GIS Framework to Evaluate Impact of Climate Change on Water Resources

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Objectives of the Study

- To Develop portal to assess the impact of climate change on water resources

- Identify Hotspots

- Identify Adaptation & Coping strategies

Changes in hydrological phenomenon is complicated by the conjoined effects of:

- Climate variability over both short and longer term time scales.

- Water Engineering and Management.

$$Q = P - E + \Delta S$$

The primary forcing function, ΔCO_2, alters Et directly, whilst the secondary forcing function, the ΔT, enhances both Es and Ew and simultaneously, through changes in atmospheric pressure belts, alters precipitation patterns and consequently, ΔS. These changes have important hydrological repercussions which need to be evaluated through model studies.

Analyzing for Impact of climate change on Water Resources

- Global climate changes will have major effects on precipitations, evapotranspiration and runoff
- Primary interest to water planners
- Understanding of hydrological response of river basin under changed climatic conditions
  - Help to solving potential water resources problems associated with flood, droughts etc.

- This framework uses the distributed hydrological modelling (SWAT) to quantify the impact of climate change on the water resources

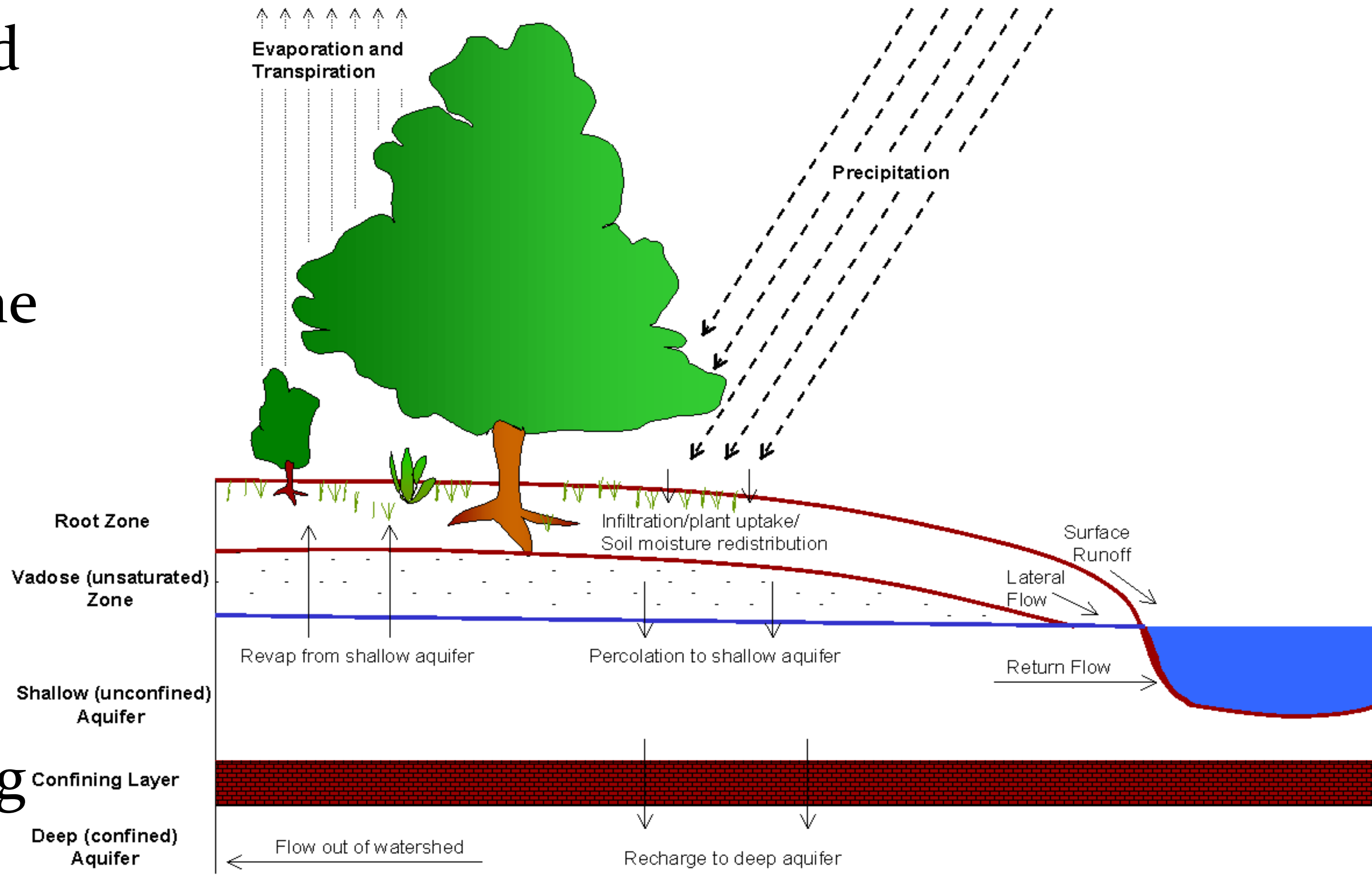
- The impact of climate change on the particular drainage area can be visualized through this Web Interface (*http://gisserver.civil.iitd.ac.in/natcom*)

- In this case the HadRM3 baseline scenario (BL) and GHG Scenario A1B, A2 & B2 are incorporated

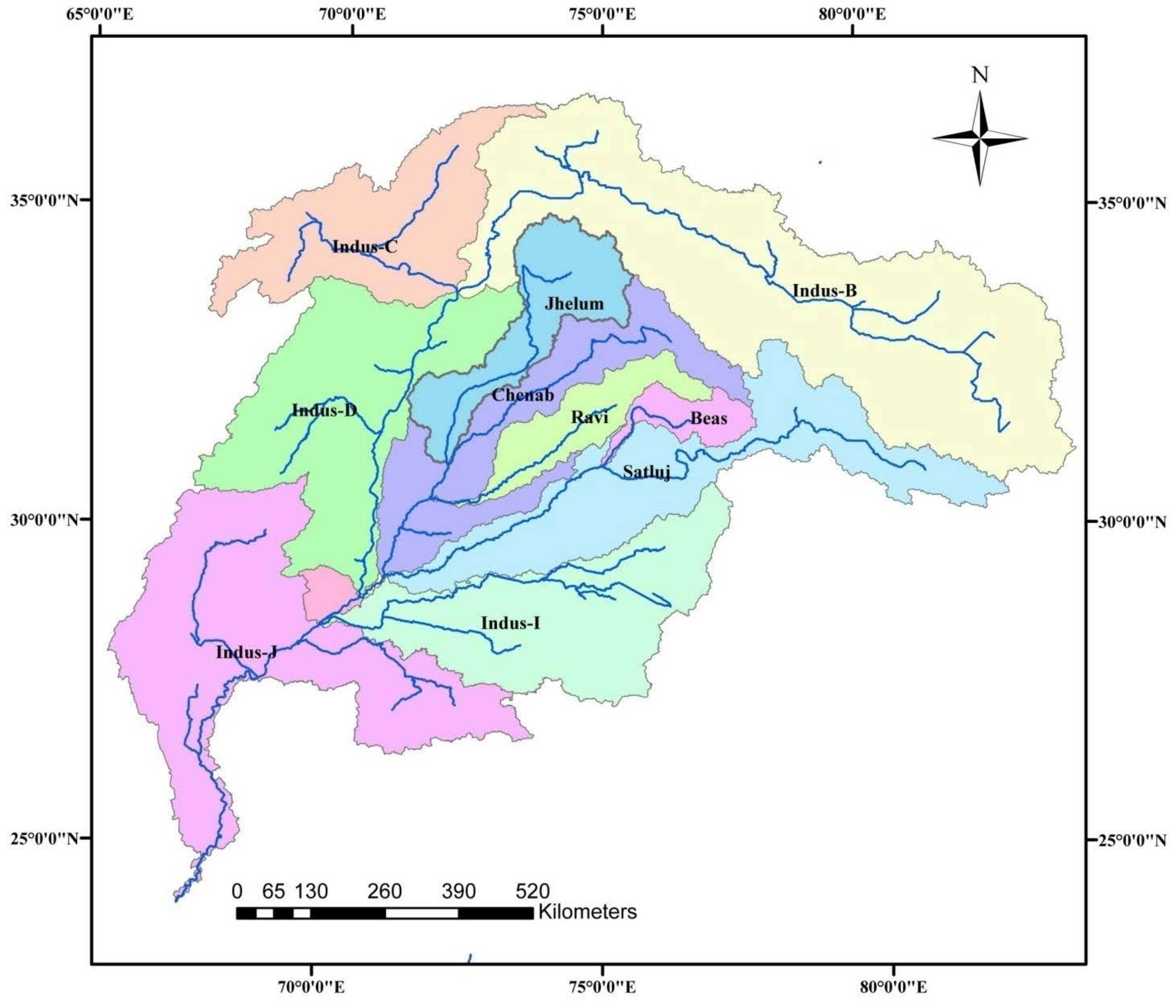
Generation of Indirect Information through simulation Soil & Water Assessment Tool (SWAT MODEL)

Features

- Physically based
  Distributed model
- Continuous time model (long term yield model)
- Uses readily available data
- Suitable for long term impact studies



Hydrological Modelling of Indus Basin (SWAT Model)



Model Set Up

The SWAT hydrological model set up for Indus basin

- The model requires climatic data pertaining to the precipitation, maximum temperature, minimum temperature, solar radiation, wind speed and relative humidity

- The model has an inbuilt weather generator which can be used for predicting the daily values of all these variables, provided certain long term weather statistics are available

