

STUDY OF TEMPORAL DISTRIBUTION OF RAINSTORMS FOR FLOOD FORECASTING

1. The magnitude of rainstorm and its temporal variation are important in estimation of peak flood discharge. In operational hydrology like flood forecasting or reservoir operation etc, over estimation of discharge is not desirable because of its social and economical implications. It is felt that if QPF is accompanied by its probable temporal distribution the estimation of peak flood discharge will be more accurate. An attempt has been made to study the characteristic

of the temporal distribution of rainstorms and to find out suitable distributions for different ranges of QPF for Tista basin.

2. River *Tista*, a tributary of river *Brahmaputra*, originates in the glaciers of north Sikkim. The total catchment area of Tista basin is about 12650 sq km up to Indo-Bangladesh border. About 75% of the catchment area lies in mountain. The main synoptic systems responsible for severe floods in the river *Tista* are break monsoon situation, passage of trough in monsoon westerlies passing over the catchment and low pressure systems in the neighbourhood of west of the catchment (Srinivasan *et al.* 1972, Biswas and Bhadram 1984).

3. *Data and method of analysis*— Analysis of the self recording rain gauge (SRRG) data of stations Tista bazar, Bagrakote, Diana, Domohani and Sevoke for the period 1976 to 1988 reveals that 97 rainstorms are suitable for the study. The rainstorms are selected on the criteria that, (i) the concurrent SRRG data of at least 3 stations are available, and (ii) at least one station reports more than 10 mm of rain during storm period. The frequency of rainstorms against their duration is 1 to 8-hr —4, 9 to 16-hr —28, 17 to 24-hr —43, 25 to 48-hr —18 and 49 to 72-hr —4. The average percentage of total 24-hr rainfall recorded at the end of each clock hour and frequency of occurrence of peak rain at the corresponding hour are given in Table 1 for average areal precipitation (AAP) over Tista basin.

As the majority of flood producing rainstorms are of duration between 17 and 24-hr and also QPF issued for duration 24-hr commencing from 0300 UTC, the detail analysis is carried out for the rainstorms of 17-24 hrs duration. For every rainstorm each hour AAP is expressed as percentage of 24-hr rainfall. The cumulative values of highest 3, 6, 9, 12 24-hr rainfall percentage is computed and re-arranged to fix the minimum, first quartile, median, third quartile and enveloping level of temporal distribution, the probability of exceedance of which can be expected as 100, 75, 50, 25 and 0% respectively. The resulting temporal variation is shown (Fig. 1). The peak discharge values for temporal variation of different probabilities of exceedance are computed for unit rain by using unit hydrograph method. As the discharge data of Tista basin is classified, hypothetical unit hydrograph triangular in shape with unit duration of 3-hr and occurrence of peak discharge at $T/4$ (where, T is the base duration of hydrograph) is assumed. The critical peak flood discharge is computed for unit rain using temporal distribution of various probabilities of exceedance and then compared with peak flood discharge of various rainstorms using its observed temporal distribution.

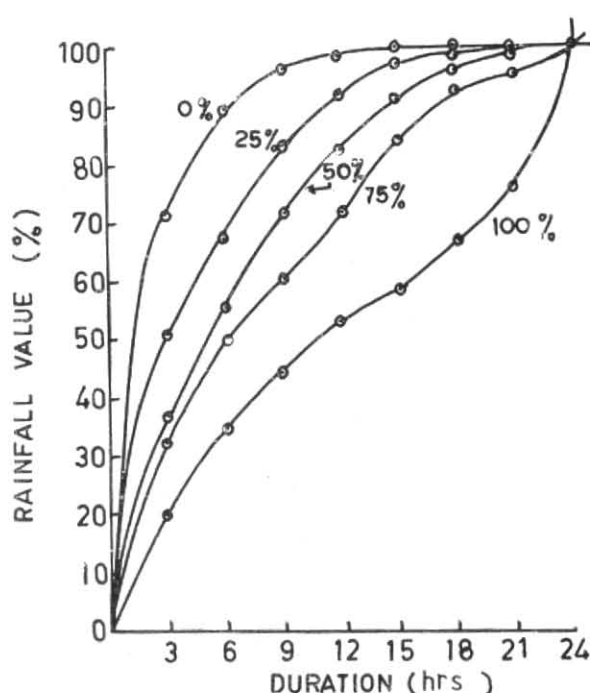


Fig. 1. Temporal distribution of rainstorms for various probabilities of exceedance (given in circle)

Further storms are divided into 2 groups having AAP 1 to 25 mm and AAP more than 25 mm. The departure of forecast discharge (using the temporal distribution of different levels of probability of exceedance) and actual discharge (using observed temporal distribution) is expressed as percentage of actual discharge for each rainstorm. The mean and model departure values for each group of AAP are computed (Table 2). The probability level of exceedance of temporal distribution which gives minimum departure is to be adopted for computation of peak discharge for expected QPF.

For estimation of design floods for irrigation structures, average and enveloping temporal distribution of design storm of Tista basin for 24, 48 and 72-hr duration are shown in Figs. 2 & 3.

