SESSION-4 :

FLOOD ESTIMATION, FREQUENCY ANALYSIS

14th National Symposium on Hydrology with focal theme on "Management of Water Resources under Drought Situation", 21-22 December, 2010, Organized by National Institute of Hydrology, Roorkee and Malaviya National Institute of Technology, Jaipur at Jaipur, Rajasthan

FLOOD INUNDATION MODELLING FOR THE DELTA REGION OF MAHANADI RIVER BASIN

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ABSTRACT

The delta region of the Mahanadi River basin in the state Orissa, India, is chosen as the study area. In this study the effects of reduction in peak discharge at Mundali is observed using a MIKE 11 set up calibrated for the year 2004 and validated for the year 2002 with the observed discharge and water level data. From observed results it is clear that if we store part of the water during peak flood period upstream of Naraj as a temporary storage, the water levels in the rivers can be reduced successfully. All available river escape data is incorporated in the existing MIKE 11 river network and simulation of MIKE 11 as well as MIKE FLOOD is carried out to obtain the flood inundation for the years 2001, 2003 and 2006. The simulated flood inundation for the year 2001 is compared with the actual inundated areas obtained from IRS-1D WiFS image of 31st July, 2001 whereas the simulated flood inundation for the year 2003 is compared with the actual inundated areas obtained from MODIS image of 9th September, 2003. The simulated flood inundation pattern using MIKE FLOOD is found to be in reasonable agreement with the observed pattern of flood inundation obtained from the remote sensing images. Subsequently feasibility of escapes is studied over Main Mahanadi, Kathajodi and Devi and it is found that river escape is a very useful for controlling water levels in the rivers at the time of peak flows thereby reducing flood inundation.

At-site flood frequency analysis has been carried out for Naraj gauging site using 50 years flood peak data. From frequency analysis at Naraj gauging site it is observed that for 25 year return period peak flood 39000 cumec, 43000 cumec for 50 years and 47500 cumec for 100 years. From obtained results flood hazard assessment for 100 year return period is carried out using MIKE FLOOD model. Flood hazard maps are prepared using SAR images for the year 2001 and 2006. From the obtained results of flood frequency and flood inundation map obtained using SAR images, flood hazard map for 20 and 35 years of return period are prepared.

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SIMULATION OF STAGES USING HYDRODYNAMIC MODEL MIKE 11: A CASE STUDY OF LOWER TAPI RIVER

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ABSTRACT

The Surat city has been prone to river flood in the past, particularly recent floods for year 1998, 2002 and 2006. Hydrodynamic models for lower Tapi basin (Ukai dam to Surat city) has been developed to predict water level using well known unsteady flow model MIKE 11. The model has been developed using field surveyed geometric data. The model has been used to simulate the flood of year 2006 taking appropriate boundary conditions. The observed and simulated flood and stage hydrographs are compared at different stations on the river. The performance indices reveal that simulated flood level is in closed agreement with observed flood levels.

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FLOOD ESTIMATION FOR AN UNGAUGED CATCHMENT USING GEOMORPHOLOGICAL INSTANTANEOUS UNIT HYDROGRAPH (GIUH) MODELS

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ABSTRACT

Estimation of runoff response from ungauged catchments is an important subject of research in the area of surface water hydrology. Conventional techniques of unit hydrograph (UH) derivation require historical rainfall-runoff data. Due to obvious reasons, adequate runoff data for short intervals are generally not available for many small and medium size catchments. Hence, regional approaches are used for such ungauged catchments. In the process of regionalization, the parameters of UH or instantaneous unit hydrograph (IUH) models are related with physiographic and climatologic characteristics for gauged catchments in hydro-meteorologically homogeneous regions. These relationships are then used for runoff estimation for the ungauged catchments of the hydro-meteorologically homogeneous regions. This process of regionalization is a difficult task since it not only requires a huge amount of rainfall-runoff data for the gauged catchments, but establishing hydro-meteorological homogeneity of the region is also quite difficult and uncertain. Further, with the change of the land-use and climate patterns, the model parameters are required to be updated from time to time.

A geomorphological instantaneous unit hydrograph (GIUH) is derived from the geomorphological characteristics of a catchment and it is related to the parameters of the Clark instantaneous unit hydrograph (IUH) model as well as the Nash IUH model for deriving its complete shape. The developed GIUH based Clark and Nash models are used for estimation of the direct surface runoff (DSRO) hydrographs for rainfall-runoff events of the Ajay basin up to Sarath gauging site of eastern India. The geomorphological characteristics of the Ajay catchment are evaluated using the GIS package, Integrated Land and Water Information System (ILWIS). The performances of the GIUH based Clark and Nash models in simulating the DSRO hydrographs are compared with the Clark IUH model option of HEC-1 package and the Nash IUH model, using some of the objective functions. The DSRO hydrographs are computed with reasonable accuracy by the GIUH based Clark and Nash models, which simulate the DSRO hydrographs of the catchment considering it to be ungauged.

