Evaluation of Climate Change Impact on Water Resources in Upper Sind River Basin, India using SWAT model

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- The water resource of any river basin is basis for the economic growth and social development.

- High temporal and spatial variability in rainfall, prolonged dry seasons, global environmental changes and population growth has a serious pressure on water resources.

- Increasing population growth lead to significant increase in water demand, particularly, for crops and livestock production in the future.

Water Resources in India

Annual Precipitation (including snowfall) : 4000 km³

Av. Annual Potential flow in rivers : 1869 km³

Utilizable Water Resources

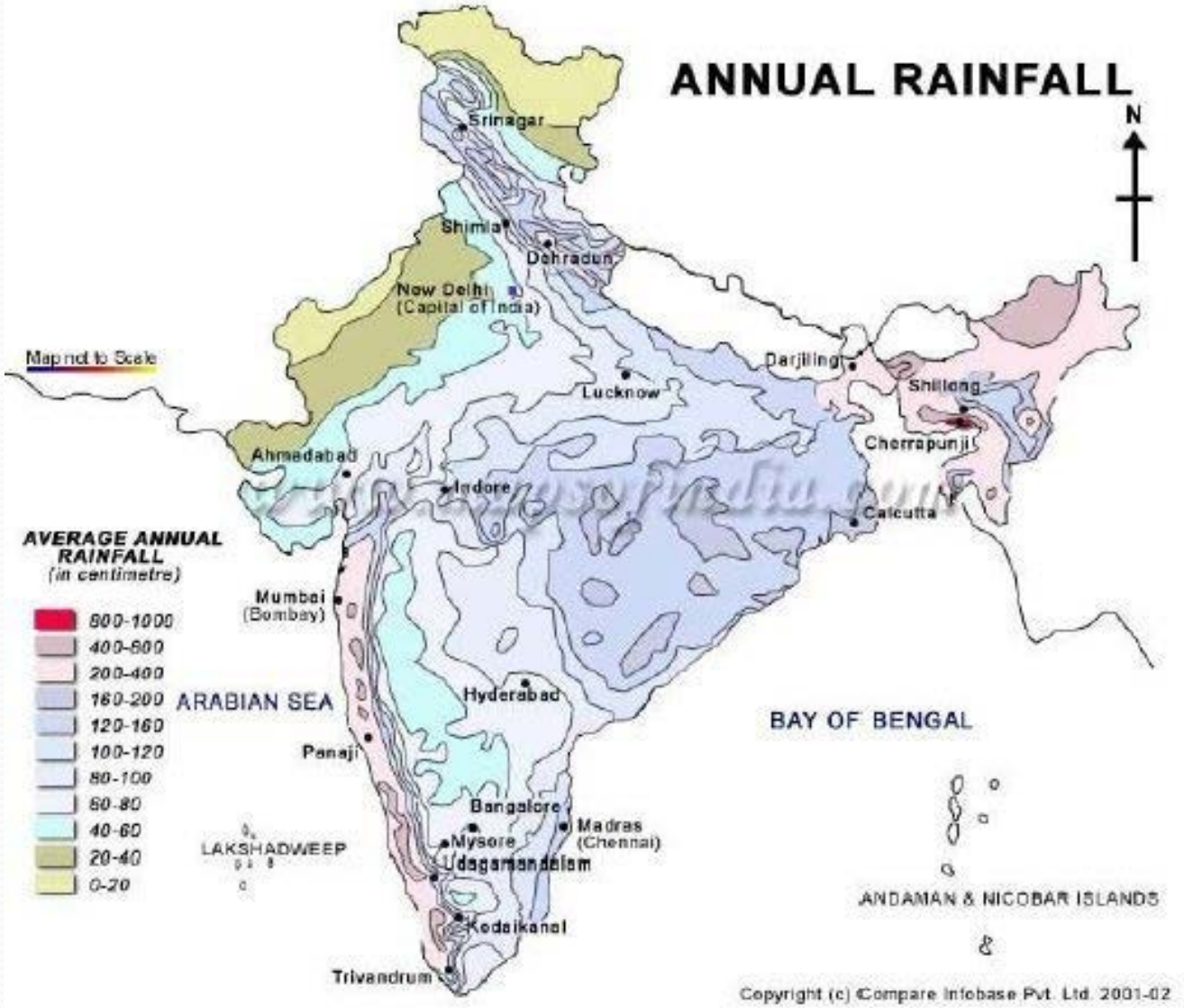
- **Surface Water : 690 km³**
- **Ground Water : 432 km³**

Long term mean monsoon rainfall : 900 mm

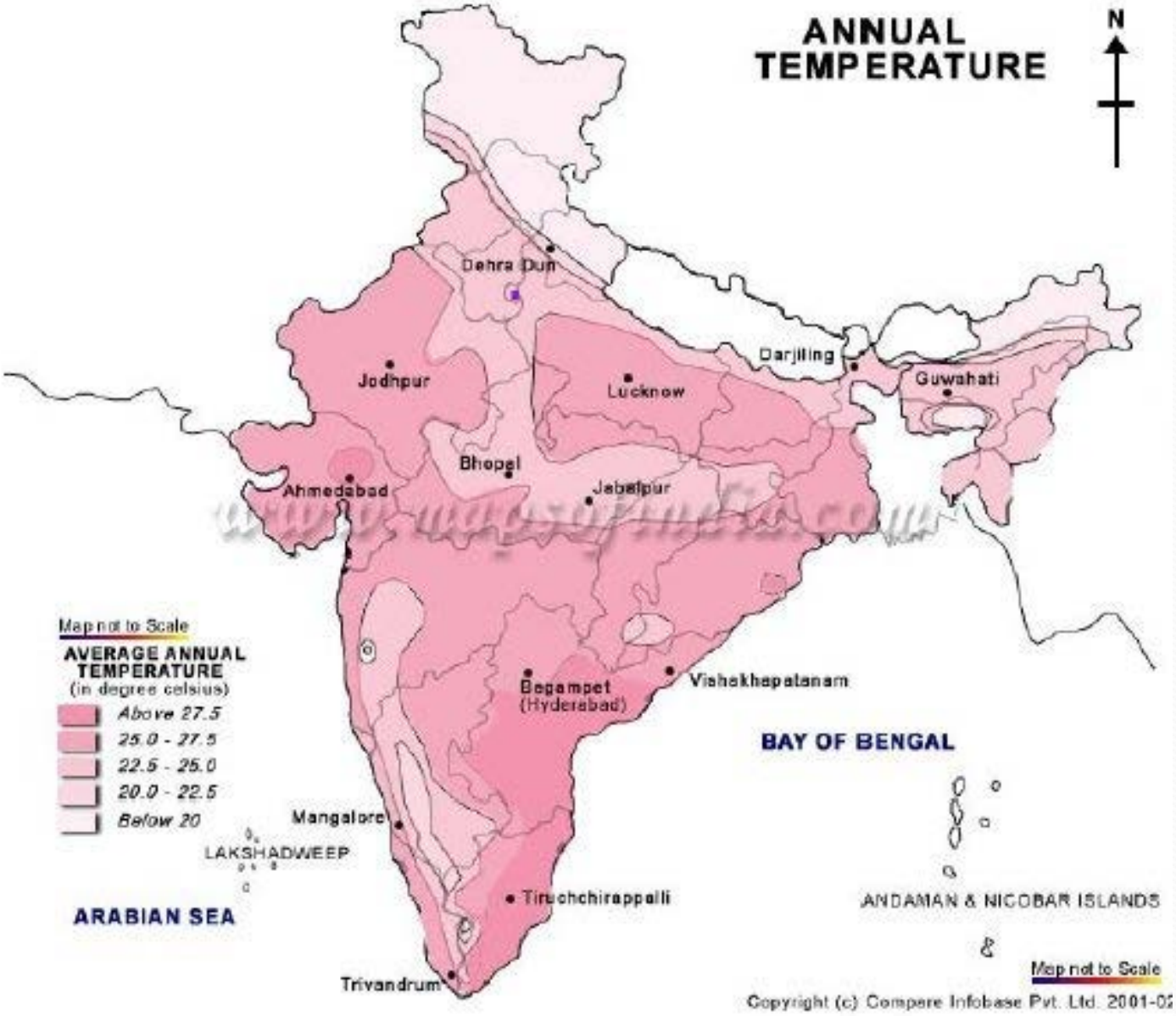
(Source: MoWR 1999)

