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Development of Regional Flood Formulate Using L-Moments for Middle Ganga Plains (Subzone 1-F)

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ABSTRACT

Estimation of magnitudes of likely occurrence of floods is of a great importance for solution of a variety of water resources problems such as design of various hydraulic structures, urban drainage systems, flood plain zoning and economic evaluation of flood protection works etc. Whenever, rainfall or river flow records are not available at or near the site of interest, it is difficult for hydrologists or engineers to derive reliable flood estimates directly. In such a situation, the regional flood frequency relationships or the flood formulae developed for the region are one of the alternative methods which may be adopted for estimation of design flood specially for small catchments. The choice of method primarily depends on the design criteria applicable to the structure and availability of data. As per the Indian design criteria, frequency based floods find their applications in estimation of design floods for almost all the types of hydraulic structures viz. small size dams, barrages, weirs, road and railway bridges, cross drainage structures, flood control structures etc., excluding large and intermediate size dams. However, for design of large and intermediate size dams probable maximum flood and standard project flood are adopted, respectively (NIH, 1992).

In this study, regional flood frequency relationship and flood formula have been developed for the small to moderate size gauged and ungauged catchments of the Middle Ganga Plains (Subzone 14). The Subzone 1(f) lies between latitude 24° to 29° North and longitude 80° to 89° East and its total areal extent is 1, 71, 350 km2. It covers parts of Uttar Pradesh, Bihar and West Bengal. The major rivers flowing in this Subzone are Ganga, Yamuna, Gomti, Gandak, Ghagra, Rapti, Kosi including Kamla, Mahananda and others. Annual maximum peak flood data of 11 gauging sites of Subzone 1(f) have been considered.

Screening of the data has been carried out for assessing the suitability of the data for using for regional flood frequency analysis by computing the Discordancy measure (Di) in terms of the L-moments. Also, homogeneity of the region has been tested using the L-moment based heterogeneity measure, H. To establish what would be the expected inter-site variation of L-moment ratios for a homogeneous region, 500 simulations were carried out using the four parameter Kappa distribution for computing the heterogeneity measure, H. Kappa distribution includes as special cases the GLO, GEV and GPA distributions and it is capable of

representing many of the frequency distributions. Based on the homogeneity test, it has been observed that the data of 8 out of 11 sites constitute a homogeneous region. Hence, the data of these eight sites have been used in this study. The record length of the data varies from 23 to 33 years. Catchment areas of these sites vary from 32.9 to 447.8 km^2 and the mean annual peak floods range from 24.3 m^3/s to 555.2 m^3/s. Comparative regional flood frequency analysis studies have been carried out using the various L-moments based frequency distributions viz. Extreme value (EVI), General extreme value (GEV), Logistic (LOS), Generalized logistic (GLO), Normal (NOR), Generalized normal (GNO), Exponential (EXP), Generalized Pareto (GPA) and five parameter Wakeby (WAK). L-moments of a random variable were first introduced by Hosking (1990). They are analogous to conventional moments, but are estimated as linear combinations of order statistics. In a wide range of hydrologic applications, L-moments provide simple and efficient estimators of characteristics of hydrologic data and of a distribution's parameters (Stedinger et al., 1992). Hosking (1997) presented state of the art application of L-moments in frequency analysis.

The Z^{dist} statistic values for GEV, GNO, PT-III and GLO distributions are found to be less than 1.64. Its value is found to be minimum i.e. 0.01 for the GEV distribution. Thus, based on the L-moment ratio diagram and Z^{dist} statistic criteria, GEV distribution has been identified as the robust distribution for the study area. For estimation of floods of various return periods for the gauged catchments of the study area, the regional flood frequency relationship has been developed using the L-moment based GEV distribution. Also,, for estimation of floods of desired return periods for the ungauged catchments, the regional flood formula has been developed by coupling the regional flood frequency relationship with the regional relationship between mean annual maximum peak flood and catchment area.

When data of all the 11 bridge sites are used instead of data of only 8 bridge sites, without meeting the L-moment based criteria of regional homogeneity: the deviations in growth factors show that the percentage deviations in general increase from 1.5° o to 18.5% for the return periods varying from 5 to 1000 years. Thus, excluding the three catchments for meeting the criteria of regional homogeneity leads to under estimation of floods of various return periods for the gauged catchments. In case of the ungauged catchments, the deviations in flood estimates for return periods 25, 50 and 100 years show that there is under estimation for floods of 25, 50 and 100 return periods for lower range of catchment area i.e. 20 to 80 km^2. And there is over estimation for larger size catchments varying in areal extent from 80 to 1000 km^2.