Work Package-2

Water Availability and Access

International Water Management Institute

BFP Framework

Water Availability

Climate (and its change)

Water account

Water allocation

Water hazards

What is the water balance?

How people access this water ?

Levels of Analysis

- Basin Scale Analysis
  - Monthly water accounting using data
  - **PODIUM-Sim** analysis for the two basins
  - Set-up and possibly validate **WEAP-Ganges** and *WEAP- Indus*(…?)
  - Impact of **climate change** on water resources
- Sub-basin Scale
  - Detailed water balance calculations for four sub-basins
  - **Water Hazards-** Floods and Flood Management

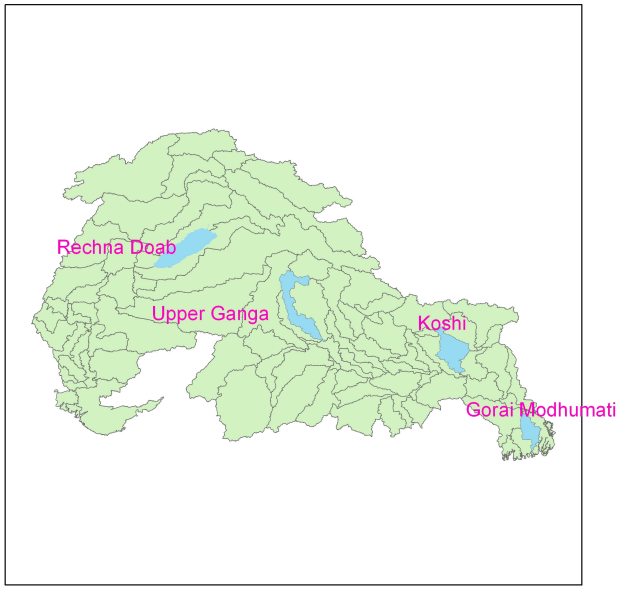
•Sub-Basin Scale Analysis

- The Soil Water Assessment Tool (SWAT)/ SWAP model will be applied
- The primary physical components of the hydrologic cycle inclusive of atmospheric, surface and subsurface processes (groundwater) will be analyzed
- The water balances will be calculated
- Simulate how change in land use patterns affects water balances

Water Availability and Access: Sub-Basin Scale

- Detailed analysis will be don
  for four sub-basins
  - **Gorai River basin in Bangaladesh**
  - Ganges upstream of Kanpur
  - Koshi Basin (China- Tibet, Nepal,India)
  - Rachna Doab in The
  - Indus(Pakistan)

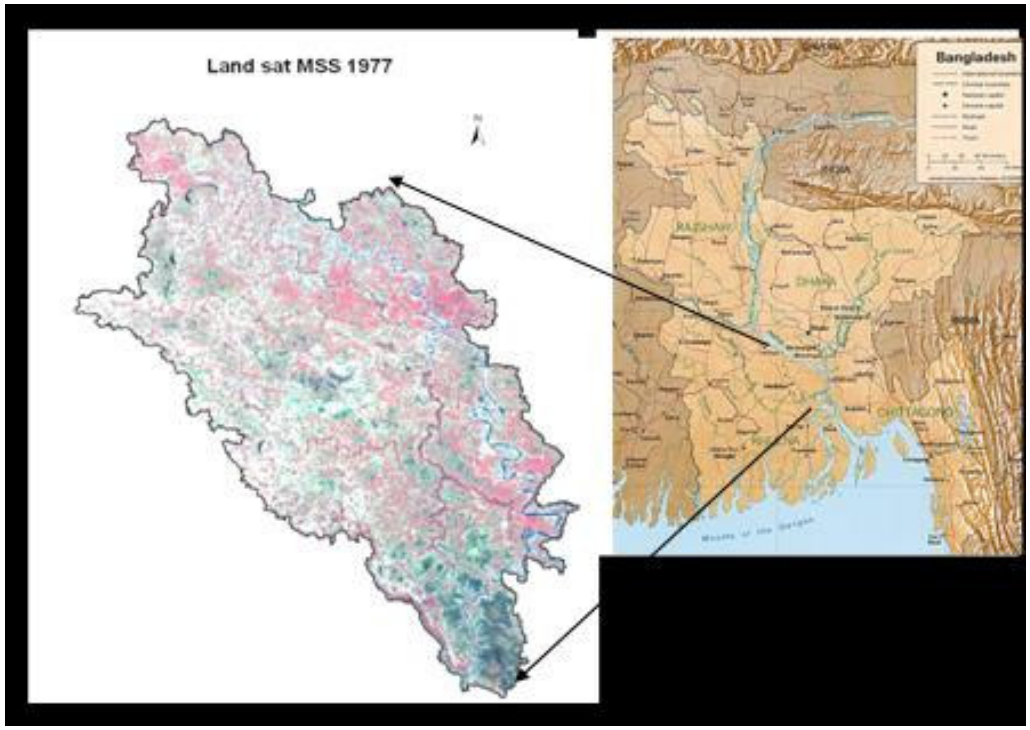
Selected Sub Basins in Indo Ganges



Gorai-River Catchment

Main Objectives:

- Study the effect of upstream water resource development and as well as the influence of land use change on the hydrology and water balance of the Gorai River Catchment



Gorai-River Catchment: Background

- The Gorai river is the largest perennial distributory of the Ganges River in Bangladesh
- Gorai River water supplies are crucial to the environmental and economic well being of the Southwest corner of Bangladesh which also includes the threatened Sundarbans mangrove forest
- The freshwater supplies from the Gorai has been important to control salinity intrusion

Gorai-River Catchment: Background

- Bangaladesh claims that the dry season flow of the Gorai has drastically decreased since the operationalisation of the Farraka Barrage in India in 1975

- Water flow management of the Ganges basin at Farakka is the major dispute between India and Bangladesh

Gorai-River Catchment: Specific Objectives

- Set up the Soil and Water Assessment Tool (SWAT) for the period from1969-1975 (Pre-Farakka) and 1990-1997 (Post Farakka)

- Prepare two land use maps for the model for 1977 and 1997

- Calculate and compare water balances for the catchment for both periods (1969-1975 vs. 1990-1997)

- Scenario analysis of different water management options

Methods: SWAT Model Description

- Conceptually, SWAT divides a watershed into sub watersheds. Each sub watershed is connected through a stream channel and further divided in to **Hydrologic Response Unit (HRU).**
- HRU is a unique combination of soil and vegetation type in a sub watershed, and SWAT simulates water balances, vegetation growth, and management practices at the HRU level.
- The subdivision of the watershed enables the model to reflect differences in evapo-traspiration for various crops and soils.
- Runoff is predicted separately for each HRU and routed to obtain the total runoff for the watershed.

