

Impacts of Climate Change and Socioeconomic Change on flows and nutrients in the Ganges

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University of Oxford

**ESPA Deltas:
ASSESSING HEALTH, LIVELIHOODS, ECOSYSTEM
SERVICES AND POVERTY ALLEVIATION IN POPULOUS
DELTAS**



Ganga Modelling Strategy

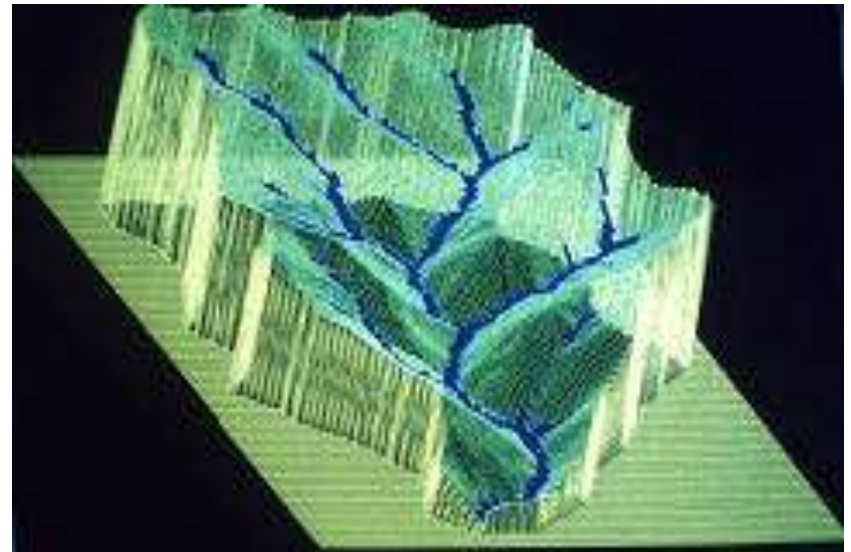
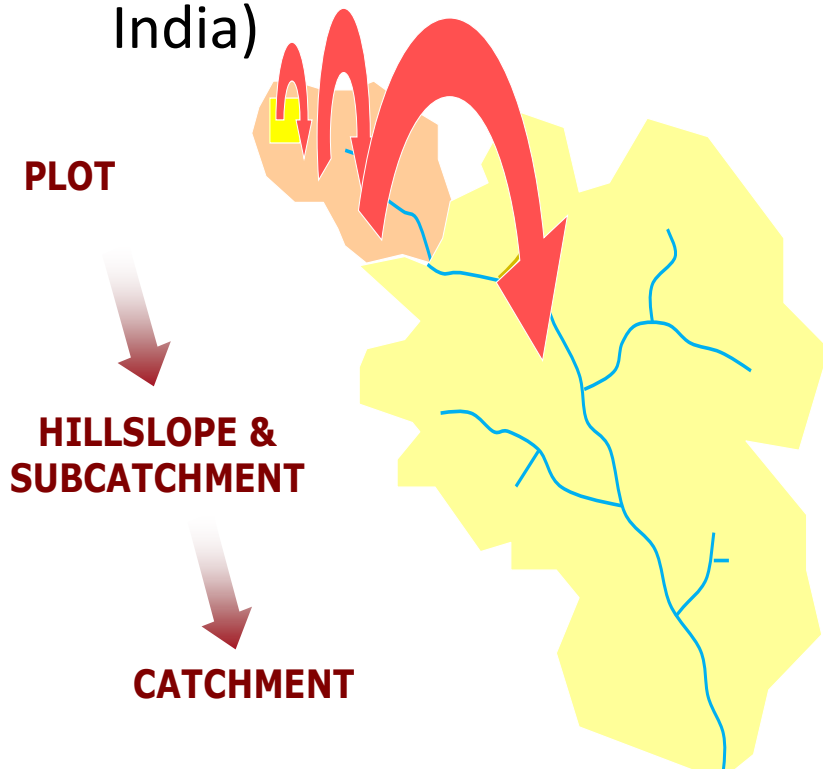
How will future climate change and socio-economic change in the Ganga River System---flows and nutrient fluxes moving down the river system



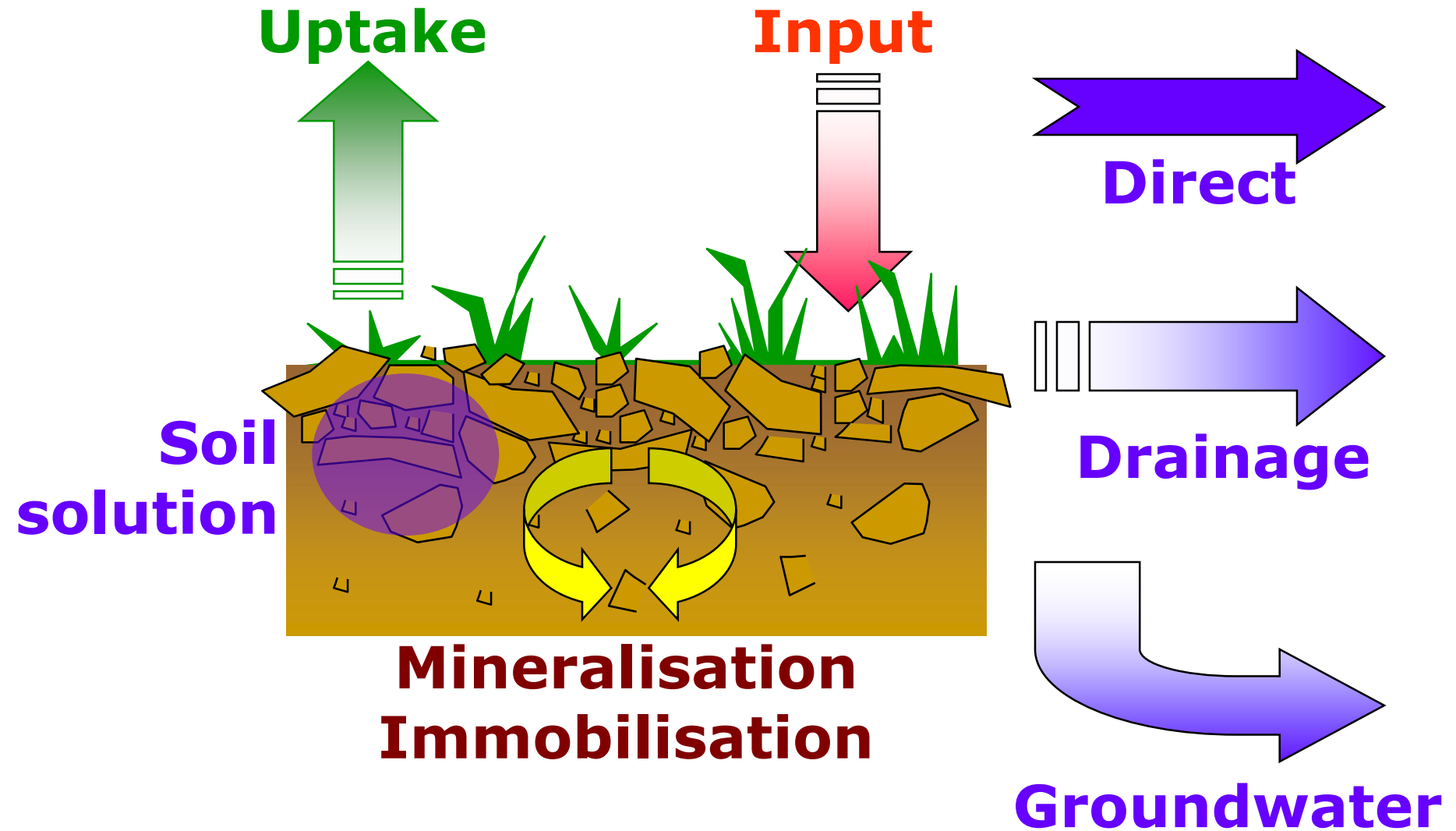
Integrated Catchment Model (INCA)

