in various seasons

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**ABSTRACT.** A study has been made of the minimum density of network of rain-gauge stations necessary for a proper appraisal of the character of rainfall in a given small area. Apart from the statistical value of the results obtained, this study has thrown some useful light in regard to our criteria for the assessment of rainfall forecasts for small areas such as those included in the Farmers' Weather Bulletins. Some of the findings of the study are of particular interest. For example, while one would conclude, on the basis of data of Calcutta alone that the liability of the area round about the station to get rain of 10 cents or more during the premonsoon season is only 11 for every 100 days, the analysis based on data of all rain-gauge stations within 50 miles round about Calcutta shows that on as many as 53 per cent days one or more stations in that area is likely to have rain of 10 cents or more. Similar findings, as have been obtained for other areas and in other seasons, are of value in connection with the districtwise forecasts that are being issued for the use of farmers.

## 1. Introduction

A detailed study of day to day distribution of rainfall over even a small area shows that the record of only one particular station does not correctly represent the true character of raininess of the area on each individual day. In this respect, the measure of precipitation at a station is not truly representative of the state of things in its immediate surroundings, in the same way as some of the other meteorological elements, for example, temperature, humidity, barometric pressure, etc are. With a view to finding out what the minimum density of network of rain-gauge stations in a given small area should be in order that their records may correctly represent whether some locality or other in that area has had some measurable rain on a day or not, Beebe (1952) examined the scatter of summer showers over two small areas within a radius of 50 miles from Birmingham and Atlanta in the southeastern United States, and found that about 40 stations were required in each of these areas to give a correct indication of the precipitation coverage. He further observed that there was a significant relationship between the areal coverage and the average amount of rain per station,—a type of knowledge which would be of value to a weather forecaster for estimating

the intensity of rainfall if he could forecast with reasonable accuracy the expected areal coverage of precipitation on a day in a particular synoptic situation. A similar detailed study has been made of the rainfall distribution over four small areas in India, 50 miles round about Calcutta, Delhi, Bangalore and Tiruchirapalli for two different seasons of rainfall and the results presented in this paper. The rainfall data examined in this study refer to the 5-year period 1941-45, and comprise all available records of provincial rain-gauge stations published by the State Governments. The precipitation character of all the four areas has been examined with reference to both "rainy days" (rainfall of 10 cents or more) and days of precipitation (rainfall of 1 cent or more) and two sets of curves have been added in each of the diagrams to represent the position in the two cases. While, basically, the results obtained are on the lines as expected, *viz.*, that the percentage number of rainy or precipitation days in an area, as judged by the records of a larger number of stations, is more than what is given by the records of a single station, some of the findings of the study are definitely revealing and should be of material help in improving and also verifying the districtwise rainfall forecasts included in weather bulletins for farmers, issued in this country. Even though the

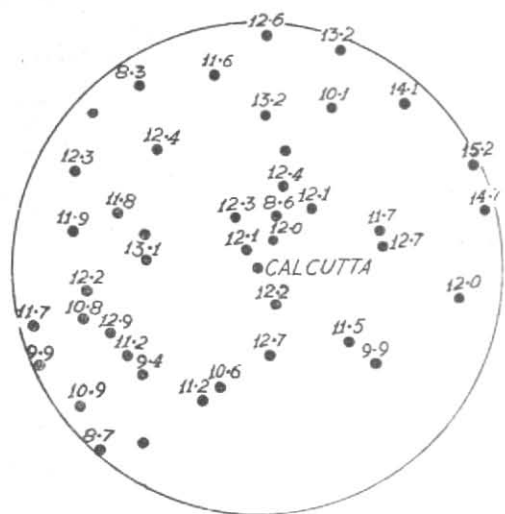


Fig. 1(a). Map showing the locations of rain gauge stations in the Calcutta area and the normal number of rainy days at the various stations during premonsoon season (March-May)

scattered nature of premonsoon showers in Gangetic West Bengal is well known to all meteorologists in India, a finding such as, that on 53 per cent of the days during the relatively dry premonsoon season some station or other gets rainfall of 10 cents or more, while for each individual station the percentage of rainy days is about 11 only, would not ordinarily have been anticipated. Also, as is revealed by the analysis of five years' data, the fact that during the monsoon season in an area like Gangetic West Bengal there may be as many as 29 per cent occasions when 10 stations or more within 50 miles of Calcutta get rain of 10 cents or more, without the station itself getting any rain at all, is not often borne in mind when verifying forecasts of dry weather in the area under consideration.

