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Hydrologic Modelling for the Wardha Basin

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MOTIVATION

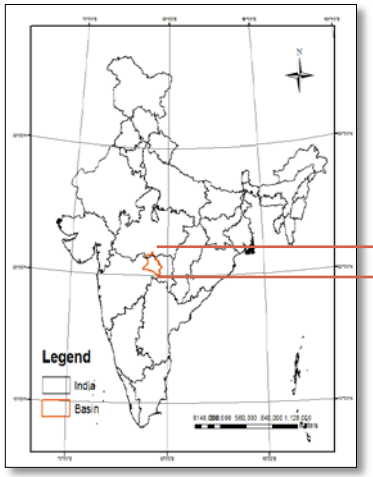
- Develop a SWAT model to predict the stream discharge in Wardha sub-basin.

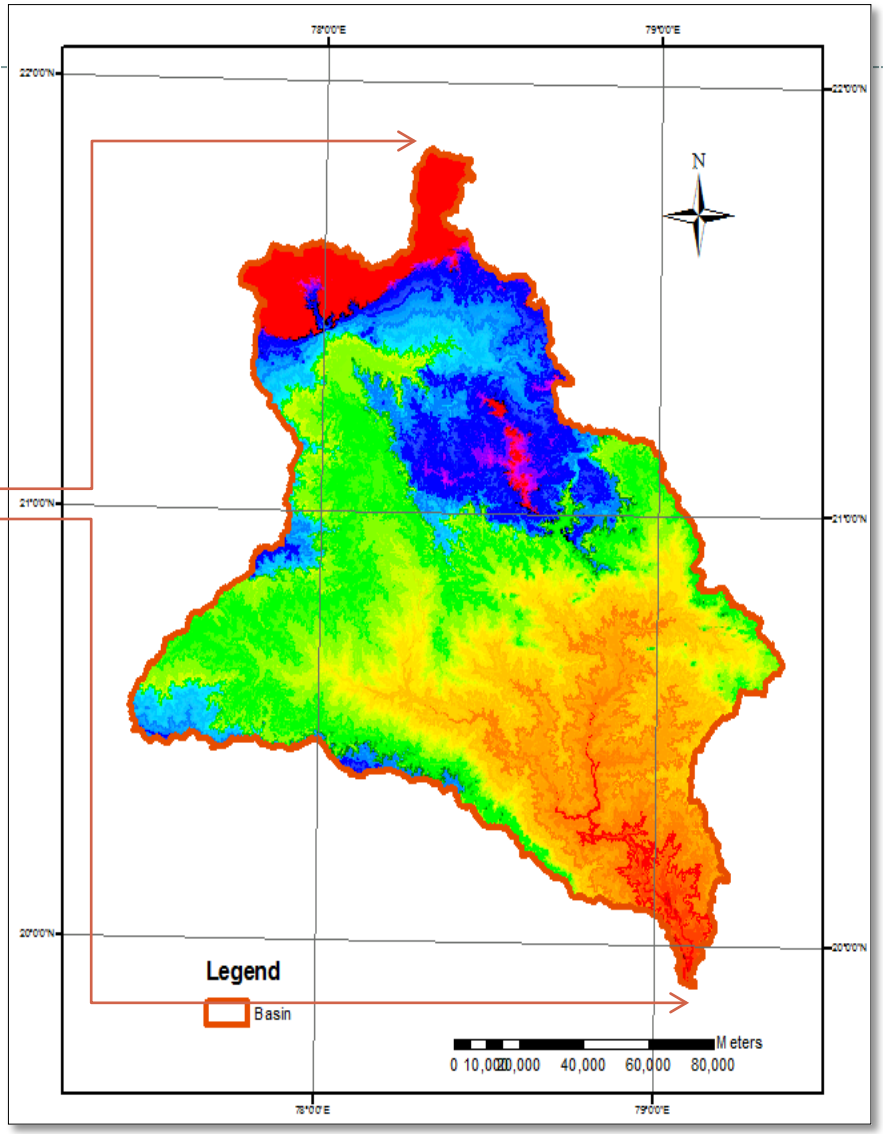
- Establish the efficiency of the model corresponding to a real scenario existing in the catchment , so that it can be used for further studies in future.

- Estimating the effect of Anthropogenic changes on the water resources availability

- Evaluation of water resources in light of future changes in the demand and availability in the basin.

