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# Development of station nomograph and intensity-duration-frequency relations in Eastern Ghat High Land Zone of Orissa

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## ABSTRACT

Rainfall data of 9 years of Semiliguda, Koraput (Orissa) of various durations were analyzed to develop rainfall intensity-duration-return period equation and nomograph for Eastern Ghat High Land Zone and discussed. The values of "a" and "b" were determined by using graphical method and those of "K" and "d" by least square method. The constants for this zone K, a, b and d were found to be 8.133, 0.1323, 0.54 and 1.2421 respectively.

***Key word:*** Rainfall intensity-duration-return period, nomograph.

Rainfall is one of the most important factors causing soil erosion. The rainfall characteristics viz. storm amount, intensity and duration play an important role in determining the rate of soil erosion. The capacity of a runoff conveyance system is usually based on a certain depth of rainfall to be expected during a selected period of time.

In USA, the generalized charts of rainfall intensity-duration-return period developed earlier by Yarnell (1935) and now revised by U.S. Weather Bureau (1961) are being used for obtaining the values of "I", the rainfall intensity in the rational formula (Ram Babu *et.al.* 1979). Since such generalized charts are not available at every places of our country because of insufficient automatic rain gauge stations, some empirical assumed values of "I" are used for estimating runoff, which needs improvement.

Ram Babu *et.al.* (1979) had already worked out intensity-duration-return period equations and developed nomographs for the whole country. But in Orissa, only Jharsuguda station was included. Therefore, here an attempt was made to develop the intensity-duration-return period equation, curves and nomographs for Eastern Ghat High Land zone of Orissa.

## MATERIALS AND METHODS

In Eastern Ghat High Land Zone (Fig. 1) only one recording rain gauge is present in meteorological observatory of CSWCRTI, Research Center, Sunabeda, Koraput, Orissa located at 82° 42' E longitude and 18° 45' N latitude and at an altitude of 900 m above msl. To derive prediction equation for whole EGHL zone, continuously recorded rainfall data from the year 1995 to 2003 (9 years) of this Research Center were used. The data were tested for reliability using the procedure of Ogrosky and Mockus (1957), which showed that the length of record is adequate, and hence could be used for frequency analysis.

Various formulae have been advanced connecting the three parameters rainfall-intensity-duration-return period (Frevert *et.al.* 1955; Linsley *et.al.* 1949; Gupta *et.al.* 1968, Skurlow 1960; Nemec 1973; Raghunath *et.al.* 1969; Khullar *et.al.* 1980; Senapati *et.al.* 1976; Ram Babu *et.al.* 1979). The general form is

$$I = \frac{KT^a}{(t+b)^d} \qquad \text{......(1)}$$

Where, I- intensity of rainfall ($cmh^{-1}$), T= return period (years), t = duration (hours); K, a, b and d are the constants.

Equation (1) was used for developing intensity-duration-frequency relationships and curves following Ram Babu *et.al.* (1979). As our data are of short period of about 9 years, graphical methods have been employed. Gumbel extreme value technique was applied for computation of return period values and the frequency lines were plotted after computing the plotted points using 'computed method' suggested by Ogrosky and Mockus (1957). Frequency lines for 5, 10, 15 and 30 minutes, 1, 2 and 24 hours intensity data were developed and plotted on lognormal probability paper. A nomograph was developed for field workers. In the present study, for developing the nomograph, there were only three variables and thus three parallel scales were so graduated and aligned such that a line which joined values on two scales intersects the third scale at a value which satisfied the given equation as described by Ram Babu *et.al.* (1979).

## RESULTS AND DISCUSSIONS

As per the procedure mentioned above, the intensity-duration-frequency curves are given in Fig.2. The equation developed for the area is as follows:

$$I = \frac{8.133\ T^{0.1323}}{(t + 0.54)^{1.3421}}$$

The precision of the equation could be recognized after verifying the reliability of the station equation. The maximum percent deviation between the rainfall intensity values obtained from developed equation and the observed values obtained from frequency lines from primary data (i.e. probability chart) for various duration and 10, 25 and 50 years frequency ranged from -20.0 to 19.1 per cent (Table 1). Notwithstanding the inherent weakness of an average equation, the developed equation seems to be quite reliable for 1 or 3-hour duration and may be used with confidence.

### *Nomograph*

Nomograph (Fig. 3) was prepared from the developed IDF equation and from this, the rainfall intensity for any desired duration from 10 to 100 year frequency (or return period) could be directly read.