(Hydrology, Nitrogen, Phosphorus, Sediments, Carbon, Organics, Metals and Ecology)

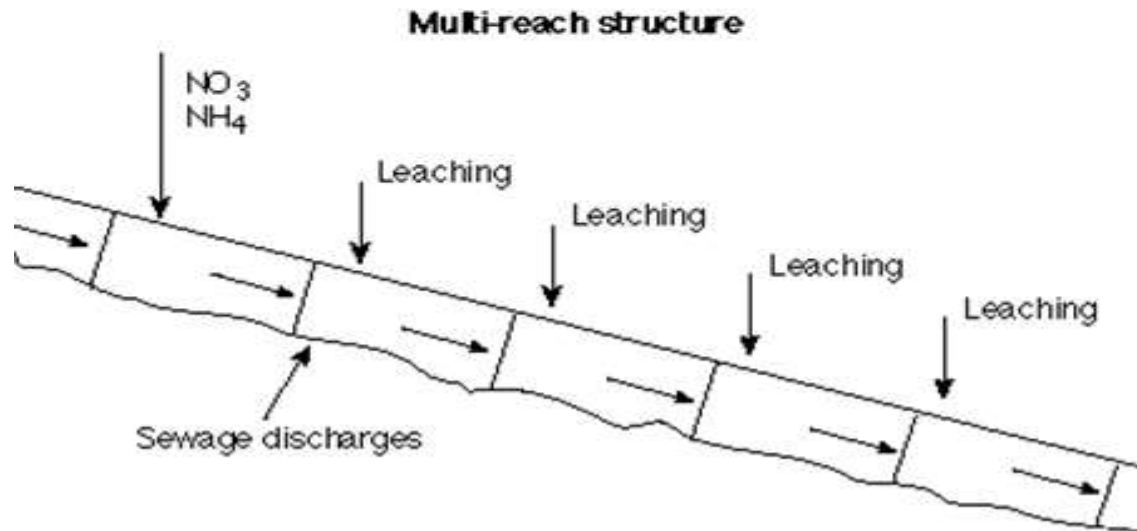
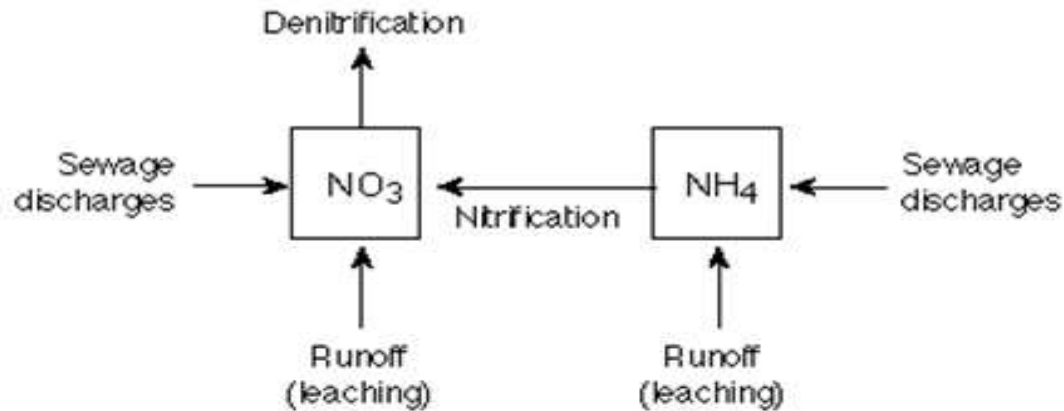
- Can account for diffuse and point sources of pollution, land use change and climate change
- Semi distributed and successfully applied to over 50 catchments (including catchments in Nepal and India)



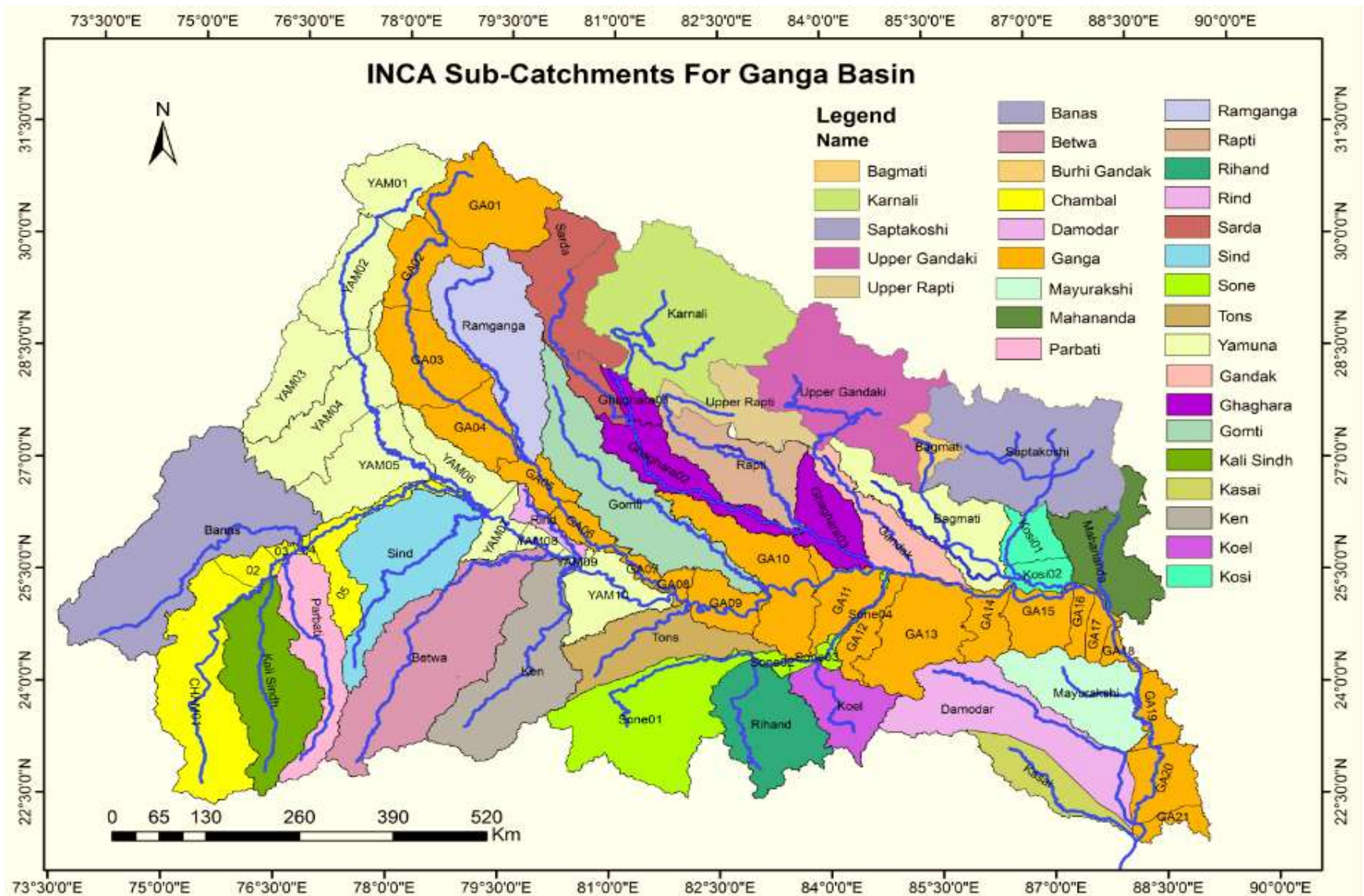
INCA-P Internal mechanisms (kg ha⁻¹ day⁻¹)



