Trans. Inst. Indian Geographers
Vol. 7, No. 2 July 1985

ANALYSIS OF HOURLY RAINFALL DISTRIBUTION OF KARANJA CATCHMENT

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ABSTRACT : Hourly rainfalls of 6 most intense 1-day rains recorded at Bidar station have been examined to determine temporal pattern of design rainfall for use in conversion of probable maximum precipitation to probable maximum flood. The analysis showed that during one hour as much as 56% of 1-day rainfall can occur and the two consecutive hours may account for 73% of total 1-day rainfall. It was further found that the general occurrence of greatest inter hourly intensity seems to be during periods of 17–24 hours time. The hourly distribution however, showed wide variations from year to year.

INTRODUCTION

A detailed hydrometeorological study of the Karanja catchment upto the Halhalli dam site has been carried out by Ramana Murthy et al (1985) in order to estimate the design rainfall of different frequencies and the probable maximum rainfall likely to be experienced by the catchment using past 94 years of rainfall records. The estimates of design rain depths are aimed at for derivation of the design spillway flood. The choice of a design rainfall is a basic step in any method for estimation of design flood. It is however, important to recognise that the shape and magnitude of the flood hydrograph is very much affected by the distribution of rainfall within the storm period. In nature a wide range of storm patterns are possible. Some storms have their peak intensity occur early while other storms have the peak rainfall intensity occuring towards the end of the storm and some have a tendency for the peak to occur more or less centrally. As such, a knowledge of the amount of temporal variation of rainfall intensity throughout a storm period and of the time of the peak intensity is of interest to hydrologists concerned in the application of the design rainfall to design flood estimation. In this paper the hourly distribution of rainfall during storm periods of 1-day duration for Karanja catchment have been studied and results reported

2. THE KARANJA CATCHMENT AND ITS RAINFALL CHARACTERISTICS

The Karanja catchment upto dam site at Halhalli (fig. 1) is located in the northern part of Karnataka and adjoining

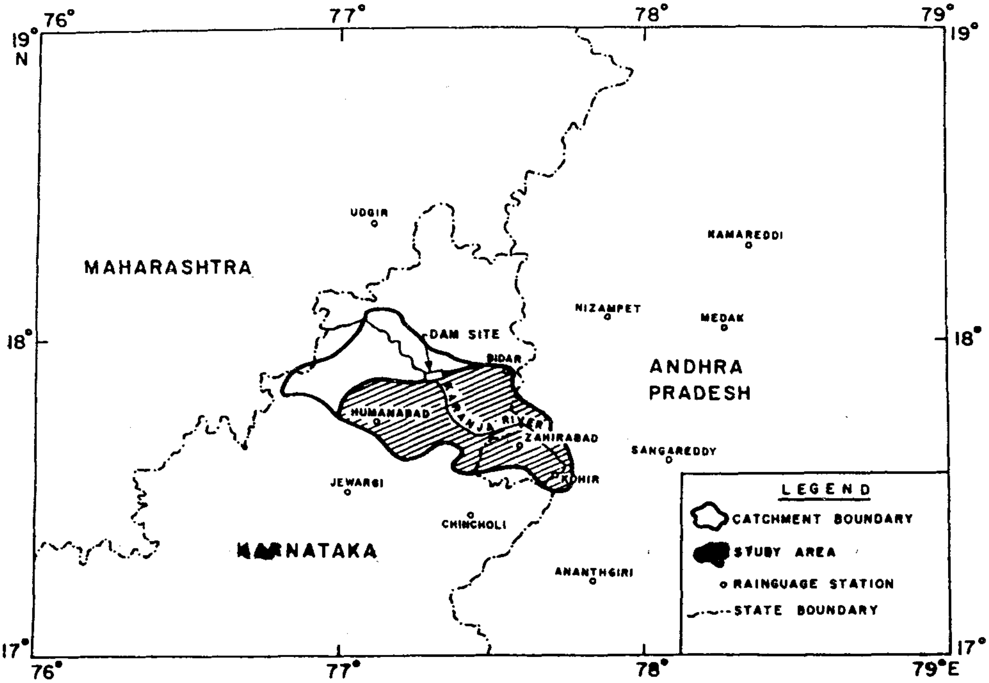

Fig. 1 : Location of the Karanja Catchment

Andhra Pradesh at longitude 77^{0} 0'E to 77^{0} 45'E and latitude 17^{0}30' to 17^{0}55'N. and occupies 2025 km^{2}. The length and gradient of Karanja river are 77 km and about 1m km−1 respectively. The mean annual rainfall and the number of rainy days per year of the catchment are about 898 mm and about 52 respectively. The southwest monsoon season from June to September contributes nearly 80% of the annual rainfall. The Karanja catchment receives heavy rainfall towards the end of August and beginning of September when the monsoon depressions move in a more southerly direction.