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DESIGN FLOOD ESTIMATION THROUGH REGIONAL FLOOD FREQUENCY ANALYSIS FOR UPPER KRISHNA BASIN

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ABSTRACT

The problem of flood frequency prediction i.e. Estimation of the relationship between the magnitude of peak flow and corresponding return period is a central one in the field of applied hydrology. Attempts to solve this problem are usually based on the analysis of a record of peak flow data at the site in question and use of previously established relationship between the characteristics of other catchments in the region and the parametric values of the corresponding magnitude return period relationship. The latter approach is known as regional frequency analysis used for estimating floods at sites where there is a very short peak flow record or no record available. The objective of this study is to establish a regional relationship between mean annual peak flood and the catchments area based on the frequency analysis for available annual peak flood for various gauging sites of hydro logically homogeneous region of Krishna basin, and to use the same for estimating the floods for various recurrence intervals for the catchments which are not used for analysis. This paper describes a study carried out for the Krishna basin with annual peak flood series data available for 24 sites for varying number of years. The Index flood method was used for analysis. Out of 24 sites, 4 sites were omitted after the USGS homogeneity test since they fall outside the envelope curves of homogeneity test. From the remaining 20 sites only 18 sites were considered for the analysis and data of other 2 sites were used as test sites for judging the performance of the developed regional formulae.

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REGIONAL FOOD FREQUENCY ANALYSIS USING L-MOMENTS FOR CHAMBAL BASIN - SUBZONE 1 (B)

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ABSTRACT

Estimation of magnitudes of likely occurrence of floods is of great importance for design of various types of hydraulic structures as well as for taking up some of the non-structural measures of flood management. As per the Bureau of Indian Standards hydrological 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 (PMF) and standard project flood (SPF) are adopted, respectively. However, in these two cases also flood frequency analysis is invariably performed for assessing the return periods of PMF and SPF. 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, which may be adopted for estimation of design floods especially for small catchments.

The L-moments are a recent development within statistics and offer significant advantages over ordinary product moments. Regional flood frequency relationships are developed based on the L-moments approach for Chambal Basin Subzone 1 (b). The annual maximum peak floods data of 13 stream flow gauging sites 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 (PE3), Exponential (EXP), Generalized Pareto (GPA), Kappa (KAP) and five parameter Wakeby (WAK) are employed. Based on the L-moments ratio diagram and $|Z_i^{dist}|$ -statistic criteria, PE3 is identified as the robust frequency 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 PE3 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.

REGIONAL ANALYSIS OF ANNUAL MAXIMUM AND PARTIAL DURATION FLOOD SERIES USING NON-PARAMETRIC AND L-MOMENT APPROACHES

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ABSTRACT

Regional frequency analysis often includes identification of homogeneous regions and a suitable frequency distribution. In this study, annual maximum (AM) flood series (of 23 gauging stations) and peak over threshold (POT) series of the selected 14 gauging stations of 10-34 years of River Brahmaputra (India) and its tributaries are analyzed using five L-moments-based statistics: (i) discordancy measure (ii) cluster analysis using covariance matrix' (iii) heterogeneity measure' (iv) L-moment diagrams, and (v) Z-test. Data were screened using (i) outlier test (ii) randomness test utilizing the first order serial autocorrelation coefficient (r_1), (iii) cross-correlation test, and (iv) discordancy measure. Techniques for flood estimation at a single station and in a regional context using partial duration series are analyzed. This involves using a Poisson distribution to describe the occurrence of floods, while the generalized Pareto distribution is used for flood magnitudes. The fitting technique used is that of probability-weighted moments, and the regionalization scheme adopted is the index flood method. The problem of threshold choice is also analyzed. Examples given throughout the paper use partial-duration series abstracted from daily hydrographs recorded at hydrometric stations in the study area. Finally, regional formulae are derived, and General Pareto distributions are recommended as suitable distributions

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ENSEMBLE MODELLING FOR RUNOFF ESTIMATION

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ABSTRACT

This study compares predictions from a range of catchment models applied to two upper catchments lying in the middle reaches of Mahanadi River Basin in Orissa and to assess various ensemble predictions of catchment daily discharge. The models encompass a large range in inherent complexity and input requirements. They are MIKE-SHE, HEC HMS, Arc-SWAT and Rainfall Runoff Library models, viz. AWBM, SIMHYD, SACRAMENTO and SMAR. The models are calibrated by using same sets of input data. The predictions from each model are then combined by simple averaging and weighted methods to produce a multi model ensemble prediction and their performance is evaluated in terms of efficiency, RMSE and correlation coefficient. The multi-model ensembles are shown to provide predictions that are generally superior to those of their respective constituent models, both during calibration and validation period. The best model combination method for Salebhata catchment is weighted ensemble method and for Kesinga multimodel combination technique OLS and MMSE give better performance indices in terms of efficiency, RMSE and correlation.

A feed forward back propagation ANN with sigmoid transfer function in the hidden layers is also used for simulating runoff. Also, a computationally efficient second-order training method, the Levenberg–Marquardt method is used to minimize the mean squared error between the predicted and observed discharge. The study also explores the potential of bootstrapping techniques to develop an accurate and reliable Bootstrap based ANN (BANN) model. The bootstrap resampling method is used to generate different realizations of the datasets to create a set of bootstrap samples that provide a better understanding of the average and variability of the original unknown distribution or process. Performance of BANN, ANN model is then compared with the best combination techniques obtained by simple averaging and weighted methods by using RMSE and Nash Sutcliffe Coefficient.