STUDY AREA





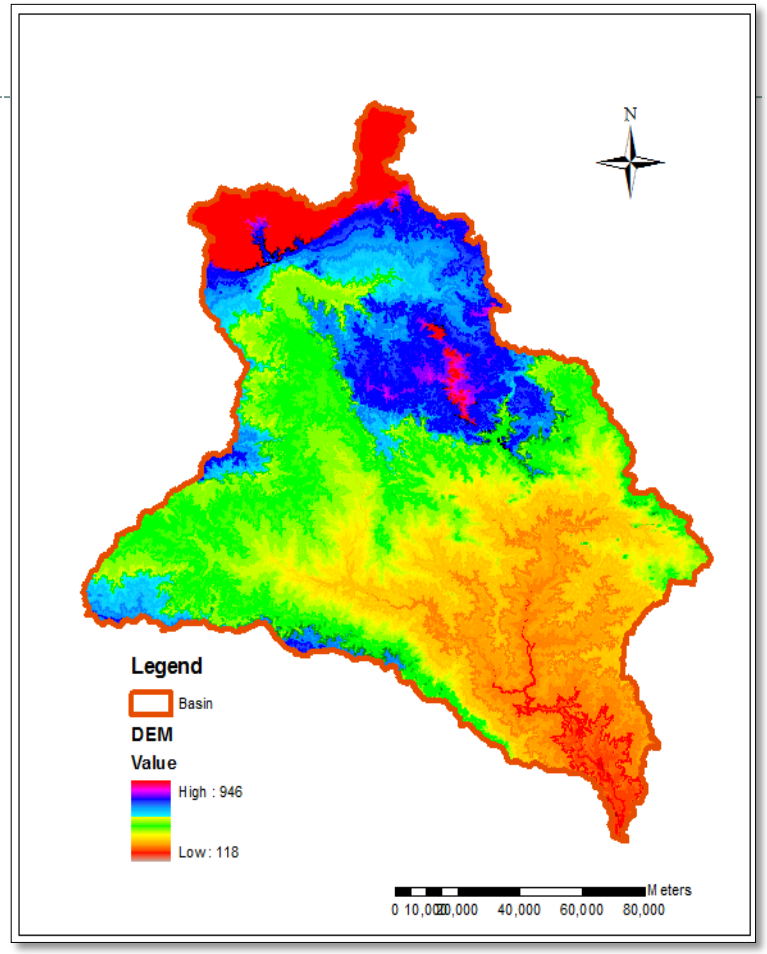
•The study focuses on the hydrology of Wardha sub basin of Godavari River in Eastern Maharastra state of India.

•The area lies between latitudes 19^0 18’ N and 21^0 58’N and longitudes 77^0 20’E and $79^0$45’ E.

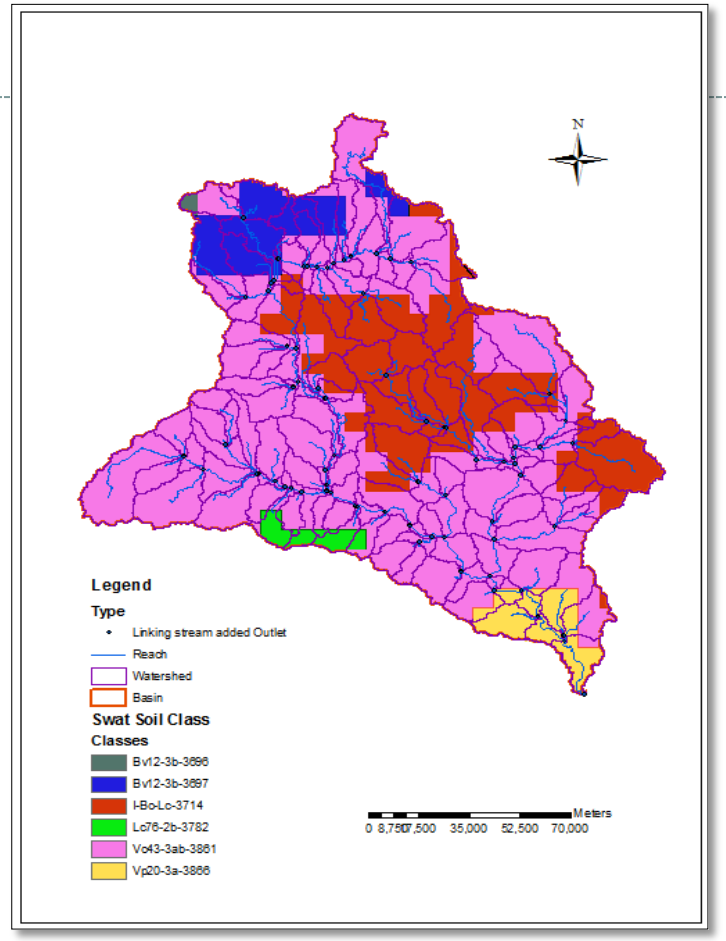
•The sub basin is triangular in shape with an average width of nearly 90 km.

