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Time distribution of design storm rainfall over various sub-catchments of river *Mahanadi*

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सार – अभिकल्प बाढ़ के आकलन के लिए प्रयुक्त एक आधारभूत प्राचल अधिकल्प तूफान है। अभिकल्प तूफान परिकलन में वर्षा के स्थानिक और कालिक वितरण शामिल है। प्रस्तुत शोध-पत्र में महानदी के विभिन्न उप-जलग्रहण क्षेत्रों के वर्षा के समय वितरण के मूल्यों की तुलना। समूचे जलग्रहण क्षेत्र के मूल्यों के साथ करने का प्रयास किया गया है।

ABSTRACT. In estimation of design flood a basic parameter used is design storm. Design storm computation includes spatial and temporal distribution of rainfall. In the present study an attempt has been made to compare the values of time distribution of rainfall of different sub-catchments of the river *Mahanadi* with that of the entire catchment.

1. Introduction

The hydrological design of irrigation structures depends upon the value of design flood adopted which may be estimated from design storm value or from flood frequency analysis by empirical relations. Design storm value adopted is either Standard Project Storm or Probable Maximum Precipitation or the rainfall of pre-determined return period. For the given value of design storm the important parameter controlling the peak flood value is the temporal distribution of design storm. Since the non-uniformity in time distribution results in higher peak discharge as compared with those resulting from uniformly distributed rain a precise knowledge of temporal distribution of rainfall is an absolute necessity. Shenoy and Chopra (1966) tried to obtain break-up of 24-hour storm rainfall for shorter duration like 1, 2, 3,...... hr by analysing self recording raingauge (SRRG) data for some major station over India. Huff (1967) obtained time distribution of station rainfall by relating cumulative rainfall (in terms of percentage of total storm rainfall) of intermediate durations with the respective duration itself (in terms of percentage of total storm duration) for number of storms after classifying the storms in four groups according to whether the peak rainfall occurred in first, second, third or fourth quarter of the storm period. He then assigned the probability of exceedance to each of the time distribution values so derived in each group. He also concluded that first and second quarterly storms occurred more frequently and fourth quarterly storm most infrequently. None of these studies indicate anything regarding relation of time distribution of rainfall with the location of the centre of the rainstorm.

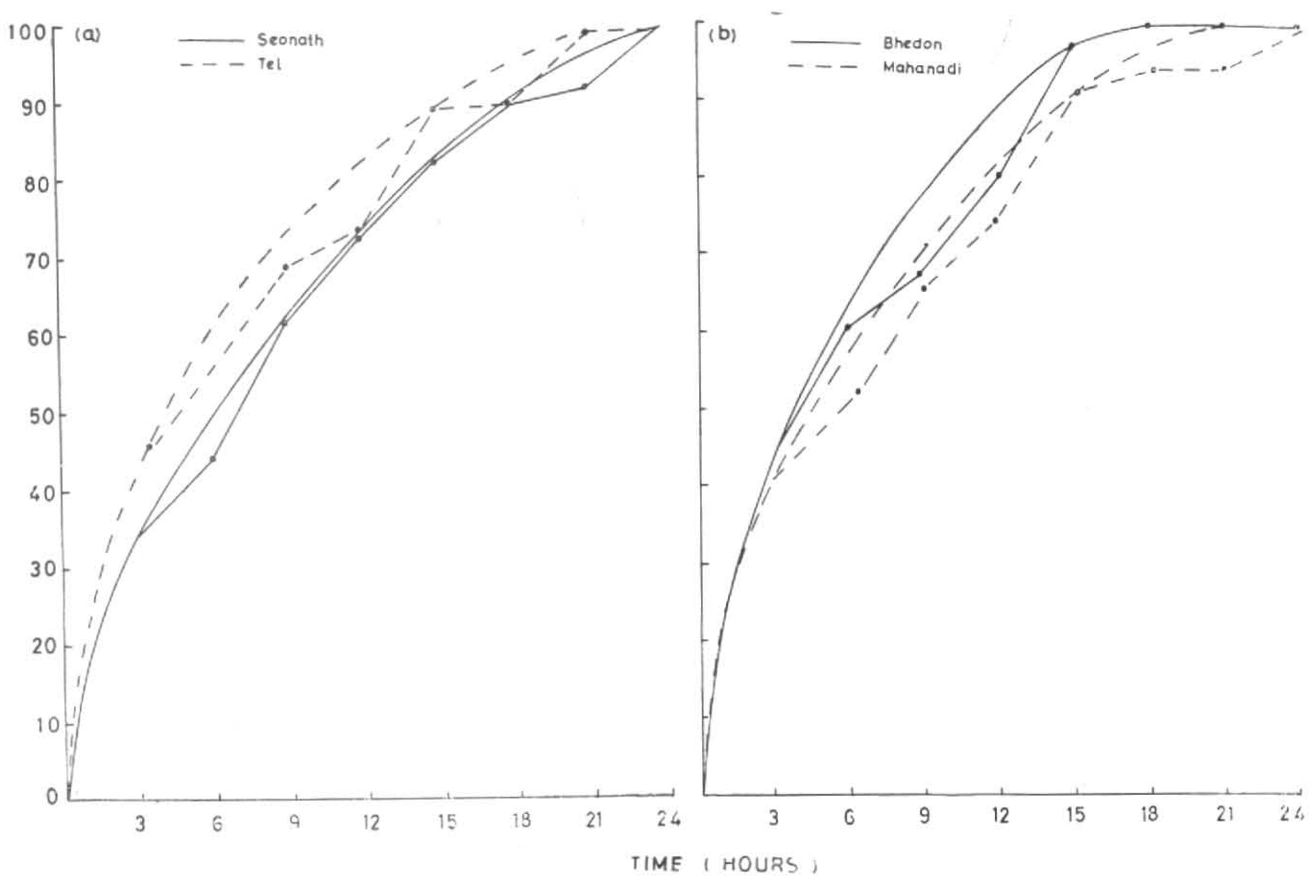
In the present study an attempt has been made to derive the time distribution of rainfall in the three of the sub-catchments of river *Mahanadi* and compare these values with the time distribution of rainfall over entire catchment as it is felt that the time distribution of a sub-catchment may depend upon the location of the centre of the storm with respect to the sub-catchment.

