Water and Industry

- Water Demands – conflicts with water for public supply and also water for irrigation and agriculture
- Water Quality– discharges from Industry and impacts
- Organic loads causing problems with Dissolved Oxygen levels in rivers– affecting ecology/fisheries etc
- Nutrients– supplementing diffuse runoff from agriculture
- Pathogens
- Metals– tanneries
- Other Contaminants – eg POPs, Pesticides, Herbicides, antibiotics etc

Modelling flow and water quality in the Ganga catchment: Impacts of pollution control strategies and climate change

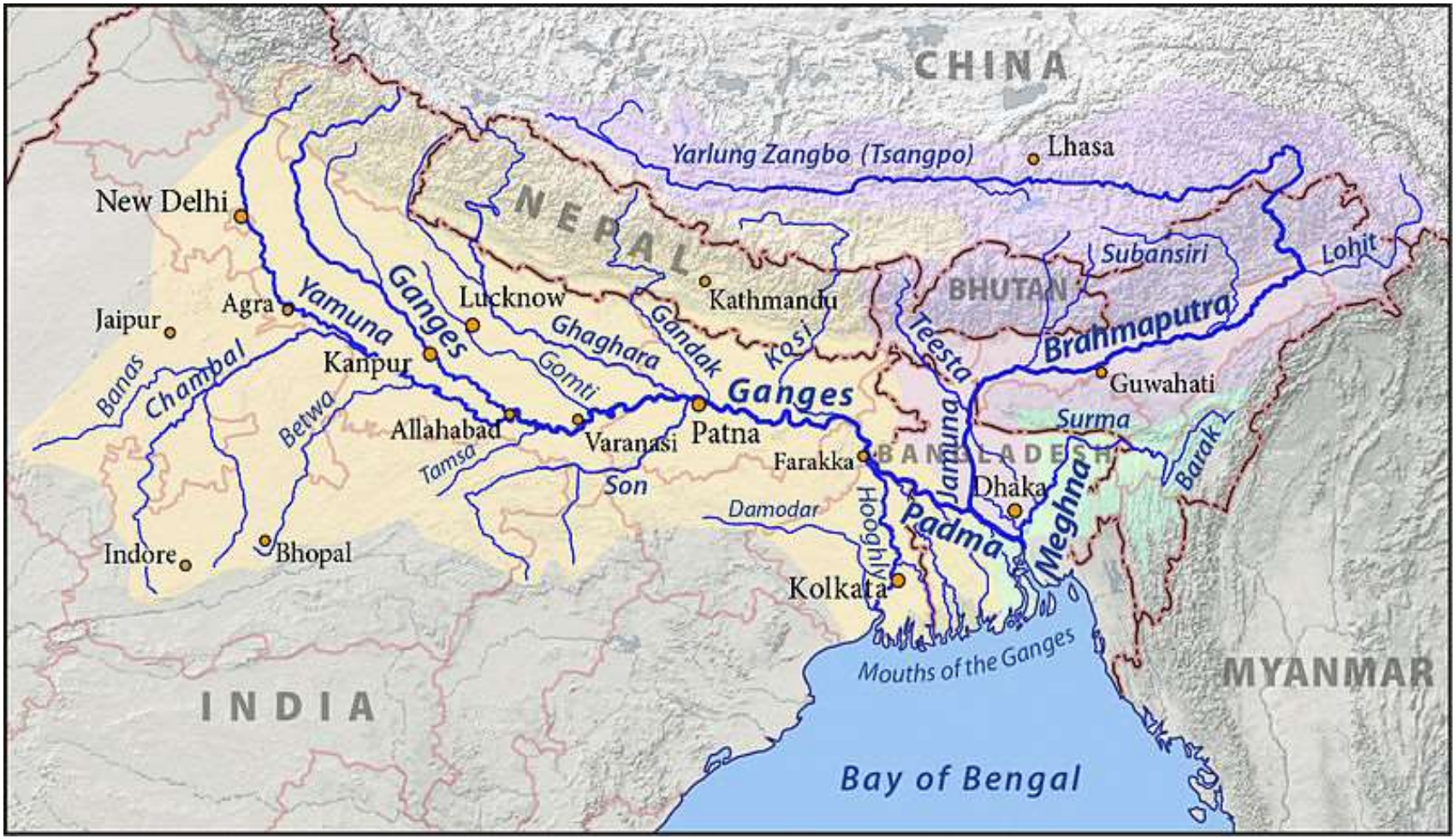
Prof Paul Whitehead

University of Oxford

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

Ganga Modelling Strategy

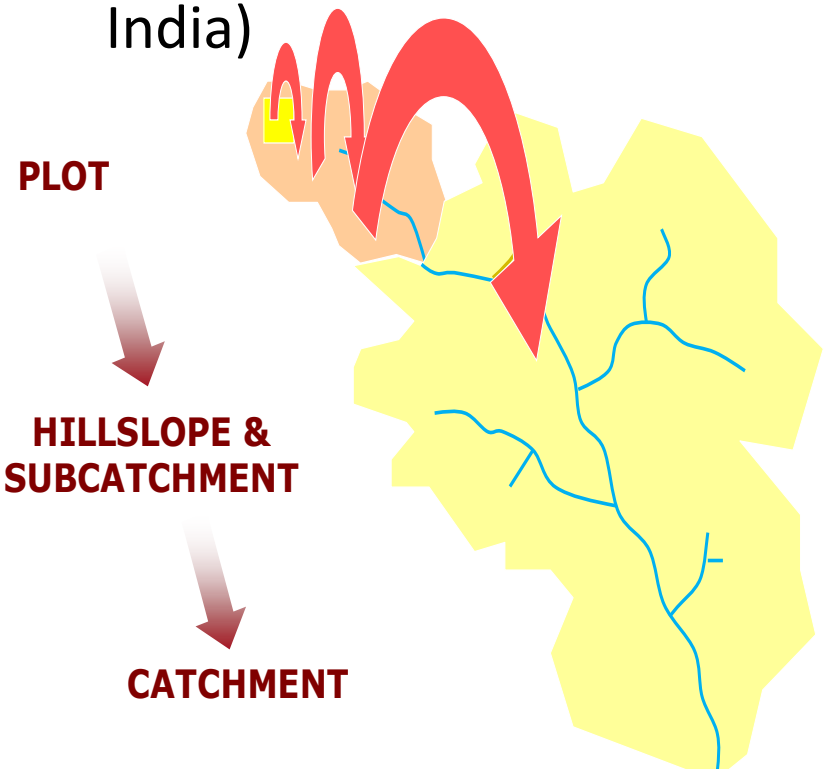
How will future climate change and socio-economic change in the Ganga River System---flows and nutrient fluxes moving down the river system

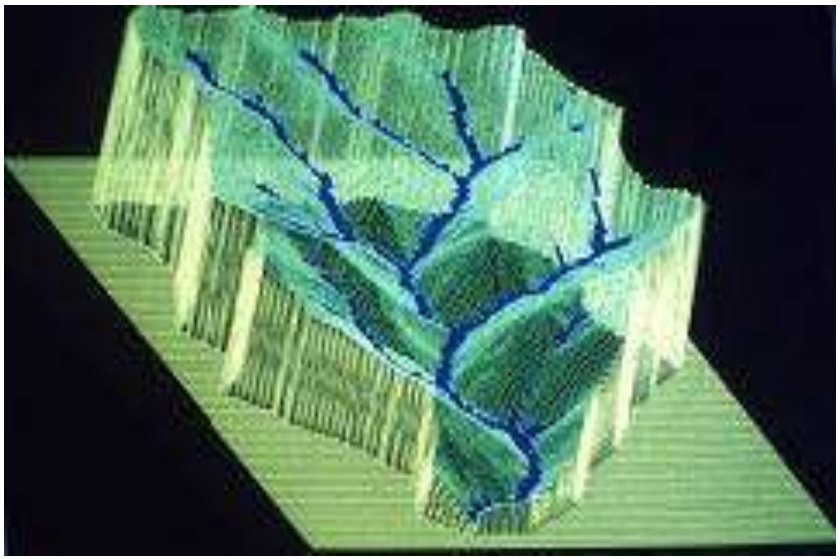


Integrated Catchment Model (INCA)

