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Title of Ph.D Thesis – Hydrological Impact Assessment of Climatic Changes of Sabarmati River Basin

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Findings

Water is an essential resource for the survival of living species on earth. Since the inception of civilization, human beings have shown an inclination to settle near rivers due to the guaranteed availability of water. Due to global warming, there is a rise in the temperature of the earth's atmosphere and oceans resulting in significant changes in the hydrology of a region. There is considerable evidence to suggest that anthropogenic activities are largely responsible for the global temperature rise. The fifth assessment report of the intergovernmental panel on climate change (IPCC) indicates an increase in global temperature of around 1.5˚C between 2030 and 2050.

In this thesis, an HEC-HMS model was developed to simulate the discharge from the Upper Sabarmati River basin (USRB). The impact of climate change on the discharge from the river basin was also assessed for two scenarios - RCP 4.5 and RCP 8.5. Moreover, the impact of land use change on the hydrological regime of the USRB was analyzed. A conceptual model, namely the HEC-HMS model was used to simulate rainfall-runoff processes in the Upper basin of Sabarmati River, Gujarat. The SCS-Curve Number method, SCS unit hydrograph method, Muskingum routing method, and recession method were applied to model the infiltration loss, transforming the rainfall excess into the surface runoff, flow routing of the channel reach, and baseflow model. The data for the period 2001-2010 was used for calibration, whereas the validation was carried out using the 2011-2015 data. The performance analysis was done on two criteria - Coefficient of Determination (R^2) and Nash-Sutcliffe Efficiency (NSE) and is carried out for three sub-basins whose discharge is known. For the Vautha sub-basin, R^2 was 0.88 and NSE was 0.84 during calibration. During

validation, the values of R^2 and NSE were 0.87 and 0.84, respectively. The model performed well for the other two sub-basins as well, namely, Jotasan and Kheroj during both the calibration and the validation stages. The results of the research work clearly show the potential of the proposed model in adequately simulating the stream flows in the basin.

The proposed HEC-HMS model has also been used to assess the hydrological impact of climate changes on the Upper Sabarmati River Basin (USRB) by simulating the discharge under RCP 4.5 and RCP 8.5 of CMIP5 for four GCM models bcc_csm1_1_m, gfdl_cm3, ccsm4, and ipsl_cm5a_lr. The results show that the USRB will encounter an increase in the basin's discharge under climatic change in the future. The peak discharge predicted for RCP 4.5 is in the month of July for bcc_csm1_1_m, ccsm4, and gfdl_cm3 models indicating an early shift from the present peak discharge. For RCP 8.5, the predicted peak discharge for two models - ccsm4 and ipsl_cm5a_lr is in July indicating an early shift and in August for bcc_csm1_1_m and gfdl_cm3 models.

Further to account for the impact of LULC change on the hydrological regime of the USRB, the LULC maps for 1985, 1995, 2005, and 2015 were prepared using ArcGIS software and remote sensing data. LULC map of India for the years 1985, 1995, and 2005 were downloaded from the Decadal land use site. The LULC for the year 2015 was generated using Landsat 8 images using the MLC algorithm. The overall accuracy, and the Kappa coefficient value for the classified image of 2015 were obtained as 90.09 and 86.86, respectively. There is an increase in agricultural land by 2.81% (505.18 km^2) and a decrease in forest area by 2.88% (-518.32 km^2). The results also exhibit an increase in the barren land by 0.14% (22.15 km^2) and the built-up area by 0.21% (37.44 km^2). It also depicts that the water bodies area decreased by 0.27% (49.48 km^2).

The CN value for the years 1995, 2005, and 2015 is calculated. The discharge is calculated for different CN values. The discharge calculated using LULC 1995 is low compared to that of LULC 2015. Due to increased urbanization, the CN value has increased resulting in more runoff in 2015. The runoff is also increased due to the depletion of the forest area and increasing agricultural land.

Keywords *– Hydrological Modeling, Climate change, HEC-HMS, LULC, Curve Number, RCP, NSE.*