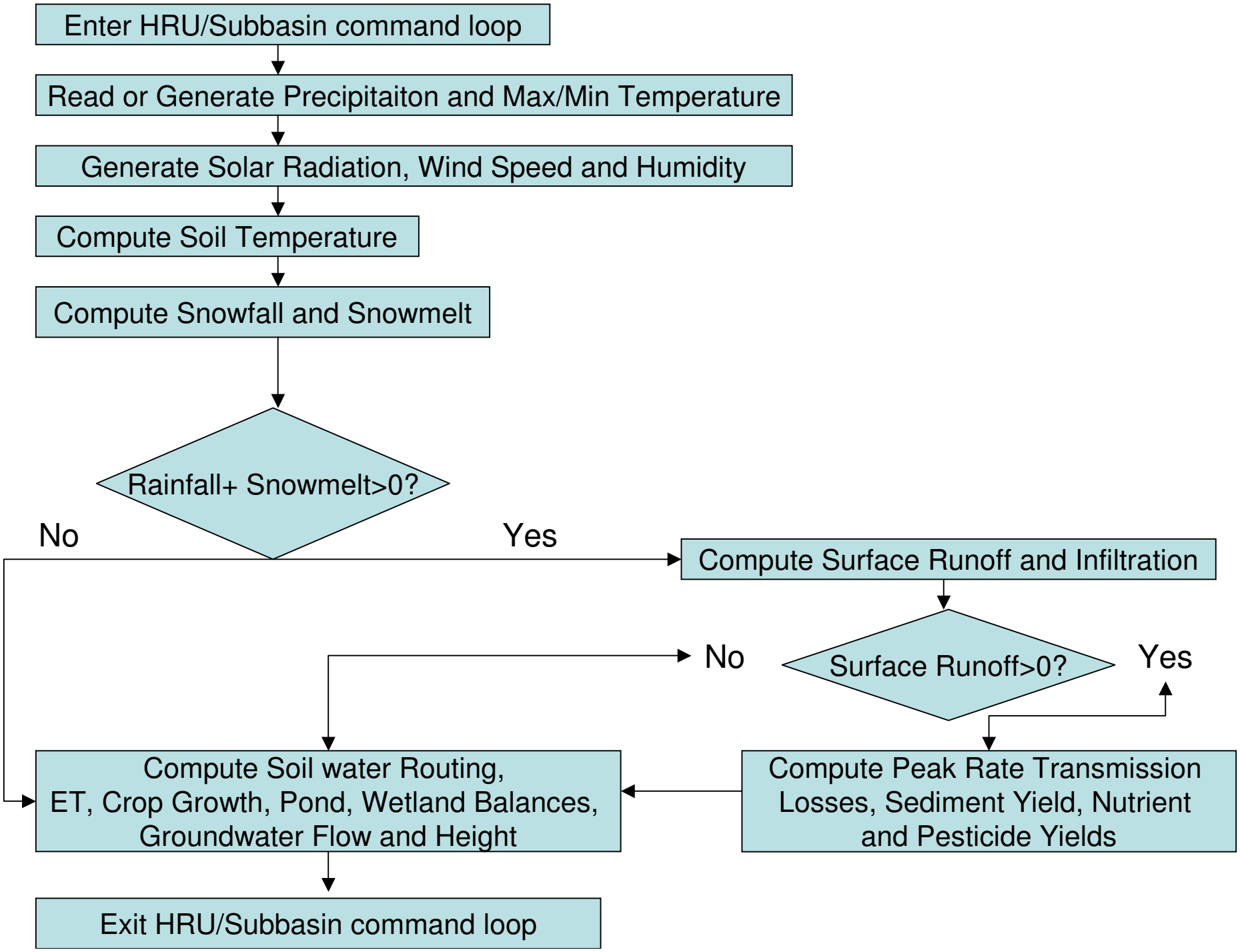
Methods: SWAT Model Description

The hydrologic cycle as simulated by SWAT is based on the water balance equation:

$$SW_t = SW_o + \sum_{i=1}^{n} (R_{day} - Q_{surf} - E_a - w_{seep} - Q_{gw})$$

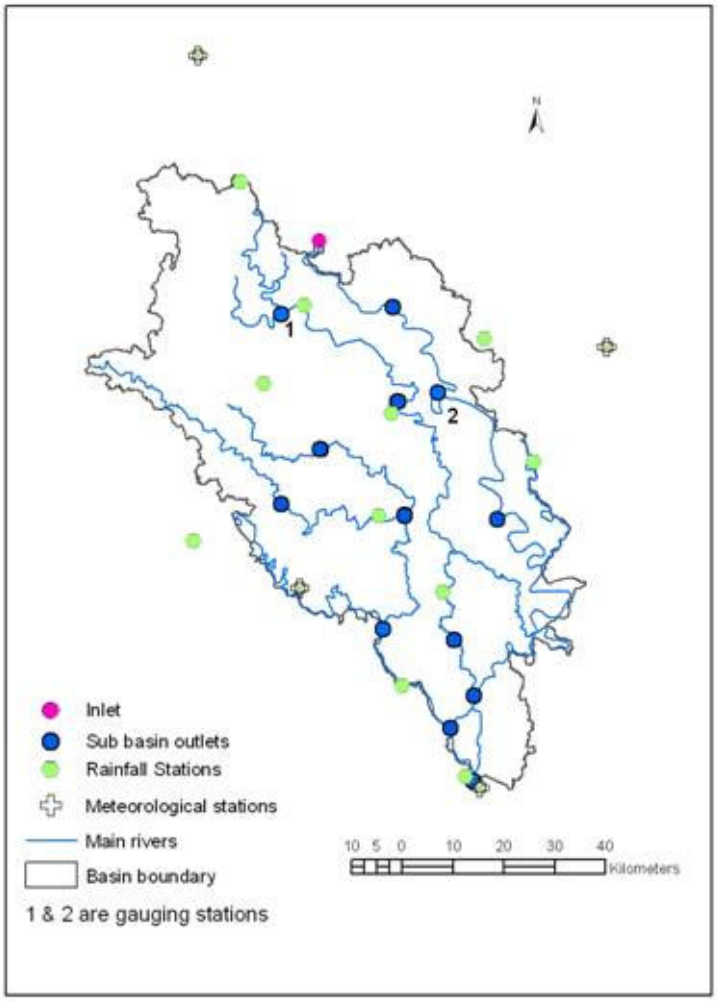
Where,

- *SWt* :Final soil water content (mm)
- *SWo*: Initial soil water content (mm)
- *t* :Time in days
- *Rday* : Amount of precipitation on day i(mm)
- *Qsurf* : Amount of surface runoff on day i (mm)
- *E*a: Amount of evapotranspiration on day i (mm)
- *wseep* : Amount of percolation on day i (mm)
- *Q*gw: Amount of return flow on day i (mm)