- Using IMD girded data

  Rainfall data (0.5° X 0.5°)- 1971-2005

  Temperature data (1° X 1°)- 1969-2005

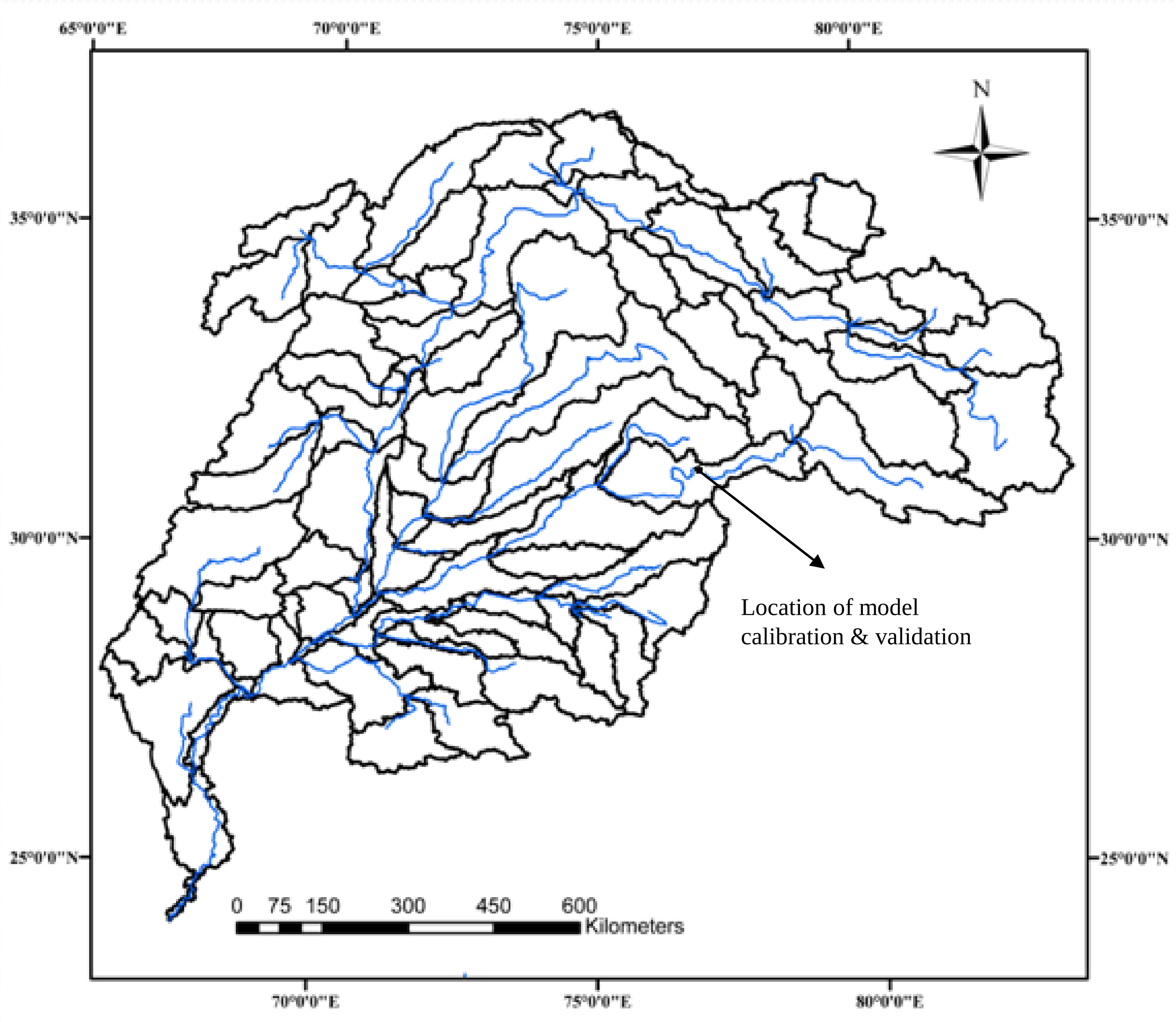
- HadRM3 (RCM-PRECIS model) control and future GHG climate scenarios

  - In the present study control (1961-1990) and two future GHG scenarios A2 (2071-2100) and B2 (2071-2100) is used to capture the range of uncertainties associated with driving forces and emissions

  - Digital Elevation Model (DEM) – Shuttle Radar Topography Mission (SRTM) 90m
  - Land Use Layer: Global Land Cover Facility (one km grid cell size)

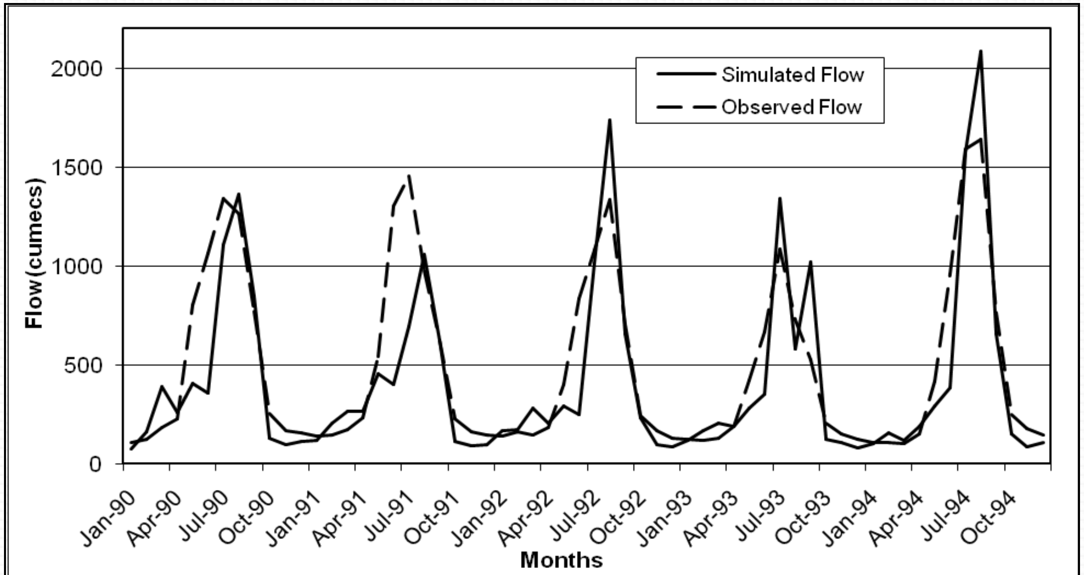
  - Soil Layer : FAO Digital Soil Map (scale of 1:5,000,000)

- Different Threshold
  - Catchment
  - Sub-Catchment
  - Watershed



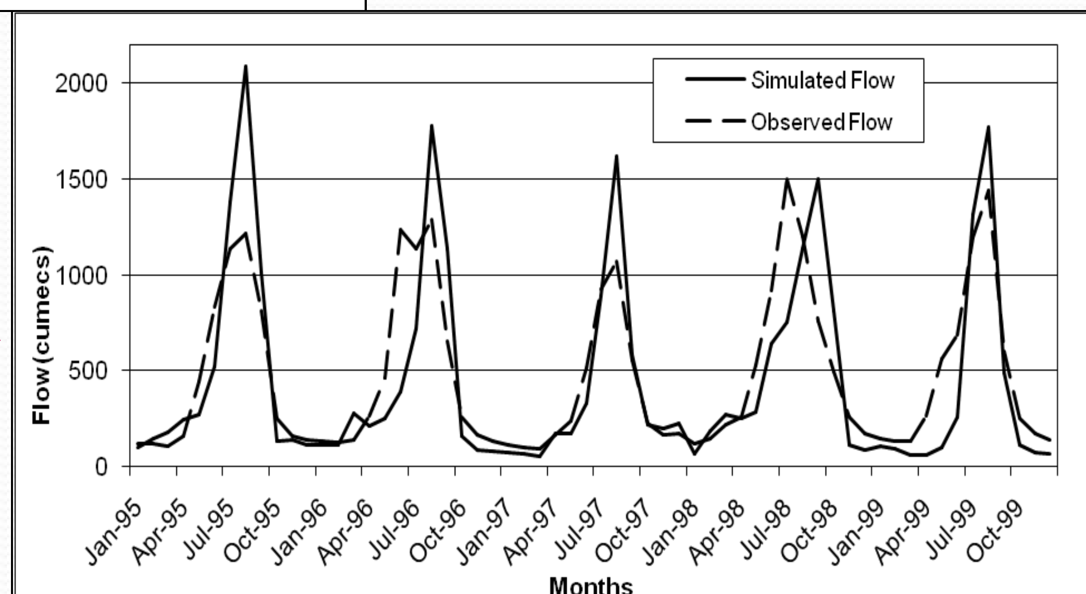
Location of model calibration and validation