TABLE 1

	Time (IST)																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Average percentage of total 24-hr rainfall recorded at the end of clock hr	8	9	8	7	5	6	5	5	3	3	2	2	1	2	1	2	3	3	3	3	4	4	5	6
Frequency of occurrence of peak rainfall	8	13	10	7	3	6	7	4	7	1	2	0	0	2	1	3	1	4	4	2	2	1	6	3

TABLE 2

Percentage variation (*A*) of forecast discharge (*B*) from actual discharge (*C*) with respect to actual discharge is shown at each level of exceedance of adopted temporal variation of rainstorm

	Expected level of exceedance of adopted temporal distribution with forecasting discharge (<i>B</i>) for each case				
	100 (0.642)	75 (0.698)	50 (0.752)	25 (0.828)	0 (0.926)
Actual discharge (<i>C</i>)					
AAP 1 to 25 mm					
Mean (0.736)	-12.8	-5.2	2.2	12.5	5.8
Modal (0.847)	-24.2	-17.6	-11.2	- 2.2	9.3
AAP > 25 mm					
Mean (0.665)	-3.5	5.0	13.1	24.5	39.2
Modal (0.726)	-11.6	-3.9	3.6	14.0	27.5

$$(1) A = \frac{B - C}{C} \times 100$$

(2) Figures in brackets are ratio of computed peak discharge to the peak discharge of 3-hr unit hydrograph.

(3) (—) sign indicated under estimation.

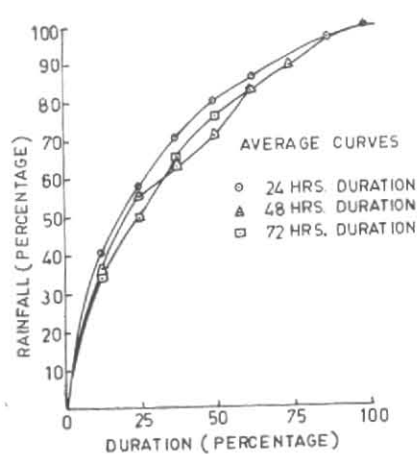


Fig. 2. Time distribution

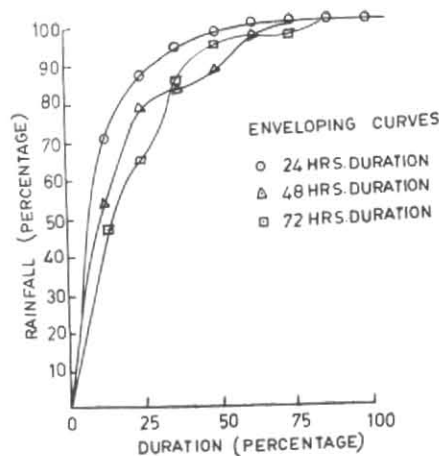


Fig. 3. Time distribution

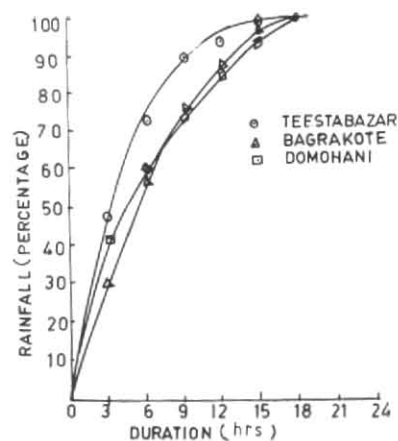


Fig. 4. Time distribution of rainstorm on 13 Aug 1987 for Tista Bazar, Bagrakote and Domohani

In India rainfall is recorded at 0300 UTC. Therefore, one day rainfall cannot represent 24-hr rain as rainstorm can commence at any time of a day and hence rain recorded at 0300 UTC is a part of 24-hr rainfall. Therefore, clock hour correction which is a ratio of maximum 24-hr rainfall recorded by SRRG to the 1-day rainfall recorded 0300 UTC is worked out for each storm. Average value of clock hour correction factor is 1.18 which is to be applied over QPF for estimation of peak flood discharge.

In medium and large catchments it is desirable to work out temporal distributions of different level of probabilities of exceedance for different sub-catchments particularly with reference to the distance of sub-catchment from the centre of the storm. It was concluded for Mahanadi catchment that sub-catchment nearer to the centre of the storm exhibits the temporal distribution that has lower level of probability of exceedance than that for the sub-catchment away from the centre of rainstorm (Mukherjee & Apte 1990).

This aspect is examined for Tista basin for the heaviest rainstorm of 13 August 1987 centred at Sevoke. The current SRRG data of this storm is available for Tista bazar, Bagrakote and Domohani which are 12 km, 15 km, and 42 km away respectively from Sevoke. The temporal distribution of this storm for above stations is shown in Fig. 4.

4. *Results and discussion*—In order to adopt proper level of probability of exceedance of temporal distribution, it may be observed from Table 2 that enveloping temporal distribution is adequate for QPF between 1 & 25 mm. The over estimation of forecasted peak discharge may be of the order of 10%. However, for the storms of higher magnitudes (AAP more than 25 mm), even the temporal distribution of the probability of exceedance level 50% over estimates the peak flood discharge in majority of the cases. Keeping in view the economic implications as well as adverse public reaction to the over estimation of peak flood discharge, forecaster is expected to be more cautious for selecting the proper probability level of exceedance of temporal

distribution. 50% probability level of exceedance may be adequate for rainstorms of AAP more than 25 mm as the expected over estimation will be of the order of 3.6%.

The relation between the temporal distribution of sub-catchment with respect to its distance from centre of the rainstorm may be observed from Fig. 4. The temporal distribution of Tista bazar which is nearest to the centre of storm, Sevoke is the most critical one among the other stations Domohani and Bagrakote. Thus, if the centre of the rainstorm is forecasted the appropriate level of probability of exceedance can be selected for the temporal distribution of different sub-catchments depending upon their distance from the centre of the storm.

5. *Conclusions*—(i) For Tista basin 50% level of probability of exceedance for temporal distribution is adequate for forecasting peak discharge resulting from heavy rainstorms, and (ii) the level of probability of exceedance of temporal distribution is more for the sub-catchment which are away from the centre of exceptionally heavy rainstorm than those near to the centre.

References

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