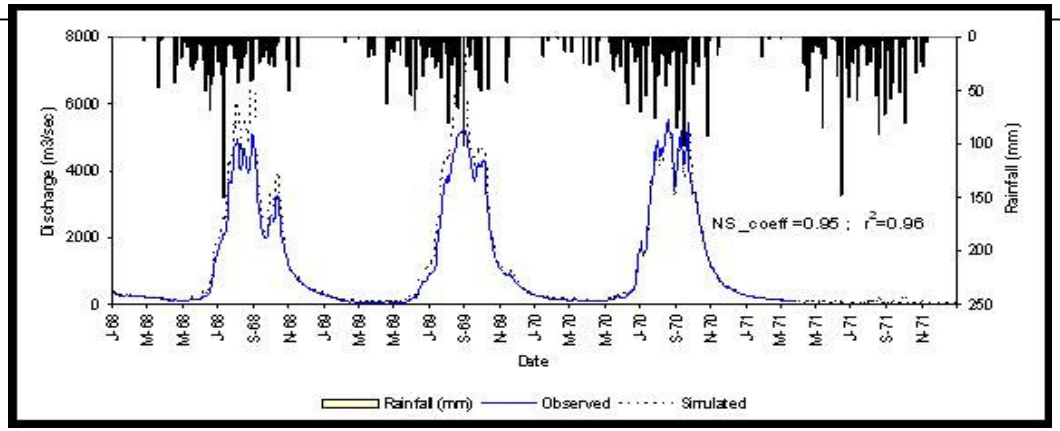

Enter HRU/Subbasin command loop
Read or Generate Precipitaiton and Max/Min Temperature
Generate Solar Radiation, Wind Speed and Humidity
Compute Soil Temperature
Compute Snowfall and Snowmelt
Rainfall+ Snowmelt>0?
No
Yes
Compute Surface Runoff and Infiltration
Surface Runoff>0?
No
Yes
Compute Soil water Routing, ET, Crop Growth, Pond, Wetland Balances, Groundwater Flow and Height
Compute Peak Rate Transmission Losses, Sediment Yield, Nutrient and Pesticide Yields
Exit HRU/Subbasin command loop

Methods: Input Data

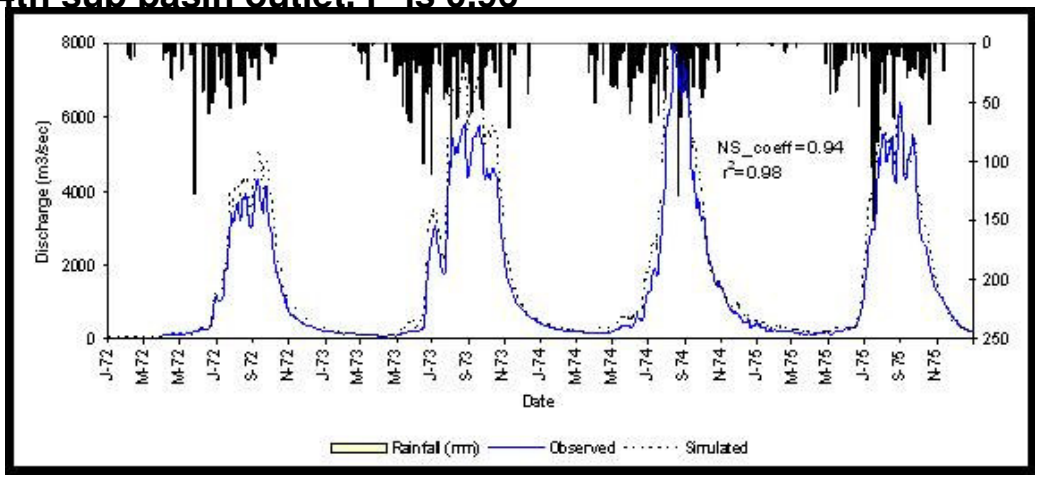
- Spatial Data
  - Digital Elevation Model
  - Land Use Map
  - Soil Map and Soil Properties
  - River network
- Time Series Data
  - Meteorological data (Rainfall , Maximum and minimum temperature, Relative humidity, Sunshine hours, Wind speed)
  - Flow data



Model Performance Evaluation



Observed and simulated flow during the calibration period for the 4th sub basin outlet, r^2 is 0.96



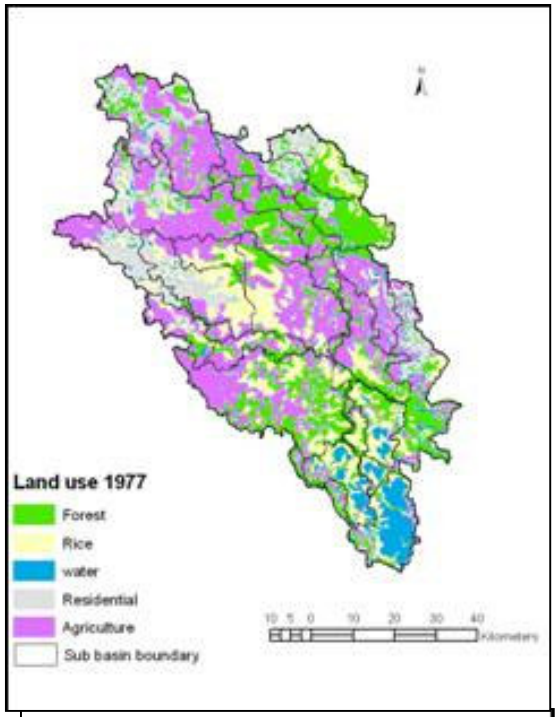
Observed and simulated flow during the validation period for the 4th sub basin out let. $r^2$is 0.94

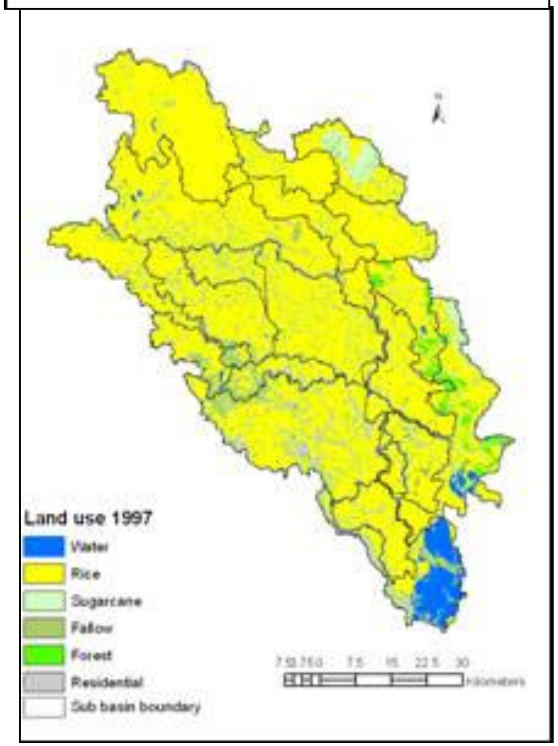
Land use change

•1997 Classified Land use map was obtained from the Bangladesh Water Development Board and 19977 Land sat MSS image was downloaded and classified using the visual observation technique. Both the maps were re-sampled at 30m for direct comparison.