Major River Basins

WWW. Maps of India.com



Rainfall map (http://www.mapsofindia.com/maps/india)



Temperature map (http://www.mapsofindia.com/maps/india)

Per capita surface water availability in India

Per capita	year	m^3
Present	1991	2309
	2001	1902
Future Projected	2025	1401
	2050	1191

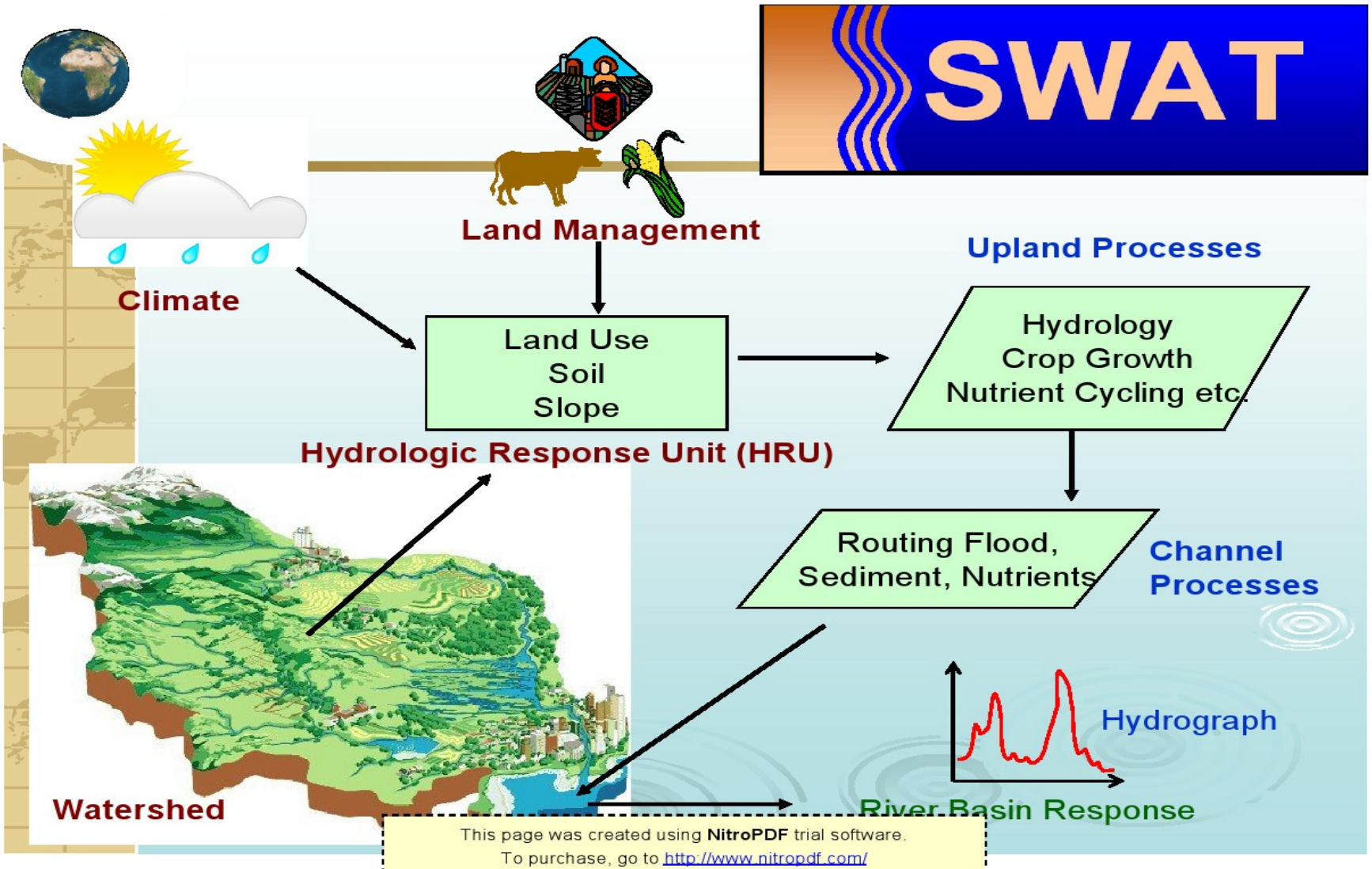
Rakesh et.al., 2005

- Nearly all regions of the world are expected to experience a net negative impact of climate change on water resources and freshwater ecosystems (IPCC, 2001).
- The climate projections over India indicate that temperature rise is likely to be around 3°C and rainfall increase is expected by 10-20 per cent over Central part of India by the end century (IPCC, 2007).
- Such increases will affect water availability for use by the different water sectors, particularly, agriculture with serious implications for many livelihoods.
- Therefore, evaluation of water resources in light of future climate change is very important for sustainable planning and management of the resources.

The Soil and Water Assessment Tool (SWAT) model is applied to simulate the water resources of the Upper sind river basin and to evaluate the impact of future climate change.