2. Methodology

The prevalent practice of deriving time distribution of design storm is from envoleping depth-duration curve (depth expressed in terms of percentage of total rain depth of storm) of number of storms of design duration. The general criticism on this procedure is that the envelope curve is well representative of the storms of lower magnitudes only. The peak floods, derived by applying time distribution so computed, on design storm values are of unrealistic high magnitude.

The applicability of the time distribution of individual station/s over entire catchment is also criticised as it is felt that it may not be well representative of the whole catchment. For computing the average effect of number of self recording raingauge stations on time distribution studies appropriate weightage is to be found out for each station.

In order to remove the drawbacks mentioned above some modifications have been suggested in the existing methods. In the first place the highest rainfall observed in the intermediate durations for number of stations in and around the catchment are plotted. The iso-analysis for each of the intermediate duration and design duration



Figs. 1(a-b). Time distribution of 24-hr storm with sub-catchments : (a) Sheonath and Tel and (b) Bhedon and Mahanadi catchment

is done. The depth duration value is computed for the catchment and its sub-catchments. This automatically takes care of the shape and size of the sub-catchment and also allot proper weightage to each SRRG station. The iso-analysis represents a theoretical storm where all the stations experience the highest, rainfall values. Thus it is logical to assume that time distribution value derived from depth-duration values of each intermediate duration is well representative of design storm magnitude. The rainfall of the intermediate duration is represented in terms of percentage of total storm-rainfall of design duration. The time distribution is thus worked out for whole Mahanadi catchment and three of its sub-catchments.

3. Data and analysis

For this study self recording raingauge data of 22 stations in Mahanadi catchment and its neighbourhood was studied. The list of these stations and their length of SRRG data is given in Table 1. Mahanadi catchment up to Cuttack has an area of about 129800 sq. km. The three sub-catchments selected for this study are (*i*) Sheonath, (*ii*) Tel, (*iii*) Bhedon having area of 31300 sq. km, 32400 sq. km and 12400 sq. km respectively. The time distribution values of different intermediate

TABLE 1

Station	Data used
Raipur	64-79
Paralkote	70-79
Pendra	69-77
Kawarkha	70-80
Deogarh	71-79
Anjul	67-74
Jagdalpur	62-75
Phulbani	71-77
Kanker	68-80
Sonepur	63-71
Mandla	69-80
Titlagarh	67-79
Umaria	69-78
Khairagarh	71-80
Hirakund	64-80
Ambikapur	67-80
Bhubaneswar	69-80
Baripoda	68-75
Chandbali	69-76
Raigarh	73-80
Khijrawan	69-80
Jharsuguda	48-77