Percentage deviation of rainfall

Table 1: Comparison among calculated, nomographic and observed intensities of rainfall ($cmh^{-1}$) and their percent deviation

| Duration | $i_{calc}$ | | | $i_{nomo}$ | | | $i_{obs}$ | | | $\sigma_i$ | | | $\sigma_{nomo}$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Frequency years | | | Frequency years | | | Frequency years | | | Frequency years | | | Frequency years | | |
| | 10 | 25 | 50 | 10 | 25 | 50 | 10 | 25 | 50 | 10 | 25 | 50 | 10 | 25 | 50 |
| 15 min | 14.78 | 16.69 | 18.29 | 14.0 | 16.0 | 18.0 | 12.41 | 14.24 | 15.58 | +19.1 | +17.2 | +17.4 | +12.8 | +12.4 | +15.5 |
| 30 min | 10.51 | 11.86 | 13.00 | 10.0 | 10.5 | 11.0 | 9.29 | 10.45 | 11.30 | +13.1 | +13.5 | +15.0 | +7.6 | +0.5 | -2.7 |
| 1 hr. | 6.45 | 7.28 | 7.98 | 6.40 | 7.00 | 8.0 | 6.39 | 7.18 | 7.94 | +0.9 | +1.4 | +0.5 | +0.2 | -2.5 | +0.8 |
| 3 hrs. | 2.29 | 2.59 | 2.84 | 2.25 | 2.5 | 2.75 | 2.50 | 2.70 | 2.85 | -8.4 | -4.1 | -0.4 | -10.0 | -7.4 | -3.5 |
| 6 hrs. | 1.07 | 1.21 | 1.32 | 1.05 | 1.20 | 1.30 | 1.15 | 1.40 | 1.65 | -7.0 | -13.5 | -20.0 | -8.7 | -7.1 | -21.2 |

$i_{calc}$ – Calculated intensity of rainfall ($cmh^{-1}$) from developed equation
$i_{nomo}$ – Observed intensity of rainfall ($cmh^{-1}$) from nomographs of the station
$i_{obs}$ – Observed intensity of rainfall ($cmh^{-1}$) from the frequency lines from primary data, and
$\sigma_i$ – Percent deviation of observed values from the frequency lines to those calculated with the developed equation
$\sigma_{nomo}$ – Percent deviation of nomographs values from those calculated with the developed equation

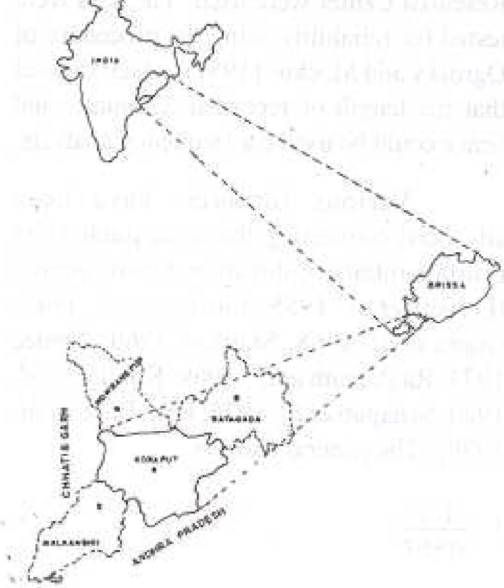


Fig. 1: Location map of the study area

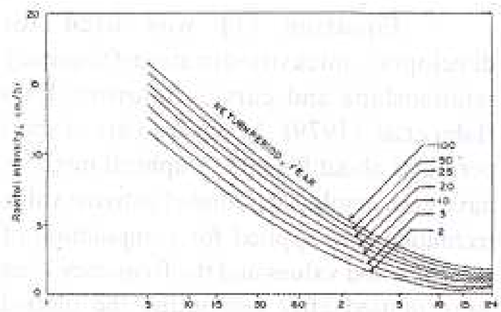


Fig.2 : Intensity-duration-frequency curves for EGHL zone

intensity values observed from nomograph and those calculated from corresponding mathematical equation for various duration and 10, 25 and 50 years frequencies showed

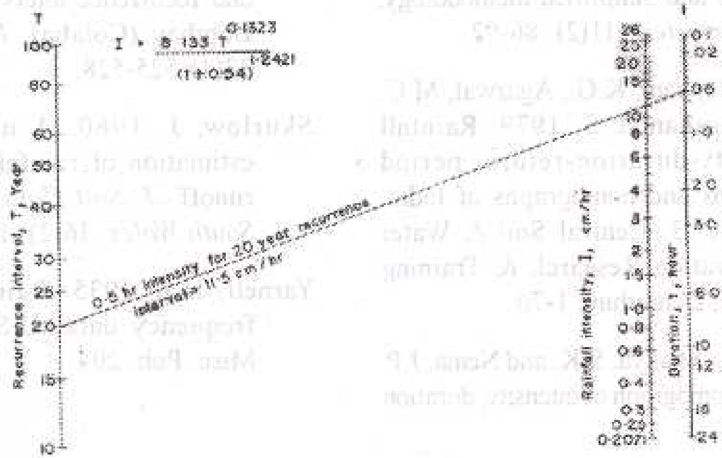


Fig.3 : Nomograph for solving intensity-duration-return period equation for EGHL zone

maximum deviation ranging between -21.2 to +15.5. Looking into simplicity and quick in use, nomographs appear to be the handiest tool for field workers.

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