SWAT Model

- SWAT is the result of over 40 years of modelling and field research
- USDA – ARS
- USDA – NRCS
- EPA
- Universities and research institutes in USA and across the world
- Validated by several researchers around the world and Several peer-reviewed publications
- Used by several countries for water resource assessment



Data Used for Modeling

- Digital Elevation Model : SRTM 90 m x 90 m grid data
- Landuse Landcover: National Remote Sensing Centre data 1:50 000 m
- Soil : NBSSLUP – ICAR data, 1: 50 000 m
- Stream flow time series : Central Water Commission, MoWR, GOI
- Weather : Indian Meteorological Department regridded data
  Rainfall: Daily 0.5° x 0.5° and Temp.: Daily 1° x 1°

Future climate datasets

- Weather : Data generated by The Hadley Centre for Climate Prediction U.K. at a resolution of 0.44° x 0.44° latitude by longitude grid points obtained from Indian Institute of Tropical Meteorology, Pune, India.
- PRECIS(Providing regional climates for impact studies) Regional Climate Model
- A1B IPCC SRES Climate Change Scenario
- Baseline (1961 - 1990)
- Mid Century (2021 – 2050)
- End Century (2070 – 2100)
- HadRM3 for A2, B2 scenarios
- Baseline and End century scenarios

- The present (1997-2005) and future (2040-2050) water resources were simulated with the calibrated SWAT model and compared.

- The future water resources were simulated using climate series generated by The Hadley Centre for Climate Prediction U.K. at a resolution of 0.44° x 0.44° latitude by longitude grid points obtained from Indian Institute of Tropical Meteorology, Pune, India.

SRES Emission Scenarios

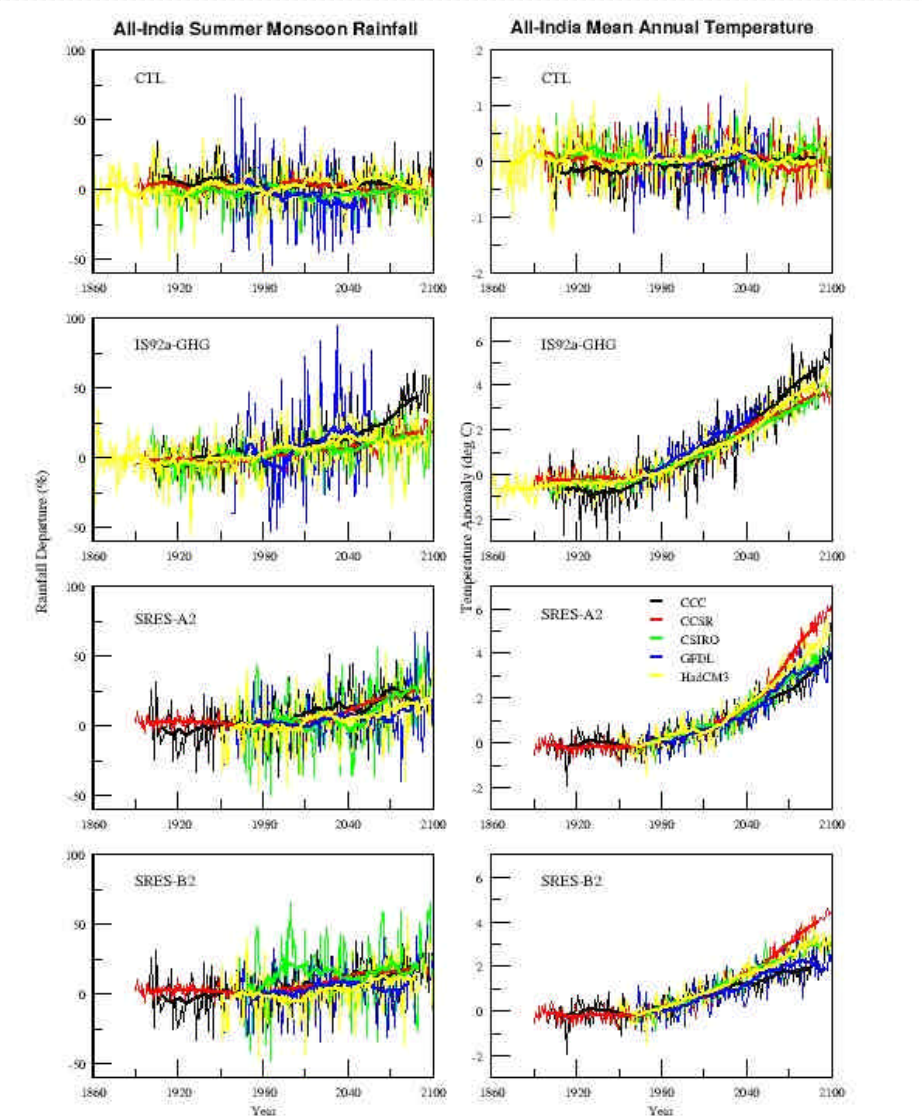
- A1 - a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Three sub groups: fossil intensive (A1FI (A1B).), non-fossil energy sources (A1T), or a balance across all sources

- A2 - A very heterogeneous world. The underlying theme is that of strengthening regional cultural identities, with an emphasis on family values and local traditions, high population growth, and less concern for rapid economic development.

- B1 - A convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline.