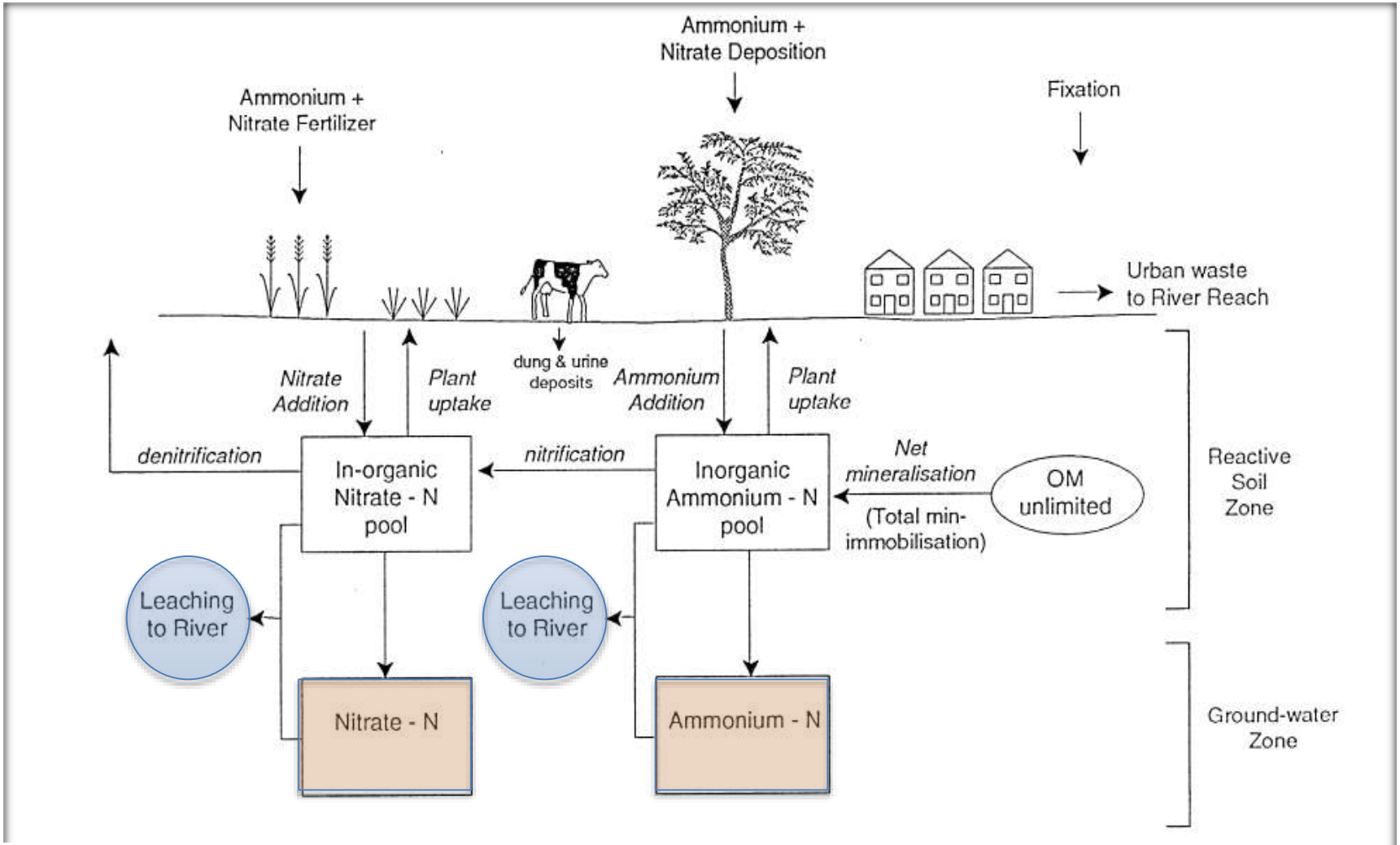
(Hydrology, Nitrogen, Phosphorus, Sediments, Carbon, Organics, Metals and Ecology)

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



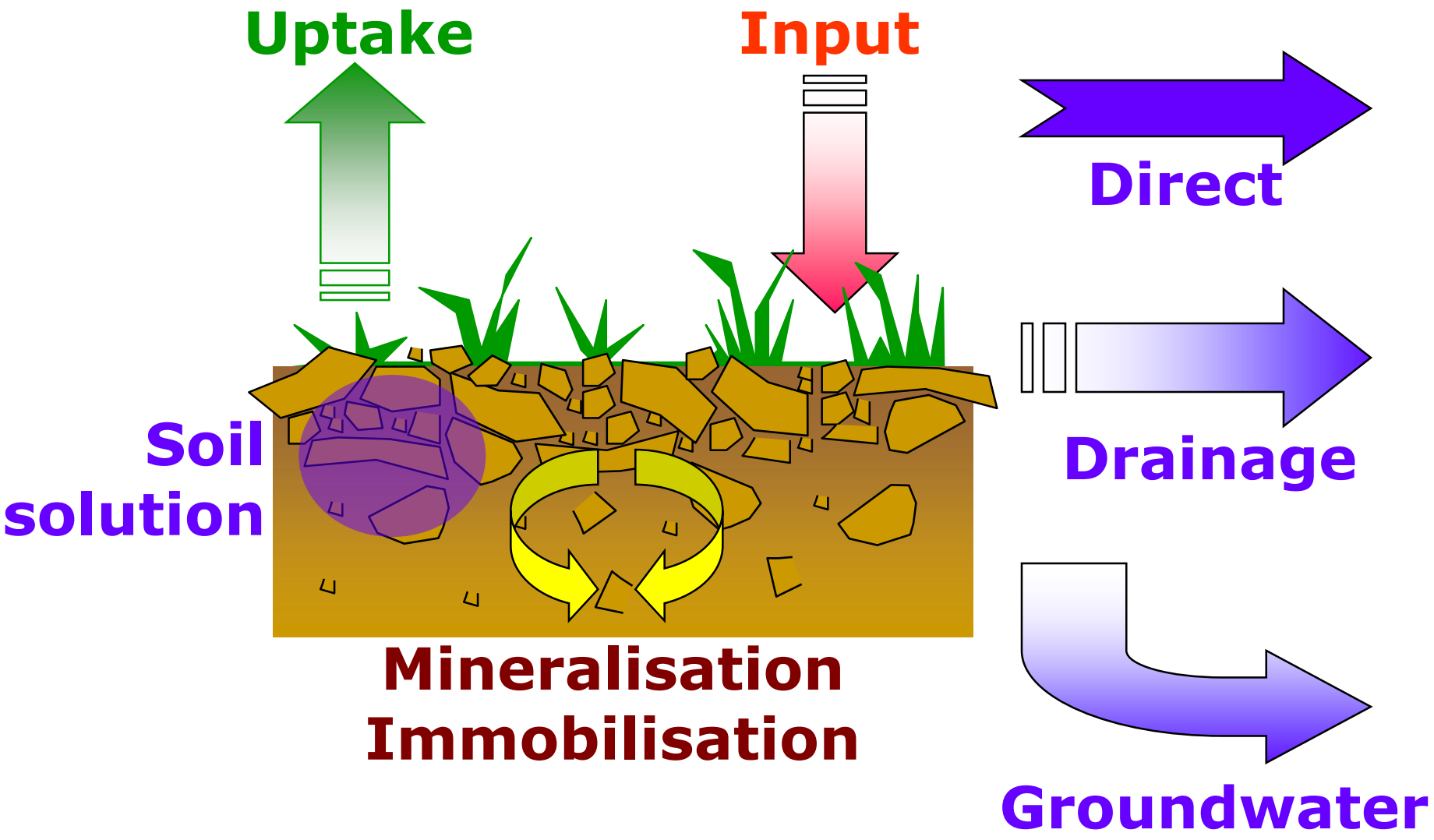


The INCA-N NITROGEN Model Process Pathways

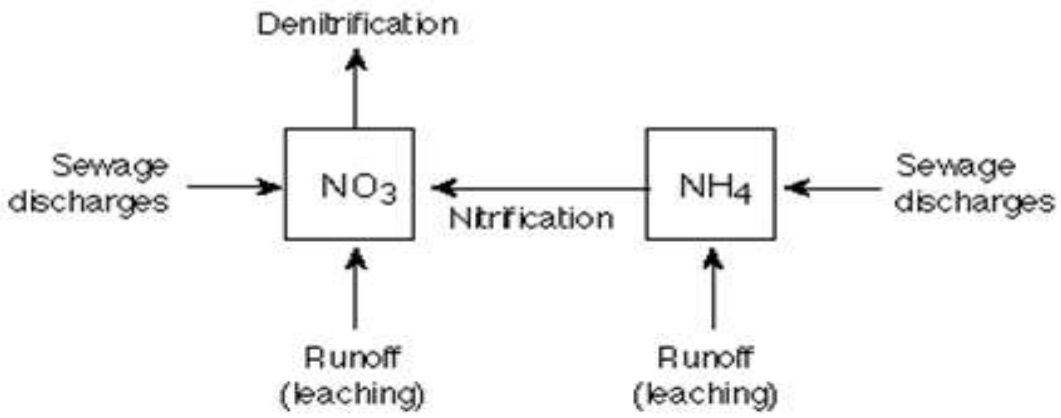


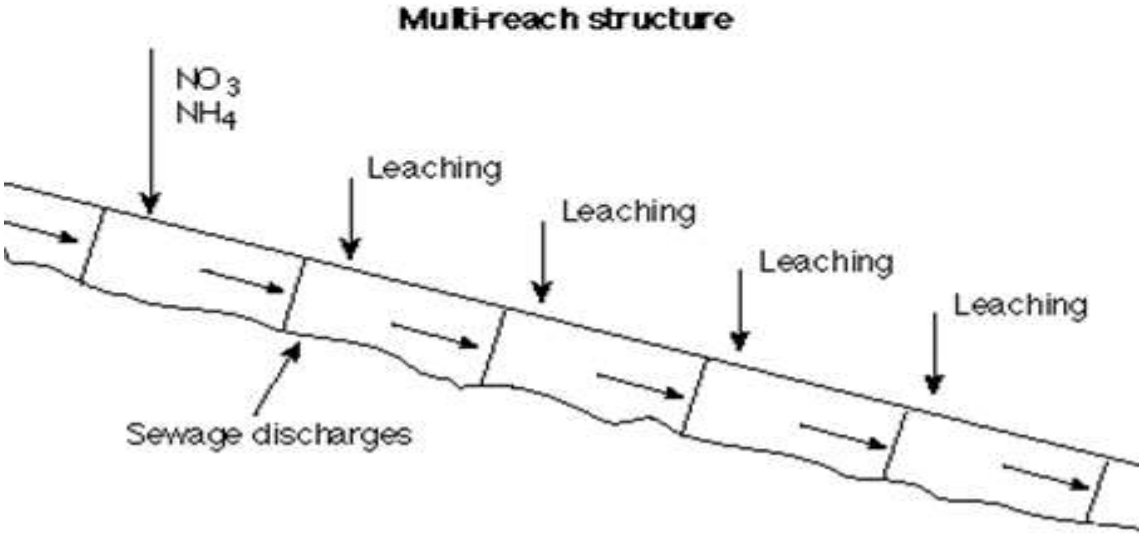
Source: P.G. Whitehead et al./The Science of the Total Environment 210/211 (1998) 547-558