## 2. Detailed features of rainfall distribution in the four areas under study

(a) *Calcutta Area*—Rainfall distribution around Calcutta has been studied for two periods, March-May and June-September, when the area gets the bulk of its

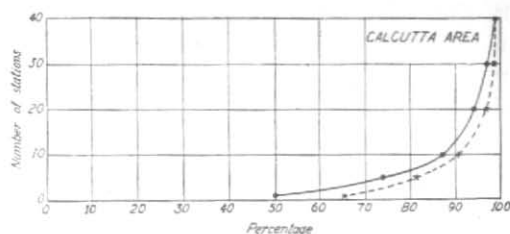


Fig. 1 (b). Diagram showing the percentage of days when at least one station within a group of 1, 5, 10, 20 etc stations reported rain during monsoon season

annual rainfall, although under distinctly different types of synoptic situation. The locations of the 40 stations within 50 miles of Calcutta, whose records have been taken into account, together with the normal number of rainy days for each station during the premonsoon season (March-May) are shown in Fig. 1(a). It is seen that the frequency of rainy days during this season is fairly uniform over the area. In this respect, the features are more or less the same during the monsoon season also.

Using data of a single station, *viz.*, Calcutta only, it is seen that, during monsoon season, rain of 10 cents or more occurs in the area on about 50 per cent of all days. By increasing the station density to 5 (Calcutta plus one from each quadrant) and considering the incidence of rainfall at any one of them, the percentage of rainy days comes to 74. Similar percentage figures have been determined using data of a still larger group of stations, 10, 20, 30 etc and plotted against the number of stations in Fig. 1(b). The full curve relates to rainfall of 10 cents or more and the dotted curve refers to any measurable precipitation of 1 cent or above. Fig. 1(c) shows similar sets of curves for the premonsoon season.

The curve for the monsoon season shows that as we consider data of a larger number

of stations, the frequency of rainy days in the area increases rapidly from 50 per cent for one station to 87 per cent for a group of ten. Thereafter, the increase is less rapid and, after reaching the value of 98 per cent for 30 stations, the curve becomes nearly asymptotic to the ordinate, suggesting that a network of about 30 stations in the area should give a fairly correct indication of the occurrence or non-occurrence of rain in the area during the monsoon season, and that the existing network of 40 stations should be adequate for a critical study of rainfall features of the locality. The curve for the premonsoon season (Fig. 1c) also shows a similar trend. The increase in the percentage of rainy days with the number of stations slows down when the number exceeds 30, but does not become quite asymptotic to the ordinate even when data of 40 stations are taken into account. In view of the more scattered nature of precipitation during this season, about 45 or 50 stations would appear to be necessary to confirm that rain of 10 cents or more has not occurred anywhere during the day within 50 miles of Calcutta. As mentioned already, the most important feature of the results indicated by the curve for this season is that appreciable rain occurs at some station or other within the limited area of 50 miles around Calcutta on some 53 per cent of all days, and that we would be making a greatly erroneous conclusion if we thought that synoptic situations on all or most of the 89 per cent non-rainy days for Calcutta are really innocuous from the point of view of rain in the area.

An examination of the dotted curves relating to days of precipitation shows that they run almost parallel to the frequency curves for rainy days, indicating that the broad features are the same irrespective of whether we consider rain of ten cents or above or any precipitation amounting to 1 cent or more.

An examination has been made of the character of raininess in the area around Calcutta on days on which the meteorological

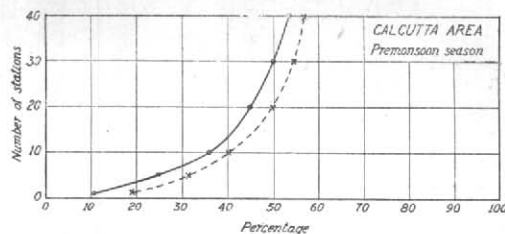


Fig. 1 (c). Diagram showing the percentage of days when at least one station within a group of 1, 5, 10, 20 etc. stations reported rain

observatory at Calcutta did not report any precipitation during the period of 5 years under study. On days of this type, the number of occasions when 1, 2, 3 or more stations in the area had received precipitation amounting to 10 cents or more are shown in Table 1. It is seen that during the monsoon season, the maximum number of stations reporting rain of 10 cents or more, when Calcutta itself did not record any precipitation, was 25. Five stations or more received rain on as many as 62 per cent and ten stations or more on 29 per cent of the days on which Calcutta was dry. Thus, of the 50 per cent dry days for Calcutta during monsoon season, more than half the days are really not non-rainy when a small area around Calcutta is taken into consideration, and from the point of view of the general synoptic situation, the rain record of Calcutta on these days does not correctly represent its rain giving character. Coming to the premonsoon season, it is found that the highest number of stations that got rain when Calcutta itself was dry was 21. Five stations or more had rain on 16 per cent and ten stations or more on 6 per cent of those occasions when Calcutta had no rain.