Model Calibration and Validation Satluj Sub-catchment at a monthly time scale



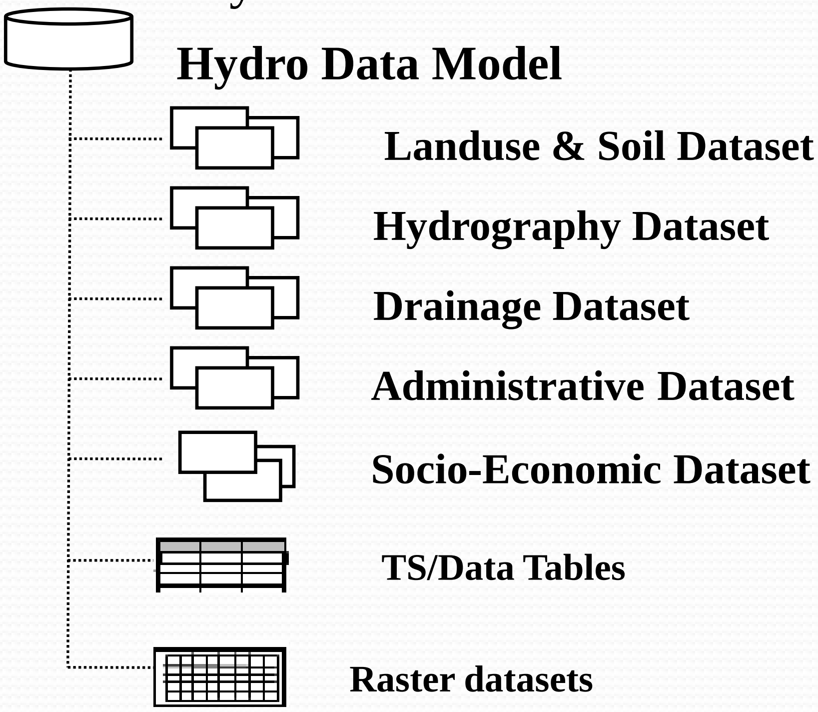
Calibration

Validation



Physical Database Design of the Spatial databases

Hydro Geodatabase Datasets



Model Base to Hydro Geodatabase

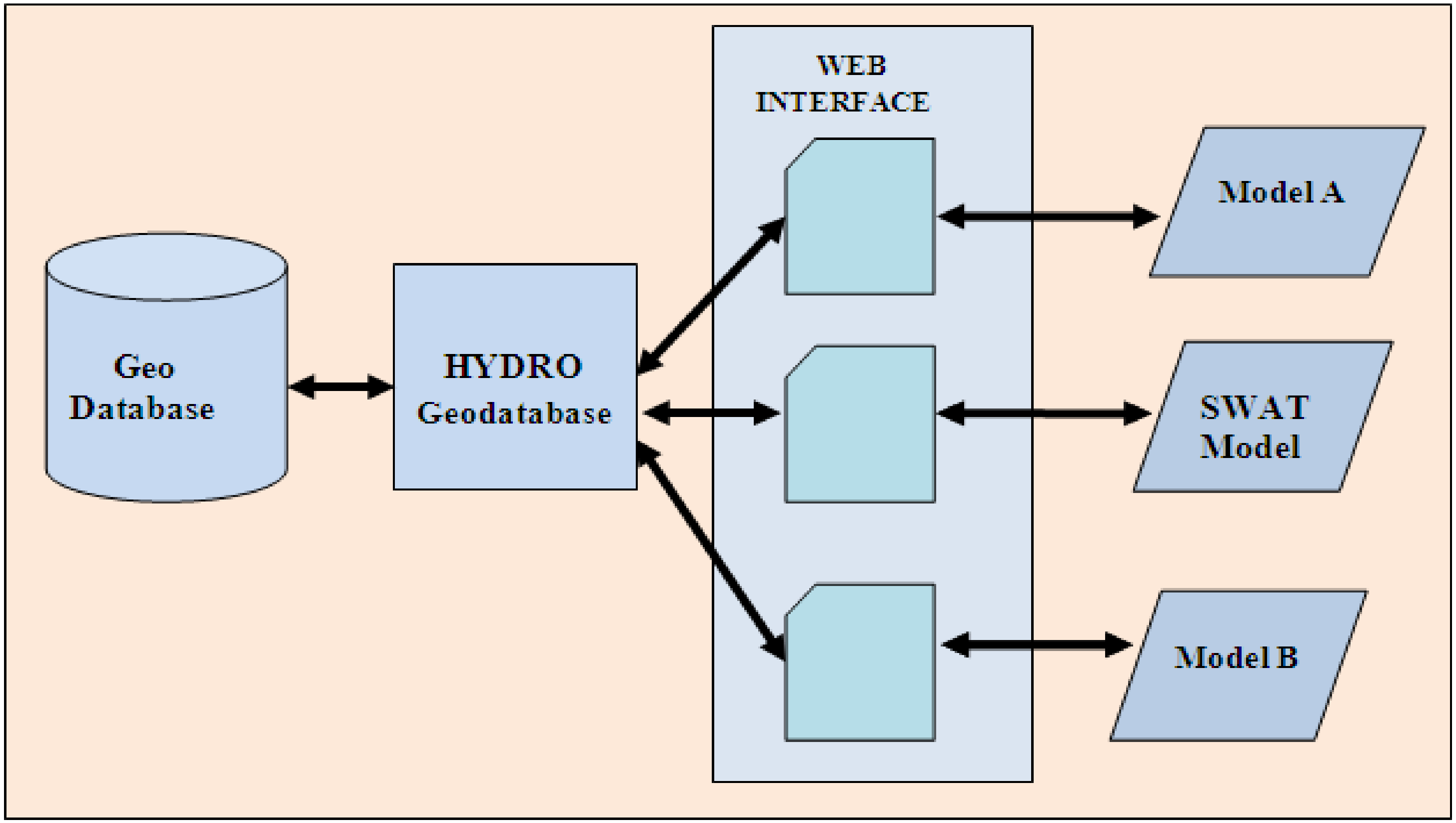
- In Geospatial integration HIS is constructed which contains a central Geodatabase and the simulation models required for the analysis

- The output of a model simulation are imported into the central Geodatabase

- Hydro data model was design to support SWAT model output (Viz. Suboutput, Reachoutput)

- SWAT Model was run on desktop
- Monthly and Daily model results of Subbasin & Reach where upload to Hydro geodatabase (Central Geodatabase)

Geospatial integration of Hydro geodatabase with SWAT model



Interface Designed and Developed for connecting SWAT model output

- A large amount of information shall be generated indirectly by using various kinds of models ranging from hydrological; hydraulic to environmental model that can form the model base to be attached to the framework (simulated output of the SWAT model is incorporated into the Hydro Geodatabase)

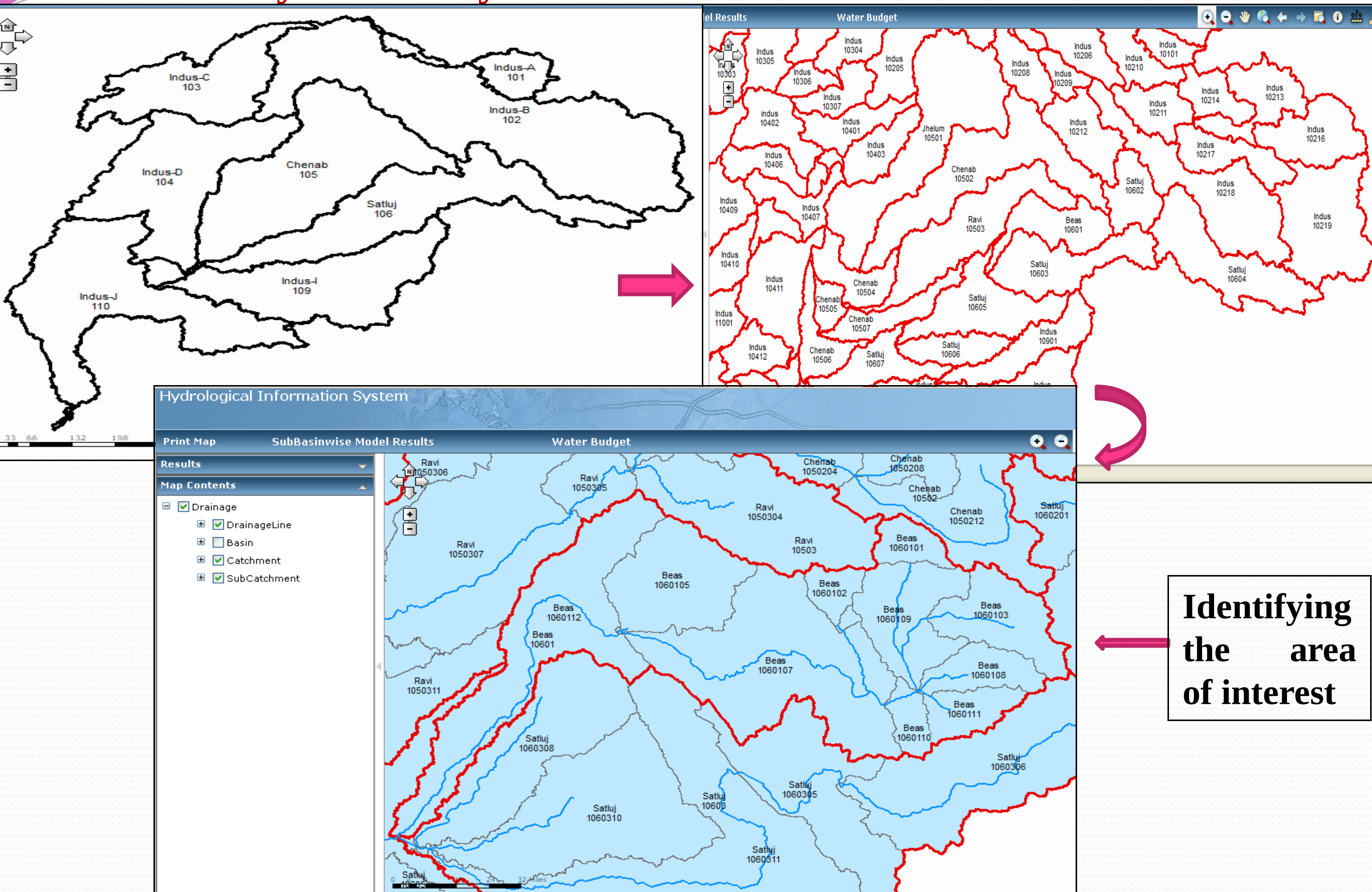
- Integrating SWAT model output with this framework provides a simple but powerful mechanism to understand the spatial variability of water quantity and quality variables within the context of the drainage system.

- The recent concerns of vulnerability on account of climate change and safe adaptation options are also in the realm of modelling.

- It can address the issue of evaluating the change in water availability under anthropogenic changes .