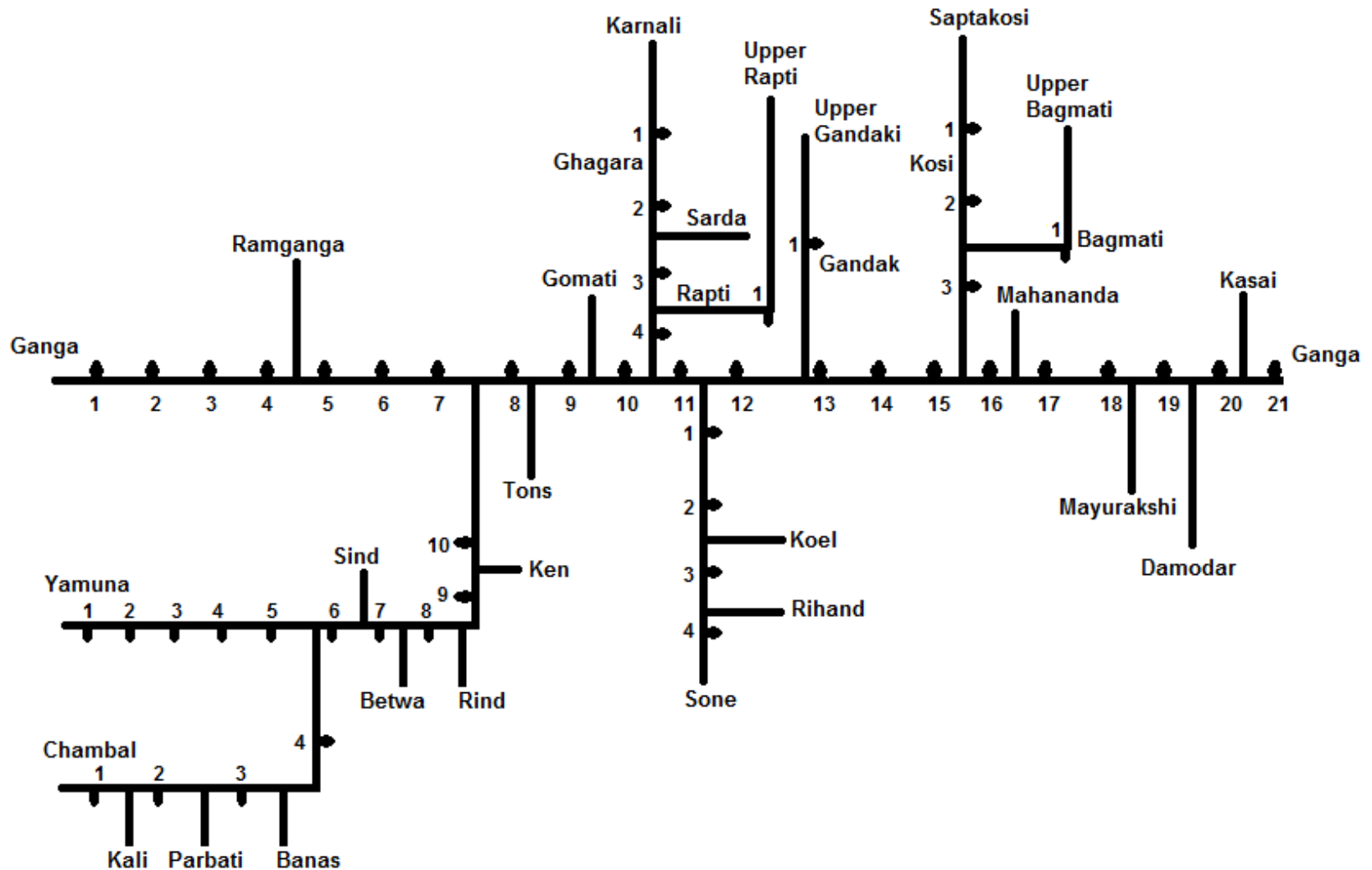
Instream Mass Balance and Processes



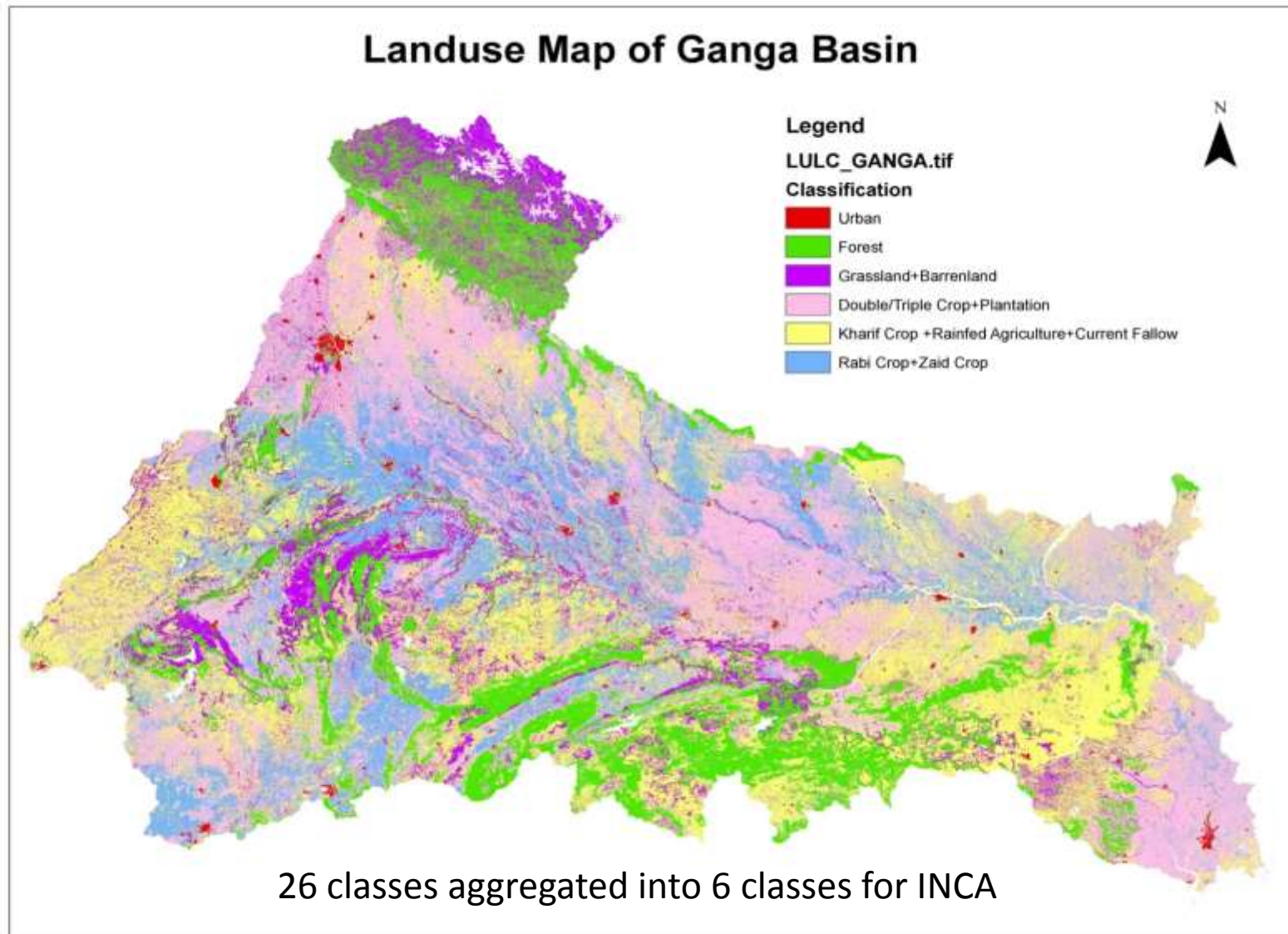