•Comparison of both land use map shows:

- **2% reduction** in water bodies from 1977 to 1997
- Settlement area remains constant
- Agriculture area including rice has **increased from 52% to 80%** from the total basin land extent
- **Forest area has decreased from 29% to 4%** from 1977 to 1997

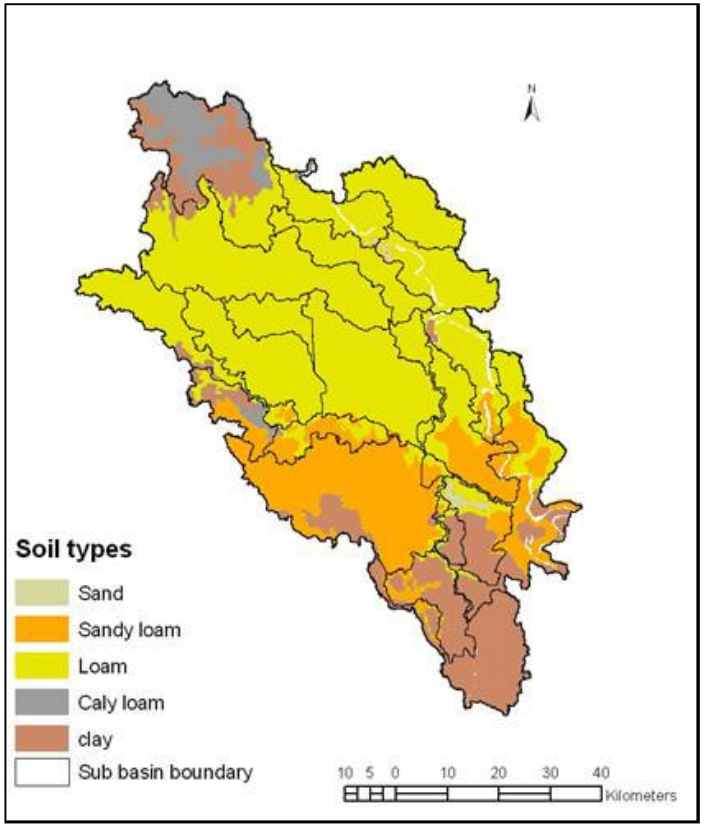




Gorai River Catchment

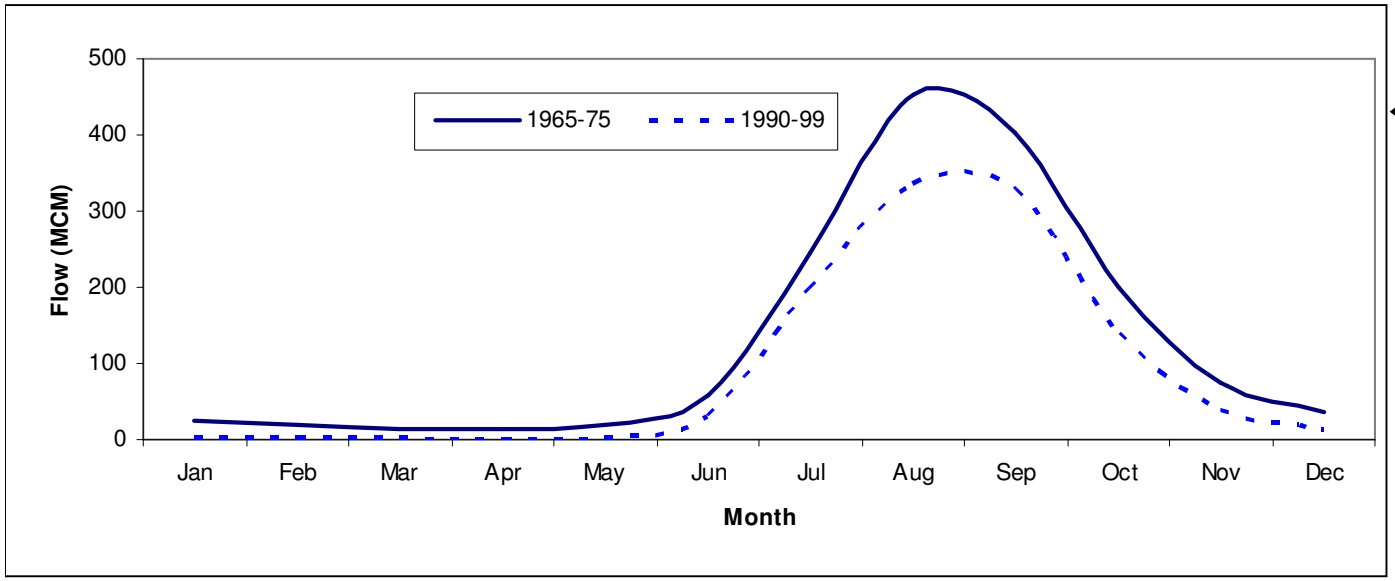
Soil Types of Study Area

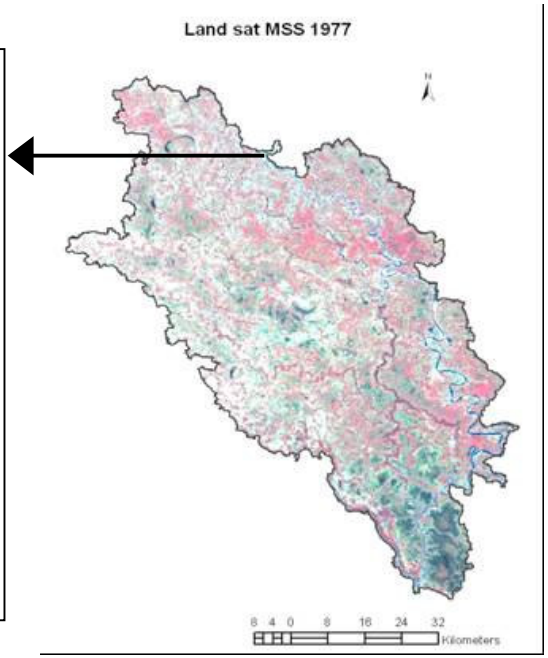
- Loam soil : 55% of the basin
- Sandy loam : 20%
- Clay soil: 17%