INCA-P Internal mechanisms (kg ha^{-1} day^{-1})



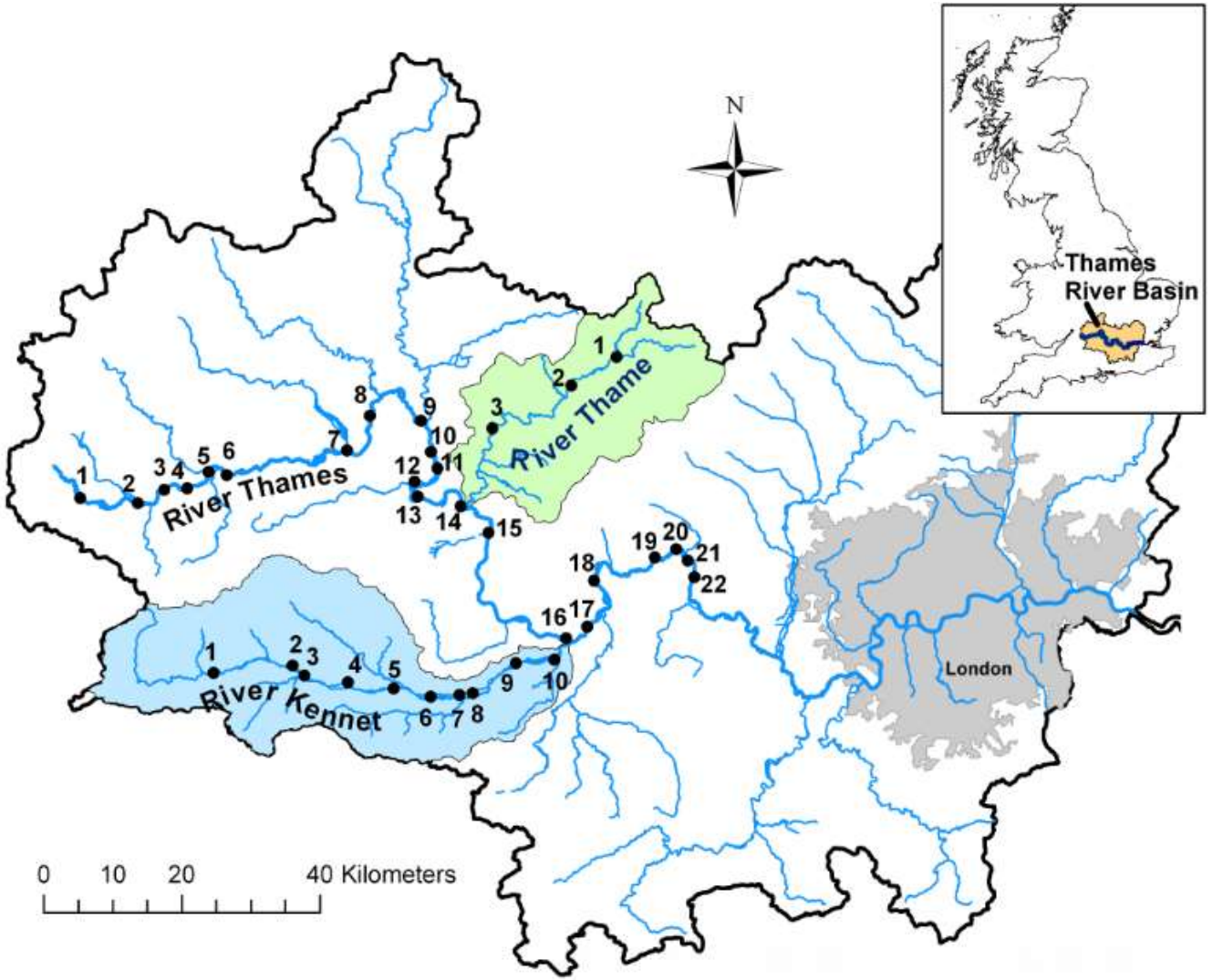
Instream Mass Balance and Processes



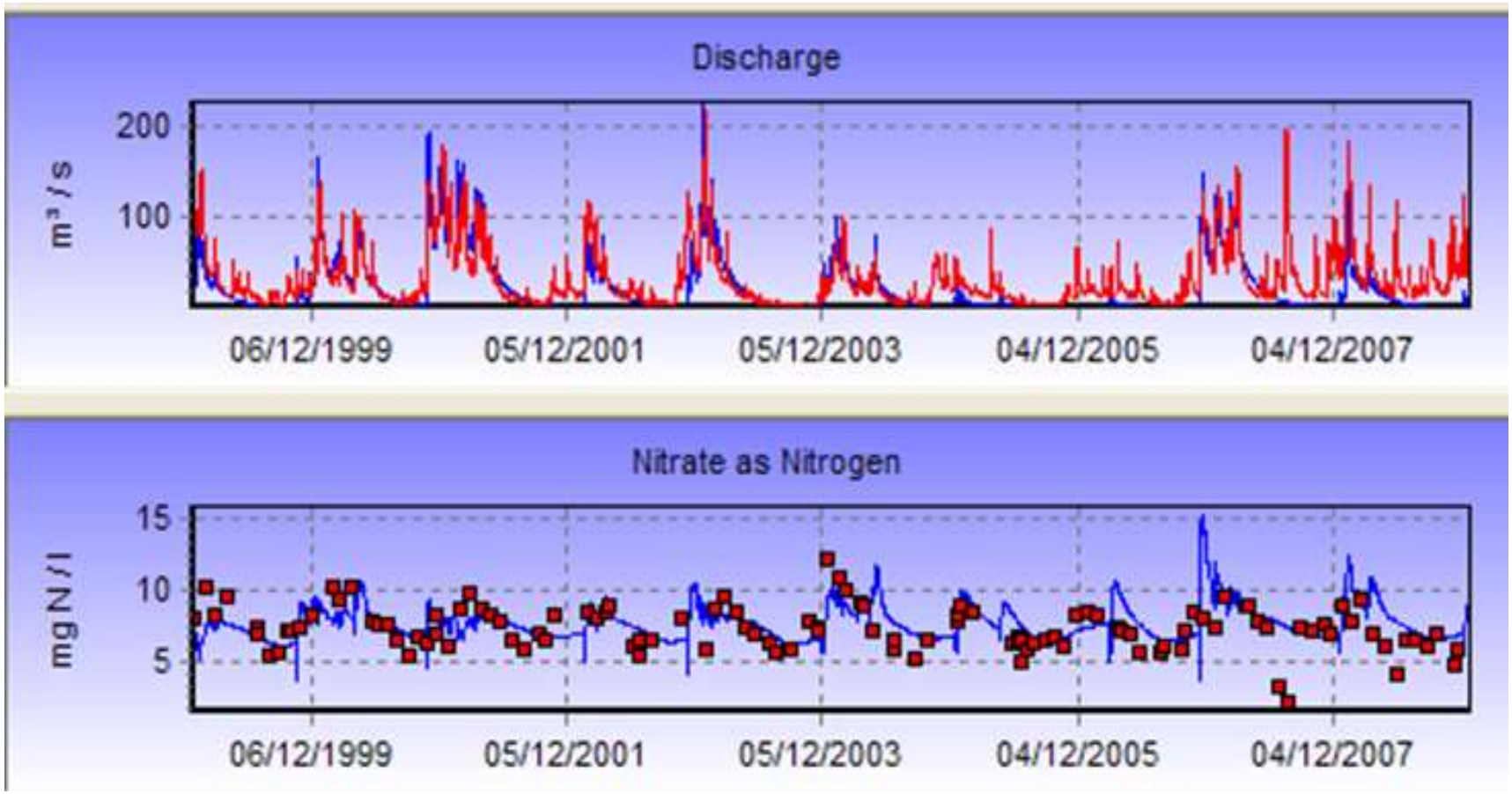


River Thames and London

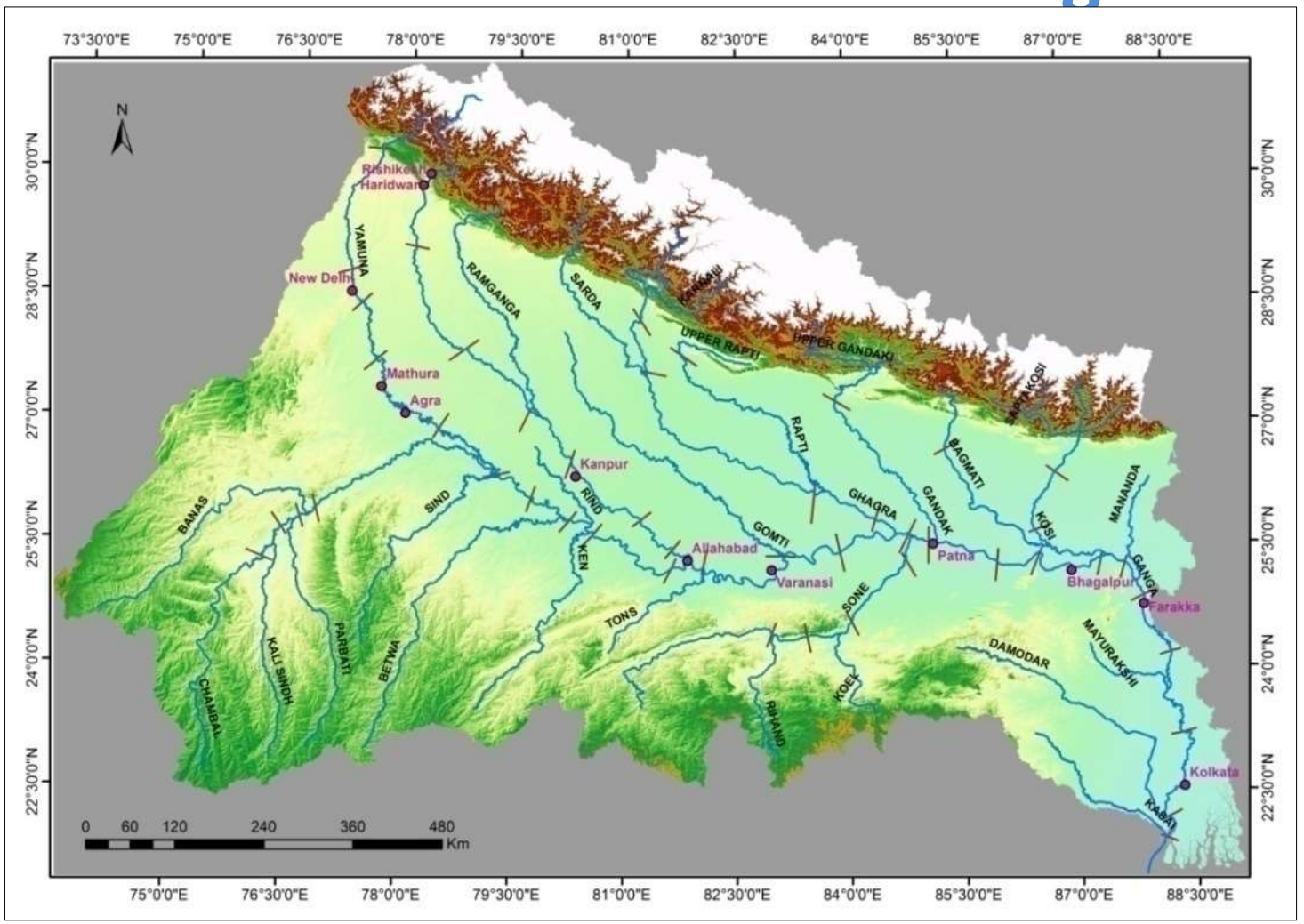
Thames Catchment



