

Center for Studies in Science Policy
School of Social Sciences
Jawaharlal Nehru University

UGC Research Award Interim Progress Report

Research Title: **Climate Change, Variability, and Water Resource Policies: A Case Study of the Sutlej River Basin, Western Himalayas**

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Research objective

The overall objectives of this research is to assess the likely impacts of climate change on the water resources availability in the catchment of Sutlej River in the mid and late 21st century using hydrological modelling approach and indicate the implications for policy formulation.

Targets Completed

Simulation of Sutlej River's Hydrological Regime

The hydrological regime of Sutlej basin for the period 1995-2005 has been simulated at a daily time-step using: the SNOWMOD model; satellite imageries derived daily snow cover time series and topography, ground stations based climate and river discharge data.

Ground Truth Campaign

Two field trips/ground truth campaign were conducted during 10th May 2010 to 26th May 2010 and 22nd August to 11th August 2010 and Shimla , Rohtang, Koksar, Kunjum, Kaza, Khab , Kalpa, Rekong Pio, Rampur and areas were visited. Following data sets were collected.

- Land-cover/land-use ground truth at 400 locations and in all three seasons: winter (mid-October to Feb) summer (March to June), and monsoon (July to mid-October).
- GPS data collection for special referencing the satellite images.
- Semi-structured interviews for land/forest management practices with the farmers, pastoralists, forest officials and agricultural experts.

Data base creation

The present study has used ASTER digital elevation model and around 450 NOAA and MODIS satellite images covering a period of 10 year for the estimation of seasonally changing characteristics of – snow-cover and soil moisture – for parameterization of SNOWMOD model.. Ground based point-scale meteorological

information from 11 metrological stations located within the Sutlej basin used as the precipitation and temperature inputs on a daily time step for a period of ten years. River discharge data at 5 different gauging locations have used for calibration and validating the model simulated river discharge. Data were assembled from following sources:

- Eight day composites of Terra MODIS imageries were downloaded from the The NASA's Earth Observing System (EOS) Data and Information System (EOSDIS) and Satellite Active Archive site <http://ecsinfo.gsfc.nasa.gov>.
- The ASTER DEM was downloaded from ASTER data distribution website: <http://gdem.aster.ersdac.or.jp>. ASTER DEM was used for generation of watershed of Sutlej basin
- The NOAA images were procured from the National Institute of Hydrology, Roorkee.
- The meteorological data(temperature and precipitation, originally collected and maintained by the Bhakra Beas Management Board (BBMB)were procured and made available by the National Institute of Hydrology, Roorkee.
- River discharge time series procured from Bhakra Beas Management Board (BBMB).

Assessment of Impact Temperature Rise on the water resources

- Impact of the impact of climate change on stream flow assessed under three hypothetical temperature rise scenarios (T+1, T+2 and T+3 °C).
- Findings indicate early melting of snow cover in the catchment and alterations in timings of peaks bottom in the hydrograph in the early summer season.

Limitations of current findings from the perspective of water resources policy framework

The outcome of hypothetical temperature rise scenarios is not very useful for water resources policy formulation. The IPCC has made available predicted/estimated 21st century climatic data sets generated by various Global Climate Models. Nonetheless this data is of very coarse resolution (at a grid size of 375*375 km) and cannot be used for hydrological modeling at regional or river basin scale where

climatic variables change every 10 km due to the effects of rugged mountainous topography. Statistically downscaled future climate data is essential for simulating reasonably accurate climatic conditions at the river basin scale. But downscaling global climate models is a very time consuming enterprise, due to limitations of computational resources.

Remaining Targets and Timeline for Completion

Downscaling Global Climate Models

Statistical downscaling of the available coarse spatial resolution Global Climate Models for better prediction of climatic variables at river basin river basin for 21st century. Downscaling GCMs task would be completed by February 2012.

Ascertaining the rate of recession of bench mark glaciers in Sutlej basin

One visit to glacial fields in basin has been made. Two more visits in September 2011 and May 2012 have been planned. An attempt is being made to acquire high resolution CARONA satellite data from NASA for ascertaining the position of glacier snouts in the 1960s and 1970s. This task would be finished by June 2012.

Field data requirement

- Glacier snout position referencing.
- Collection of ground control points for georeferencing high resolution satellite imageries

Satellite data requirement

- LISS IV data time series of the study area for the period 2005 to 2010.
- LISS III and pan merged imagery for the period 2001 to 2004.
- CORONA imagery of the study area for the years 1960s and 1970s for ascertaining the glacier snout positions during the above said period.
- Cartosat satellite data for the years 2005 and 2010 for ascertaining the DEM volume changes.

Publications during the Research Award Period

Published papers

- (1) Rajesh Bhakar, "Extraction of Irrigation Network Details from Medium Resolution Satellite Imagery: a Comparative Assessment of LISS-III and ASTER Data Products". *International Journal of Engineering and Earth Sciences*, Volume 3 (6), 2010.
- (2) Rajesh Bhakar, "Recent Advances in Geo-informatics Based Assessment of Waterlogging and Salinization Hazards: a Review of Studies of the Irrigated Tracts in Desert Environments. *Oikoassay*, Volume 24, 2011.
- (3) Rajesh Bhakar, S.K. Srivastav, and Milap Punia, "Assessment of the Relative Accuracy of ASTER and SRTM Digital Elevation Models along Irrigation Channel Banks of Indira Gandhi Canal Project Area, Rajasthan", *Journal of Water & Land-use Management*. Volume 10 (1-2), 2010.
- (4) Kamleh Punia, Milap Punia and Rajesh Bhakar, "Road Accessibility and its Role in Rural Development: A Case Study of Rajasthan". *Annals of the Rajasthan Geographical Association*. Volume 26, 2009
- (5) Rajesh Bhakar, "Geographic Thought: A Praxis Perspective George", book review of Henderson and Marvin Waterstone (editors): Geographic Thought: A Praxis Perspective. *Annals of the Rajasthan Geographical Association*. Volume 26, 2009.

Under Review

1. Rajesh Bhakar, Victor Jetten and S.K. Srivastav, "Integrating Geospatial Technologies with Conventional Methods for Identifying Areas with Potential for Groundwater Development in an Irrigated Landscape Underlain by Shallow Hydrologic Barrier", *Irrigation: Types, Sources and Problems*, InTech - Open Access Publisher, <http://www.intechweb.org/> (extended abstract submitted to reviewing editor, March 2011)
2. Rajesh Bhakar, S.K. Srivastav, Victor Jetten and R.D. Garg, Upscaling Soil-Hydrologic Parameters for Distributed Hydrological Modelling in Sandy Desert Environment. *Asian Journal of Geoinformatics*, (First revision submitted after review, February, 2011).

3. Rajesh Bhakar and Vinod Singh, "Linking Archival, Survey and Remote Sensing data for Identification of Rain-water Harvesting Sites in Bikaner City", *Journal of Water & Land-use Management*. (Manuscript submitted to the reviewing editor, February 2011).

Submitted by:

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