Details of Research

Significant Contributions in the area of Flood Modeling

Flood modeling includes (i) flood inundation modeling, hazard and risk assessment, (ii) flood forecasting and (iii) flood estimation. They facilitate flood disaster prediction and preparedness. A major deterrent in carrying out flood modeling studies in developing countries like India, Bangladesh, Nepal, Bhutan etc. is lack of sufficient and accurate calibration and validation data sets, high resolution DEM, cross-section data etc. In light of this, my contributions aim at addressing the data scarcity issues through use of satellite remote sensing data and developing new methodologies for data scarce countries like India. These contributions have been published in high impact factor journals. The significant contributions made in the major areas of flood modeling are highlighted below.

1. Flood inundation modeling, hazard and risk assessment:

(i) Assessment of Cartosat-1 DEM for modeling floods: The potential of low cost IRS satellite based CartoSat data and global SRTM DEM to carry out flood modeling in a data scarce delta region of Mahanadi basin is evaluated. It is inferred that the DEM generated with CartoSat-1 along with GCPs performs best while the one generated with CartoSat-1 along with bias corrected SRTM elevations performs reasonably well for hydrodynamic modeling.

(ii) Hydrodynamic modeling of emergency flood storage area: The effectiveness of a proposed flood emergency storage area at the middle Elbe River, Germany in reducing the flood peaks is investigated using hydrodynamic modeling. The results show that during large floods the utilisation of the storage area with controlled gate operations significantly reduces the Elbe River peak discharges.

(iii) Flood risk modeling for optimal rice planning: An optimal rice planning methodology is developed considering the flood risk through hydrodynamic floodplain modeling (using MIKE FLOOD model) in flood-prone delta region of Mahanadi river basin in India. This would increase the annual benefit to Rs. 601 million compared to Rs. 432 million for the existing practice of normal rice variety cultivation throughout the delta.

(iv) Flood inundation modeling and hazard assessment: MIKE FLOOD model is used to assess the flood hazard for lower Bharathapuzha basin in Kerala. The flood hazard is assessed in terms of the areal extent and depth of flooding for different return period floods.

The developed flood hazard map may be used to regulate different activities in the floodplains.

(v) Site specific flood hazard assessment: Hydrodynamic flow modeling is carried out using MIKE FLOOD model in northern India where an industrial plant is proposed. Flood hazard assessment for upstream catchment together with a local scale study is found to facilitate determination of plinth level for the plant site and helps in identifying the flood protection measures.

(vi) Identifying reasons for recent frequent high floods in Mahanadi basin: Five out of six high floods occurred in the last decade in Mahanadi basin. In order to identify the reasons, the trends of extreme rainfall in the upstream reaches are analyzed in relation to the trends of extreme flows. The analysis reveals that the recent incidence of high floods in Mahanadi basin is due to an increase in extreme rainfall in the middle reaches (downstream of Hirakud dam) of the basin.

(vii) Flood mitigation study of IIT Kharagpur campus: Model simulations using MIKE URBAN and SWMM were used to propose a solution by construction of retention cum detention pond. This pond will serve to prevent floods, absorb peak flows and act as a rain water harvesting structure. A comprehensive drainage plan for the entire campus is also provided.

(viii) Development of management model for waterlogging problem: A non-linear optimization model is formulated and solved for minimizing the waterlogged areas in Mokama group of Tals in Bihar and creation of irrigation potential in the Tal areas and its upstream catchment. The developed model provides a solution for the longstanding problem of waterlogging in the area.

(ix) Flood modeling study of NTPC Kahalgaon power plant: Flood modeling study was carried out to identify the reasons of heavy flooding in NTPC Kahalgaon power plant during 1995 and 1999 and also to provide likely areas of inundation under different scenarios of rainfall and man-made structures like road/rail embankments, power plants etc. and level of water in river Ganga. Safe values of plant elevation and openings in existing structures were recommended.

(x) Evaluation of shifting characteristics of river: The shifting characteristics of a reach of the river Ganga from Ara to Patna (66 km stretch) is evaluated using Satellite data. The

shifting characteristics are evaluating for the period 1974 to 2000 and critical locations are identified where shifting has occurred.

2. Flood forecasting:

(i) Evaluation of Satellite based TRMM rainfall estimates for flood forecasting: The correspondence between TRMM rainfall estimates and rain gauge data are evaluated along with the quality of TRMM estimates in the context of rainfall-runoff simulation for Mahanadi river basin. TRMM data are found to be moderately correlated with gauge-based counterparts and moderate results are obtained for rainfall-runoff simulation.

(ii) Flood forecasting using wavelet-bootstrap based neural network (WBNN) model: A new WBNN model is developed for daily discharge and hourly water level forecasting at Naraj gauging station in Mahanadi river basin. The WBNN model forecasts along with confidence bands are found to improve the reliability of river flow forecasts.

3. Flood estimation:

(i) Development of regional flood formulae using L-moments approach: Regional flood formulae are developed using L-moments approach for small size gauged and ungauged catchments of India covering (i) Middle Ganga Plains Subzone 1(f), (ii) North Brahmaputra river system and (iv) Mahanadi Subzone 3(d). These may be conveniently used by the field engineers for estimation of floods of various return periods for the gauged and ungauged catchments.

(ii) PMF and dambreak flood estimation for Nagarjunasagar dam: The PMF peak for Nagarjunasagar dam is estimated to be 77,945 cumecs using HEC-HMS model. Failure of only five monolithic slabs of Srisailam dam using MIKE 11 model causes a peak flood of 1,23,381 cumecs at NS dam. This flow would only take 12 hours to reach providing little time for taking up any preventive measures.

(iii) Development and uncertainty analysis of GIUH based Clark and Nash models: GIUH based Clark and Nash models are developed for Ajay basin and their performance is compared with the HEC-1 package and Nash IUH model. Also, relative sensitivity and uncertainty analyses are carried out. The developed GIUH model is especially useful for estimation of floods, particularly in developing countries like India where adequate runoff data are generally not available.