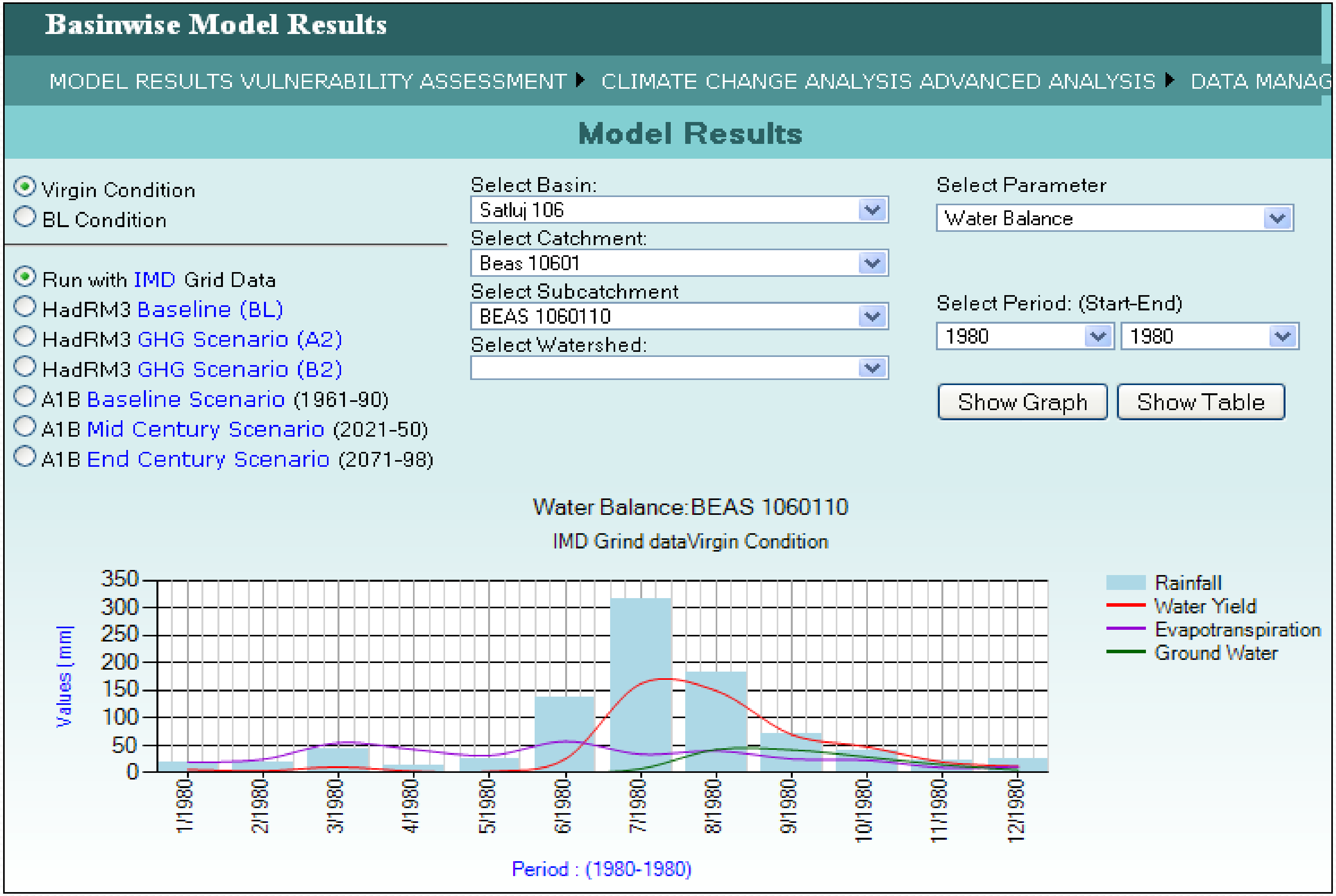
- Provide sufficient information on hydrologic and environmental sustainability of the drainage system that can be used for planning, management and evaluation process.

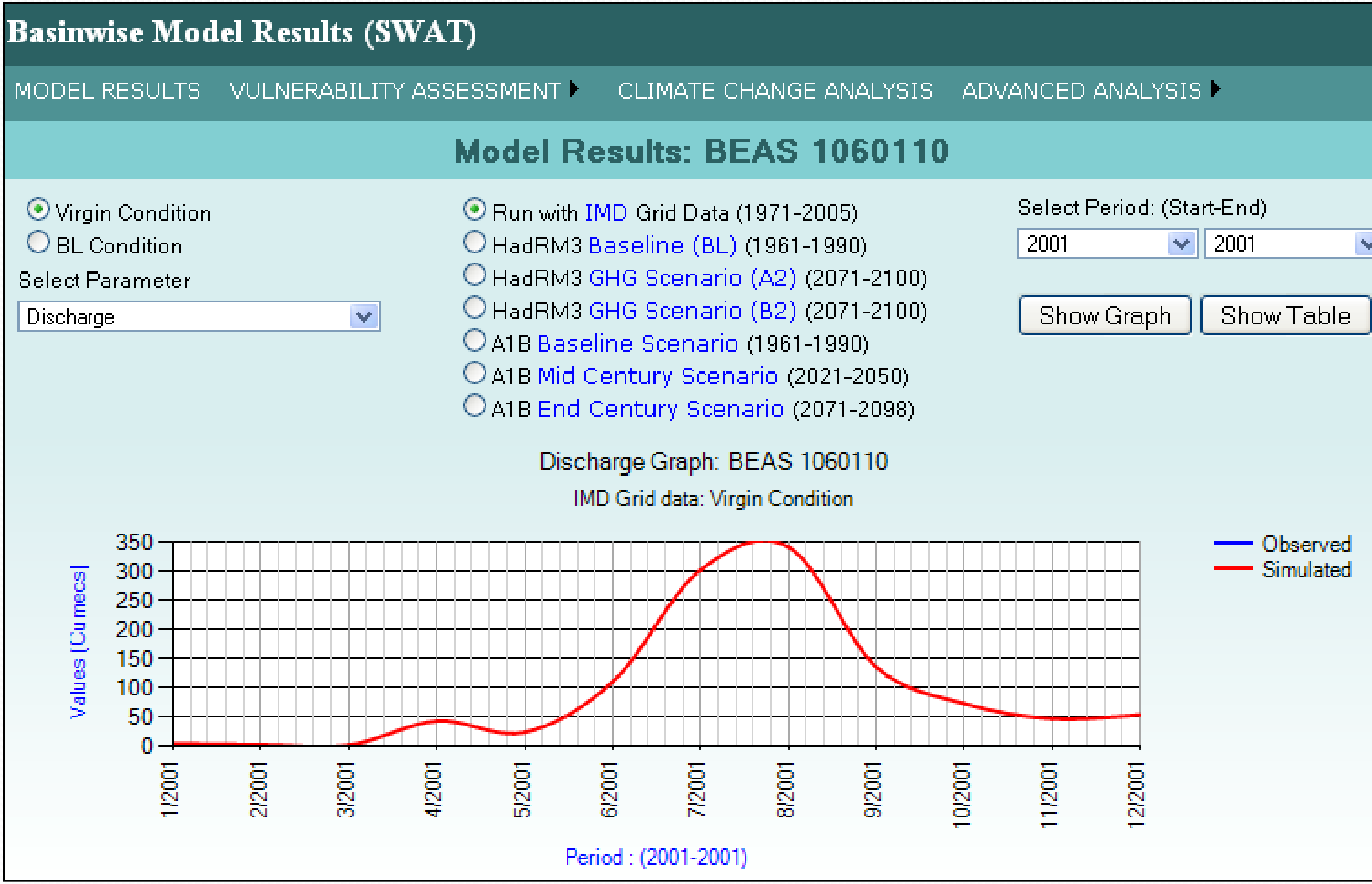
Facility to identify the area of interest



Identifying the area of interest

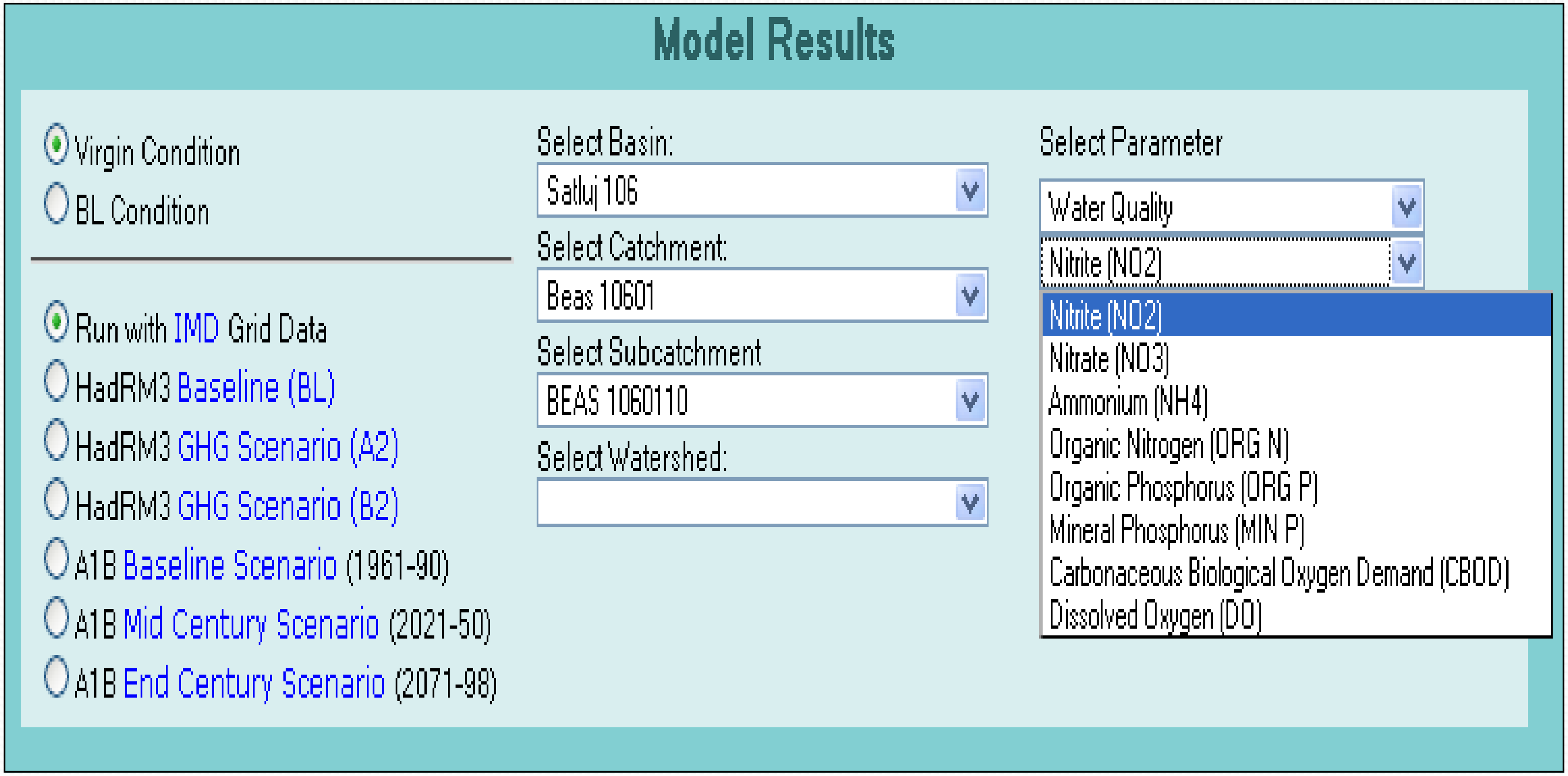
Accessing the hydrological model output for sub-areas