Modelled Sub-Catchments in Ganga



INCA Reach Structure for the Ganges

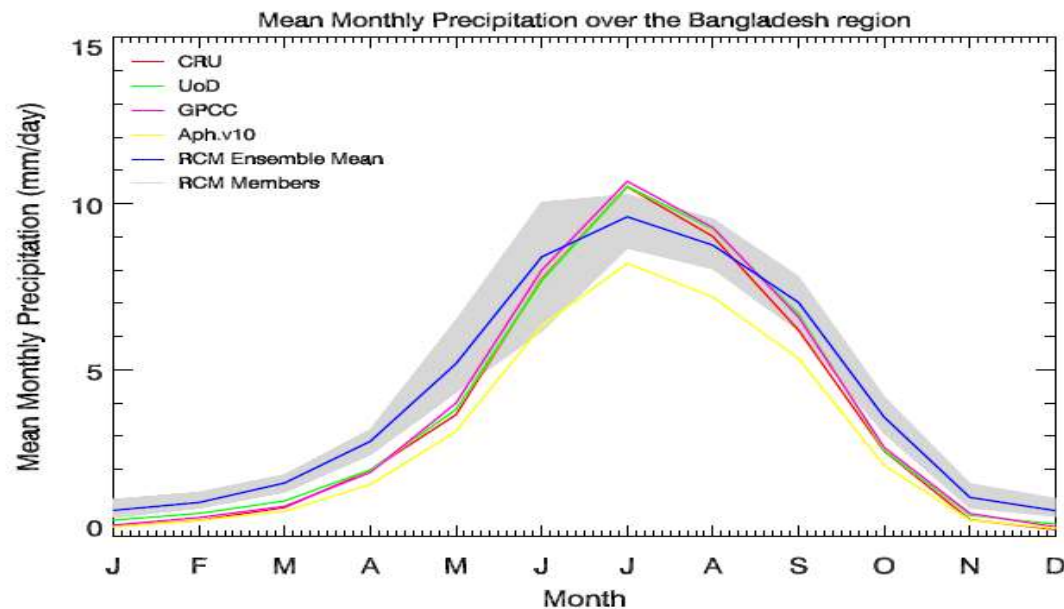
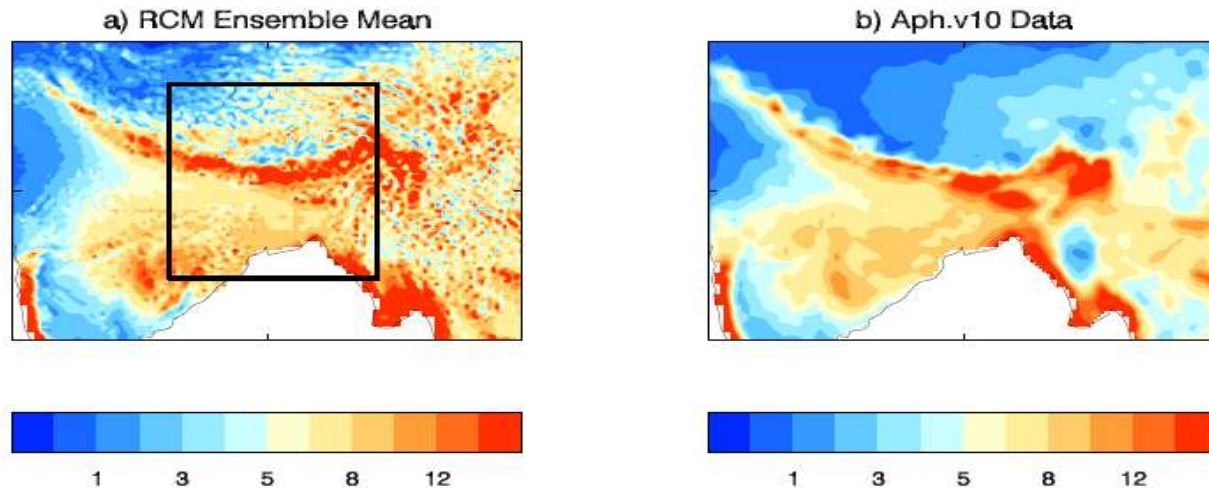