•The flow in Wardha is observed at the CWC G&D site at Ghugus where it drains an area of 19759.95 km^2.

MODEL INPUT DATA

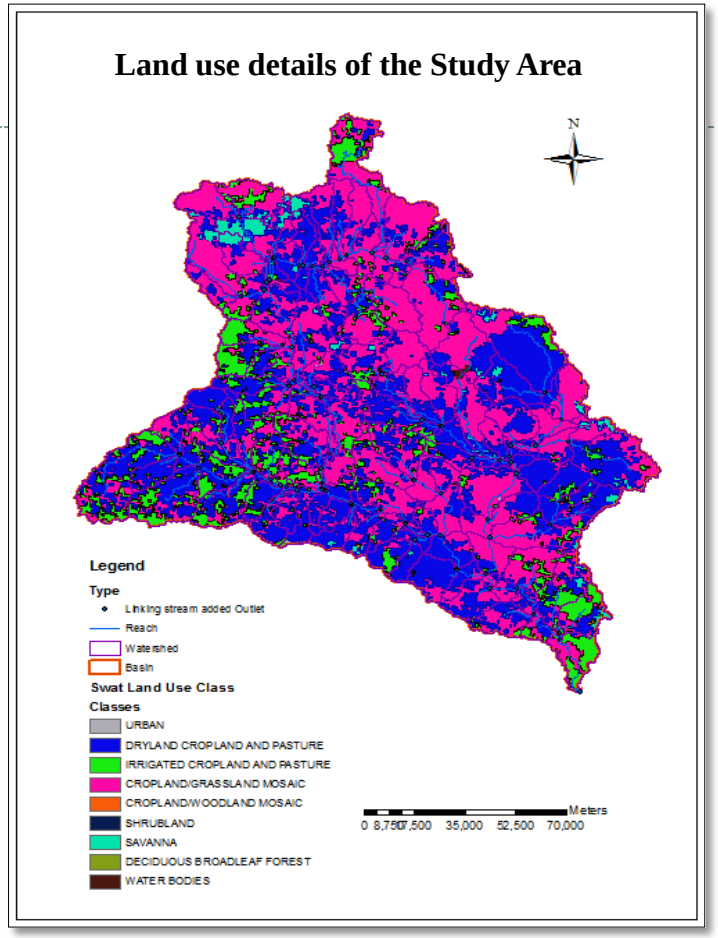


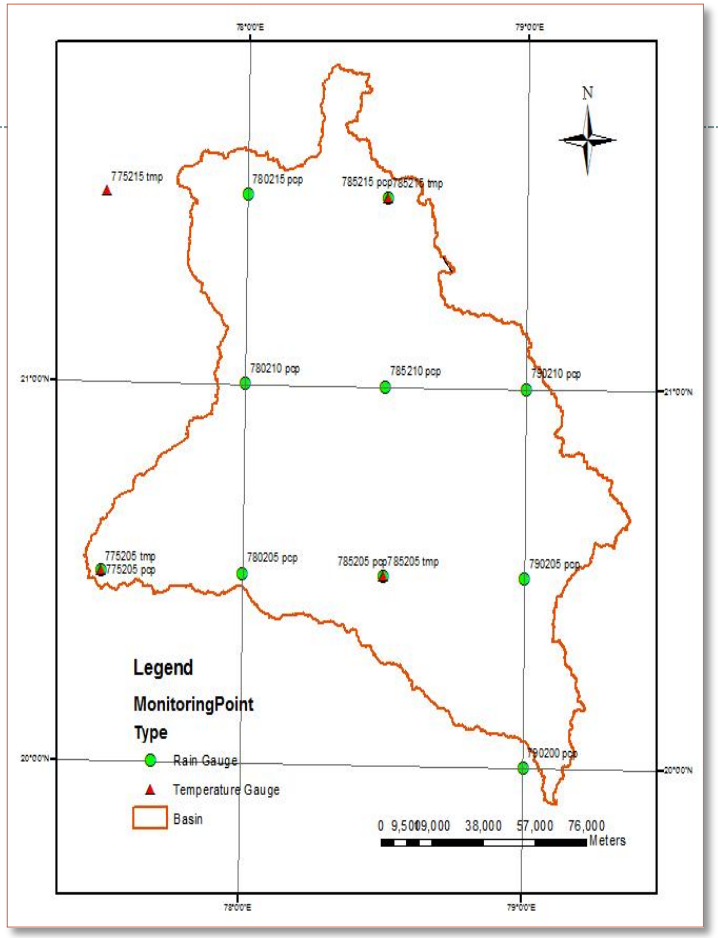
The Digital Elevation Model (DEM) of the Wardha sub basin as extracted from SRTM data at 90-m resolution has been used.