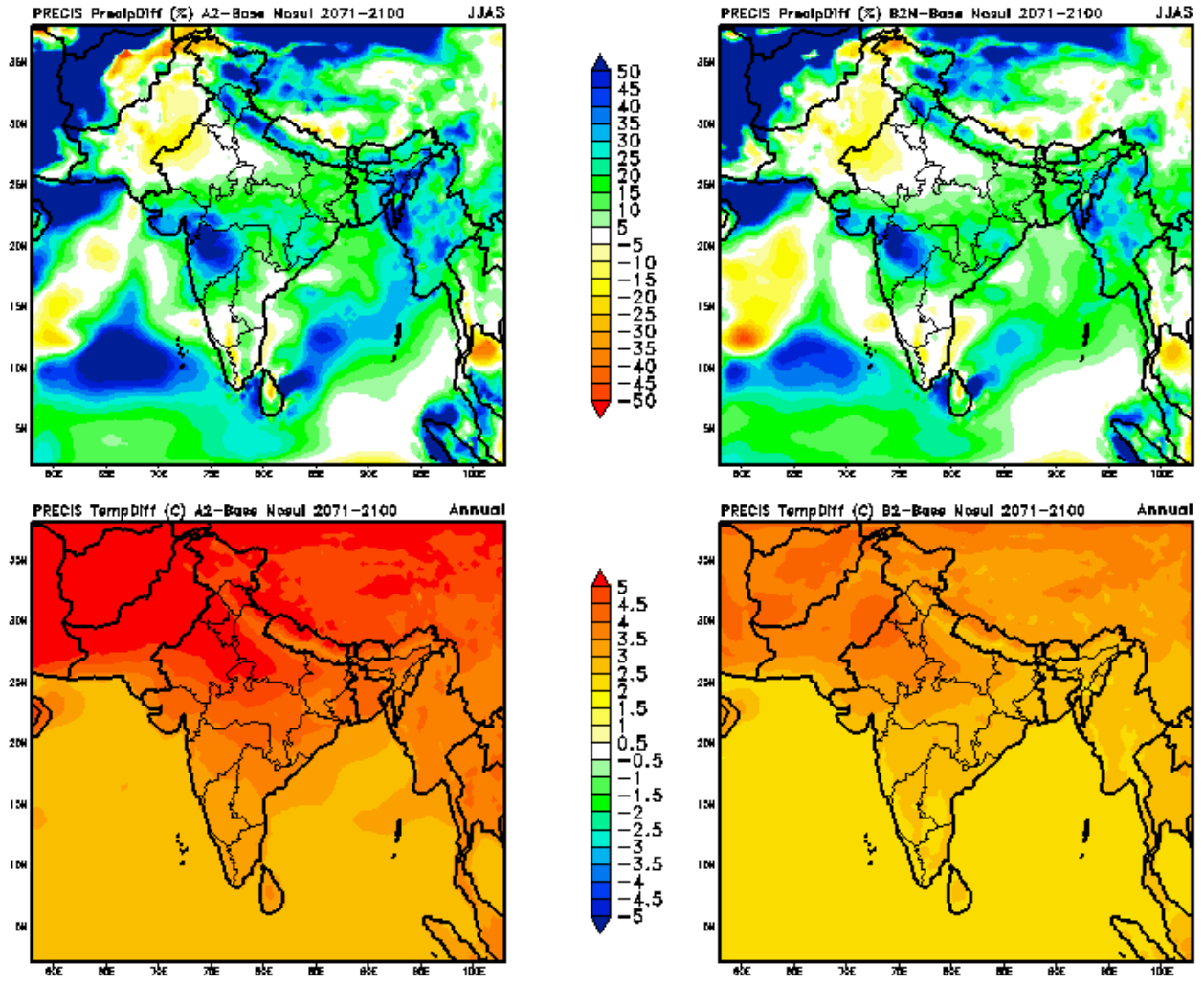
- B2 - a world in which the emphasis is on local solutions to economic, social and environmental sustainability.

Present (CTL) and future (IS92a-GHG, SRES-A2 and SRES-B2) simulations for all-India mean temperature and precipitation, based on five global atmosphere–ocean GCMs



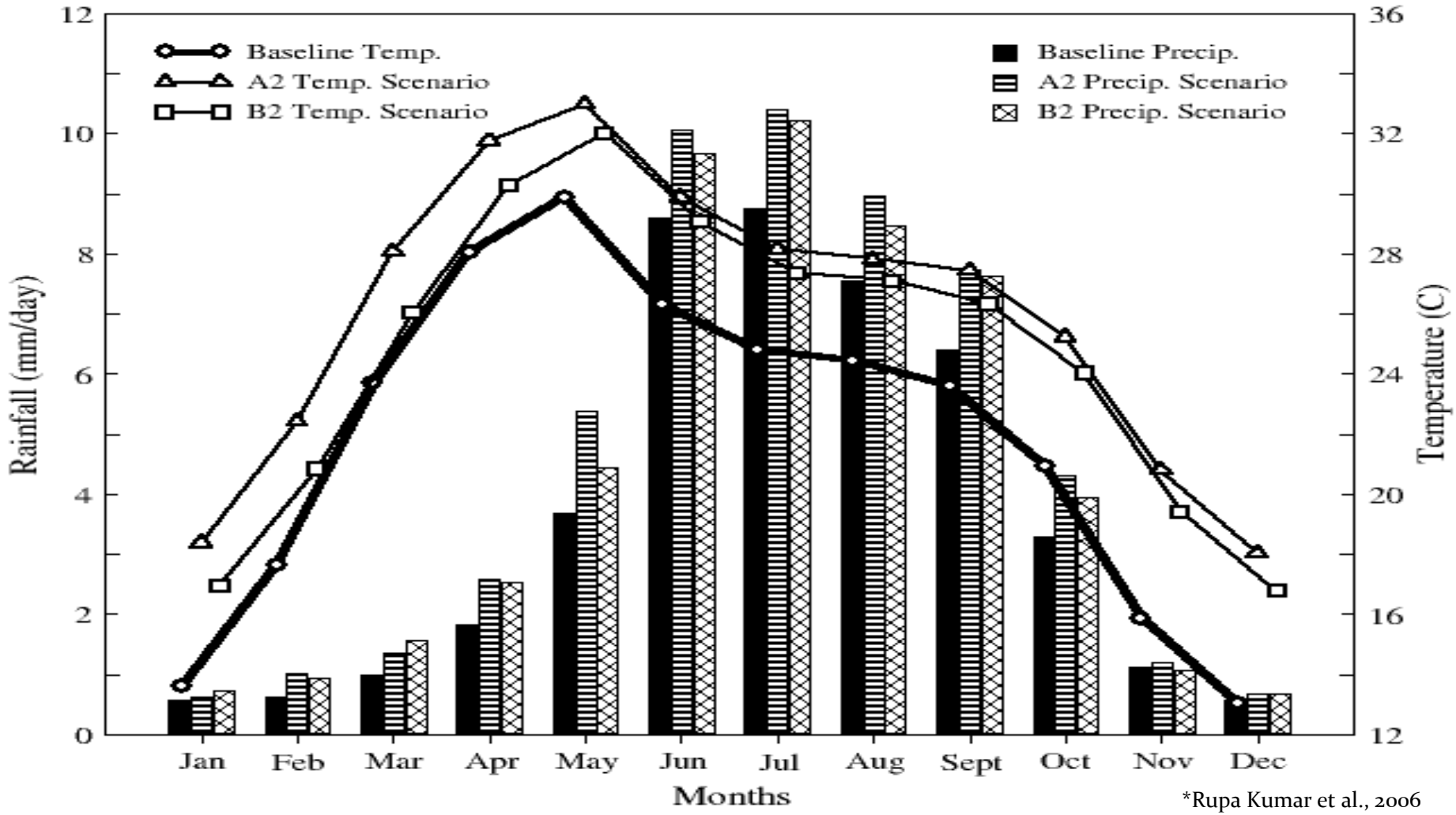
*Rupa Kumar et al., 2006

Projected changes in precipitation and temperature for end century 2070-2100, with A2 and B2 scenarios (PRECIS Model)



*Rupa Kumar et al., 2006

Mean annual cycles of all-India mean precipitation and surface air temperature for the baseline period (1961–1990) and the future scenarios (2071–2100) of A2 and B2



