Climate Hydrology

a) Assessing Impacts of Climate Change On Rainfall And Streamflows Using Downscaling Models

The climate impact studies in hydrology often rely on climate change information at fine spatial resolution. However, general circulation models (GCMs), which are among the most advanced tools for estimating future climate change scenarios, operate on a coarse scale. Therefore, the output from a GCM has to be downscaled to obtain the information relevant to hydrologic studies. Towards this, Support vector machine (SVM) and Relevance Vector Machine (RVM) approaches have been developed.

Impacts of climate change on water resources were assessed by downscaling appropriate predictors simulated by General Circulation Models (GCMs). With a relatively small number of GCMs available and a finite number of scenarios simulated by them, uncertainties in hydrologic impacts at a smaller spatial scale become particularly pronounced. A methodology has been developed to address such uncertainties for a specific problem of drought impact assessment, in the Orissa Meteorological sub-division, India with results from GCM simulations. Samples of a drought indicator were generated with downscaled precipitation from available GCMs and scenarios. Models and methodologies were developed for assessing impacts of climate change on streamflows of Mahanadi river basin, India (Fig. 4.56). Downscaling with Relevant Vector Machines (RVMs) and uncertainty modeling with possibilistic theory were considered to provide probability distributions of future streamflows under climate change scenarios (Fig 4.57). Possibilities were assigned to all the GCMs with scenarios based on their performance in modeling the streamflow of the recent past (1991-2005), when signals of climate forcing are evident. The possibilities associated with different GCMs and scenarios were used as weights in computing the possibilistic mean of the CDFs projected for three standard time slices 2020s, 2050s, and 2080s. Currently, the scenarios provided in the Assessment Report #4 (AR4) of the IPCC are being used in uncertainty modeling of climate change impacts. Results from these studies are useful in developing adaptive responses to climate change.

Downscaling models based on SVM approach were used to obtain future projections of precipitation in meteorological sub-divisions of IMD (India Meteorological Department) for simulations of second generation Canadian coupled GCM (CGCM2) under IS92a scenario. A novel strategy was developed to obtain projections of future wet and dry seasons. Figure 58 shows projections for four time slices (2000-2019; 2020-2039; 2040-2059; 2060-2079).