3. SELFRECORDING RAINGAUGE NETWORK

There are only 3 raingauge stations in Karanja catchment viz. Bidar, Humanabad and Zahirabad whose daily rainfall data are available for 28 years of concurrent period. Out of these three stations, Bidar has only selfrecording raingauge and therefore, this station has been considered as representative station for Karanja catchment of 2025 km^{2} for hourly rainfall analysis.

4. DATA USED FOR ANALYSIS

Selfrecording rainfall records of Bidar station for 8 years period from 1974 to 1981 have been used. Although the length of data is not sufficient to carry out detailed temporal pattern analysis but to have the probable temporal distribution of hourly rainfall over the catchment, the 8 years period has been considered adequate. The storms which produced the highest rain depths in one day duration (9 AM to 8 AM) in each year of 8 years record have been first selected. The successive hourly intensities of these heaviest rainfall days were extracted from autographic records to study the variation of the hourly rainfall in all the spells. Table 1 lists the storms used in the study, their total rainfall (9 AM to 8 AM) and mean intensity.

TABLE 1 : STORMS SELECTED FOR STUDY

S. No.	Storm Date	Total 1–day Rainfall (mm) (9 AM to 8 AM)	Mean Intensity (mm / hr)
1	23.10.1974	71.3	2.97
2	4.10.1975	70.7	2.95
3	21. 7.1976	84.1	3.50
4	29. 9.1977	45.0	1.87
5	2.10.1978	67.6	2.82
6	20. 8.1980	62.5	2.60

Table 1 shows that the mean hourly intensity during a highest rainy day in a year varies from about 2 to 3.5mm/hr. The rainy day has been taken as a period of 24 hours commencing at 9 AM of the previous day to 8 AM of date during which heaviest rainfall was recorded. Hourly rainfall data of the years 1979 and 1981, associated with the heaviest one day rainfall were not available and as such these data could not be utilised for analysis.

5. ANALYSIS OF DATA

5.1 Actual break up of 1 day rainfall (9 AM – 8 AM)

The hourly break up of the heaviest one day rainfall for each year are plotted, which are shown in fig. 2, to examine the hourly intensity or inter hour intensity of rainfall and the time of the peak intensity. The clock hour has been taken as the unit

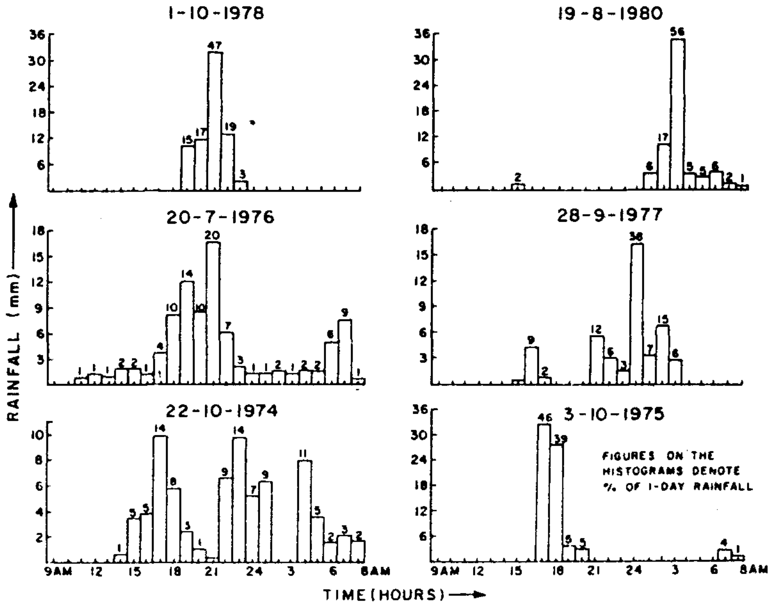

Fig. 2 : Actual Hourly Rainfall of the Highest 1-day (9 A. M. to 8 A. M.) Storms

of duration as the data for hourly intensity were readily available. Fig. 2 shows that the highest 1-hour rainfall of 35.0 mm was recorded at 03 hours of 20 August 1980 and was about 56% of the 1-day rainfall. It can also been seen that once the rain commences in about 4 to 5 hours period about 95% of the 1-day rainfall could be experienced. The periods of maximum intensity for each storm together with the rain amount and percentage of 1-day (24 hrs.) values are given in Table 2.