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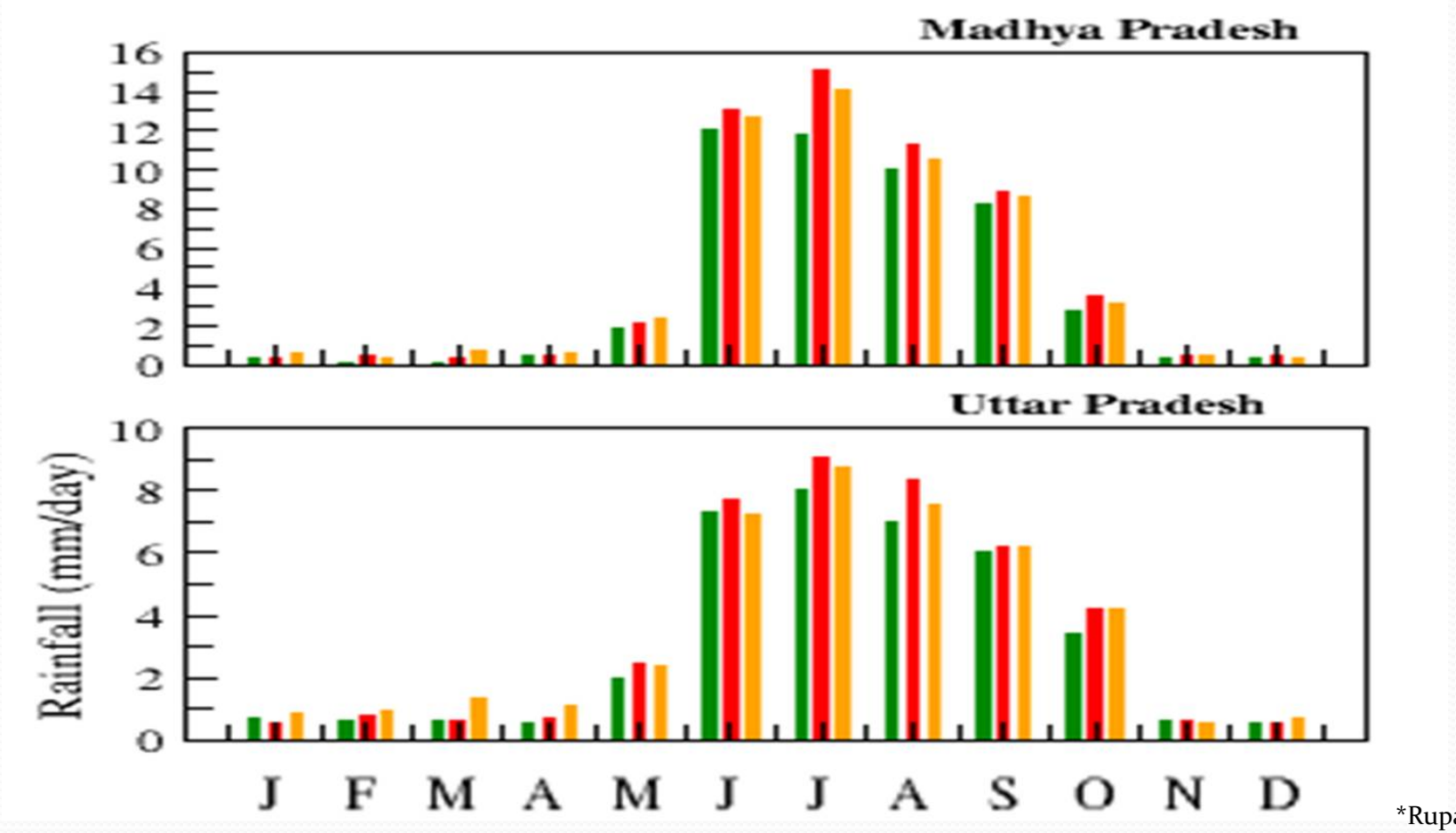
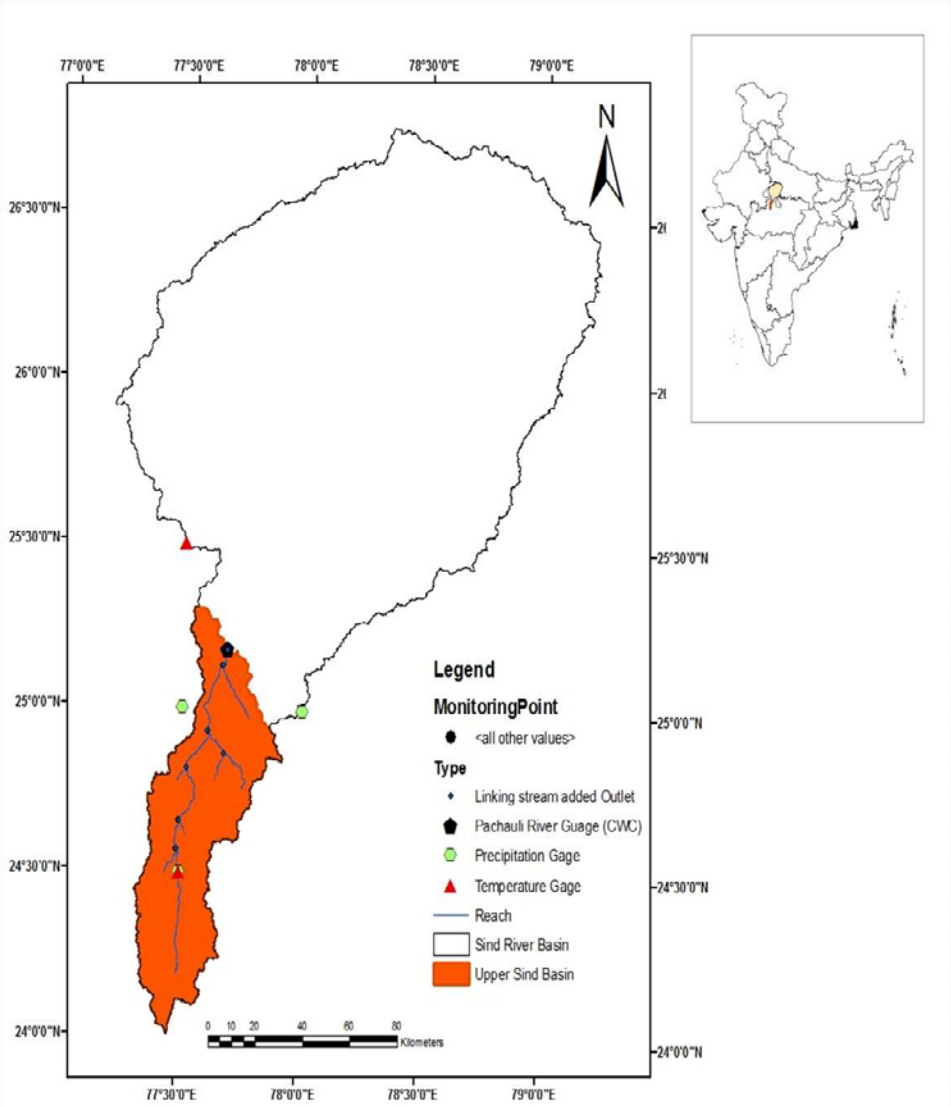
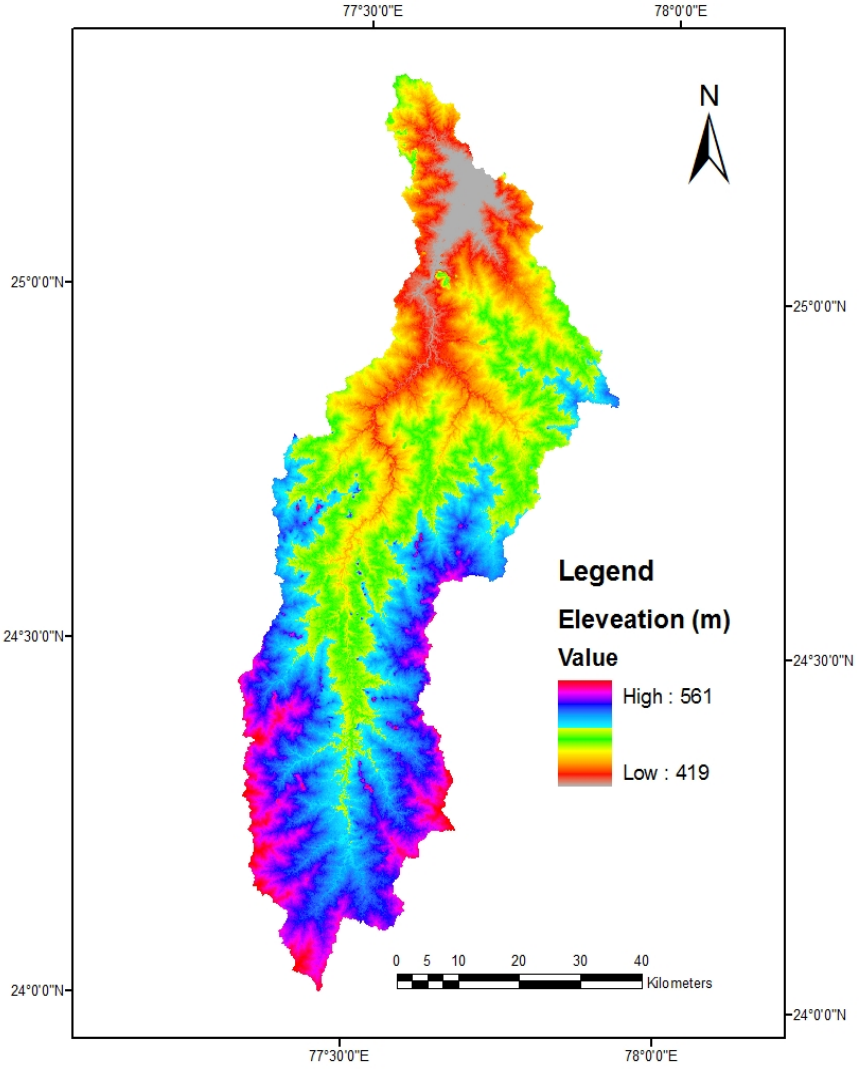
Baseline (1961-1990) and Future projections (2071–2100) of mean annual cycles of precipitation for study area, simulated by PRECIS