Soil types over the study area

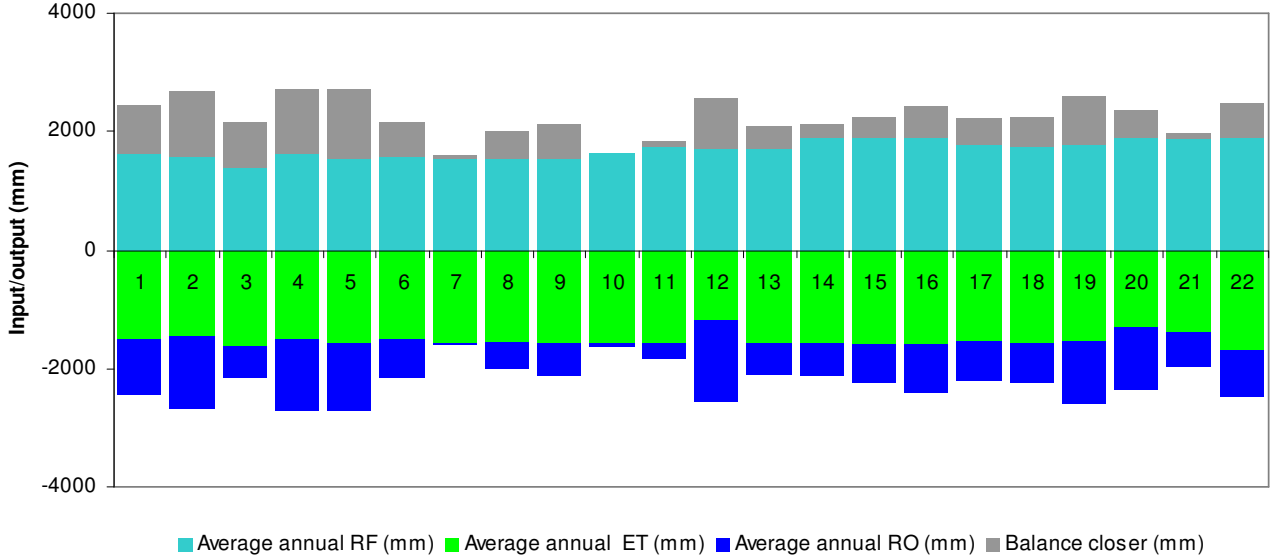
Inflow into Gorai catchment at two time periods



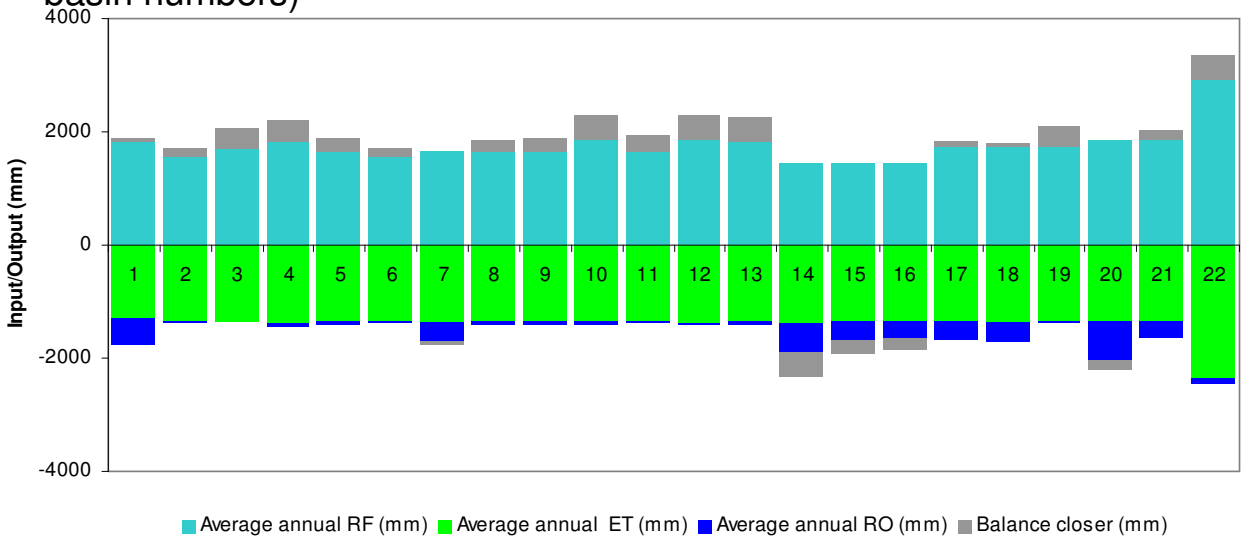


Average monthly inflow to the Gorai Catchment measured at Gorai railway-bridge

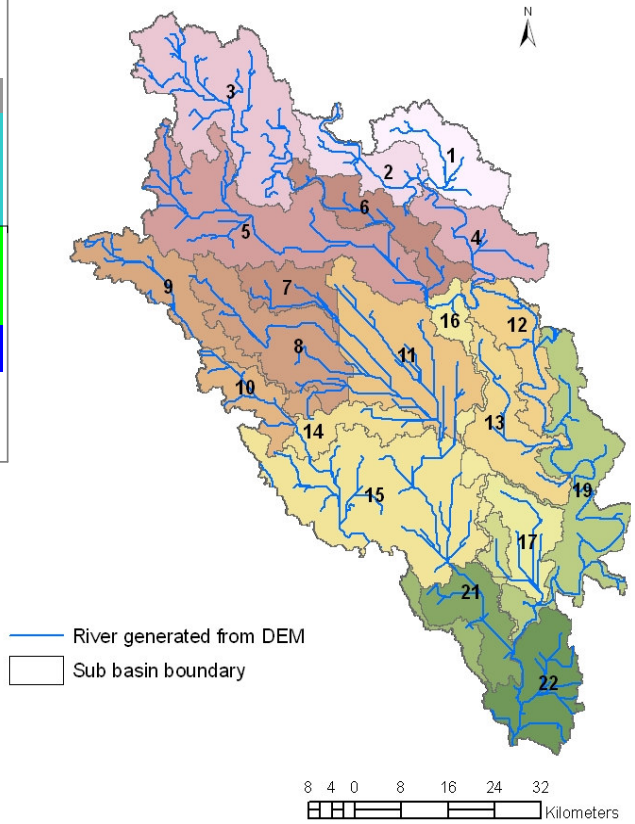
Water Balance Results



Water balance at each sub basin during 1965 to 1975 (1 to 22 are sub basin numbers)