TABLE 2 : TIME OF MAXIMUM INTENSITY AND RAIN AMOUNT

Storm Date	Time of Peak Intensity	Rain Amount (mm)	% of 24 hr. Rainfall
23.10.1974	17 & 23 hrs	9.8	14
4.10.1975	17 hrs	32.5	46
21. 7.1976	21 hrs	16.5	20
29. 9.1977	24 hrs	17.2	38
2.10.1978	21 hrs	31.7	47
20. 8.1980	3 hrs	35.0	56

Table 2 shows that there seems to be a general tendency for maximum intensity to occur between 17 to 24 hours time. It has been further observed that the intensity may go upto 56% of 1-day heaviest rainfall within a duration of 1 hour. The average rainfall in the heaviest period has been found to be about 37% of the total rainfall.

Examination of the hourly rainfall within a storm of 1-day duration, revealed that no intense storm of 1-day duration has contributed rainfall throughout 24 hours. As such the number of hours of rainfall in each day of the storm have been determined. Table 3 lists the time of commencement of rainfall, actual duration, total rainfall and the mean intensity.

TABLE 3 : CHARACTERISTICS OF HOURLY RAINFALL DATA OF 1-DAY DURATION

Storm Date	Time of Commencement of Rains	Duration of Rain including Zero Rain (hrs)	Total hrs of Zero Rain	Actual hrs of Rainfall	Total Rainfall (mm)	Mean Intensity (mm / hr)
23.10.1974	14 hrs	19	2	17	71.3	4.2
4.10.1975	17 hrs	16	8	8	70.7	8.9
21. 7.1976	11 hrs	22	0	22	84.1	3.8
29. 9.1977	15 hrs	13	3	10	45.0	4.5
2.10.1978	19 hrs	5	0	5	67.6	13.5
20. 8.1980	15 hrs	18	8	10	62.5	6.3

It appears from Table 3 that the amount of rain does not generally increase in proportion with the increase in the number of hours of rain. However, intensity of rain is quite high for short duration of rains.

6. MASS CURVE ANALYSIS

If the total rainfall is plotted against time the curve obtained is known as the mass curve of the storm. The continuous mass curves of all storms are first obtained by adding the hourly rainfall values. In order to make all recofds comparable as regards temporal pattern, the mass curves were plotted in dimensionless form with cumulative rainfall expressed as a proportion of total rainfall as ordinate and time expressed as a proportion of actual storm duration as abscissa. Smooth curves were then drawn through these points (fig. 3). The dimensionless mass curves gave a very wide scatter with peak intensities occurring as early as 6% of the duration and as late as 77% of duration after the commencement of the rains. However, a close examination shows that there is a tendency towards grouping into two typical patterns, one peaking early in the storm and second peaking just after the middle of the storm duration.

7. AVERAGE TEMPORAL PATTERN

The average variability method (Pilgrim et al 1969) has been used to derive average temporal pattern of design rainfall for Bidar station. In this method the actual rainfall in each period of one hour are ranked within each storm according to the amount of rainfall in the 1 hr. period and the percentage of the total storm rainfall occurring in the period of each rank is determined. Thus the period with highest rainfall is assigned rank number one. The next highest rainfall is assigned rank number two and so on. The average rank in each period and the average percentage of the storm rain in the period of each rank are calculated. This is done to determine the most likely chronological order of the average heaviest period, second heaviest period and so on. To assemble the final pattern the period with the lowest average rank is assigned the highest average percentage of rain, the period with the second lowest average rank is assigned the second highest average percentage of rain and so on.