River Thames simulation for 1999-2008 Hydrology and Nitrate –N



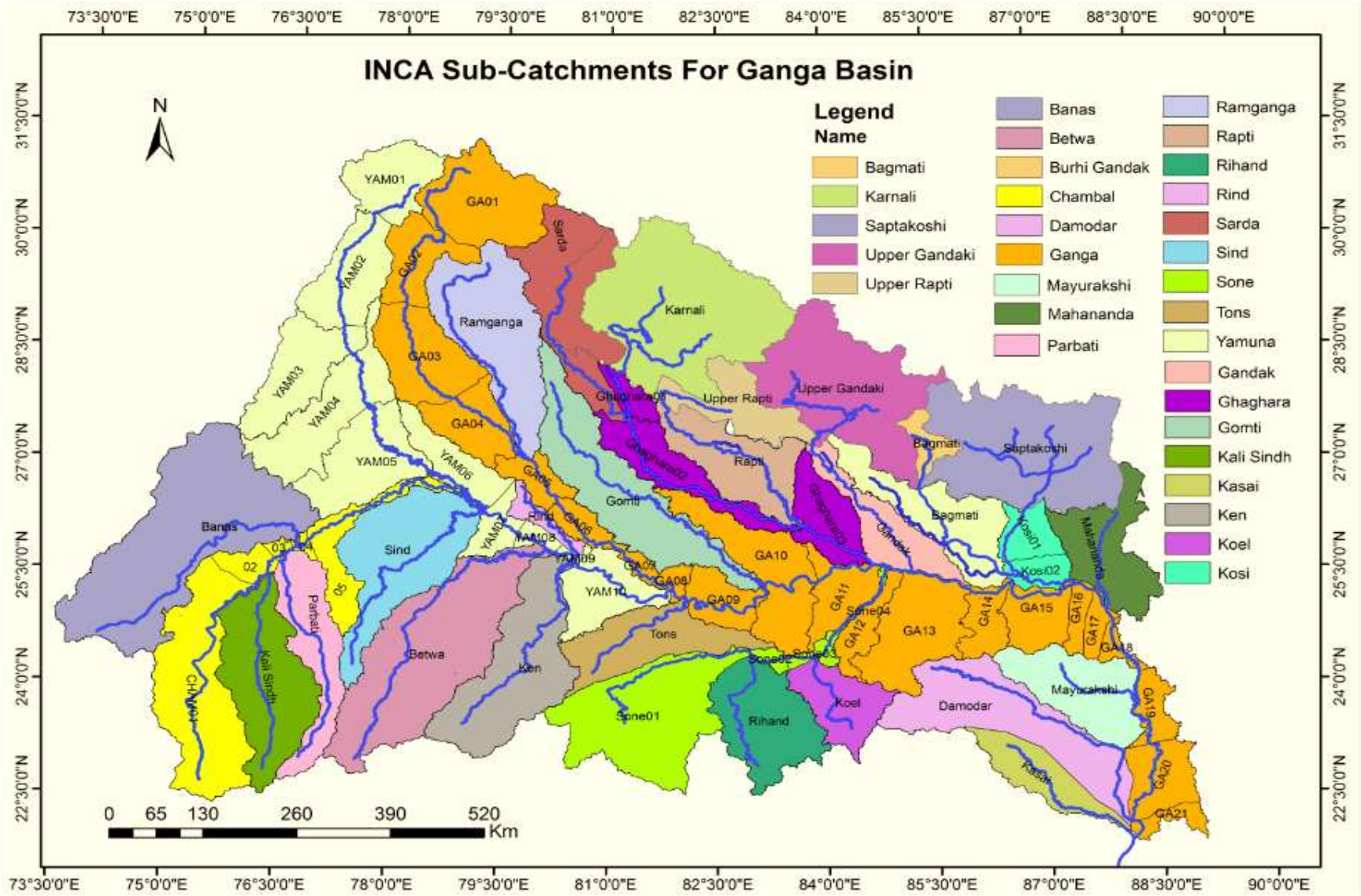
INCA reach divisions for Ganga basin



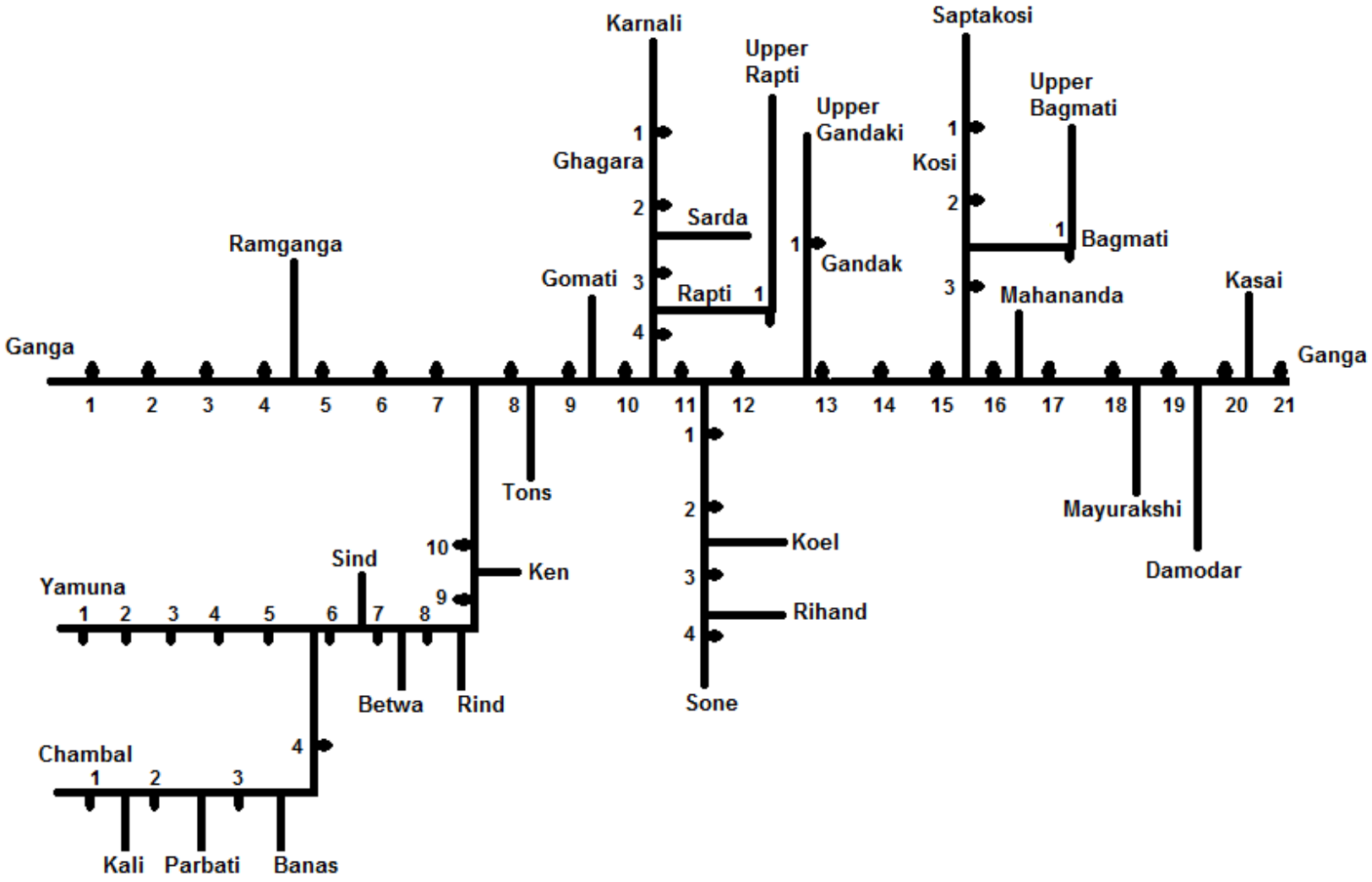
Total 70 reaches
Ganga – 21 reaches
Yamuna – 10 reaches
Other tributaries – 39 reaches