A study has also been made of the rainfall distribution in the area on days on which Calcutta recorded 10 cents or more, but many of the remaining stations did not get any precipitation. During the premonsoon season the number of such stations varied from 10 to 36. It is also seen that 50 per cent or more stations in the area did not report any precipitation on 74 per cent of the rainy days at Calcutta.

TABLE 1—Calcutta Area

Number of occasions when one, two, three etc stations in the area reported rain of 10 cents or more, but Calcutta (Alipore) did not get any precipitation

No. of stations reporting rainy day when Calcutta had no rain	No. of occasions	
	Monsoon seasons (1941-45)	Premonsoon seasons (1941-45)
0	11	217
1	22	45
2	18	23
3	11	16
4	20	15
5	18	11
6	18	7
7	9	3
8	12	5
9	13	9
10	8	9
11	8	5
12	6	2
13	8	2
14	5	1
15	6	0
16	4	2
17	4	1
18	1	0
19	5	0
20	3	0
21	1	1
22	0	0
23	2	0
24	0	0
25	1	0
26	0	0
27	0	0
28	0	0
29	0	0
30	0	0
31	0	0
32	0	0
33	0	0
34	0	0
35	0	0
36	0	0
37	0	0
38	0	0
39	0	0
Total No. of dry days at Calcutta	214	374

During the monsoon season, the highest number of stations that did not get any precipitation on occasions when Calcutta recorded 10 cents or more was 35, and 50 per cent or more stations in the area were dry on 37 per cent of the rainy days of Calcutta. Thus, for weather forecasts to be sufficiently detailed to be useful to farmers in different talukas or such restricted localities, a net work of telegraphically reporting stations with only one meteorological observatory in a district, as is the position at the present moment, can hardly be sufficient to ensure the desired accuracy of forecasts issued from day to day.

With a view to finding out if any relation exists between the areal coverage and the intensity of rainfall, the average amounts per reporting station per rainy day when 1, 2, 3 etc station reported rain were worked out. The data for monsoon and premonsoon seasons are plotted in Fig. 1(d) and Fig. 1(e) respectively. The curve for the monsoon season shows that there is a fair relation between the average amount per station and the number of stations reporting rain, the average increasing with the number of stations. It is seen that, when only 10 stations over the area reported rain, the average amount of rain per reporting station was about .46 inch and, when 35 stations reported rain, the average was about 3 times as much (1.25"). It is further observed that when the number of stations reporting rain exceed 20, the average amount of rain per station increases rapidly, indicating that such widespread precipitation is apparently linked up with large scale disturbances, such as depressions, and storms whose rain giving capacity is also correspondingly large. In this respect, the characteristics shown by the curve (*vide* Fig. 1 e) for the premonsoon season are not quite so systematic, although it is seen that the average amount of rain received when 10 or more stations report rain, is about 0.6", *i.e.*, about twice of what is received when 5 stations or less have rain. According to Sohoni (1928), the average rainfall caused by a nor'wester is about 0.5"; and it would seem that typical

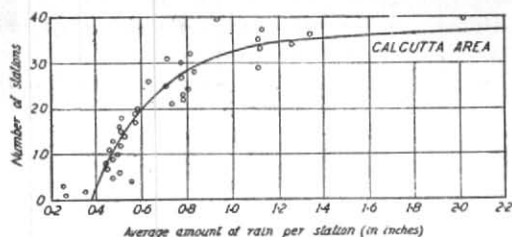


Fig. 1 (d). Diagram showing the average amount of rain per station for various numbers of stations reporting rain (Monsoon season)

nor'wester days for Calcutta are generally associated with rain at 10 or more stations in the area.