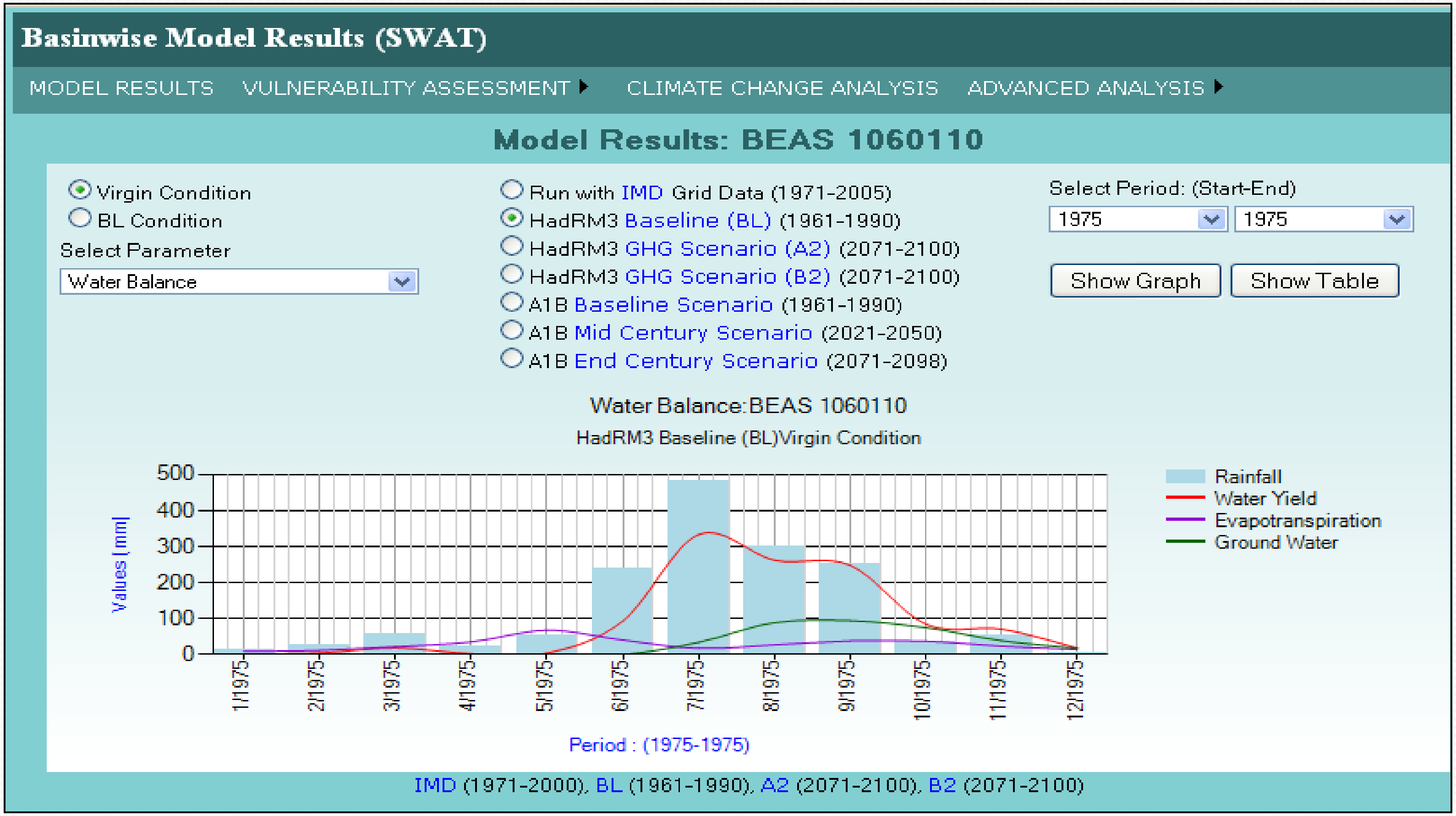
Discharge at the outlet of Beas 1060110 Sub-catchment

Framework also provides the option to store and view the water quality parameter from the SWAT model output



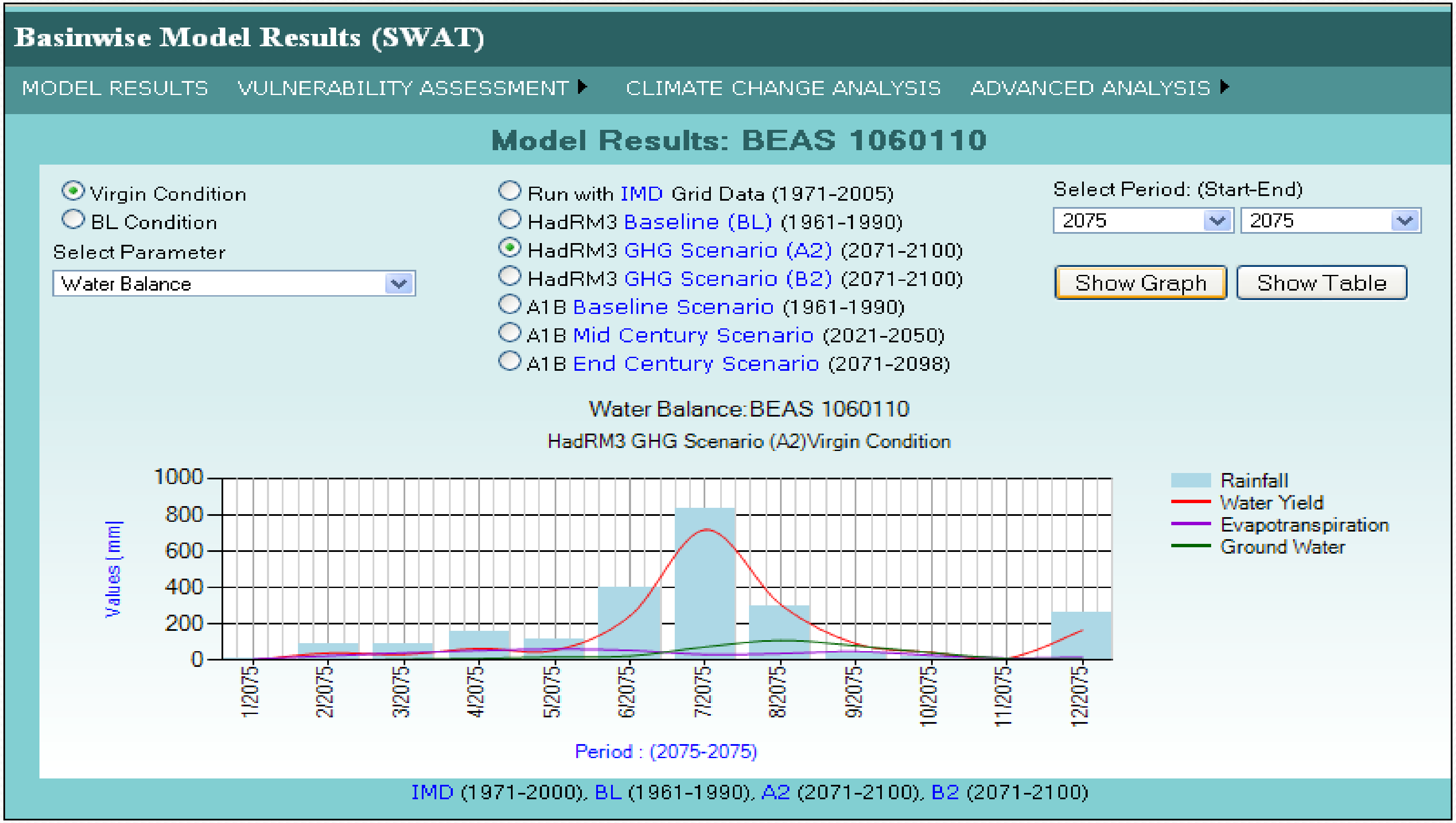
Analyzing for Impact of Climate Change on Water Resources

- Understanding of hydrological response of a river basin under changed climatic conditions will help in solving potential water resource problems associated with floods, droughts and availability of water for agriculture, industry, hydro-power generation and for domestic and industrial use.



Monthly water balance components for BL scenario for Beas 1060110 Sub-catchment

➢The user can ascertain the variation in the hydrological regime of the drainage area between different scenarios



Monthly water balance components for A2 scenario for Beas 1060110 Sub-catchment

Vulnerability Assessment

- Vulnerability is defined as the degree to which a system is susceptible to or unable to cope with adverse effects of climate change including climate variability and extremes (IPCC, 2001)