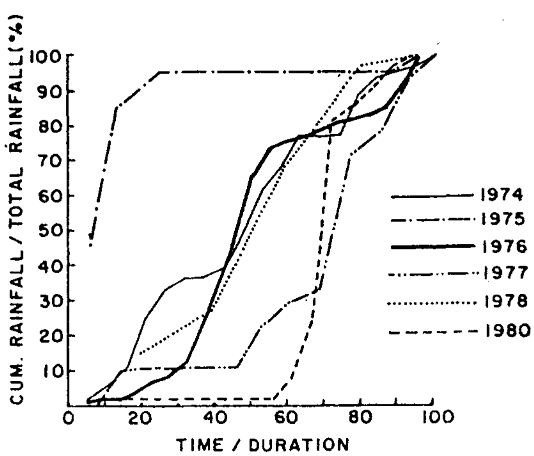

Fig. 3 : Mass Curve Analysis

TABLE 4 : AVERAGE TEMPORAL PATTERNS

Period (hrs)	Per cent of Rainfall 1-Day (9 AM–8 AM)	Per cent of Rainfall Any 24 hrs	Period (hrs)	Per cent of Rainfall 1-Day (9 AM–8 AM)	Per cent of Rainfall Any 24 hrs
1	0	4	13	37	1
2	0	5	14	10	0
3	0	10	15	5	3
4	0	3	16	1	2
5	0	1	17	4	0
6	0	1	18	1	0
7	0	1	19	0	0
8	1	1	20	1	0
9	20	2	21	0	0
10	2	8	22	1	0
11	6	35	23	2	0
12	9	19	24	0	0

Table 4 shows the average pattern of 1-day heaviest rainfall obtained by average variation method calculated from 6 most intense storms of 1-day duration rainfall with 1-hour period. It is seen that the average rainfall in the heaviest period is 37%, the second heaviest is 20% of the total 1-day rainfall and so on. The derived pattern for the 6 storms of each of the 1-day duration are shown in fig. 4.

8. TEMPORAL PATTERN OF MAXIMUM 24-HOUR RAINFALL

The one day rainfall recorded during 0830 hrs of previous day to 0830 hrs of date does not represent the true 24 hrs rainfall unless the entire amount had occured within the specified time. The hourly distribution of any 24 hrs maximum rainfall has therefore been examined. The storms

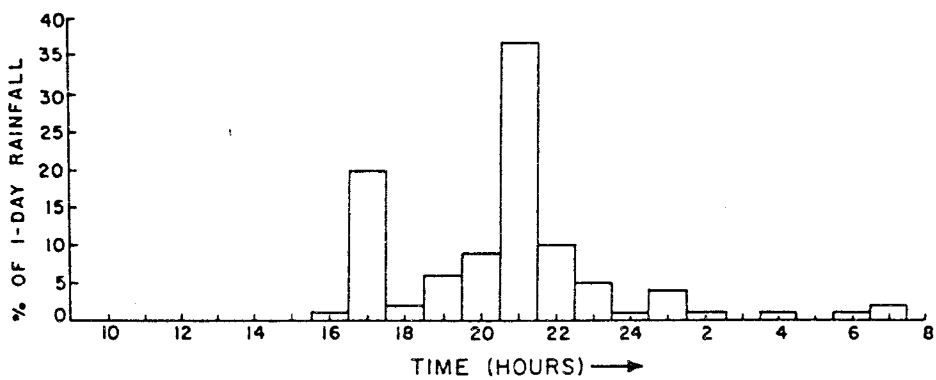

Fig. 4 : Average Temporal Pattern of Maximum 1-day Rainfall (9 A. M. to 8 A. M.)

TABLE 5 : CHARACTERISTICS OF HOURLY RAINFALL DATA OF ANY 24 HOURS DURATION

Rain Period	Total 24 hrs Rainfall (mm)	Mean Intensity (mm/hr)	Maximum One hour Intensity (mm/hr)	% of 24 hour Rainfall
14th of 22.10.1974 to 13th of 23.10.1974	71.8	2.99	8.8	14
17th of 3.10.1975 to 16th of 4.10.1975	70.7	2.95	32.5	46
12th of 20.7.1976 to 11th of 21.7.1976	97.3	4.05	16.5	17
15th of 28.9.1977 to 14th of 29.9.1977	45.0	1.87	17.2	38
19th of 1.10.1978 to 18th of 2.10.1978	77.6	3.23	31.7	41
15th of 19.10.1980 to 14th of 20.8.1980	65.7	2.74	35.0	53·

which produced the highest 24 hours (unrestricted) rainfall in each year of 6 years record have been selected. Table 5 lists the storms used, their maximum one hour intensity and total 24 hours rainfall.