(b) *Delhi Area*—Rainfall data in the Delhi area have also been studied for the same periods June to September and March to May. There are 40 rain recording stations within 50 miles of Delhi. Their locations and also the normal number of rainy days at each station during the monsoon area are shown in Fig. 2 (a). The figures for rainy days show that the distribution is not strictly uniform over the whole area, for example, the number of rainy days at Meerut is more than double of that at Salhwas. It is, however, noticed that for the most part, the differences are not unduly large. The monsoon and premonsoon curves indicating the percentage of days when at least one station within a group of 1, 5, 10, 20 etc stations reported rain are shown in Figs. 2 (b) and 2 (c) respectively. The monsoon curve shows that the frequency of rainy days rapidly increases from 20 to 52 per cent if the number of stations used to define the area is increased from 1 to 10. After 40 stations the increase in the frequency is very small, indicating that the existing 40 stations in the Delhi area are adequate for a fairly correct appraisal of the precipitation coverage during the monsoon season. The premonsoon curve in Fig. 2 (c) shows that when the data

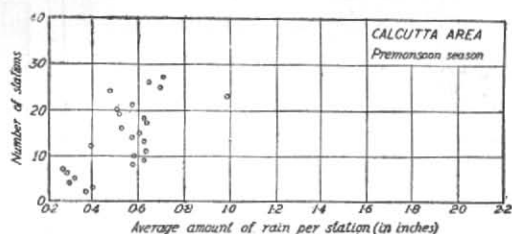


Fig. 1 (e). Diagram showing the average amount of rain per station for various numbers of stations reporting rain

of Delhi alone are considered, the frequency of rainy days is about 4 per cent only but when the data of the 40 stations are used the frequency is about 18 per cent. The area under study during this season being as a rule overrun by dry *Tc* air mass, synoptic situations favourable for rain or showers occur only very infrequently. Consideration of data of a large number of raingauge stations does not, therefore, lead to any great increase in the actual number of rainy days, although the proportionate increase is quite high. It is observed that, for the premonsoon season, 30 to 35 rain recording stations are quite adequate for a correct appreciation of precipitation coverage in the Delhi area.

Table 2 gives the number of occasions when 1, 2, 3 etc stations in the area recorded rain of 10 cents or more during the two seasons when Delhi itself did not have any measurable precipitation. It is seen that the largest number of stations that received 10 cents or more of rain when Delhi itself did not record any precipitation was 36 in the monsoon season and 17 in the premonsoon season. In the monsoon season, 5 or more stations reported rainy days on as many as 28 per cent of the occasions and 10 or more stations on 14 per cent of the occasions when Delhi was dry. The corresponding figures for the premonsoon season are 2 and 1 per cent only,

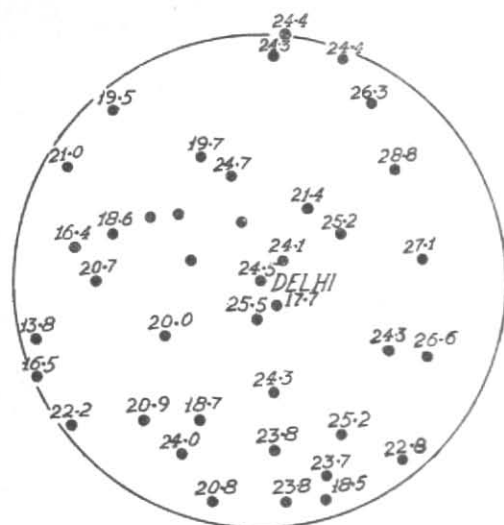


Fig. 2 (a). Map showing the locations of rain gauge stations in the Delhi area and the normal number of rainy days at the various stations during monsoon season (June-September)

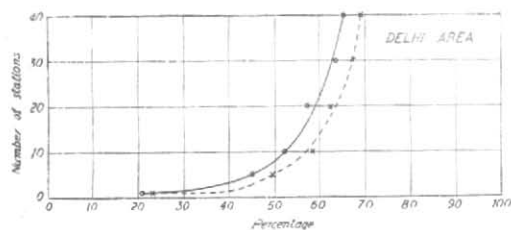


Fig. 2 (b). Diagram showing the percentage of days when at least one station within a group of 1, 5, 10, 20 etc stations reported rain during monsoon season

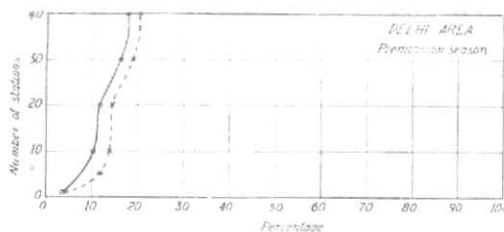


Fig. 2 (c). Diagram showing the percentage of days when at least one station within a group of 1, 5, 10, 20 etc stations reported rain