Tributary confluence
Sampling/monitoring point
Effluent input/abstraction

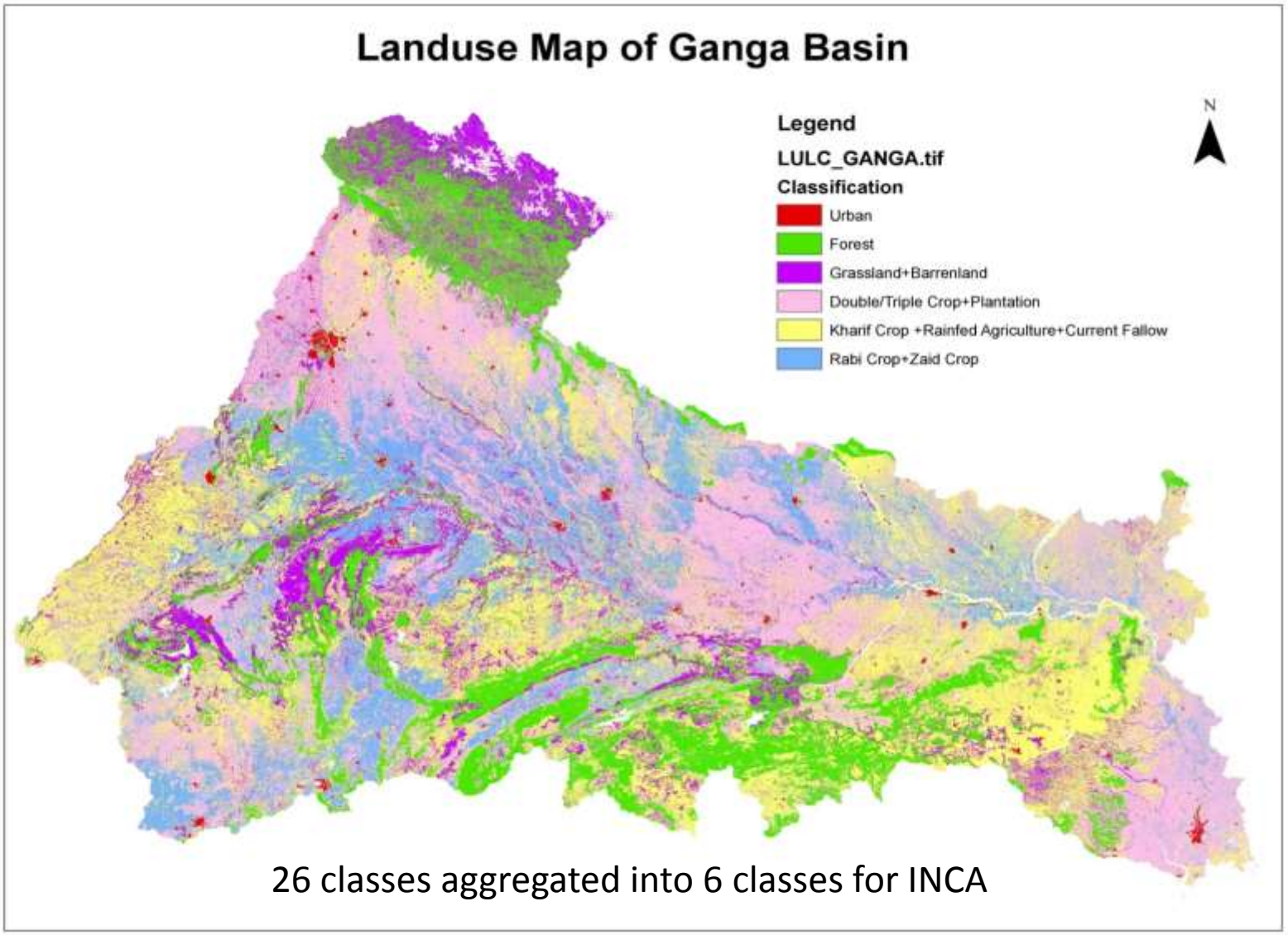
Modelled Sub-Catchments in Ganga



INCA Reach Structure for the Ganges

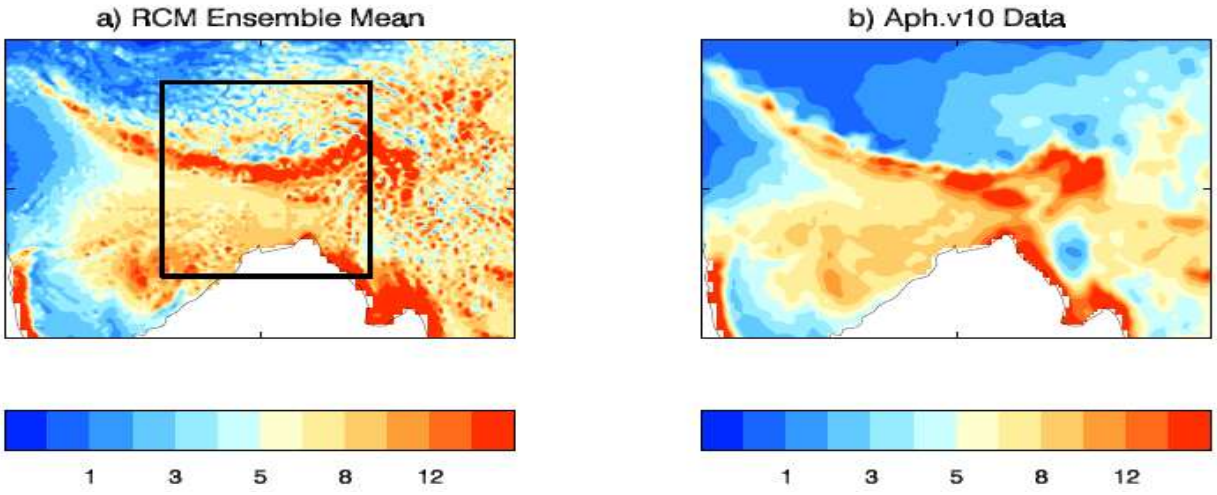


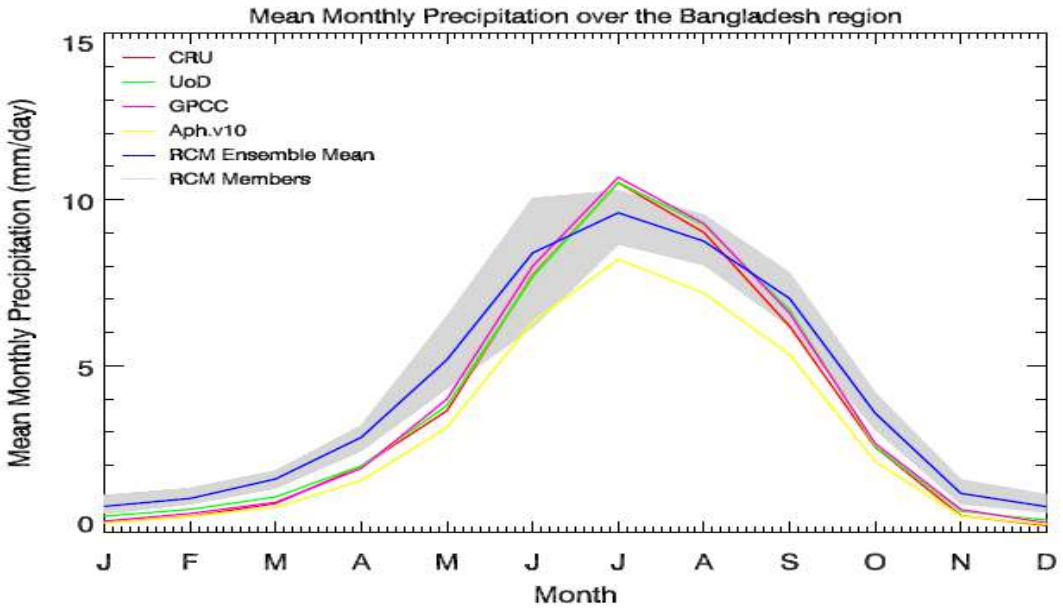
Detailed Land Use Mapping



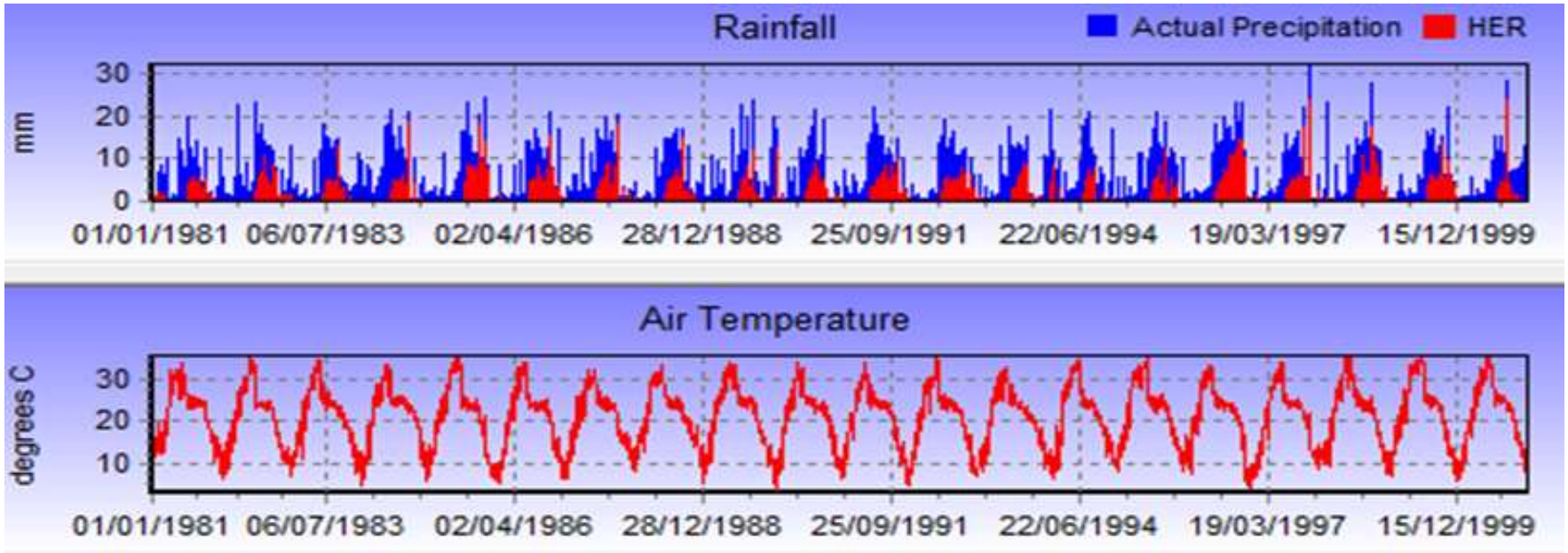
26 classes aggregated into 6 classes for INCA

Met Office Hadley Centre HadRM3P RCM