Table 5 shows that the mean intensity during the highest 24 hrs rainfall in a year has been found to vary from 2 to 4 mm/hr and the highest one hour rainfall was about 53% of 24 hours rainfall. These normal and peak intensity values are well comparable with those of 1-day duration values. The hourly distribution of the 24 hours rainfall for each year is shown in fig. 5. It is seen that no storm has contributed rainfall throughout 24 hours time.

The average variability method has again been applied to determine the temporal pattern of any 24 hours maximum rainfall. The average pattern of 24 hours heaviest rainfall obtained from 6 most intense storms are given in Table 4 and shown in Fig. 6. Fig. 6 shows that 1 hour rainfall can be 35% of the 24 hours rainfall.

CONCLUSIONS

This study of a 6 intense storms of Bidar station in Karanja catchment having 24 hours duration has shown that no single typical storm pattern exists for the catchment. Two common patterns can be recognised one with a peak intensity occurring early in the storm and other with peak intensity just after the middle of the storm. The average variability method has been applied to derive the design temporal patterns It has been found that during one hour as much as 56% and in two hours nearly 73% of one day rainfall can occur at this station.

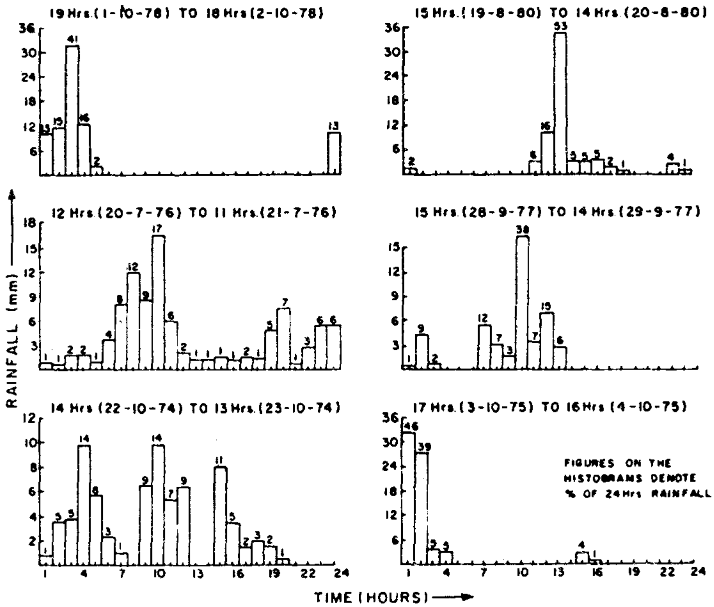

Fig. 5 : Actual Hourly Rainfall of Highest 24 Hrs. Rainfall

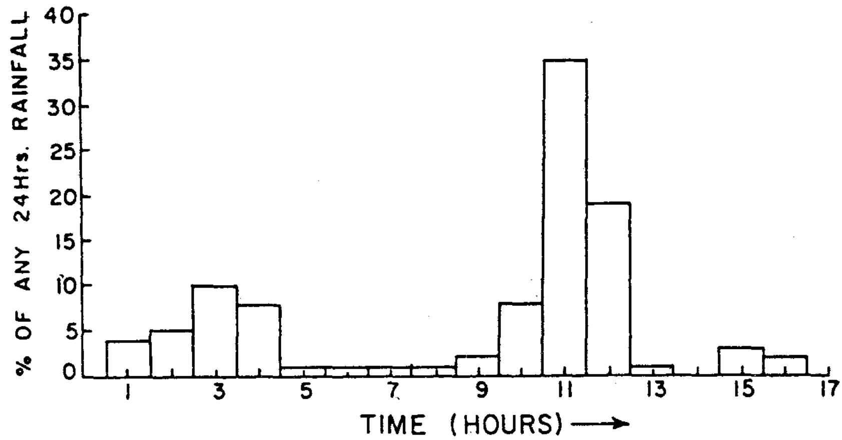

Fig. 6 : Average Temporal Pattern of Maximum 24 hours Rainfall

ACKNOWLEDGEMENT

Authors express deep sense of gratitude to Dr. Bh. V. Ramana Murthy, Director, Indian Institute of Tropical Meteorology, Pune 5 for his encouragement and keen interest in the Hydrometeorological studies. Thanks are due to Shri B. D. Kulkarni of Hydromet division for assisting in computational work and to Miss S. S. Nandargi for typing the manuscript.

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