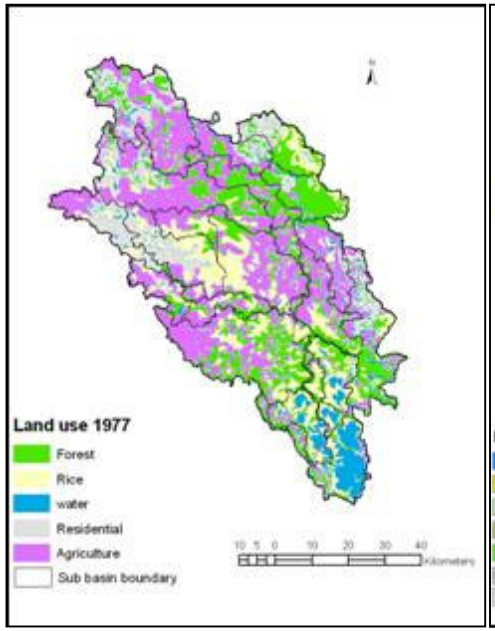
Water balance at each sub basin during 1990 to 1997

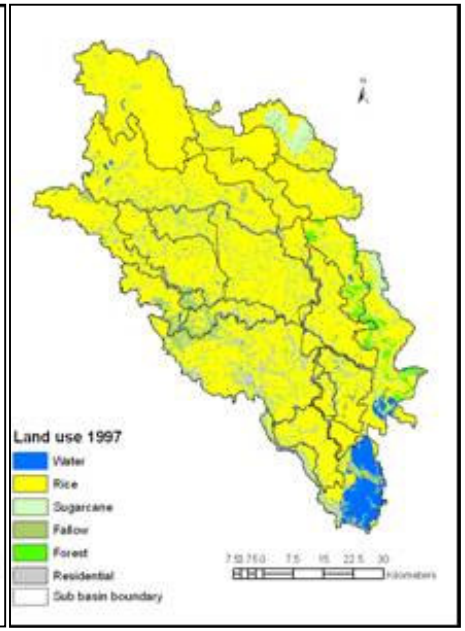


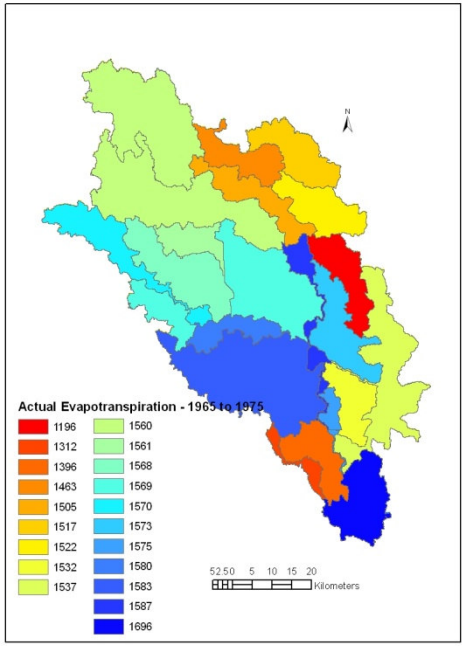
Actual ET from the two time periods:

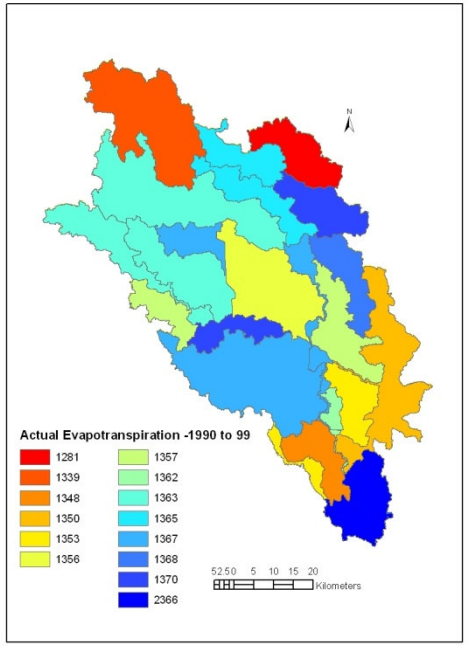
•As expected, ET changes can be linked to the landuse changes in the catchment.

•ET has decreased in Sub-basins where landcover has changed from Forest to Agriculture and increased where rice has replaced some of the traditional agricultural crops