25km grid- evaluated for spatially and temporal Patterns in Temperature and Precipitation





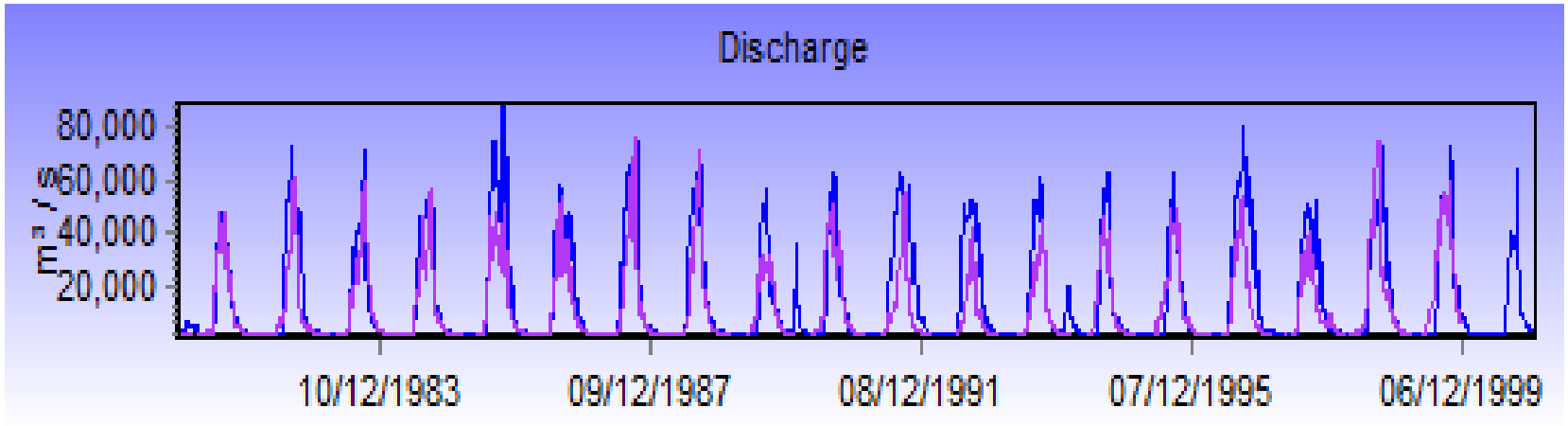
Time Series Inputs for INCA Model



1981-2000

(Daily time series data)

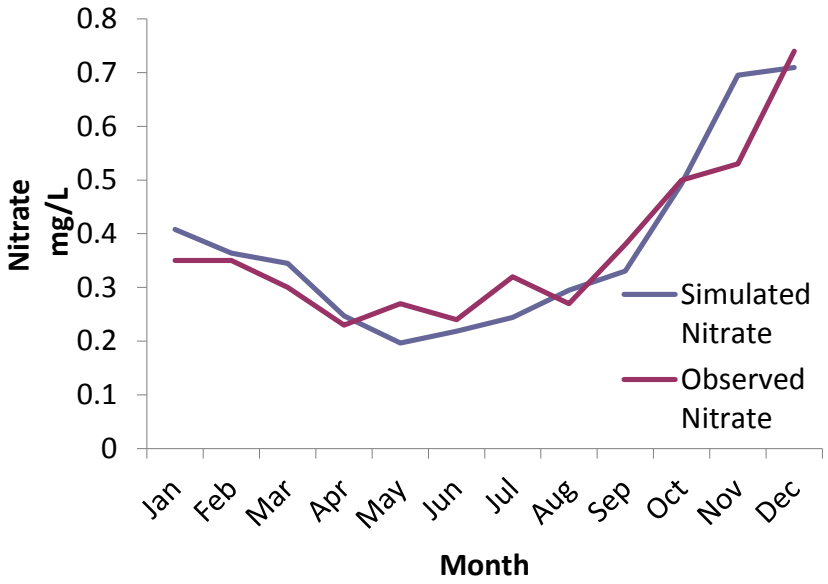
Model Calibration - flow gauges on the Ganga River system

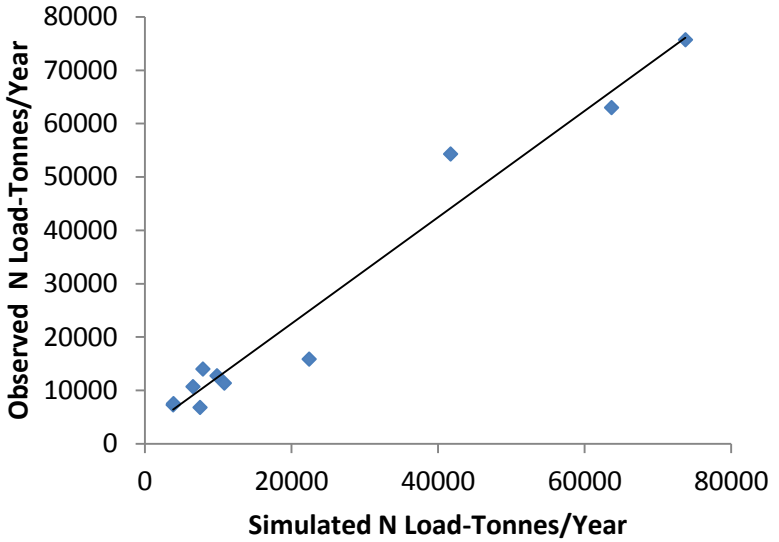


Hardinge
Bridge

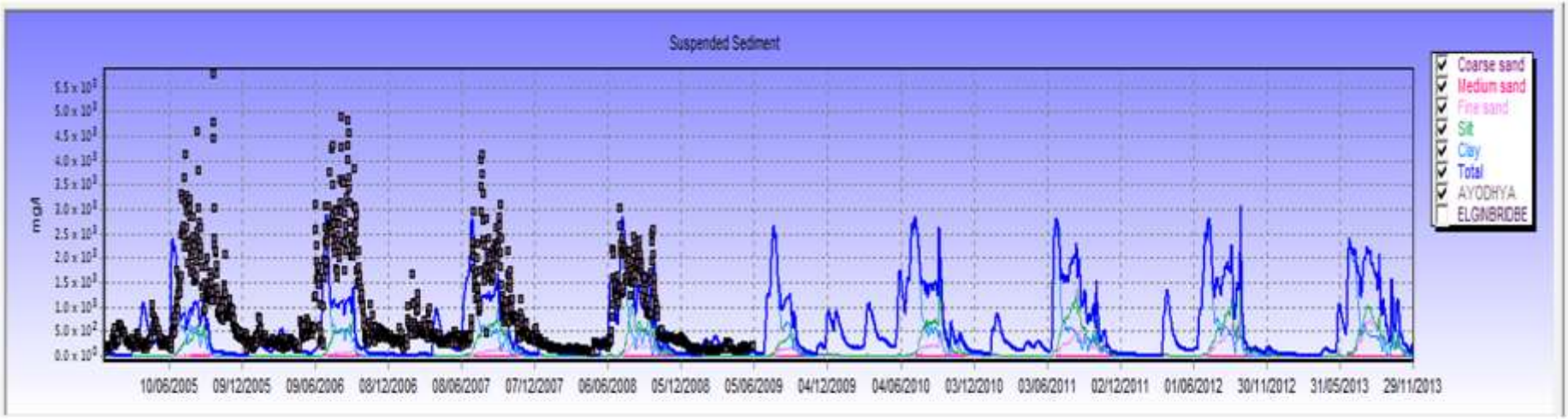
Calibration of N concentrations and Flux