*Rupa Kumar et al., 2006

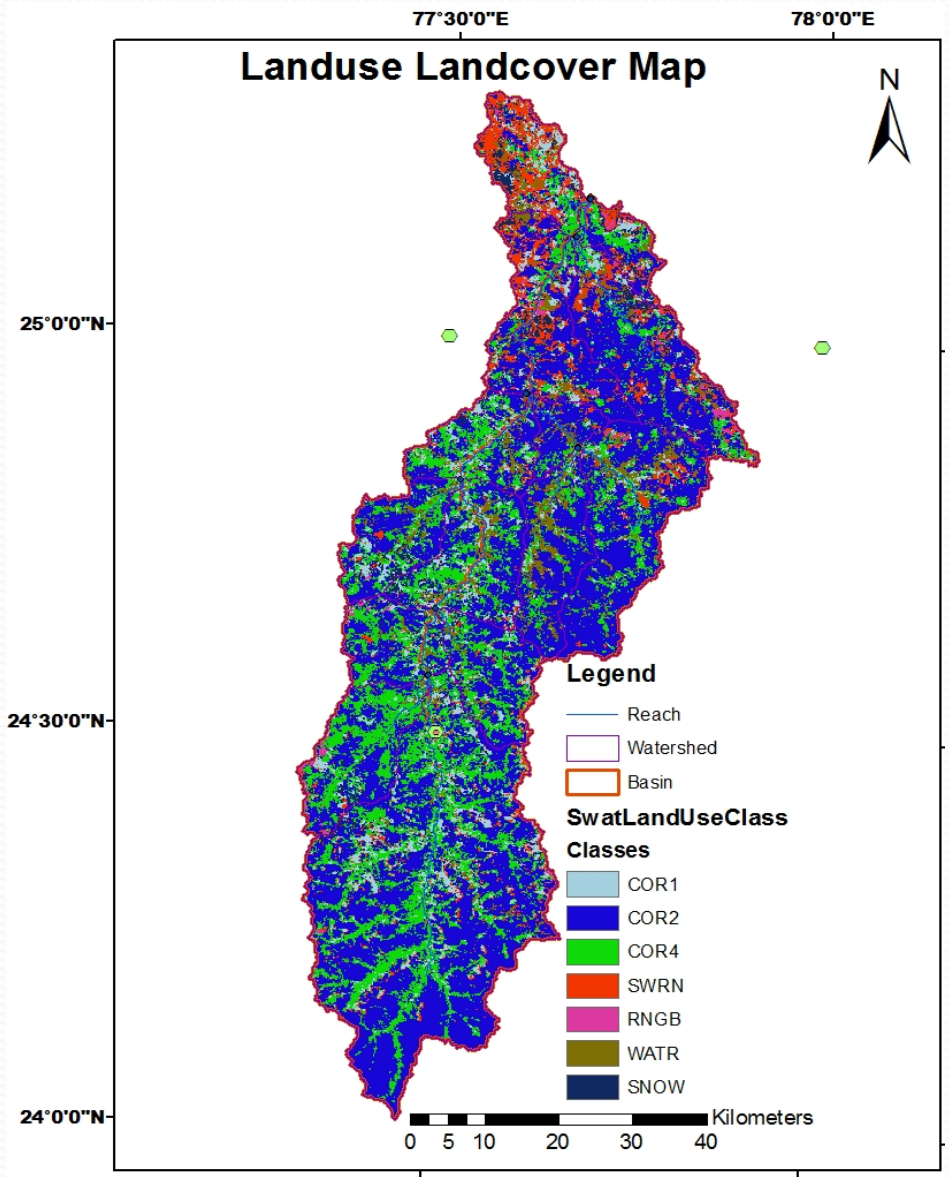
Study area (3806.34 km^2)location & DEM of Upper Sind River Basin