Detailed Land Use Mapping

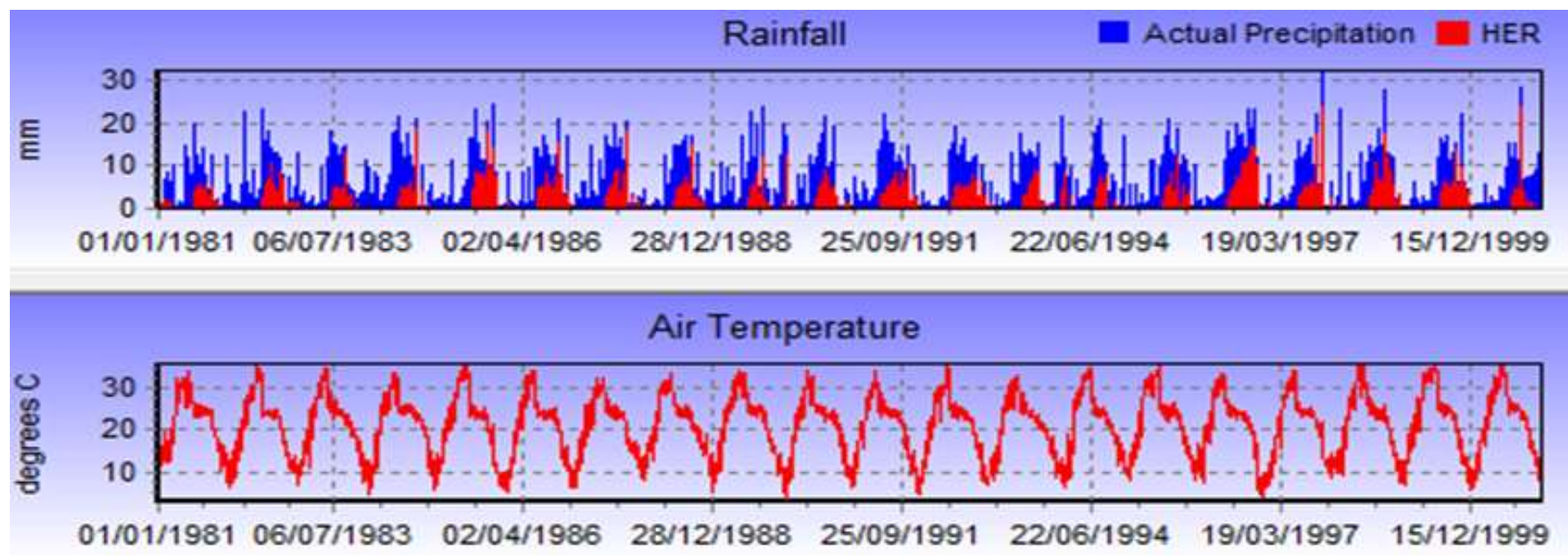


Met Office Hadley Centre HadRM3P RCM

25km grid- evaluated for spatially and temporal Patterns in Temperature and Precipitation

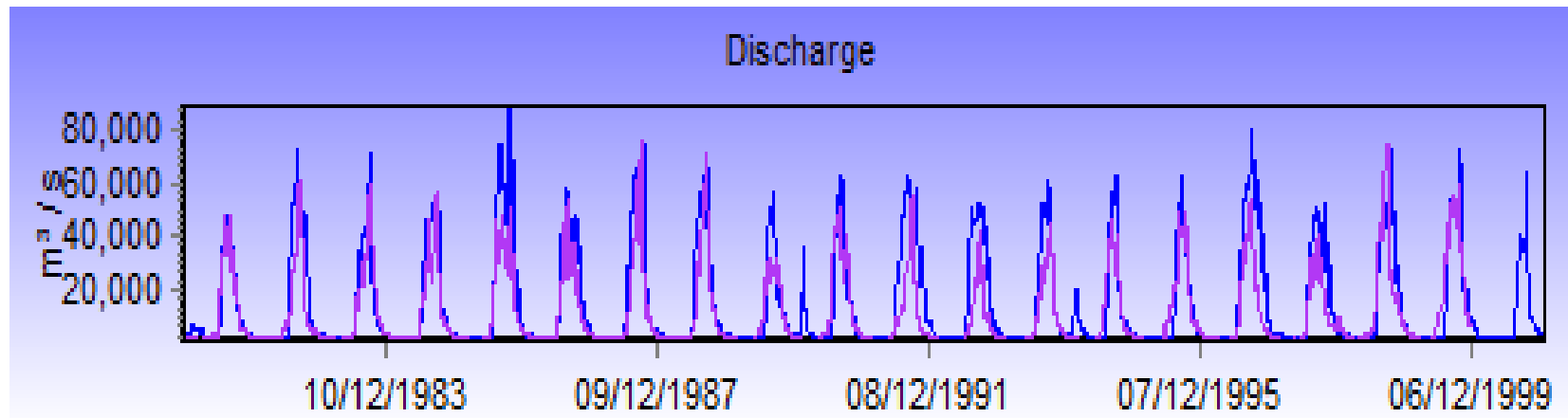


Time Series Inputs for INCA Model



1981-2000
(Daily time series data)

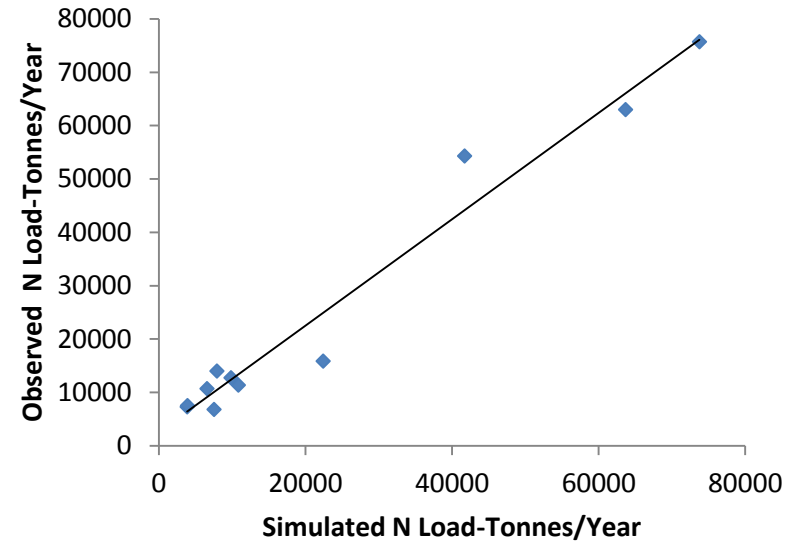
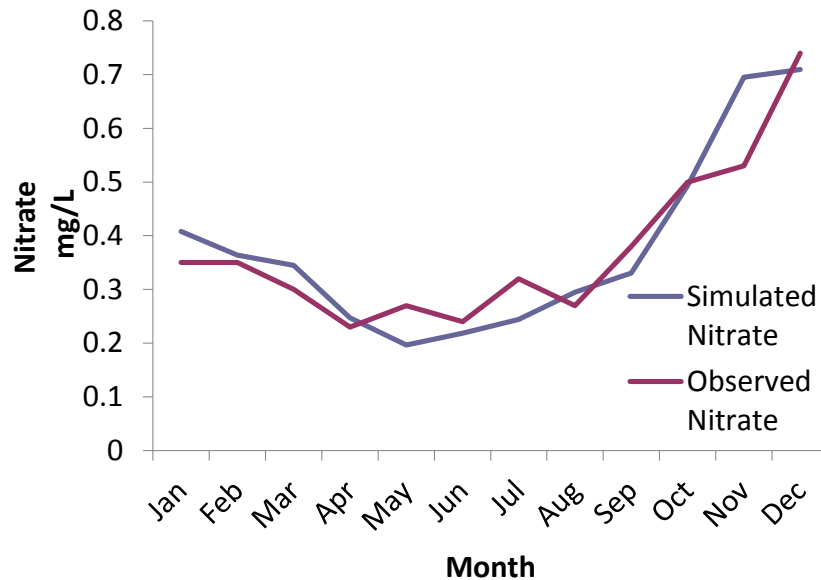
Model Calibration - flow gauges on the Ganga River system