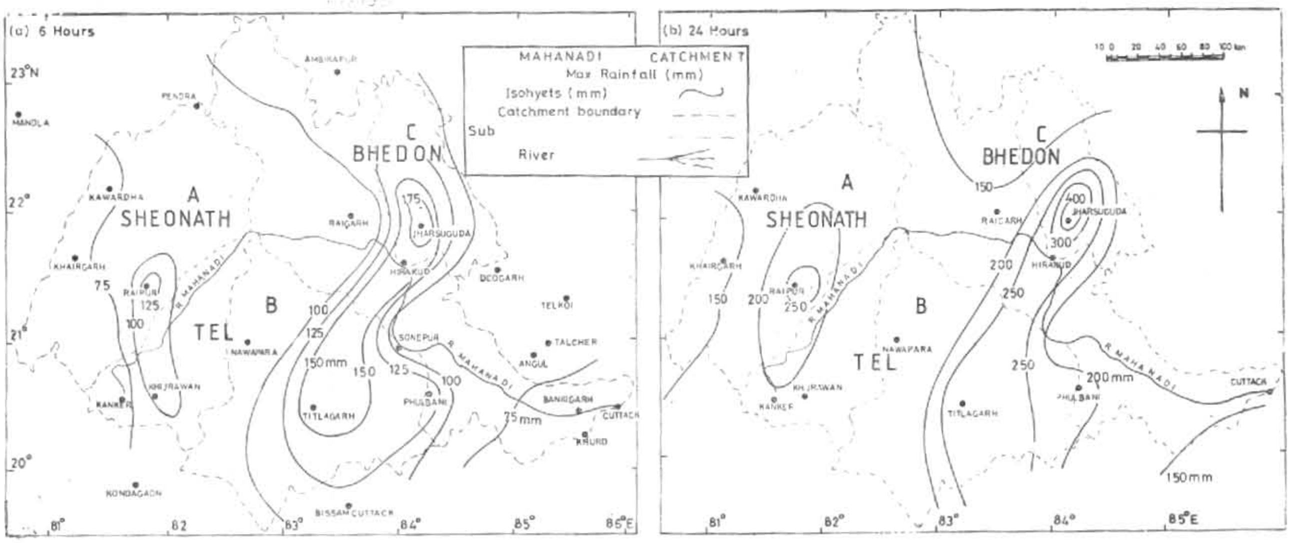


Fig. 2. Mahanadi catchment, (a) 6-hr max. rainfall and (b) 24-hr max. rainfall

TABLE 2

Time distributon of 24-hr storm in percentage

Duration (hr)	Sub-catchments: Sheonath	Tel	Bhedon	Mahanadi (whole catchment)
3	34.4	43.6	44.0	41.2
6	44.0	55.2	60.0	51.2
9	61.7	69.2	67.9	65.8
12	72.6	74.5	80.0	75.3
15	82.4	89.5	97.1	91.4
18	89.6	90.4	100.0	94.5
21	91.9	100.0	100.0	94.8
24	100.0	100.0	100.0	100.0

durations (3, 6, 9,. . . . hr) are given in Table 2 for the Mahanadi catchment as a whole and the three sub-catchments mentioned above.

It is observed that the sub-catchment Bhedon has the critical time distribution of rainfall whereas the sub-catchment Sheonath has the lowest time distribution values. It may be concluded from the index map of the Mahanadi catchment and the above mentioned three sub-catchments (Fig. 2) that the time distribution values are dependent on the location of storm centre with respect to the sub-catchment. The resulting time distribution for the sub-catchments and entire catchment is given in Figs. 1 (a & b) giving actual values and enveloping line to smooth these values. It is seen that the sub-catchment nearer to the storm centre is likely to have higher time distribution values as compared to the sub-catchment far away from the centre of the storm.

Normally the spatial distribution of rainfall in rainstorm is non-symmetrical with respect to storm centre. In case of heavy rainstorm the centre of the storm is defined by the station representing the highest rainfall over the area for given design duration. The storm duration is predecided for any design purpose. The intensity of rainfall will be directly proportional to the rainfall amount. Thus intensity of rainfall is expected to be higher near the centre of the storm compared to stations away from the centre. The present study also reveals similar characteristics.

4. Conclusion

It may be concluded from the present study that :

(*i*) Time distribution of storm rainfall over a sub-catchment is dependent on its location with respect to the centre of the storm.

(*ii*) A sub-catchment lying nearer the centre is likely to have a higher percentage of time distribution of rainfall compared to other sub-catchments in the area.

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