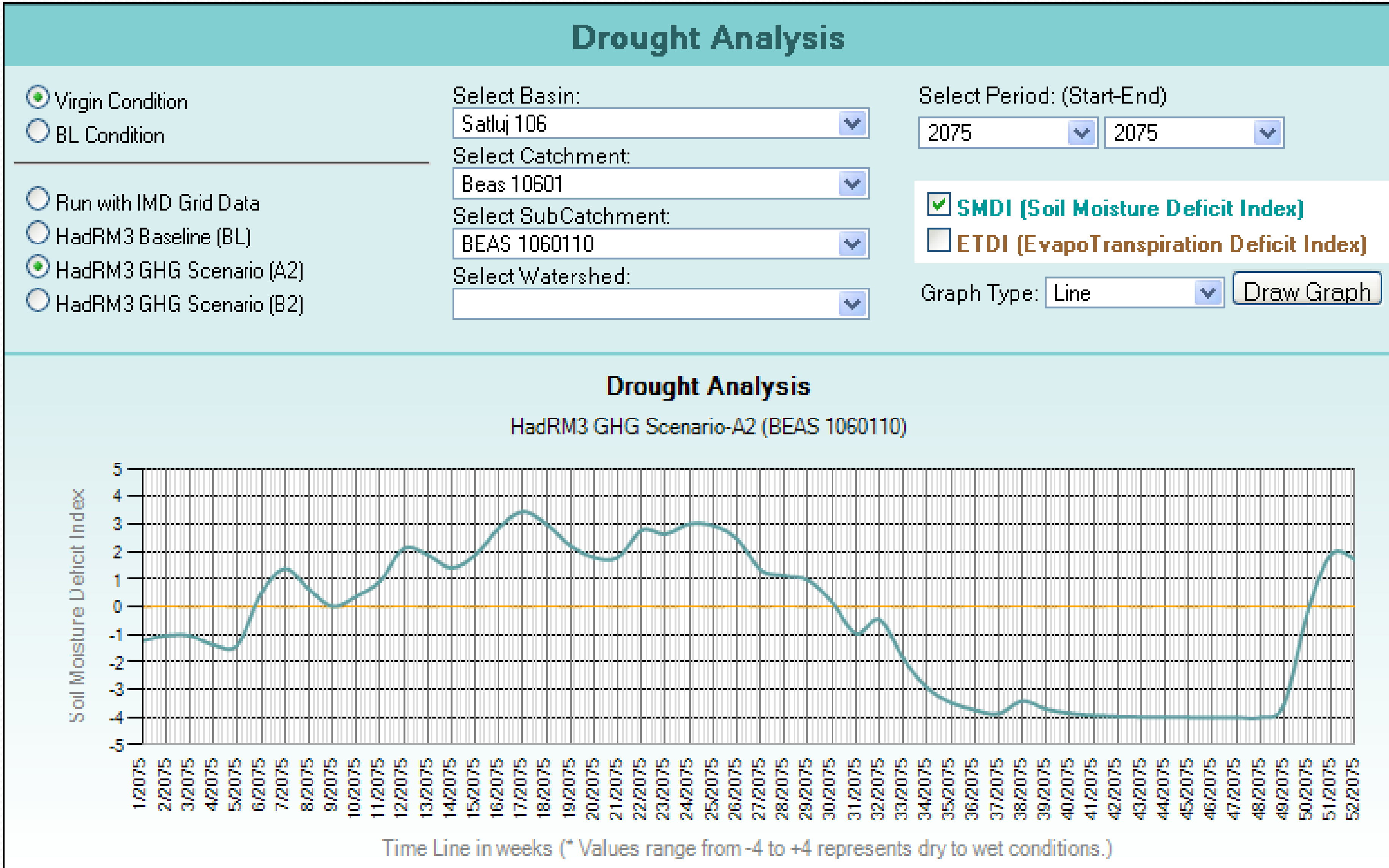
Drought Analysis

- Central and State Government Departments use drought indices to assess and respond to drought

- Soil Moisture Deficit Index (SMDI) & Evapotranspiration Deficit Index (ETDI) has been developed (Narasimhan & Srinivasan, 2005) to monitor drought severity using SWAT model output to incorporate the spatial variability

- SMDI & ETDI formulation has employed in this framework

Template Analyzing Drought Severity



Vulnerability Assessment

Flood Analysis

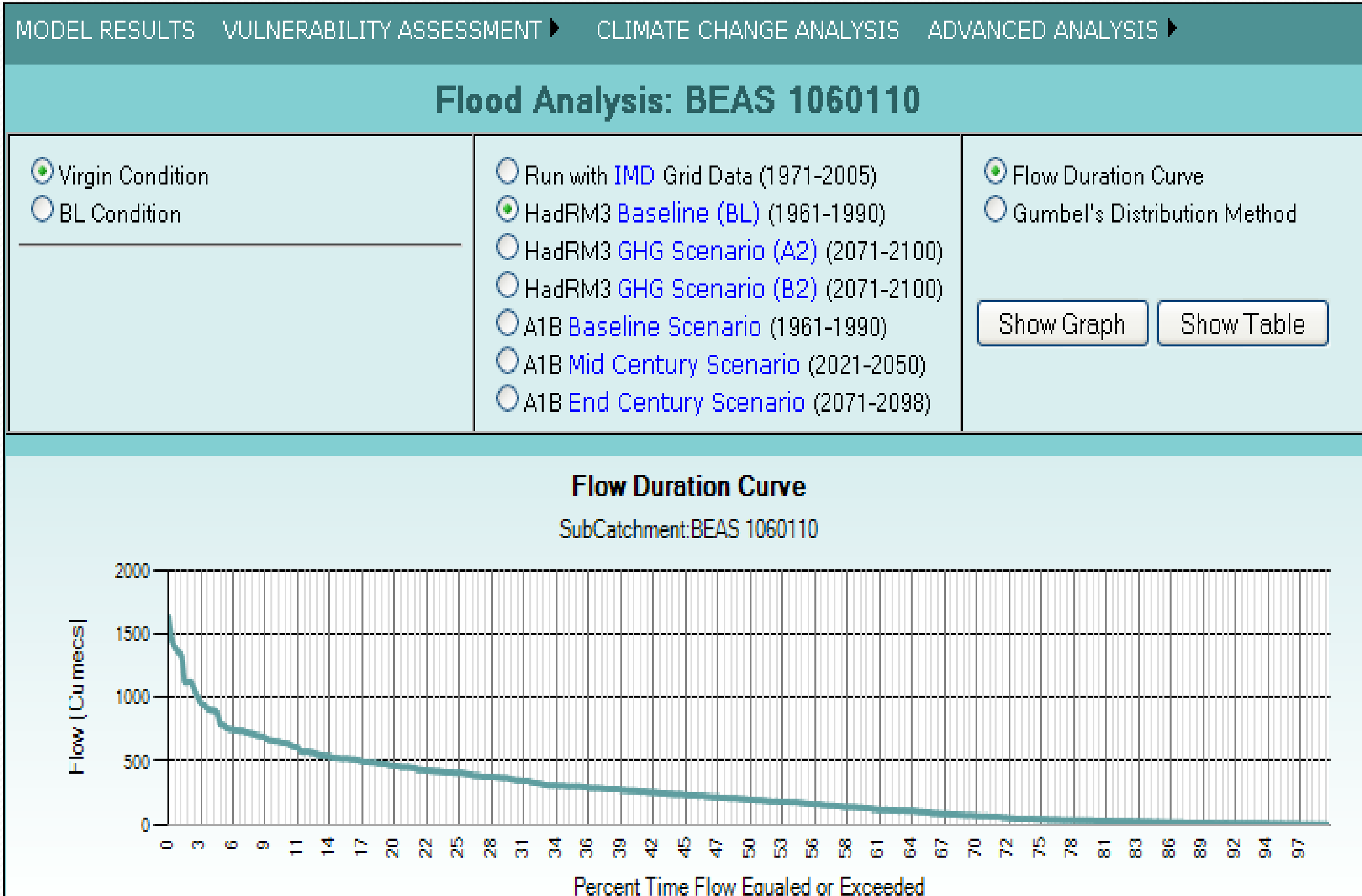
- Flood analysis has been carried out using the daily outflow discharge taken for each drainage area from the SWAT output

- These values are used to draw the **Flow Duration Curve**

- It is plot of discharge against the per cent of time the flow was equalled or exceeded

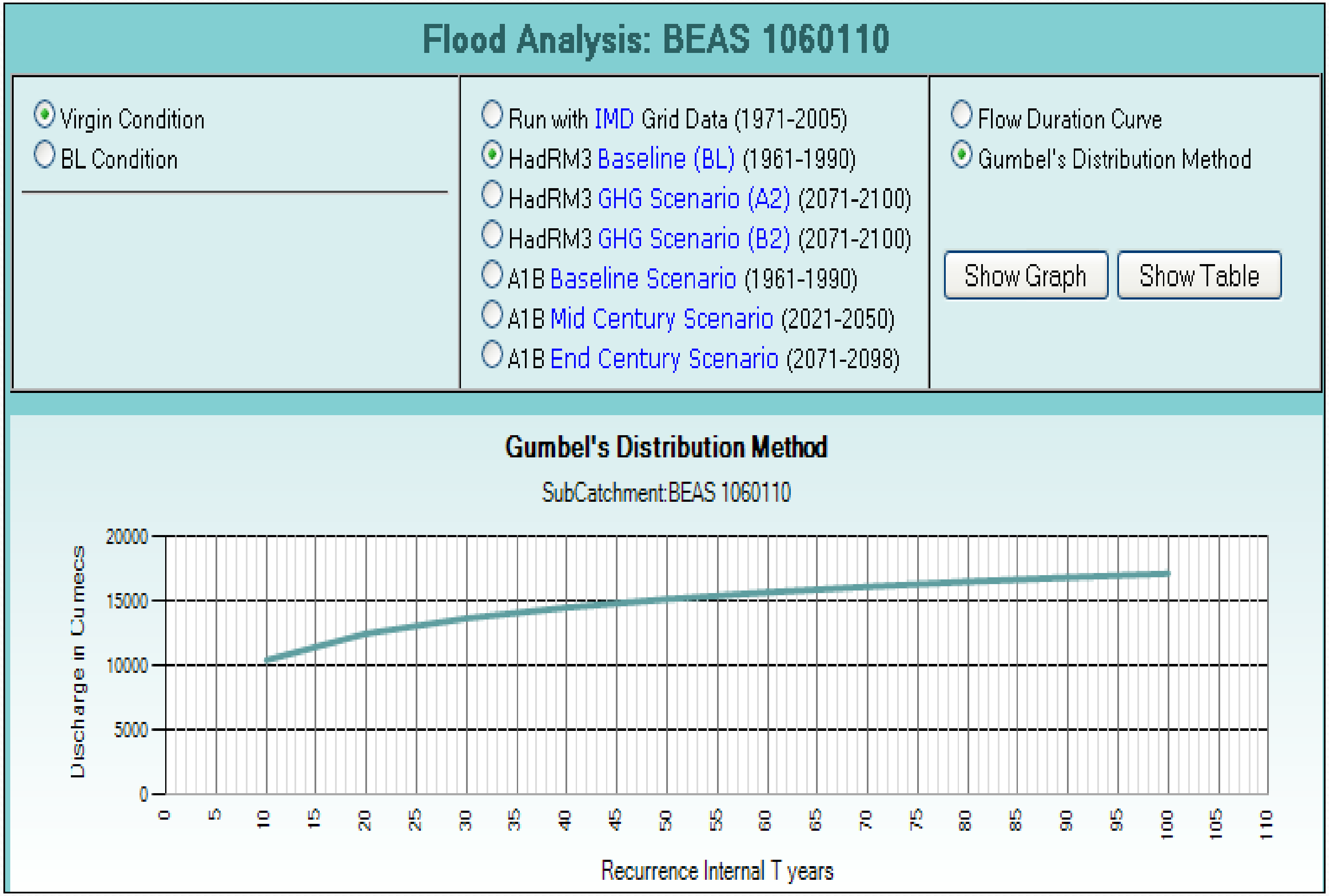
- **Flood Frequency Analysis -** Gumbel's distribution (Gumbel , 1941)