TABLE 2—Delhi Area

Number of occasions when one, two, three etc stations in the area reported rain of 10 cents or more, but Delhi did not get any precipitation

No. of stations reporting rainy day when Delhi had no rain	No. of occasions	
	Monsoon seasons (1941-45)	Premonsoon seasons (1941-45)
0	208	380
1	50	26
2	31	15
3	28	5
4	22	4
5	19	4
6	17	0
7	9	1
8	14	1
9	6	1
10	11	1
11	3	0
12	6	1
13	4	0
14	6	0
15	4	0
16	7	1
17	5	1
18	3	0
19	3	0
20	0	6
21	3	0
22	2	0
23	3	0
24	0	0
25	2	0
26	1	0
27	1	0
28	0	0
29	0	0
30	0	0
31	0	0
32	0	0
33	0	0
34	2	0
35	0	0
36	1	0
37	0	0
38	0	0
39	0	0
Total No. of dry days at Delhi	471	441

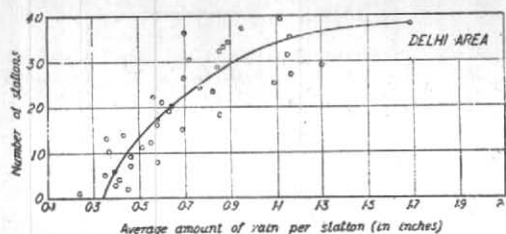


Fig. 2 (d). Diagram showing the average amount of rain per station for various numbers of stations reporting rain (Monsoon season)

as is to be expected, considering that the synoptic situations during this season are rarely favourable for widespread rain activity over the area. An examination of the rainfall distribution in the area on days when Delhi recorded 10 cents or more of rain shows that all the other 39 stations in the area remained dry on one occasion in the premonsoon season and on two occasions in the monsoon season during the 5 year period under study. During the monsoon season, 50 per cent or more stations in the area reported dry weather on 44 per cent of the rainy days at Delhi, and the corresponding figure for the premonsoon season is 47 per cent.

The average amount of rain per station in the Delhi area, corresponding to the different number of stations which recorded rain on the day, is represented by the curves in Figs. 2(d) and 2(e) for the monsoon and premonsoon seasons respectively. For 10 stations reporting rain in the monsoon season, the average rainfall amount per station is about 0.45" and for 35 or more stations, the average is nearly three times (1.2"). It thus appears that, during the monsoon season, the rate of increase in the average amounts with the increase in the number of stations getting rain is about the same in the areas around Delhi and Calcutta. In the premonsoon months also (Fig. 2e) average rainfall per station tends to increase from about 20 cents, with some 10 stations reporting rain to about 60 cents when 30 stations record measurable precipitation.

(c) *Tiruchirapalli Area*—Rainfall data of this area have been examined for the periods

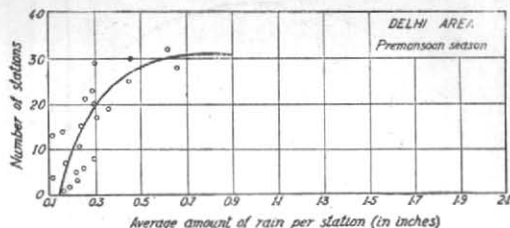


Fig. 2 (e). Diagram showing the average amount of rain per station for various numbers of stations reporting rain

June-September and October-December representing the two main wet seasons. The location of 50 raingauge stations within 50 miles of Tiruchirapalli along with their normal number of rainy days during the post monsoon season (October-December) are shown in Fig. 3 (a). It is noticed that the number of rainy days is slightly less in the northwest corner of the area. Otherwise, the distribution is fairly uniform.

The rainfall frequency curves for the two seasons are shown in Figs. 3(b) and 3(c). The curve for the southwest monsoon months shows that the frequency of rainy days increases from 10 per cent to 47 per cent as the number of stations taken to represent the area is increased from 1 to 10. With the number of stations exceeding 10, the rate of increase in the frequency of rainy days tends to decrease. The trend of the curve, however, suggests that about 60 stations would be required to give a correct indication of the precipitation coverage. On the other hand, the post monsoon curve is nearly parallel to the ordinate when the number of stations is 40 or more, indicating that about 40 stations are adequate for a fairly correct estimate of the occurrence of rainy days in the area. It would thus appear that rain in the area during the southwest monsoon season is more frequently in the nature of localised showers than during the post monsoon months.