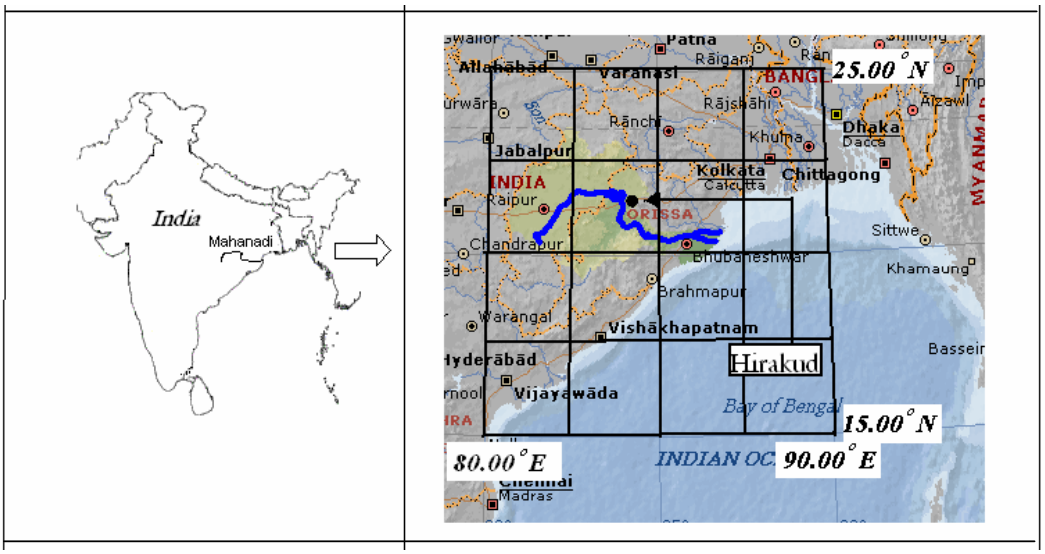

Figure 56: GCM Grids superposed on the Mahanadi River Basin

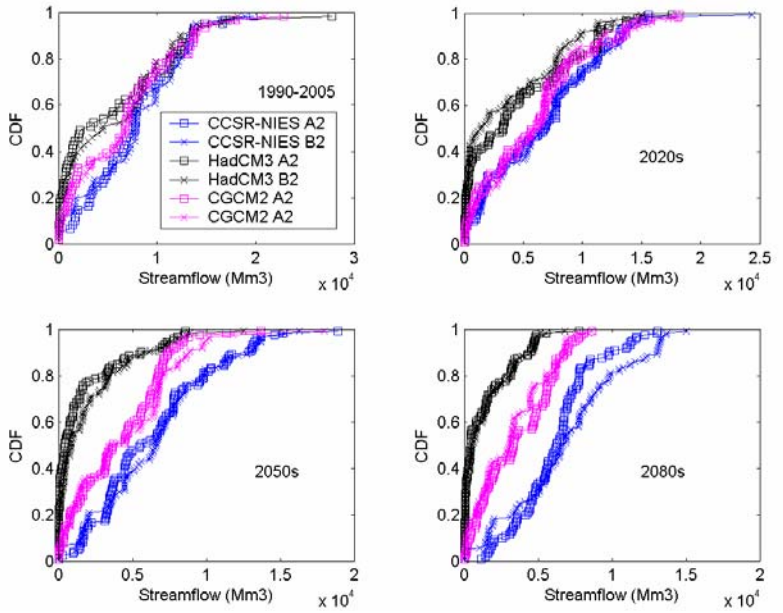

Figure 57: GCM and Scenario Uncertainty in Climate Change Impacts on Streamflow

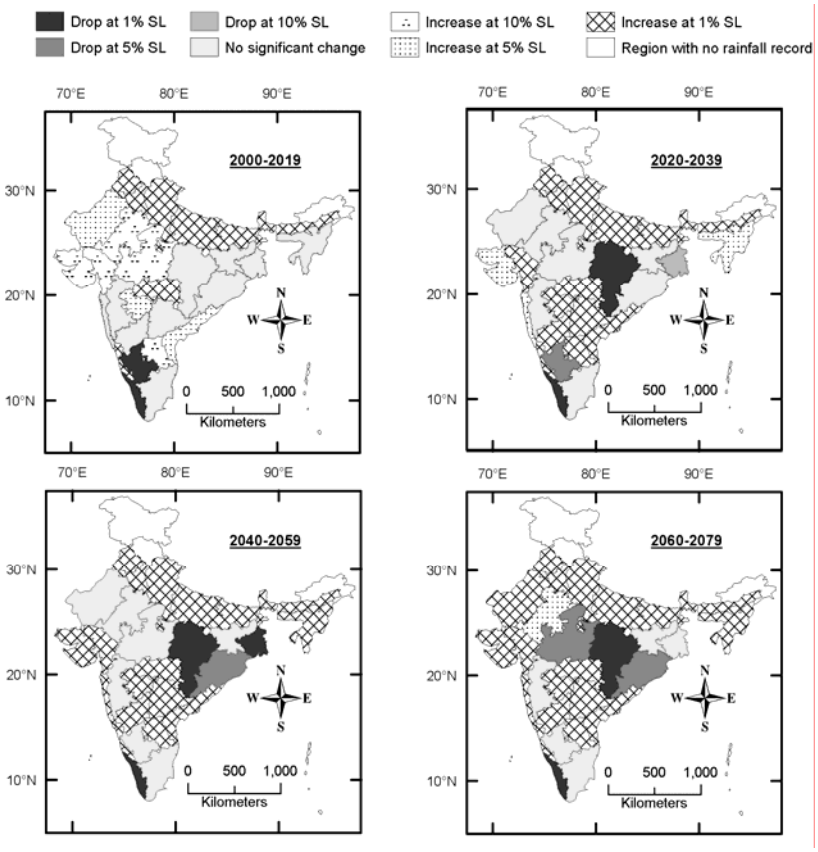

Figure 58: Precipitation in meteorological subdivisions of India projected for wet season by CGCM2 model for IS92a scenario - result from SVM downscaling model.