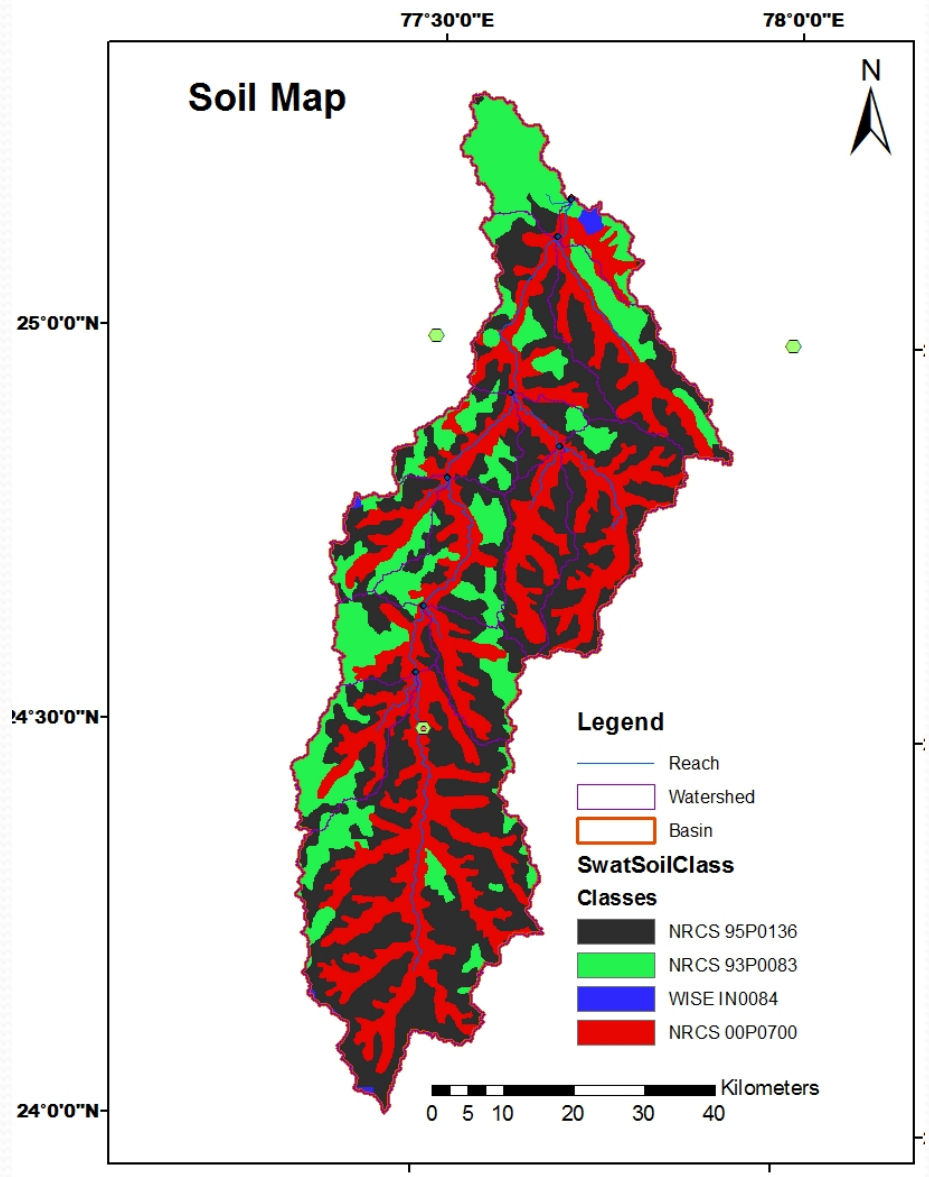




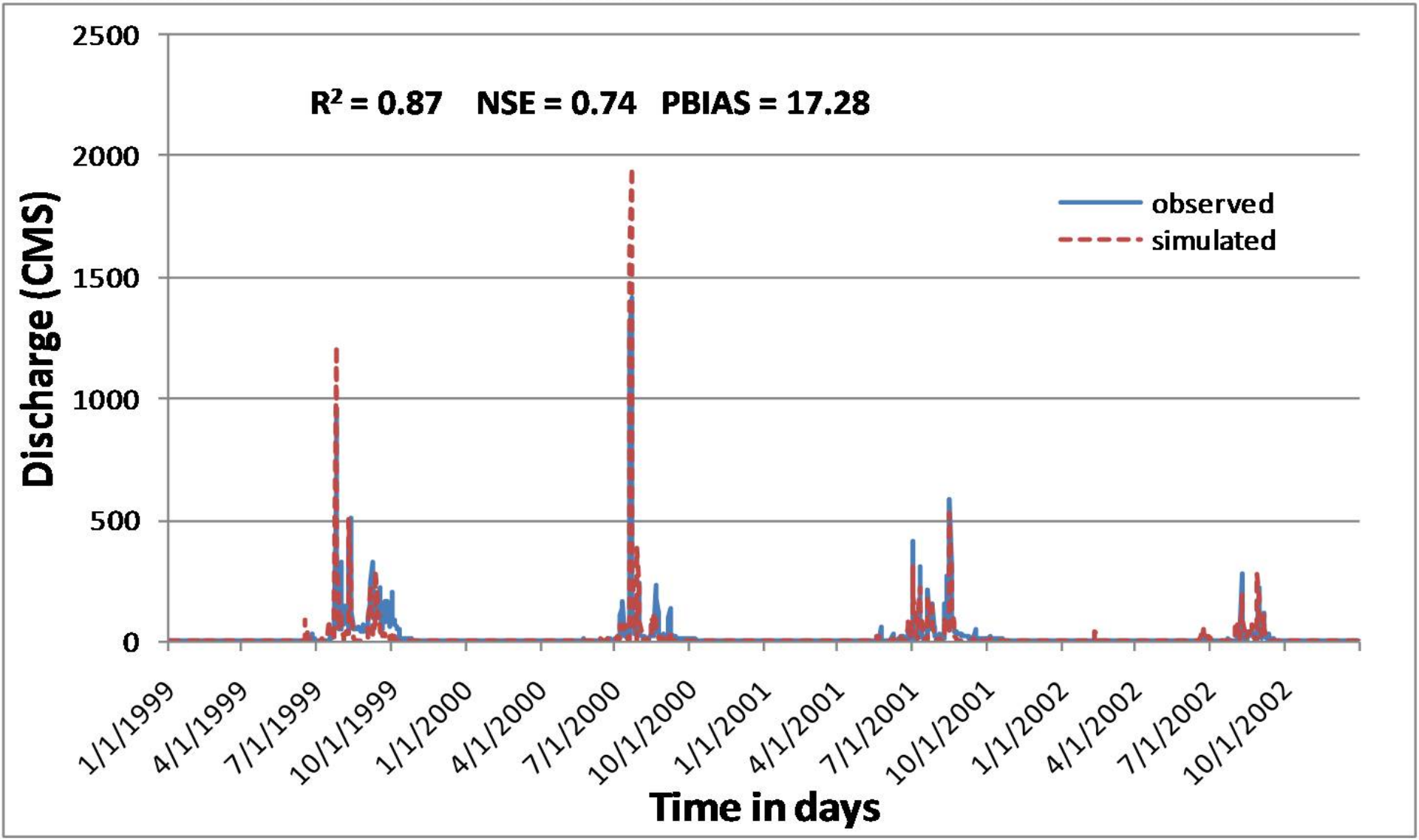
- The study area, Upper Sind river basin, a major sub basin of the Sind river basin in of India and is located between latitudes 24° 00’ 00” N to 25° 18’ 00” N and longitudes 77° 20’ 00”E to 77° 55’ 00”E.
- The altitude varies from 419 m in southwest and 561 m northeast with a mean of 519 m and standard deviation of 25.28 m.
- The main channel of the river drains a total land area of about 3,806.34 km^2 and Pachauli gauging station is located at drain point.
- The climate is semi arid to humid with annual rainfall varying from 800 - 1100 mm. The mean annual temperature and evapotranspiration are 21°C and 482 mm respectively.
- The dominant land use in the region is agriculture and the main food crops include wheat, soyabean, gram, millet, beans and the cash crops consist of mustard, rice, sunflower, and horticultural crops.
- The land cover is predominantly savannah, which consist of grassland interspersed with shrubs and trees.