The number of occasions when 1, 2, 3 etc stations in the area reported 10 cents or more rain but Tiruchirapalli itself did not record any measurable amount is shown in Table 3. It is seen that the maximum number of stations that recorded rain

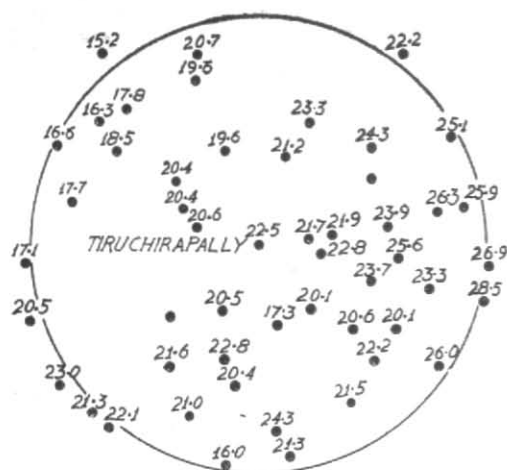


Fig. 3 (a). Map showing the locations of rain gauge stations in the Tiruchirapally area and the normal number of rainy days at the various stations during post monsoon season (October-December)

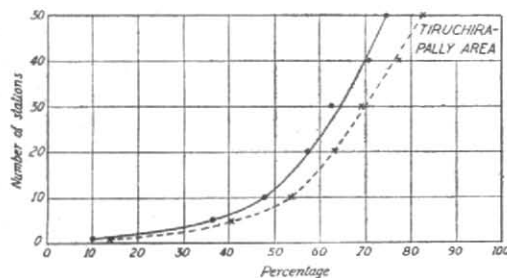


Fig. 3 (b). Diagram showing the percentage of days when at least one station within a group of 1, 5, 10, 20 etc stations reported rain during monsoon season

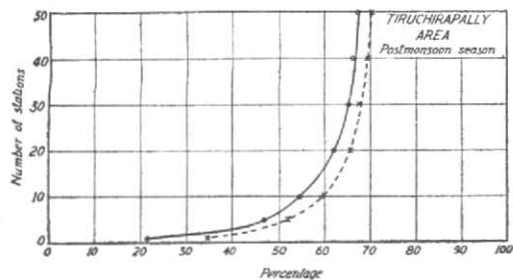


Fig. 3 (c). Diagram showing the percentage of days when at least one station within a group of 1, 5, 10, 20 etc stations reported rain

TABLE 3—Tiruchirapally Area

The number of occasions when one, two, three etc stations in the area reported rain of 10 cents or more, but Tiruchirapally did not get any precipitation

No. of stations reporting rainy day when Tiruchirapally had no rain	No. of occasions	
	Monsoon seasons (1941-45)	Post monsoon seasons (1941-45)
0	152	148
1	72	26
2	50	14
3	42	14
4	37	13
5	27	3
6	22	7
7	7	3
8	13	5
9	11	8
10	11	6
11	6	5
12	10	4
13	8	4
14	9	2
15	5	1
16	3	3
17	4	3
18	4	2
19	5	4
20	4	2
21	1	0
22	4	2
23	0	2
24	3	2
25	1	0
26	2	0
27	0	3
28	0	1
29	1	1
30	1	1
31	0	2
32	3	2
33	0	1
34	2	0
35	0	0
36	2	1
37	0	1
38	0	0
39	0	0
40	1	0
41	0	1
42	2	1
43	0	0
44	0	2
45	0	0
46	1	0
47	0	0
48	0	1
49	0	0
Total No. of dry days at Tiruchirapally	526	301



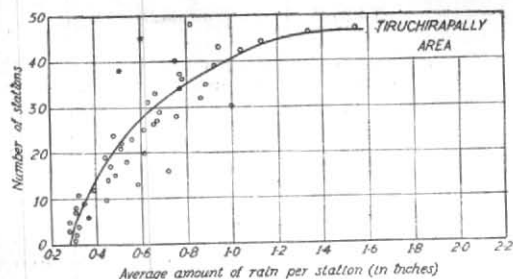


Fig. 3 (d). Diagram showing the average amount of rain per station for the various numbers of stations reporting rain (Monsoon season)

on the non-rainy days of Tiruchirapally was 46 in the monsoon season, and 48 in the post monsoon season. During the monsoon season, 10 stations or more reported rainy days on 18 per cent, and 5 stations or more on as many as 33 per cent of the days on which Tiruchirapally was dry. The corresponding figures for the post monsoon season are 20 per cent and 9 per cent respectively. Again, a study of the rainfall distribution in the area on days on which Tiruchirapally had recorded 10 cents or more shows that 50 per cent or more stations in the area remained dry on as many as 55 per cent of such days during the monsoon season, and that the corresponding figure for the post monsoon season is 31 per cent. Thus, as in the previous two cases, rainfall observation of a single station, *viz.*, Tiruchirapally does not at all correctly indicate the rain giving characteristics of the synoptic situations on a large number of days.