Studies related to hydrology of Malaprabha reservoir system in Krishna river basin, India, were carried out to project water resources in the region using SVM model, and Soil and Water Assessment Tool with Arc View interface (AV-SWAT). The AV-SWAT was used to model the relationship between hydrometeorological variables and runoff in the Malaprabha reservoir catchment. Land-use/land-cover information of the study area was obtained from satellite remote sensing images based on Indian Remote Sensing Satellite (IRS) LISS III data. The drainage network in the catchment was derived from Shuttle Radar Topography Mission (SRTM) digital elevation data. The SVM downscaling model was used to obtain projections of hydrometeorological variables (precipitation, temperature, wind speed, and specific humidity) in Malaprabha reservoir system at monthly and daily time scales from projections of third generation Canadian coupled GCM (CGCM3). Subsequently, future projections of streamflows in the Malaprabha catchment were obtained from projections of hydrometeorological variables using the developed AV-SWAT, and percentage change in projected future streamflows was estimated (Fig. 4.59).

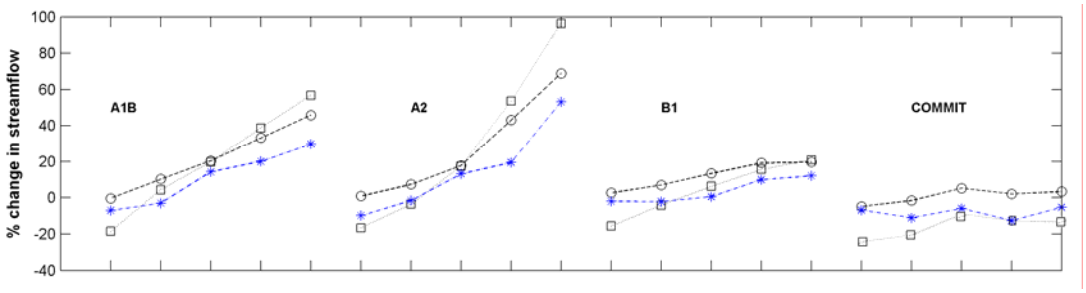

Figure 59: Percentage change in projected future monsoon streamflows estimated by three SVM based downscaling models for Malaprabha reservoir catchment for A1B, A2, B1 and COMMIT climate change scenarios, using simulations of third generation Canadian Coupled General Circulation model (CGCM3).

b) Hydroclimatic Influence of Large-Scale Circulation on the Variability of Reservoir Inflow

The nature of basin-scale hydroclimatic association for Indian subcontinent was investigated. It is found that, the large-scale circulation information from Indian Ocean is also equally important in addition to the El Niño-Southern Oscillation (ENSO), owing to the geographical location of Indian subcontinent. The hydroclimatic association of the variation of monsoon inflow into the Hirakud reservoir in India was investigated using ENSO and EQUatorial INdian Ocean Oscillation (EQUINOO, the atmospheric part of Indian Ocean Dipole mode) as the large-scale circulation information from tropical Pacific Ocean and Indian Ocean regions respectively. Individual associations of ENSO & EQUINOO indices with inflow into Hirakud reservoir were also assessed and found to be weak. However, the association of inflows into Hirakud reservoir with the composite index (CI) of ENSO and EQUINOO was quite strong (Figure 60). Thus, the large-scale circulation information from Indian Ocean is also important apart from the ENSO. The potential of the combined information of ENSO and EQUINOO for predicting the inflows during monsoon were also investigated which gave promising results. The results of this study will be helpful to water resources managers due to the fact that the nature of monsoon inflow is becoming available as an early prediction.

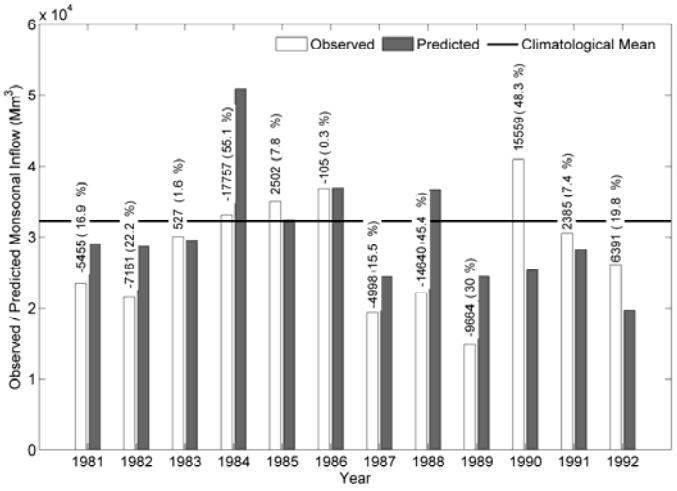

Figure 60: Plot of observed and predicted monsoon inflows into Hirakud reservoir using composite index (CI).