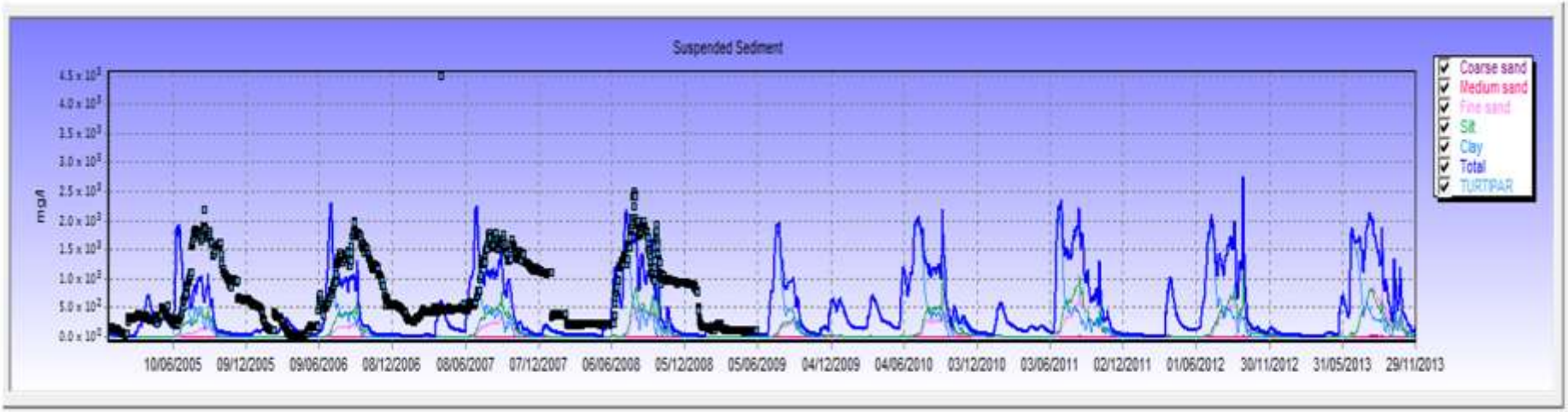
At Kanpur (Reach GA06)





Sediment simultations

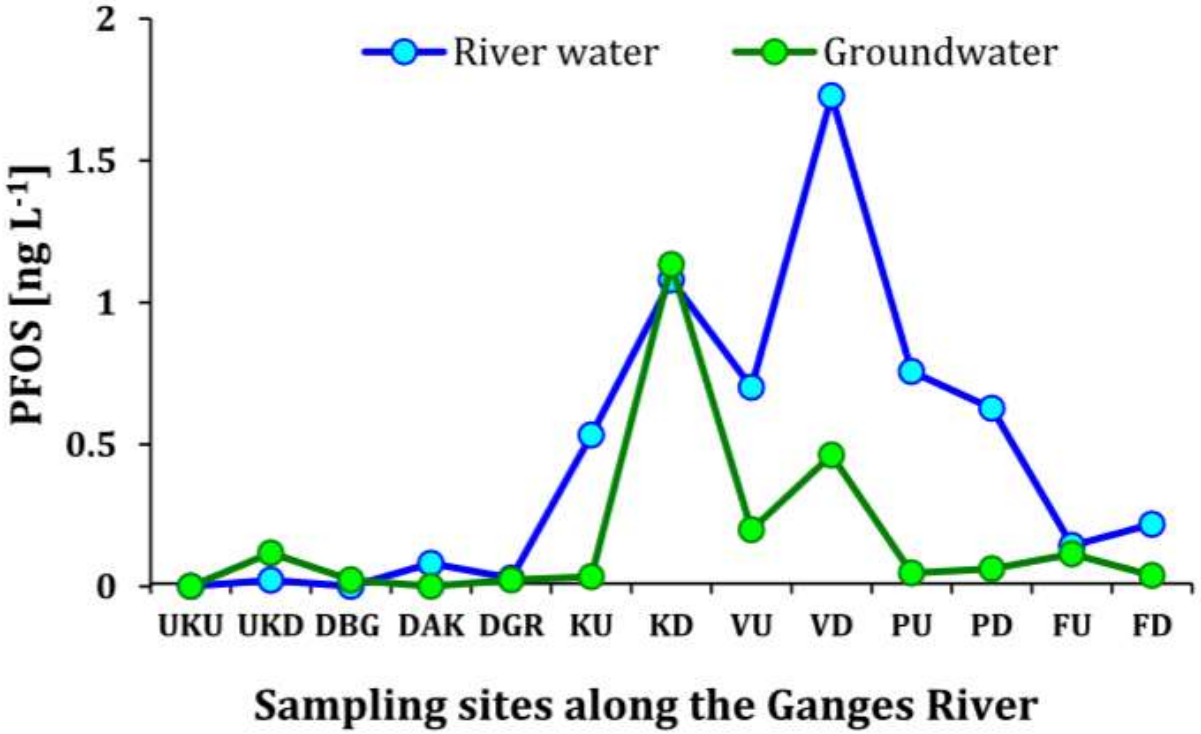




Persistent Organic Pollutants (POPs)

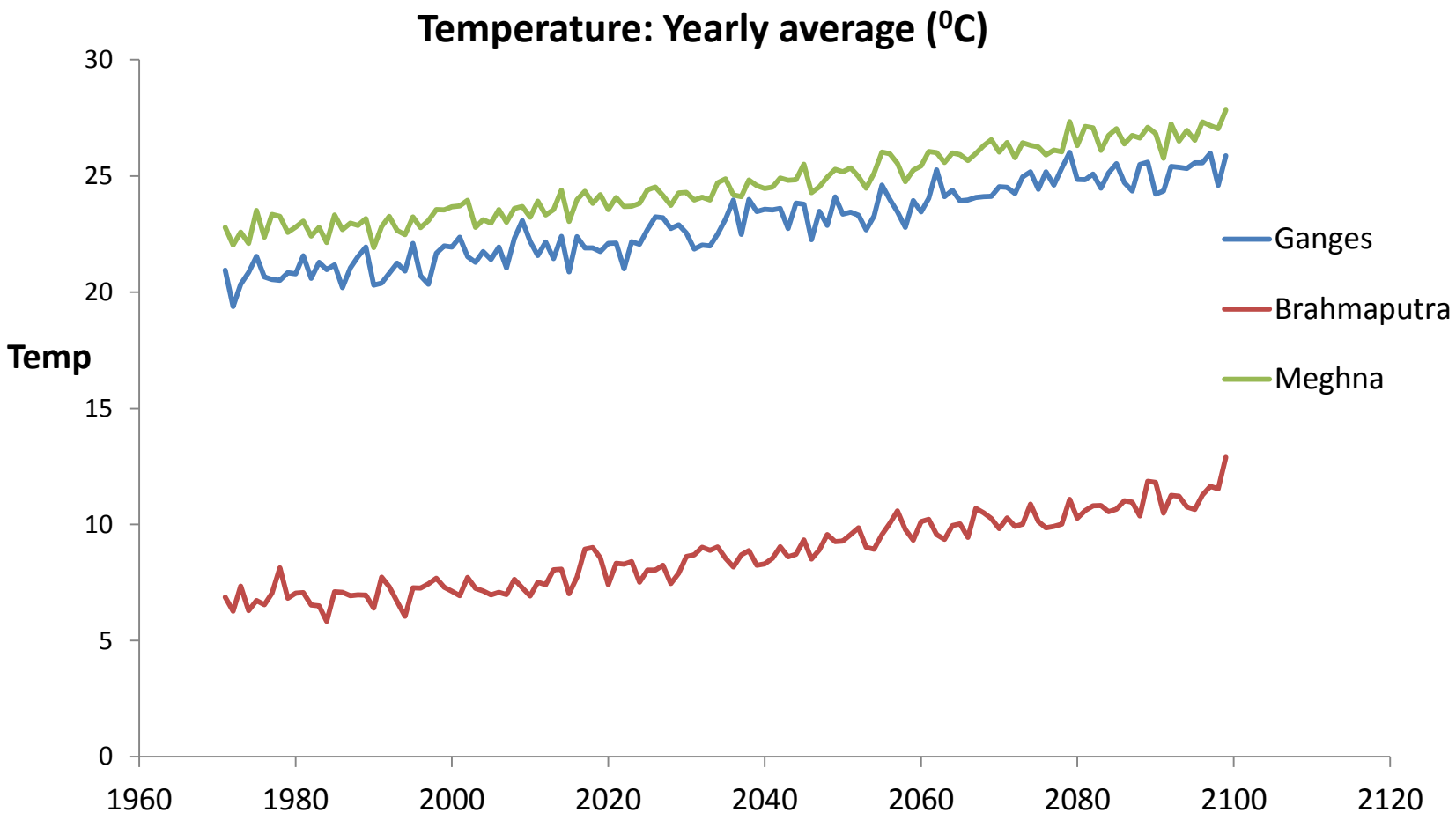
Perfluoroalkyl substances (PFAS) in river and ground/drinking water of the Ganges River basin: Emissions and implications for human exposure

