REGIONAL FLOOD FREQUENCY ANALYSIS USING L–MOMENTS AND SOFT COMPUTING TECHNIQUES FOR SUB–HIMALAYAN REGION OF INDIA

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Information on flood magnitudes and their frequencies is needed for design of various types of water resources projects/ hydraulic structures such as dams, spillways, road and railway bridges, culverts, urban drainage systems as well as for taking up various non-structural measures such as flood plain zoning, economic evaluation of flood protection projects etc. Since scientific hydrology began in the seventeenth century, one of the most difficult problems facing engineers and hydrologists is how to predict flow in basins with no records. 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 design flood estimates directly. In such a situation, regional flood frequency relationships developed for the region are one of the alternative methods for prediction of design floods, especially for small to medium size catchments.

The approaches for design flood estimation may be broadly categorized as: (i) deterministic approach using design storm, and (ii) probabilistic approach involving flood frequency analysis. The deterministic and probabilistic methods, which have been used for design flood estimation, are: empirical methods, rational method, flood frequency analysis methods, unit hydrograph techniques, and watershed models. Pilgrim and Cordery (1992) mention that estimation of peak flows on small to medium-sized rural drainage basins is probably the most common application of flood estimation as well as being of greatest overall economic importance. In almost all cases, no observed data are available at the design site, and little time can be spent on the estimate, precluding use of other data in the region. The authors further state that hundreds of different methods have been used for estimating floods on small drainage basins, most involving arbitrary formulas. The three most widely used types of methods are the rational method, the U.S. Soil Conservation Service method and regional flood frequency methods. Regional flood frequency analysis resolves the problem of short data records or unavailability of data by "trading space for time"; as the data from several sites are used in estimating flood frequencies at any site. The choice of method primarily depends on design criteria applicable to the structure and availability of data.

Considering the importance of prediction in ungauged catchments, the International Association of Hydrological Sciences (IAHS) launched "Prediction of Ungauged Basins (PUBs)" as one of its initiatives and declared the current decade as "Decade of PUBs". As per the Bureau of Indian Standards (BIS) hydrologic 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. For design of large and intermediate size dams probable maximum flood and standard project flood are adopted, respectively. Most

of the small size catchments are ungauged or sparsely gauged. To overcome the problems of prediction of floods of various return periods for ungauged and sparsely gauged catchments, a robust procedure of regional flood frequency estimation is required to be developed.

In the present study regional flood frequency analysis has been carried out using L-moments as well as the soft computing methods such as Artificial Neural Network (ANN), Fuzzy Inference (FIS) and Neuro-Fuzzy (ANFIS) for the gauged and ungauged catchments for the Sub-Himalayan region of India.

The study area comprises of small and medium size catchments of the Sub-Himalayan region. The Himalayan region up to its foot-hills, lying within the great arc passing through Madhopur near Dara Baba Nanak in the north east between 76^0 to 96^0 E longitudes and 26^0 to 32^0 N latitudes has been grouped under Zone-7; which is one of the 7 major Zones in which whole of India has been divided. These seven major Zones are further subdivided into 26 hydrometeorologically homogeneous Subzones of moderate size. This Zone holds a great potential for generation of hydropower but flood estimation for this Zone is proving to be an intractable problem as runoff from this region consists of snow melt as well as rainfall. Data availability on both these two important inputs is totally inadequate, if not nil. Catchment areas of gauging sites for which data are available for this study vary from 6 to 2,072 km^2 and their mean annual peak floods range from 17.1 to 1606.8 km^2.

For carrying out the regional flood frequency analysis using the L-moments approach (Hosking and Wallis, 2007), the annual maximum peak floods data are screened using the Discordancy measure (D_i) and homogeneity of the region is tested employing the L-moments based heterogeneity measure (H). For computing heterogeneity measure H, 500 simulations are performed using the Kappa distribution. Twelve frequency distributions namely Extreme value (EV1), Generalized extreme value (GEV), Logistic (LOS), Generalized logistic (GLO), Normal (NOR), Generalized normal (GNO), Uniform (UNF), Pearson Type-III (PT3), Exponential (EXP), Generalized Pareto (GPA), Kappa (KAP) and five parameter Wakeby (WAK) are employed. Based on the L-moments ratio diagram, the GLO distribution has been identified as the robust distribution for the study area.

For estimation of floods of various return periods for gauged catchments of the study area, the regional flood frequency relationship is developed using the L-moment based GLO distribution. Also, for estimation of floods of various return periods for ungauged catchments, the regional flood frequency relationships developed for gauged catchments is coupled with the regional relationship between mean annual maximum peak flood and catchment area (Kumar and Chatterjee, 2005 and Kumar *et al.*, 1999).

The performances of regional flood frequency analysis using L-moments based approach and soft computing methods such as Artificial Neural Network (ANN), Fuzzy Inference (FIS) and Neuro-Fuzzy (ANFIS) have also been compared for the Sub-Himalayan region of India.

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