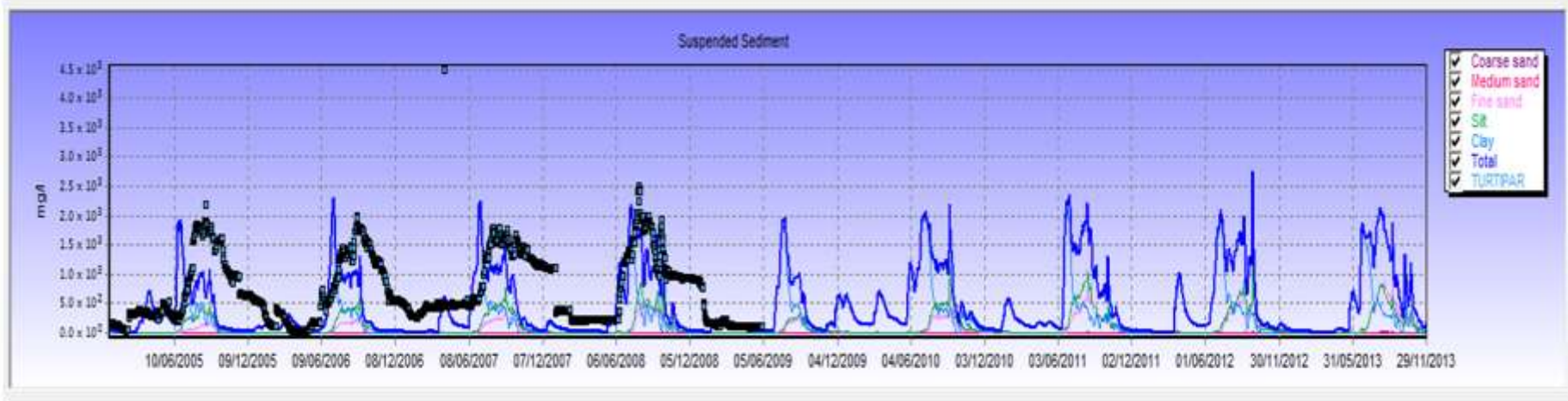
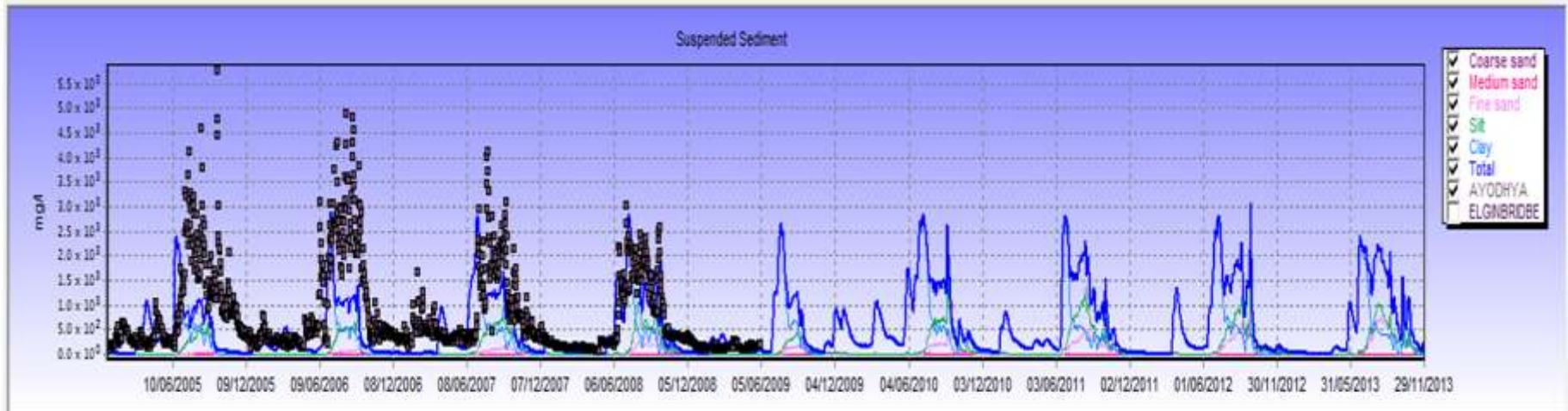
Hardinge
Bridge

Calibration of N concentrations and Flux

At Kanpur (Reach GA06)



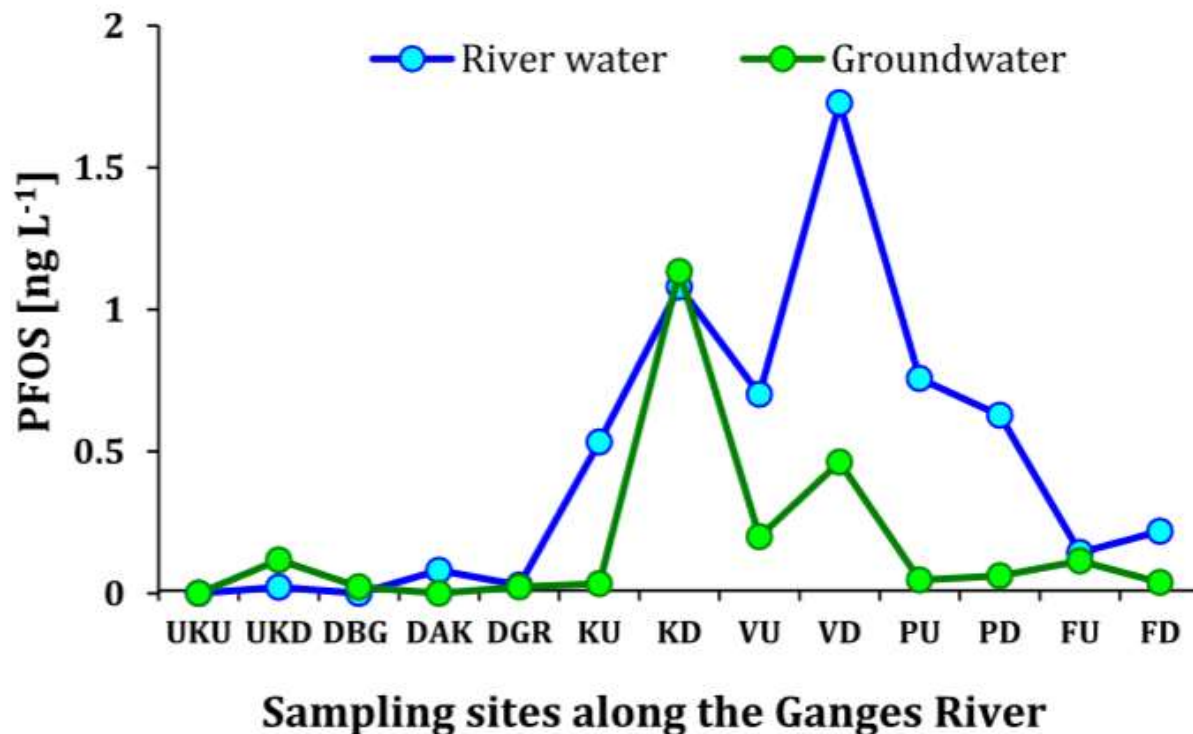
Sediment simulations



Persistent Organic Pollutants (POPs)