The curves showing the average amounts of rainfall per station per day for various number of stations reporting rain during the two seasons are shown in Figs. 3(d) and 3(e). It is seen that the average amount increases with the number of stations in both the seasons, although the rate of increase is more in the monsoon season. When rain is recorded at 10 stations or less the average amount per station during both the seasons is nearly the same (about 0.3"). With a larger number, that is, about 35 stations reporting rain, however, the average is somewhat higher (about 0.8") in the monsoon season, as against 0.58" in post monsoon months.

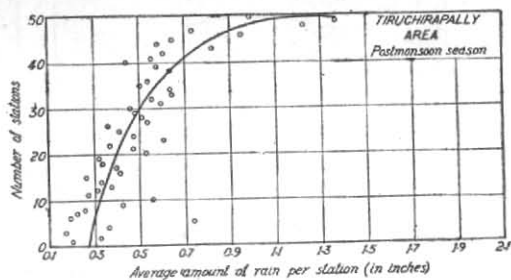


Fig. 3(e). Diagram showing the average amount of rain per station for the various numbers of stations reporting rain

(d) *Bangalore Area*—Rainfall data have been studied for the same periods as in the case of Tiruchirapally area. There are 27 rain recording stations within a radius of 50 miles from Bangalore. Their locations and also the normal number of rainy days at each station during the monsoon months are shown in Fig. 4(a). As in the previous three cases, the number of rainy days are fairly uniform over the area.

The curves showing the frequency of rain occurrence for various number of stations, used to define the area, are given in Figs. 4(b) and 4(c) for the two seasons under study. These suggest that about 45 stations would be necessary in the monsoon season and 25 in the post monsoon season, for a correct appraisal of the incidence of rainfall anywhere in the area. It would thus appear that the post monsoon showers are generally more widespread than the monsoon showers in the Bangalore area also as was observed in the Tiruchirapally area.

Table 4 shows the number of occasions when 1, 2, 3, etc stations recorded rain but Bangalore itself was dry. It is seen that the maximum number of stations that recorded rain when Bangalore got no rain at all was 11 in the monsoon season and 18 in the post monsoon season. During the monsoon season, 10 stations or more recorded rain of 10 cents or more on 2 per cent, and 5 stations or more on 11 per cent of the days when Bangalore did not receive any precipitation. The corresponding figures for the post monsoon season are 3 per cent and 7 per cent respectively. The

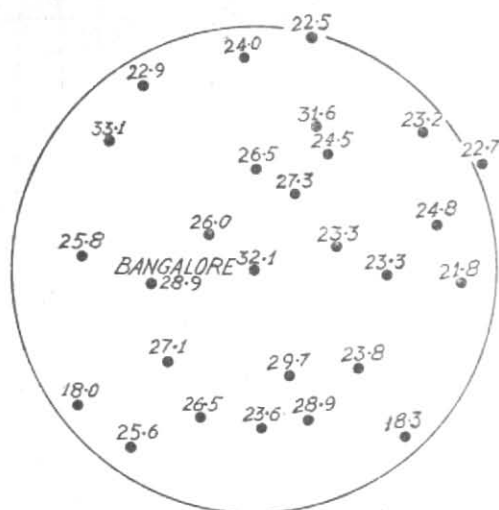


Fig. 4(a). Map showing the locations of rain gauge stations in the Bangalore area and the normal number of rainy days at the various stations during monsoon season (June-September)

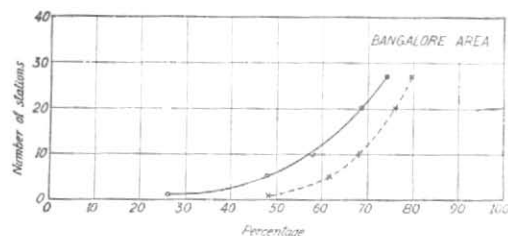


Fig. 4(b). Diagram showing the percentage of days when at least one station within a group of 1, 5, 10, 20 etc stations reported rain during monsoon season