Landuse Landcover and Soil Maps





Calibration of daily time series data at Pachauli river gauge station



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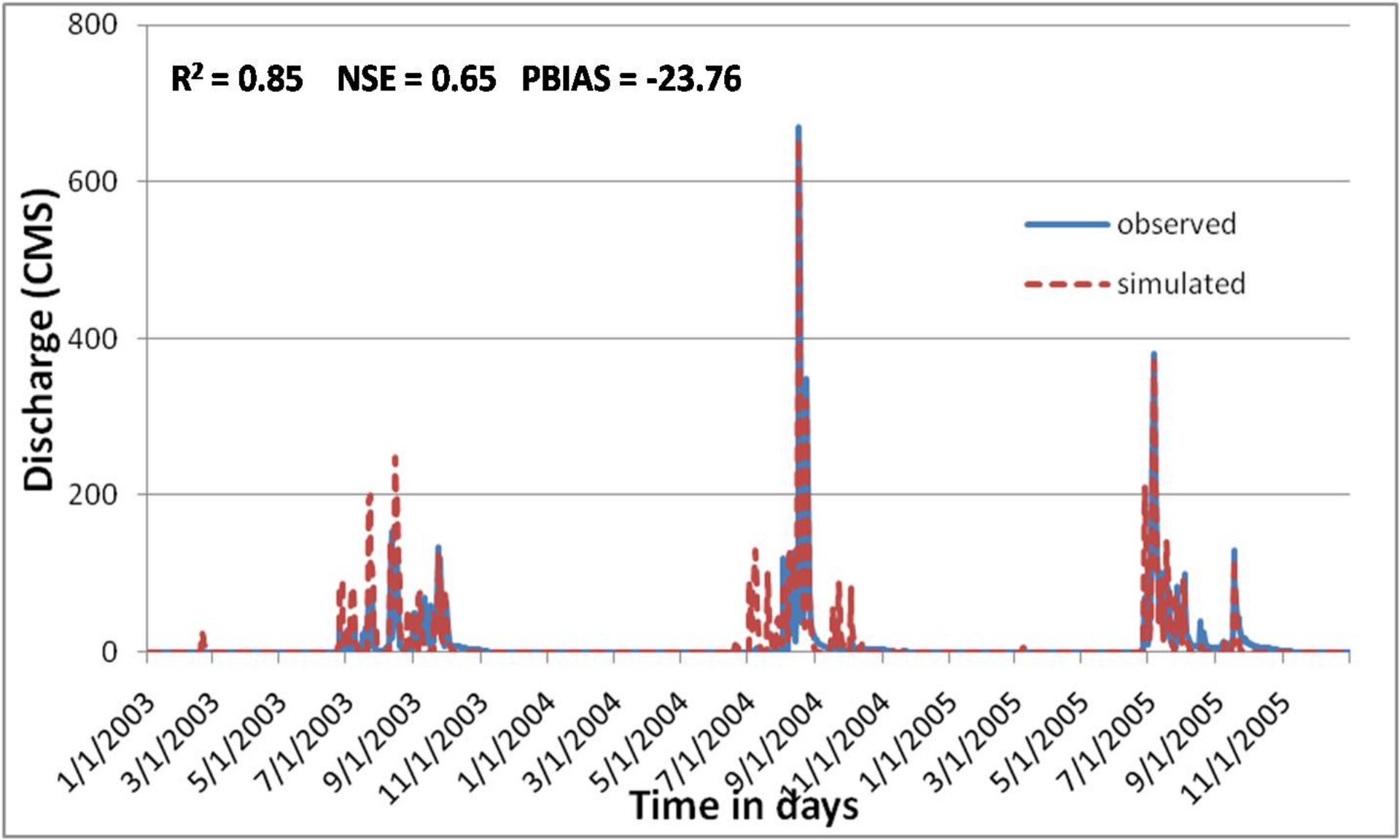

SWAT simulated annual water resources under present and future climate scenarios

Scenario	Simulation period	Mean Annual Rainfall (mm)	Potential Annual Water yield (mm)	Potential Annual Evapotranspiration (mm)
Present	1997 -2005	900	625 (32)	450 (25)
Future (Mid Century)	2021-2050	954	780 (45)	518 (31)
Percent change (%)		6	25	15

* Figures in brackets are coefficient of variation

Summary

- Future annual water yield and annual evapotranspiration in the basin shows increases over present.
- Water resources in the basin will be less reliable in future and more extreme events (floods and droughts) can be expected.
- Climate model ensembles and multiple scenarios will be useful for better understanding the impact of climate change on water resources due to uncertainties in climate forecasting.

Conclusions

- The SWAT model is well able to simulate the hydrology of the Upper Sind River Basin
- A common framework is recommended to provide integration across scales (integration of river basins) and sectors.
- Evaluation of interventions through simulation to address sustainability issues effectively under present and future conditions.
- Eco-hydrological approach based on concepts of blue and green waters may be considered in the water resources management practices by balancing water between human beings and nature.

Thank you