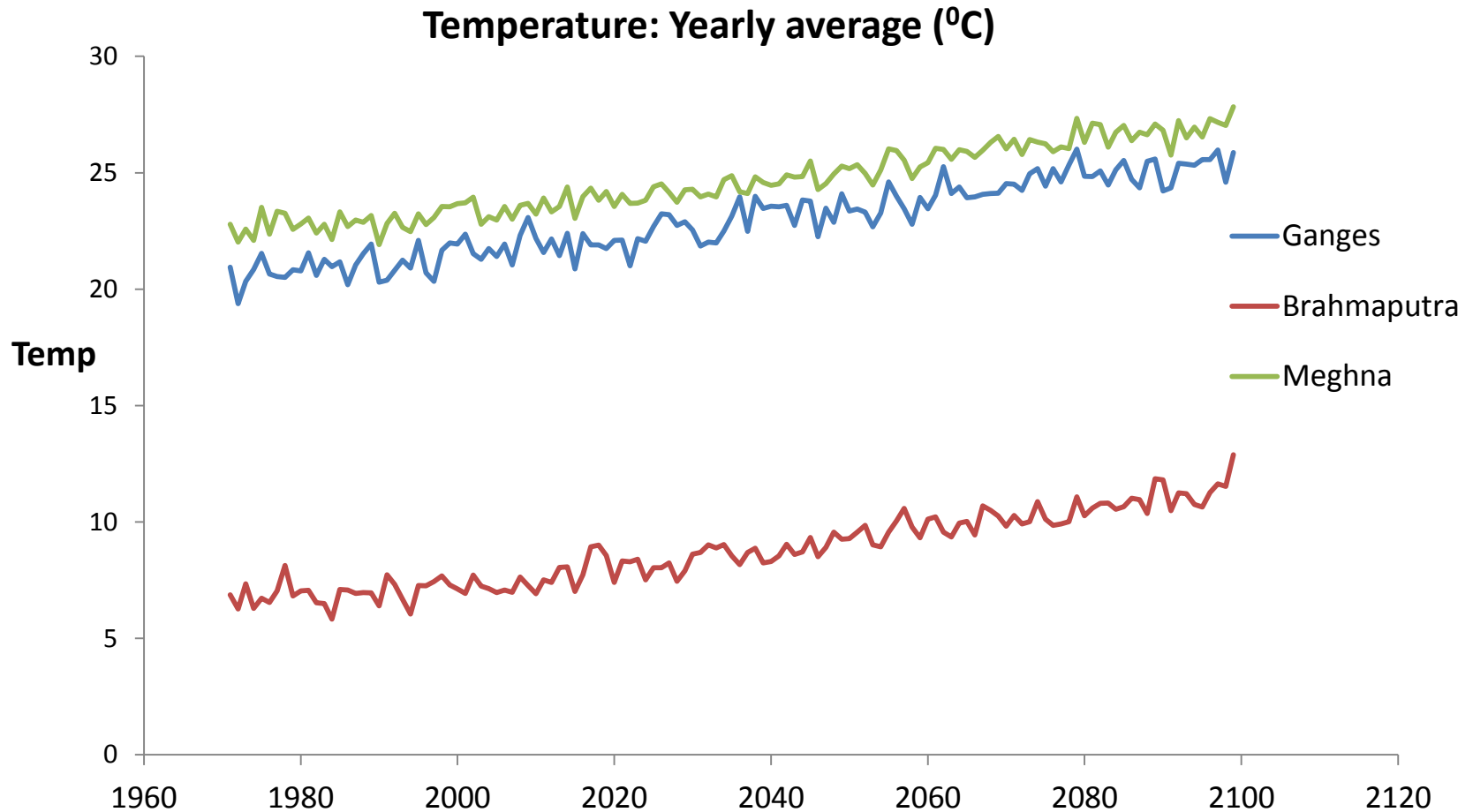
Perfluoroalkyl substances (PFAS) in river and ground/drinking water of the Ganges River basin: Emissions and implications for human exposure

Brij Mohan Sharma ^{a,*}, Girija K. Bharat ^b, Shresth Tayal ^{a,b}, Thorjørn Larssen ^c, Jitka Bečanová ^d, Pavlína Karásková ^d, Paul G. Whitehead ^e, Martyn N. Futter ^f, Dan Butterfield ^g, Luca Nizzetto ^{c,d,**}

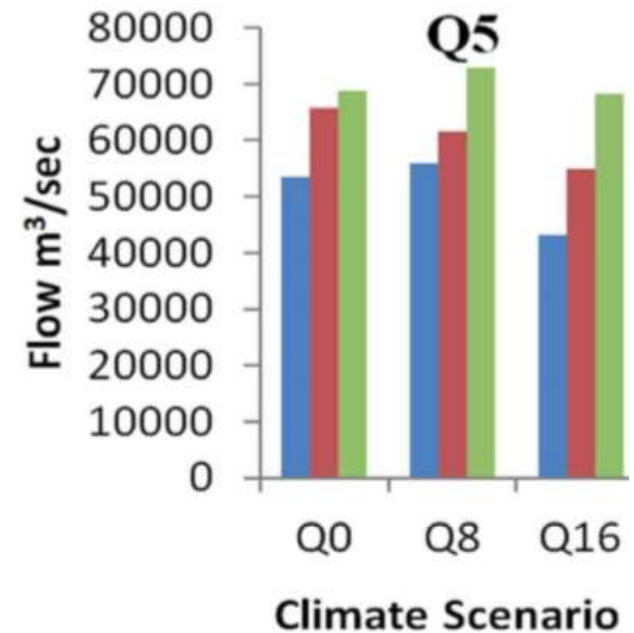
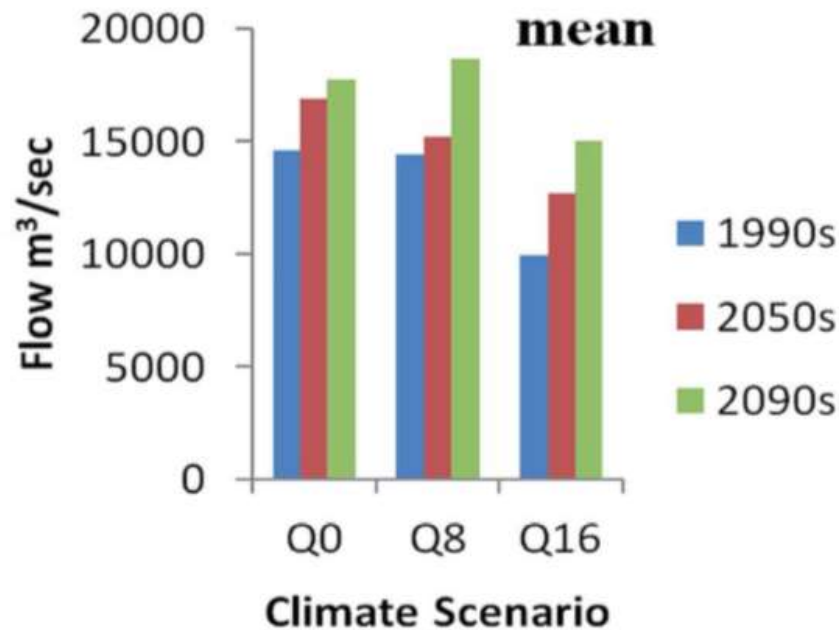


