Abstract

In the recent times, changes are noted in hydrological processes (e.g., surface runoff, lateral flow, infiltration, return flow, evapotranspiration, soil moisture and streamflow) in different river basins of the world due to the impact of climate and land-use/land-cover (LULC) changes. In upper Cauvery river basin considerable changes has been noticed in the cropping pattern over the past few decades. It is also witnessed that the farmers in the region often expand plantation by encroaching into forest and grassland. In this context, there is a need to assess the combined as well as individual impacts of climate and LULC changes over hydrological processes in the area. There is dearth of such attempts in India, and this is the first study of its kind in the Cauvery basin.

In this thesis, future projections of meteorological variables (viz., rainfall, temperature, wind speed, humidity, and solar radiation) were obtained for Hemavathi catchment in upper Cauvery basin by downscaling simulations of BCC (Beijing Climate Center) GCM and CORDEX REMO RCM (Regional Climate Model) for AR5 (Fifth Assessment Report) climate change scenarios by using multiple change factor methodology.

Accurate information on hydromorphic parameters (e.g., watershed boundary and stream network) is necessary to develop a hydrological model. Conventionally, the hydromorphic parameters are derived from satellite based DEMs which are currently available in different resolutions. Hence need for identifying appropriate DEM(s) for use in the study is realized. In this thesis, accuracy of different DEMs (i.e., SRTM, ASTER, CARTOSAT, TopoDEM) was assessed on the upper Cauvery river basin, considering catchment of Yagachi river as a representative area. Finer resolution DEMs are expected to be better in representing the morphology and topography of catchments. But the present study reveals that coarser (90 m) resolution SRTM DEM is better than the finer (30 m) resolution DEMs (CARTOSAT and ASTER) in representing the topography and morphology of the study area.

The work presented attempts to predict the future land-use changes through a Cellular Automata (CA)-Markov model developed for modelling LULC dynamics in the area. The model was found to perform fairly well in obtaining projections of two past LULC images based on historical images. Future projections of LULC were obtained at five-year intervals (i.e., 2015, 2020, 2025, 2030) using the developed CA-Markov model. The effect of using past as well as future (projected) LULC on hydrological processes simulated by SWAT was examined for Hemavathi river catchment by considering historical climate data.

In addition, combined effect of future LULC and climate changes was assessed on the hydrological processes in Hemavathi river catchment by driving SWAT model using combination of six LULC images (2006, 2010, 2015, 2020, 2025 and 2030 years) and future climate data for the period January 2006 to December 2035. Comparisons are presented with hydrological processes obtained from SWAT model for the cases where (i) only climate change (for the period January 2006 to December 2035) is considered and LULC is chosen corresponding to the year 1991, and (ii) only LULC change is considered by fixing it to a particular year (from among 2006, 2010, 2015, 2020, 2025 and 2030) along with historical climate data for the period 1977-2001.

Inferences drawn from the study include:

(I) Choice of DEM source and its resolution has an effect on future projections of hydrological processes obtained using a hydrologic model like SWAT when driven using downscaled climate variables.

(ii) SRTM and ASTER DEMs provide better representation of elevation as well as morphometric characteristics in the upper Cauvery basin.

(iii) The number of HRUs is more sensitive to the resolution of DEM, whereas the number of sub-watersheds is less sensitive to the DEM resolution.

(iv) Reduction in agricultural area (by □7.70%) and increase in coffee/plantation area (by 5.91%) was evident during the period 1991-2010. The change was high during 1991-2000 and it has started to decrease during 2000-2006 and was marginal during 2006-2010. Agricultural area is projected to further decrease by 1.45%, whereas coffee/plantation is likely to increase by 1.22% during the period 2010-2030, by the developed Cellular Automata (CA)-Markov LULC model.

(v) Duration of south-west monsoon season (June-September) is projected to extend from May to October in the climate change scenario during 2006 to 2085 in analysis with BCC GCM.

(vi) Decrease in surface runoff and increase in other hydrological processes (lateral flow, return flow, infiltration, soil water, evapotranspiration and streamflow) was evident in the historical period (1991-2010), and a similar trend is projected for the future period (2010-2030) in climate change scenario.

(vii) When changes in both LULC and climate are considered, estimates obtained for hydrological processes (except surface runoff) using SWAT are higher than estimates of the processes obtained by considering only climate change.

(viii) Lateral flow, return flow, percolation, soil water and streamflow are projected to increase relative to their historical values when either climate change, or both climate and LULC changes are considered in the analysis.

Mechanistic insights are provided on some mitigation strategies and management practices to counter some of the negative impacts of future (expected) changes in climate variability and LULC over the study area.