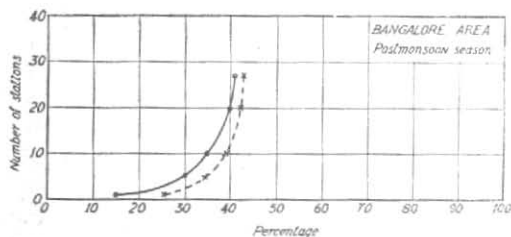


Fig. 4(c). Diagram showing the percentage of days when at least one station within a group of 1, 5, 10, 20 etc stations reported rain

study of rainfall distribution in the area shows that, on occasions when Bangalore got 10 cents or more, the maximum number of stations not receiving any precipitation was 26 in the monsoon season, and 24 in

TABLE 4—Bangalore Area

The number of occasions when one, two, three etc stations in the area reported rain of 10 cents or more, but Bangalore did not get any precipitation

No. of stations reporting rainy day when Bangalore had no rain	No. of occasions	
	Monsoon seasons (1941-45)	Post monsoon seasons (1941-45)
0	137	270
1	62	26
2	40	11
3	24	8
4	18	4
5	9	4
6	7	4
7	4	4
8	4	2
9	4	0
10	4	1
11	3	3
12	0	1
13	0	1
14	0	2
15	0	0
16	0	1
17	0	0
18	0	1
19	0	0
20	0	0
21	0	0
22	0	0
23	0	0
24	0	0
25	0	0
26	0	0
Total No. of dry days at Bangalore	316	343

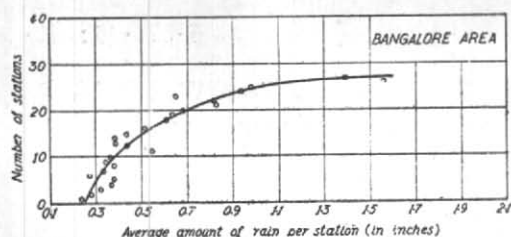


Fig. 4(d). Diagram showing the average amount of rain per station for various numbers of stations reporting rain (Monsoon season)

the post monsoon season. During the monsoon season, 50 per cent or more stations in the area reported dry weather on 58 per cent of rainy days at Bangalore, the figure for the post monsoon season being 46 per cent.

From the studies, as above, of the rainfall distribution in the four small areas, it would appear that the probability of one particular station in an area remaining dry, when the central station gets appreciable rain (10 cents or more) is higher than the probability of that station getting such rain when the central station records no precipitation.

The curves showing the average amounts of rain per station per day for various number of stations reporting rain are given in Figs. 4(d) and 4(e), representing the characteristics of the two seasons. It is seen that the rate of increase in the average amount with the number of stations is higher in the Bangalore area than in the Tiruchirappalli area in both the seasons.

### 3. Conclusion

The results of the study of rainfall in the four areas show clearly that no satisfactory conclusion regarding the rainfall feature on a day of even a small area within 50 miles can be drawn on the basis of report from one single station. With the present density of telegraphically reporting stations on our synoptic maps, there may be number of

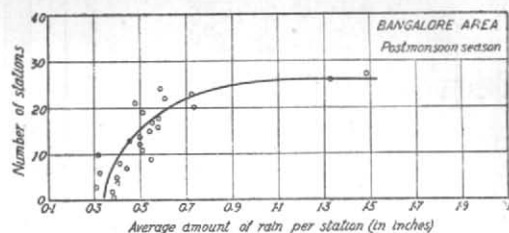


Fig. 4(e). Diagram showing the average amount of rain per station for various numbers of stations reporting rain

occasions when not merely scattered but even marked shower activity in an area in between two synoptic stations may go unnoticed by the weather forecaster. This is a positive handicap to him, for, not being in a position to appraise correctly the actual rainfall distribution associated with day to day synoptic situations, his efforts in preparing detailed forecasts for small areas for use by farmers may often prove unsuccessful. Synoptic maps of the type as are used for issue of forecasts of a more general nature to the public are, therefore, hardly adequate for issue of weather bulletins for farmers.

The observed relationship between the number of stations reporting rain in a day and the average amount of rain received per station is likely to be of some forecasting value for giving indication to different interests, such as, Flood Control Units, Agricultural authorities, Hydro-electric Concerns etc of the total amount of rain to be expected in specified areas.

### 4. Acknowledgement

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