Climate Scenarios – 17 realisations

Moderately warmer/wetter

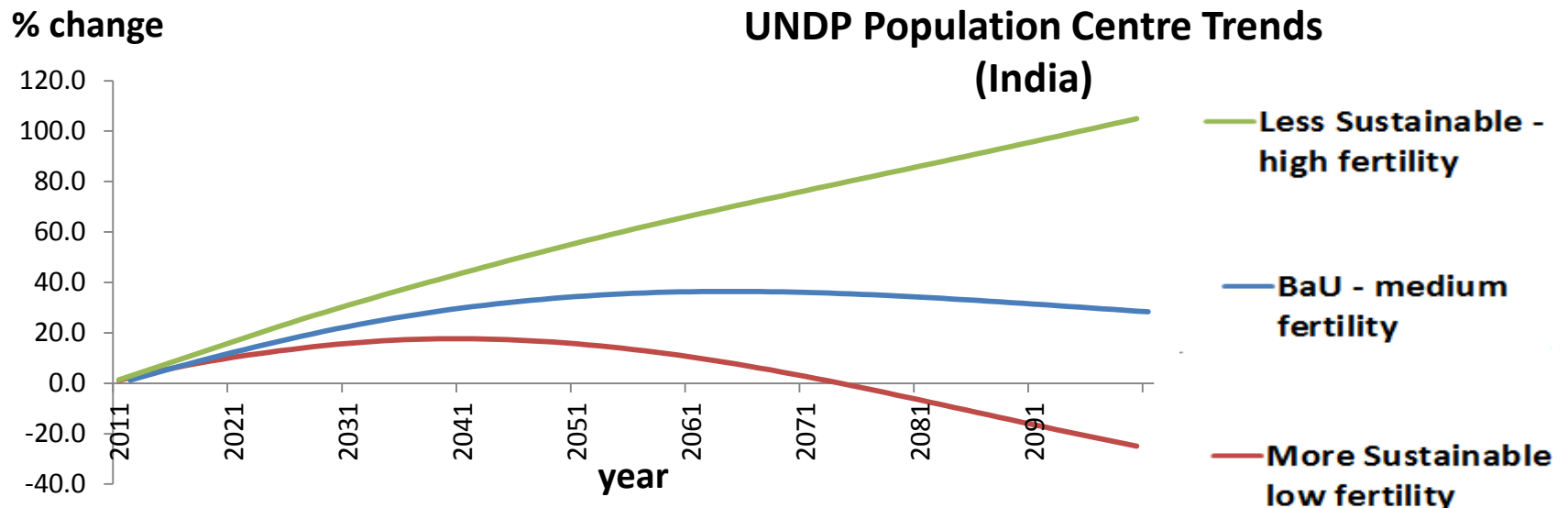


Impacts of Climate Change on Flows



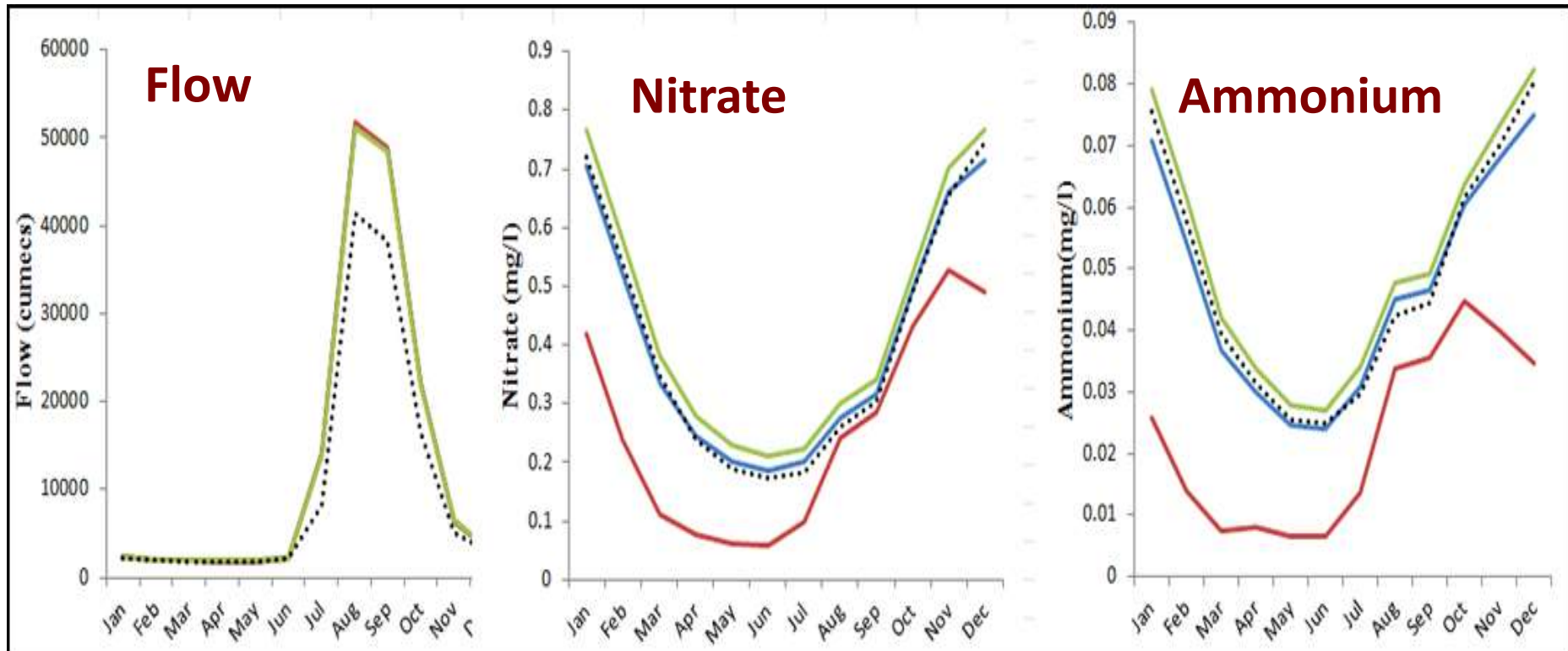
Industry---Socio-economic Scenario Analysis

- Population changes
- Sewage treatment works capacity and design for water quality control
- Water demands for irrigation and public supply
- Atmospheric nitrogen deposition
- Land use change
- Water transfer plans



Effects of Climate and Socio-economics on Ganga Flow and Water Quality

Blue – BaU; Red – MS; Green – LS; Dotted – baseline 1990s



- No major difference in flows (no major change in irrigation flows & water transfers simulated)
- Large reduction in N and NO_3 under MS scenario – reflects improved effluent treatment, implications for river ecology and reduced nitrogen load into Bangladesh (similar results for P)

Stakeholder driven process to evaluate scenario analysis– do they make sense – if so how should they affect policy at a National, Regional and Local Level