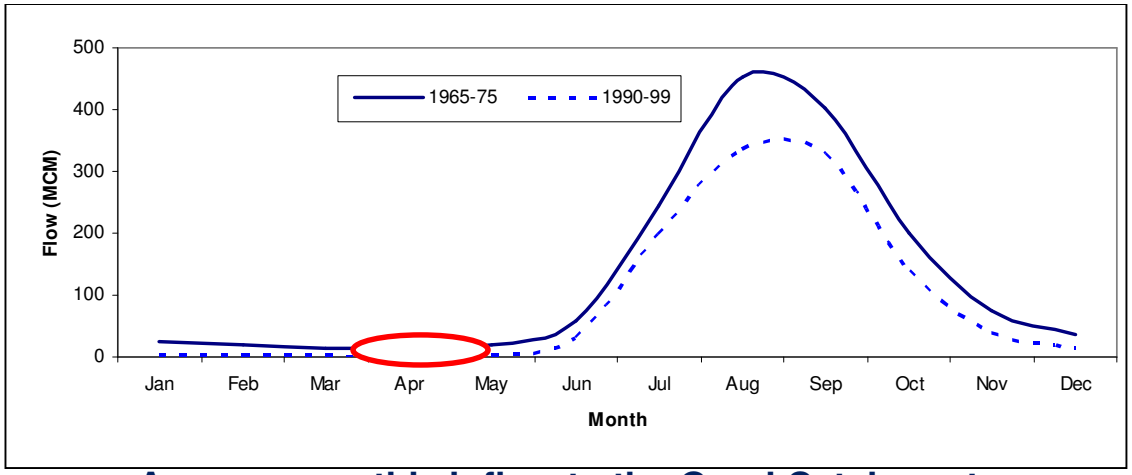




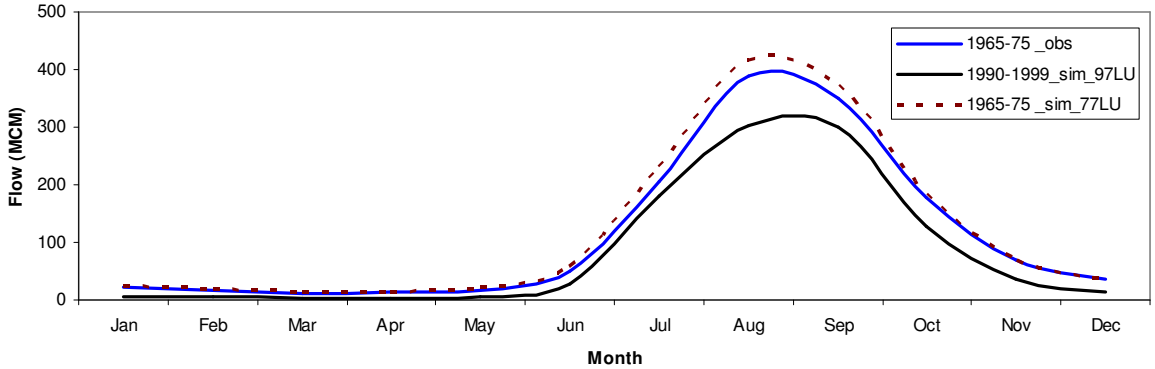


- The Upstream part of the basin is extremely effected by the Farakka barrage discharges as flow in the monsoon is reduced and flow in the dry season approaches zero

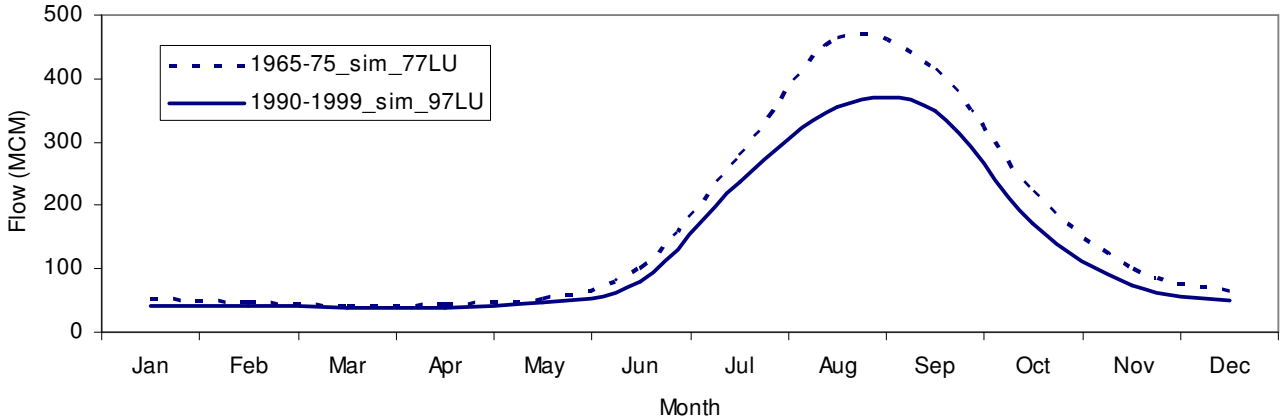
- Simulations from the downstream or the outlet of the basin shows that flows are reduced during the monsoon season, however, flows in the dry season, esp. March-May has not changed in the two periods and is effected by the land use in the whole basin



Average monthly inflow to the Gorai Catchment

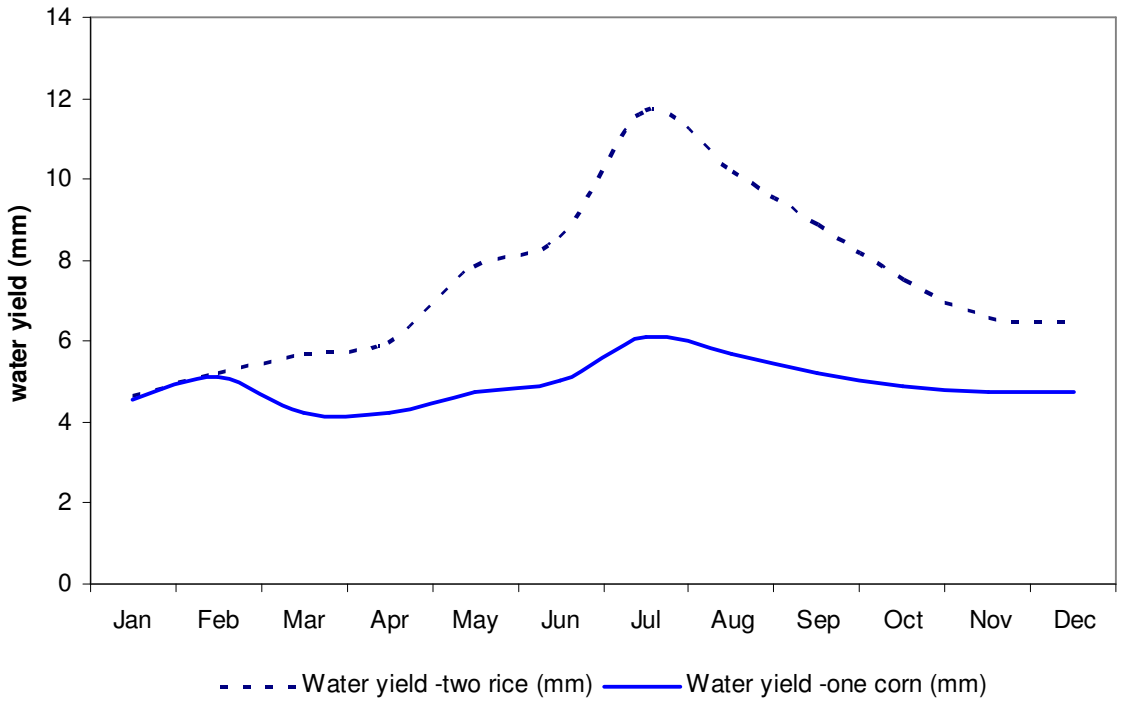


Average monthly out flow from the sub basin 4



Average monthly out flow from the Catchment outlet (sub basin 22)

Scenario Analysis



Water yield from Sub-basin 1 when changing landuse from Rice to Corn

Conclusions

- Inflows have reduced in the Gorai River Catchment due to the Farakka Barrage in India
- The upstream part of the Gorai catchment is affected more than the downstream part
- Runoff from the outlet of the catchment is affected by land use within the catchment as well as the inflow coming from the Ganges
- Land use changes within the Gorai River Catchment can significantly increase flows, providing more freshwater flow into the sundarban mangrove forests