Interface displaying Flow Duration Curve for Control scenario



Flood Frequency Analysis

Template displaying Gumbel's Distribution for BL scenario

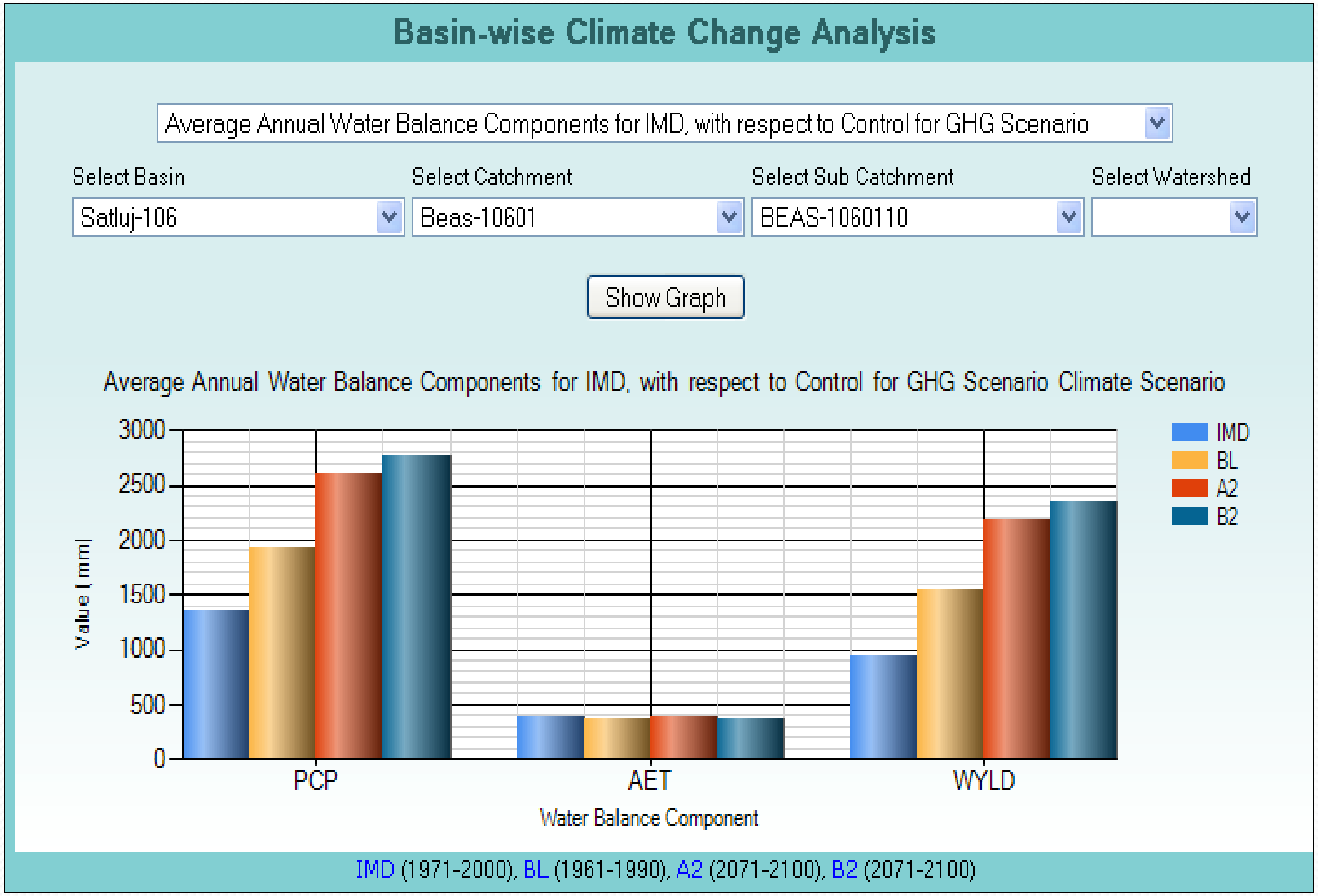


Interface to present results of various Climate Change Scenario analyses

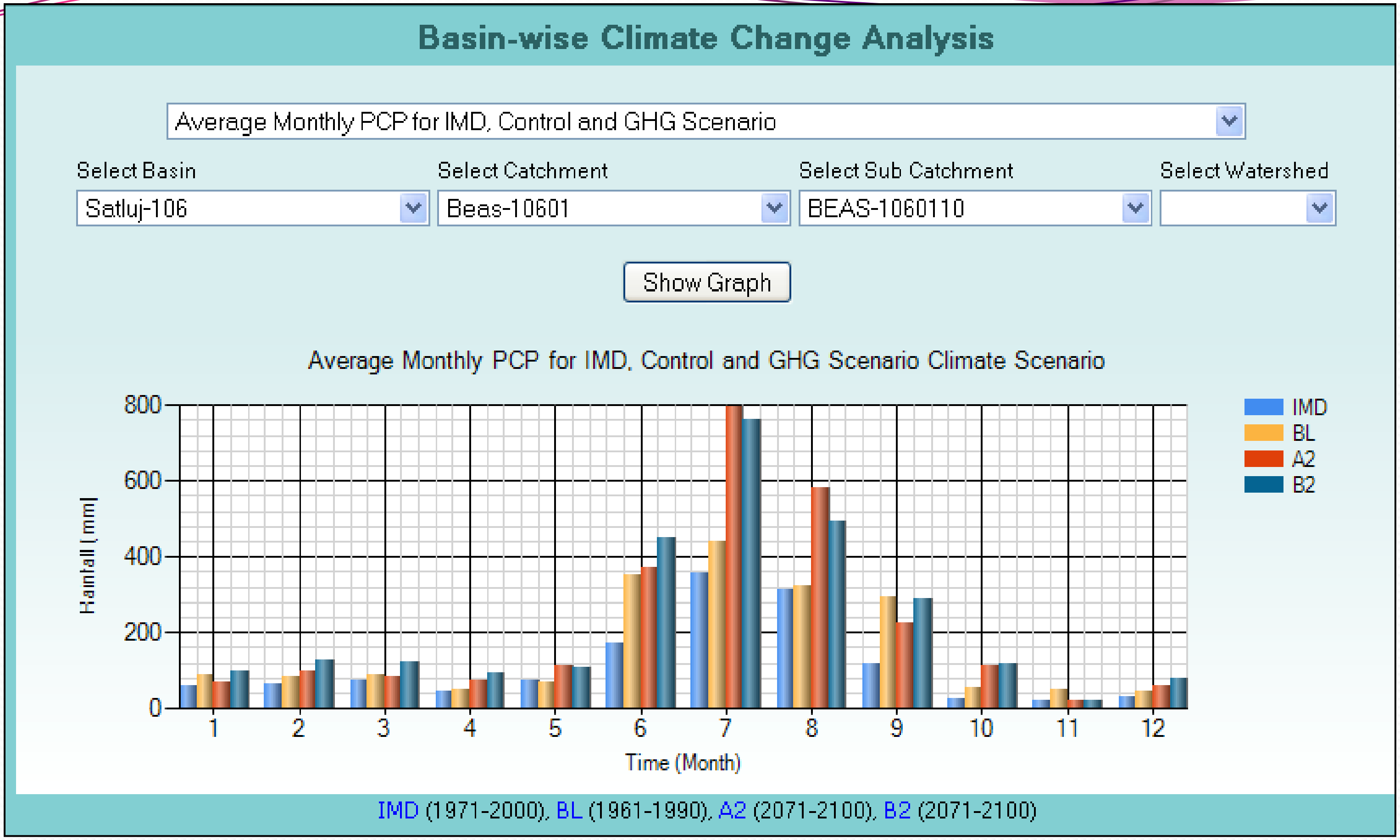
- The three basic hydrological components namely precipitation, water yield and actual evapotranspiration are the ones that have been tracked to reflect the climate change impacts.

- The analysis has been made on these components with respect to mean annual as well as mean monthly values for control and GHG scenarios.

- These analyses help the user and the water manager to understand the change in hydrological behaviour of the drainage area with respect to climate change scenarios.

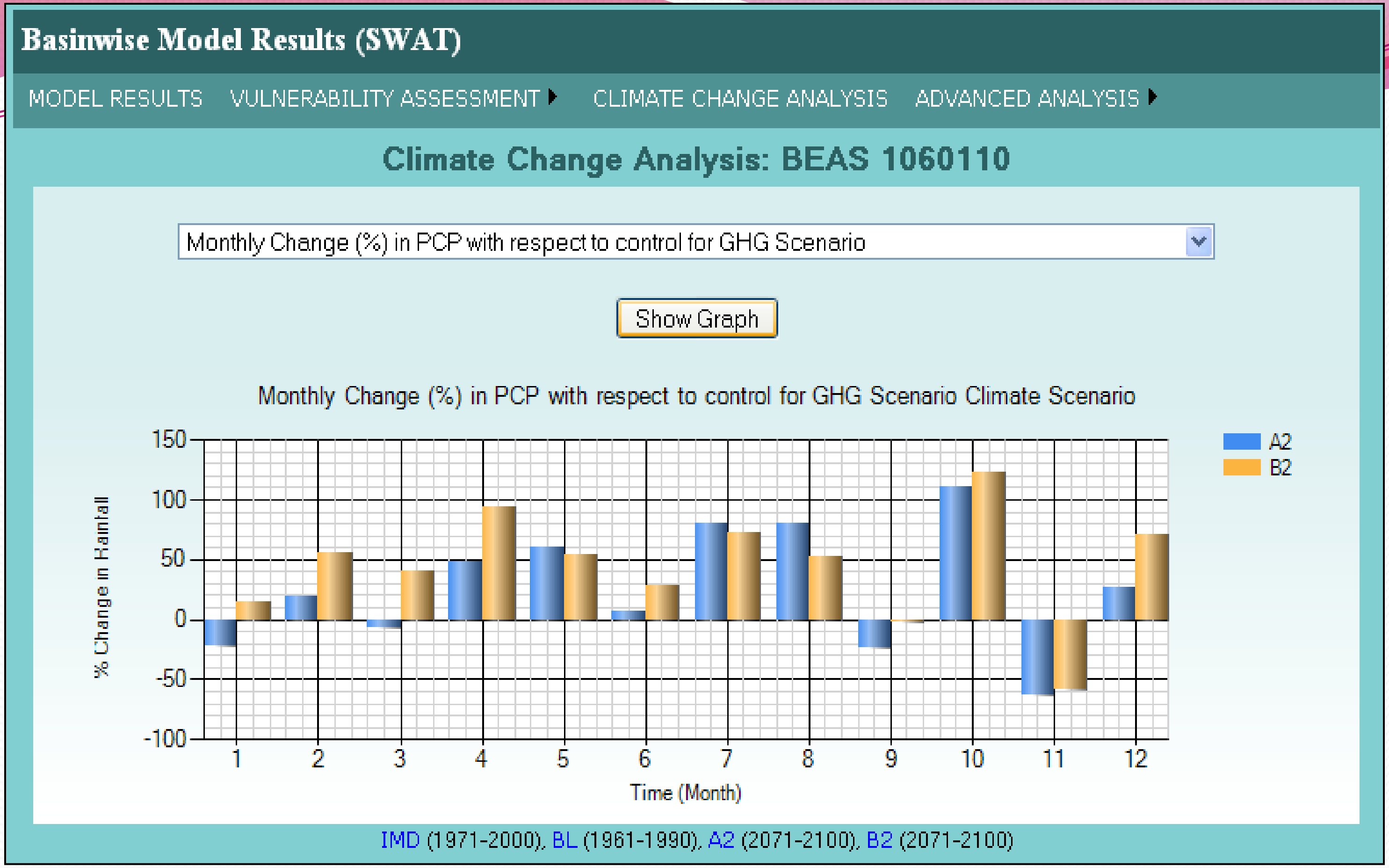


Average Annual Water Balance Components for IMD and for Control and GHG Scenarios