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, **]

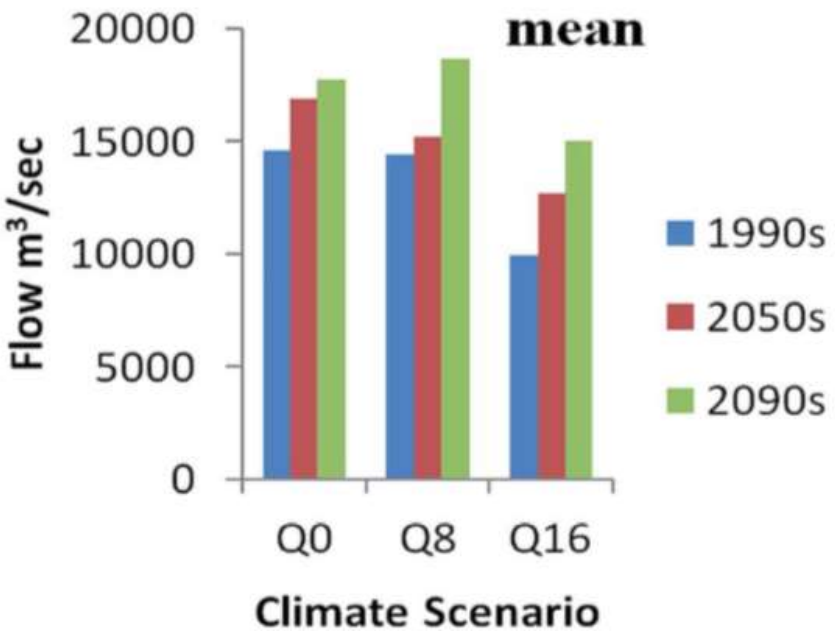


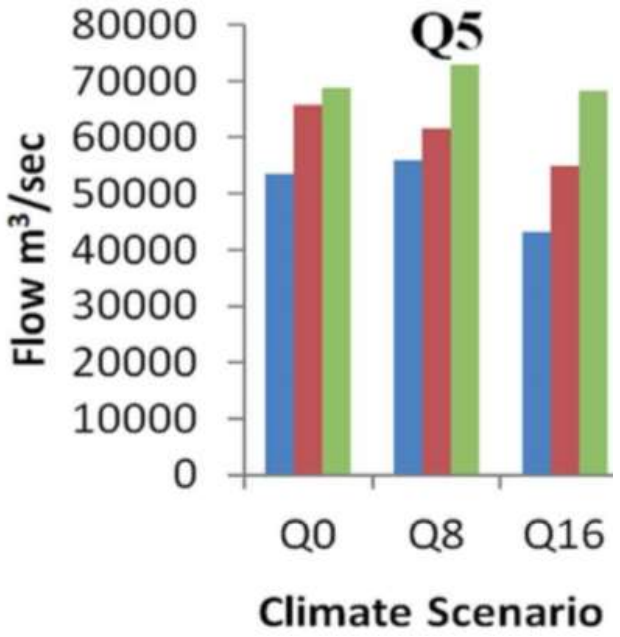
Climate Scenarios – 17 realisations

Moderately warmer/wetter



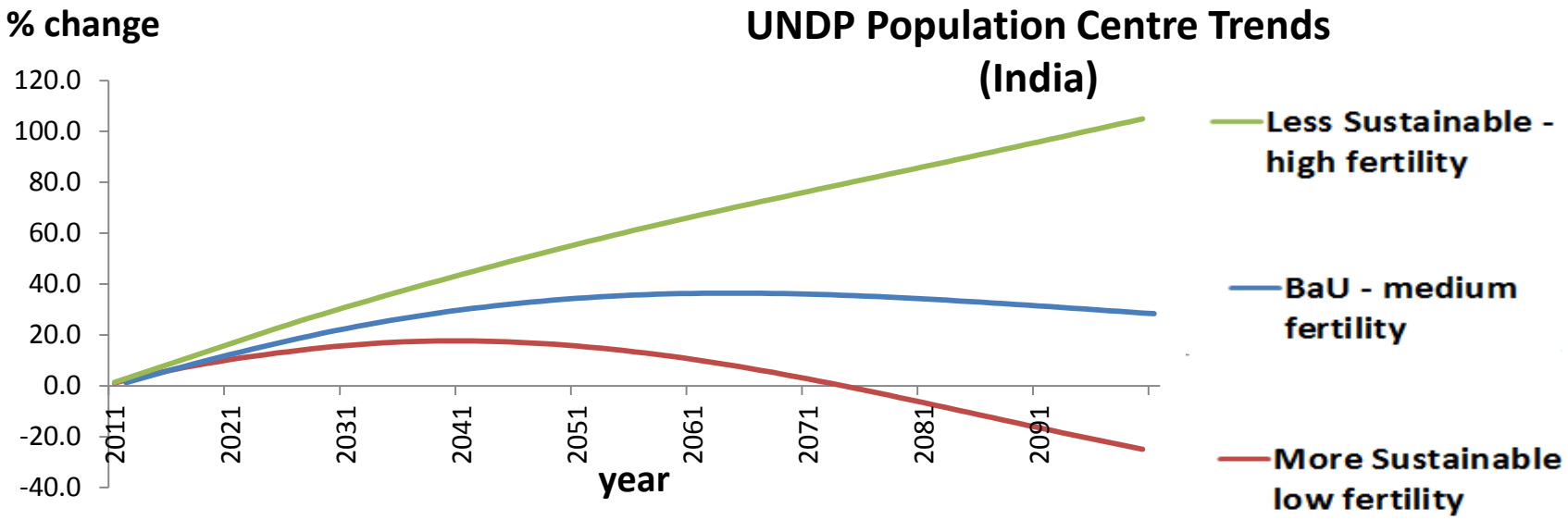
Impacts of Climate Change on Flows





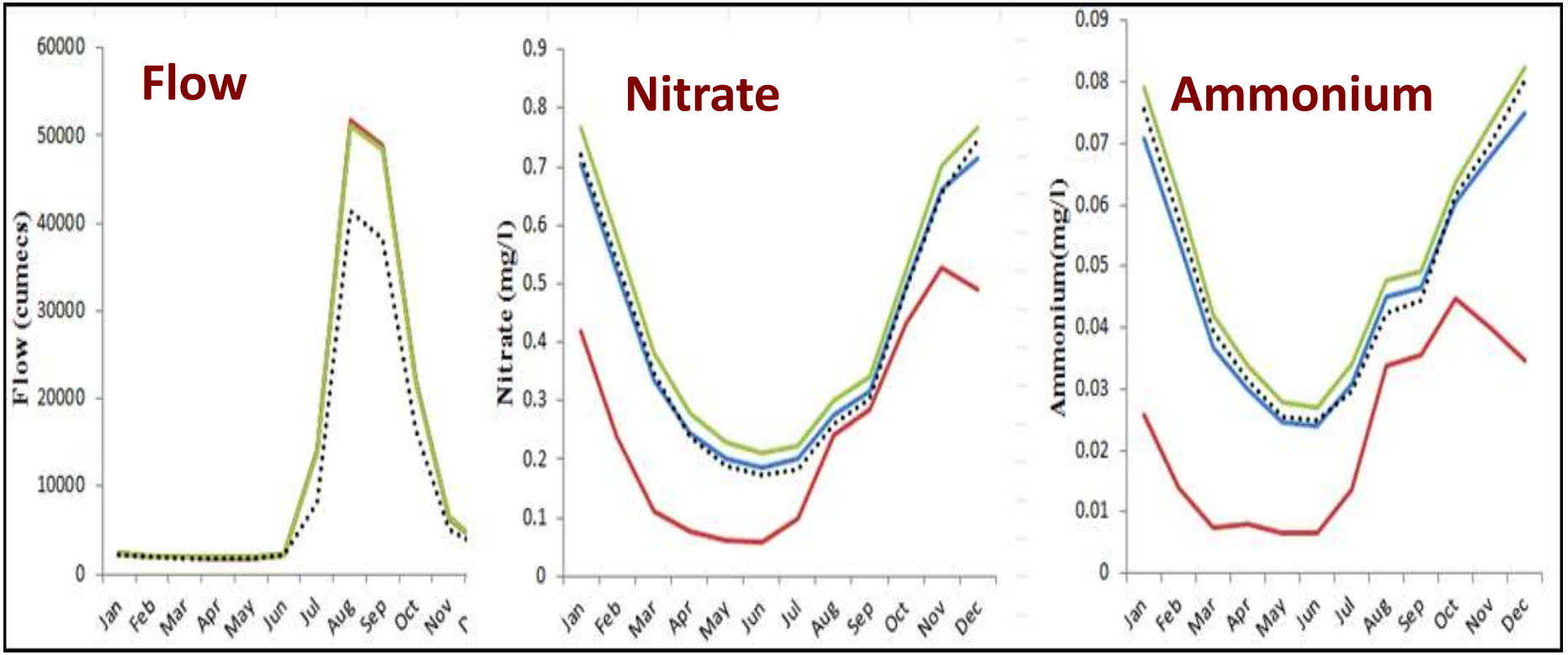
Industry---Socio-economic Scenario Analysis

- 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