Gorai River Catchment: Further Analysis

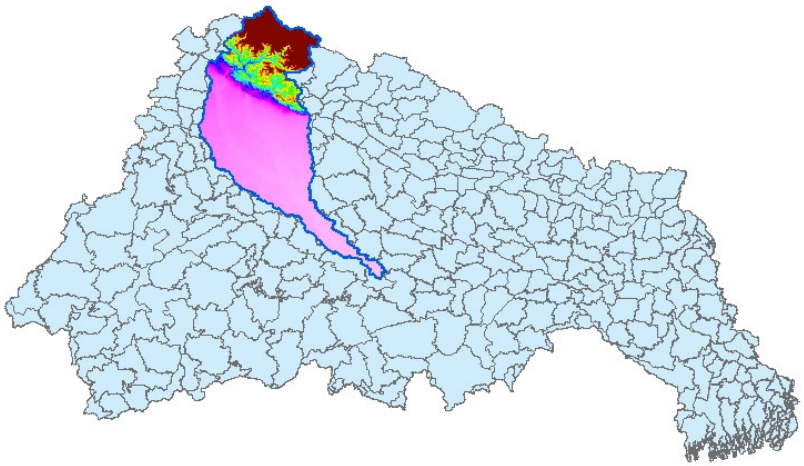
- Scenarios comparing water productivity due to different cropping patterns in the basin

- Scenarios studying the effect of change in inflows to the catchment due to increases or decreases in the releases from the Farakka barrage

Upper Ganga Sub-basin Study

Progress so far:

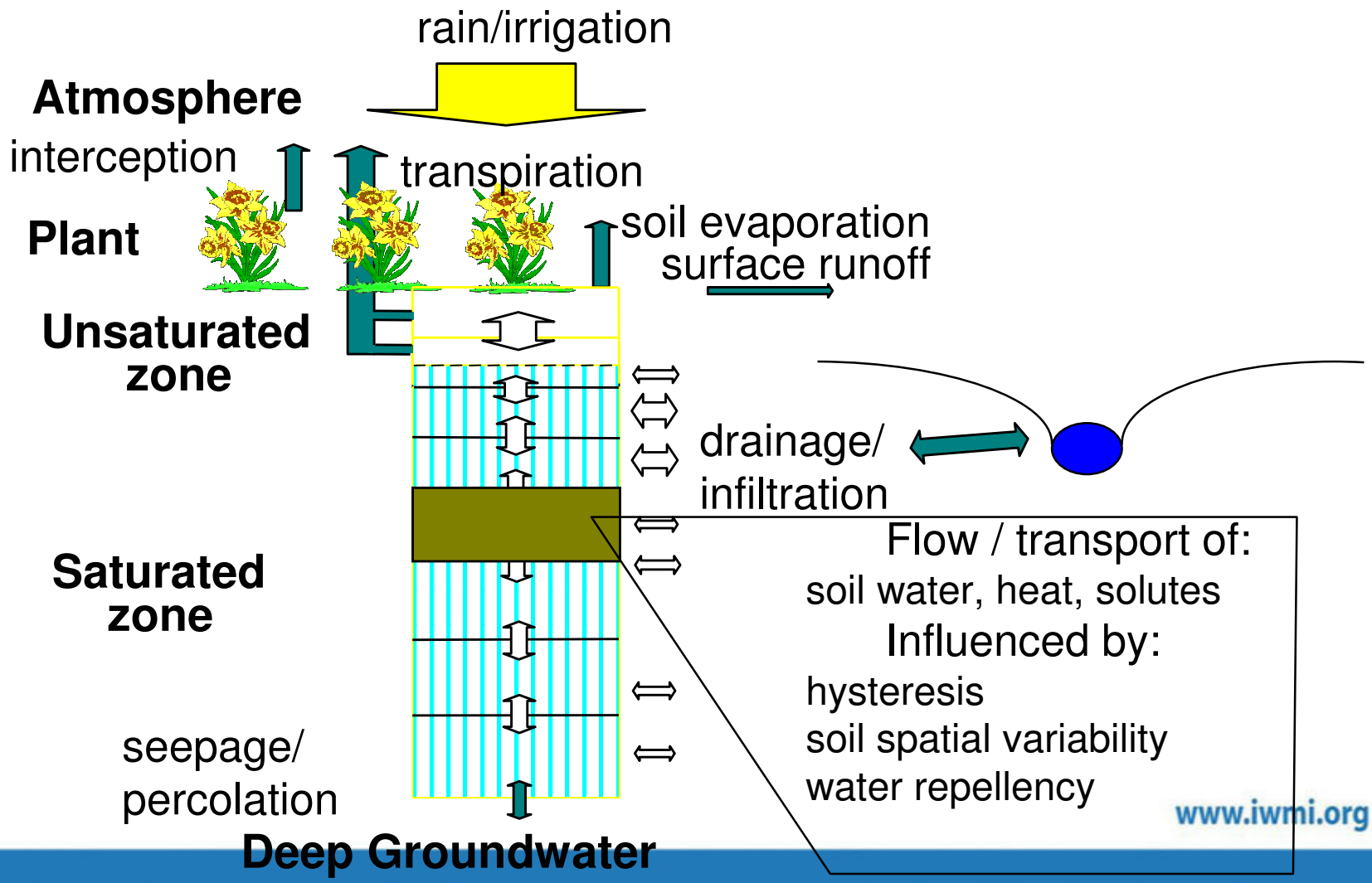
- DEM of the Subbasin using SRTM has been completed
- A landuse map using Landsat images from 2003 is in progress. We will be using ground truth points from the GIAM study.
- We are in the process of acquiring other data such as climate data, barrage and reservoir data, soil map e.t.c needed for the model
- Expected date of completion is May, 2009



Issue:

- Despite water shortage, over-use of irrigation water is common in Rechna Doab.
- Current irrigation practices are aimed at maximizing crop production—resulting in lower productivity of water
- Irrigation schedules need to be revised to control non-beneficial losses of water and improve water productivity.

SWAP—Soil-Water-Atmosphere-Plant relationship model



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Objectives:

- Quantify the impact of current irrigation practices on different water productivity indicators of main crops grown in the Rechna Doab.
- Evaluate optimal irrigation schedules for major crops under the agro-climatic conditions of Rechna Doab.
- Evaluate the impact of improved irrigation schedules on soil salinization and crop yields.
- Estimate net water saving as a result of improved irrigation schedules in the Rechna Doab.

Partners

- Punjab Irrigation department
- Punjab Agricultural Extension Department
- Center of Excellence in Water Resources, Lahore.

Output

- Report on different findings (may be targeted as RR)