Average Monthly Precipitation for IMD, Control and GHG Scenario

- Average Monthly ET for IMD, Control and GHG Scenario
- Average Monthly Water Yield for IMD, Control and GHG Scenario



Template of Monthly change (%) in PCP with respect to Control for GHG Scenario.

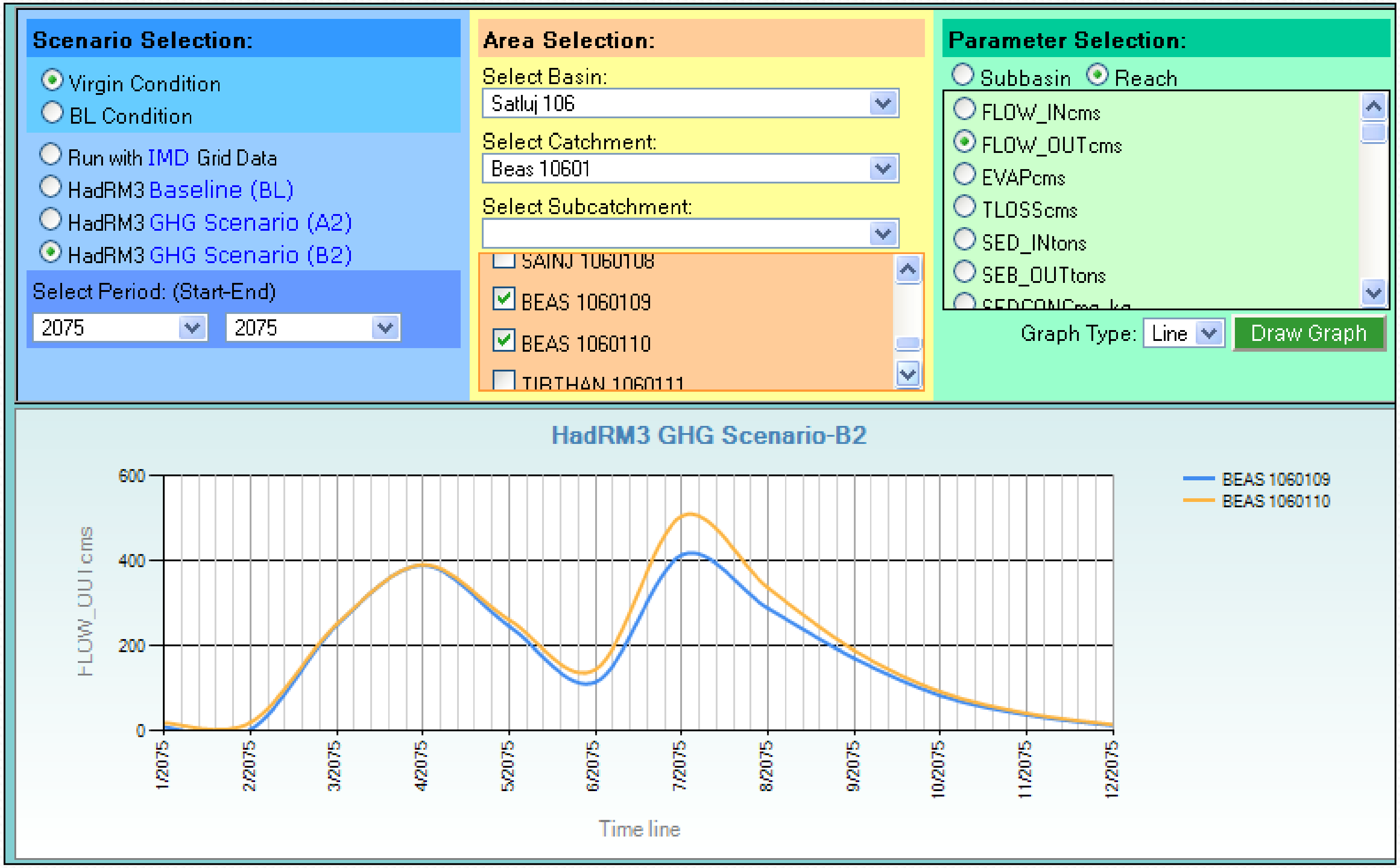
- Monthly change (%) in ET with respect to Control for GHG Scenario.

- Monthly change (%) in Water Yield with respect to Control for GHG Scenario

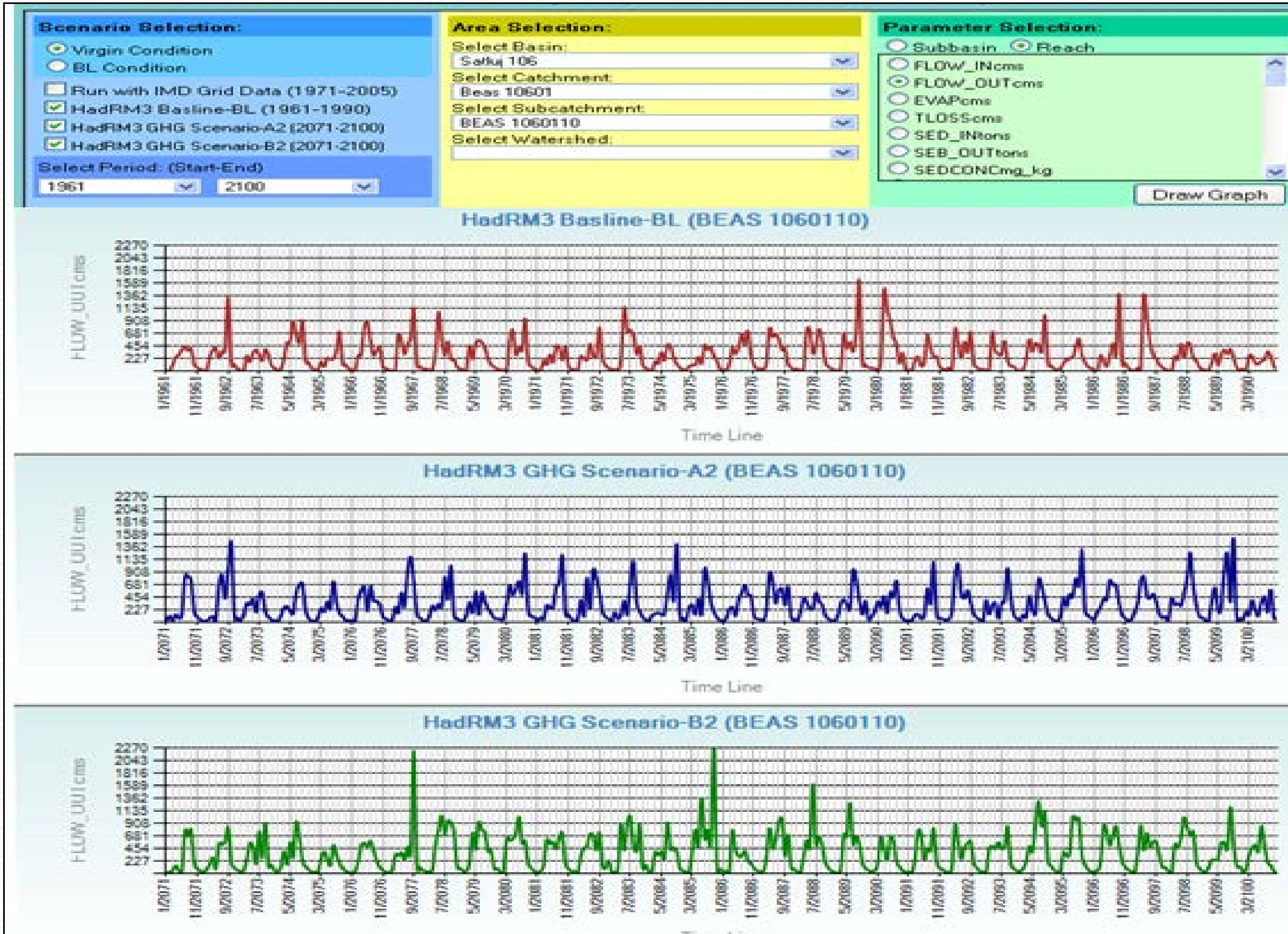
Interface to present results with respect to multiple Drainage area and multiple Scenario

- The framework has also incorporated the option to present model result with respect to multiple drainage area and multiple scenarios for the users who need to compare these for better understanding.

Multi-Area Selection



Multi Scenario Selection



Conclusions

- The present framework can serve as important tool for water resources management by integrating water resources related information on a common geospatial platform.

- This information can contribute to long term improvement in water resources decision making by providing more timely and comprehensive access to water resources data.

- Furthermore, it can also serve as a ready input for hydrological modelling which, in turn, generates scenarios for evaluating the impact of anthropogenic as well as climate changes on water resources. Thereby help in taking various adaptation strategies.

Thank YOU