The soils of the Wardha sub-basin may broadly be divided into three categories namely (i) black soil, (ii) red soil, and (iii) mixed black and red soil and, in terms of the soil type, clay and clayey loam soils

MODEL INPUT DATA

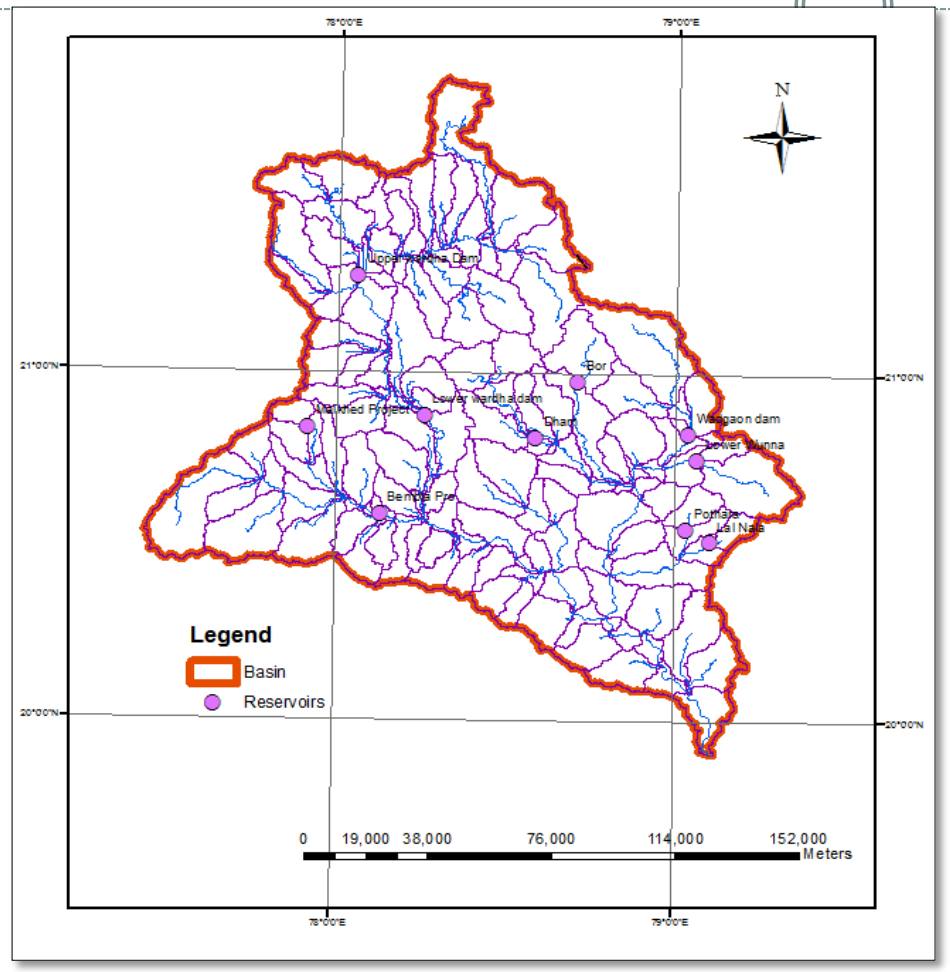




Agriculture is the principal activity in the area. The main food crops of the area are wheat, jowar, and groundnut.

The daily rainfall, corresponding to ten reference grid points and daily temperature at five locations were extracted from the IMD gridded daily rainfall data (provided by IMD using the actual point data) for the period 1969 to 2005. An examination of the rainfall data over the period 1969 to 2005 for the district indicates an annual mean rainfall of 888 mm.

MODEL INPUT DATA



Reservoirs in Wardha sub-basin

•The present modelling initiative has incorporated all known (existing as well as proposed) projects along with their respectively inferred water utilization details and the process.

•There are ten reservoirs within the Wardha basin: Upper Wardha, Bor, Lower Wardha, Malkhed, Wadgaon, Dham, Lower Wunna (Nand), Bembla, Pothara anad Lal Nala.

•Beside the location, other attributes such as storage capacity and other features were incorporated.

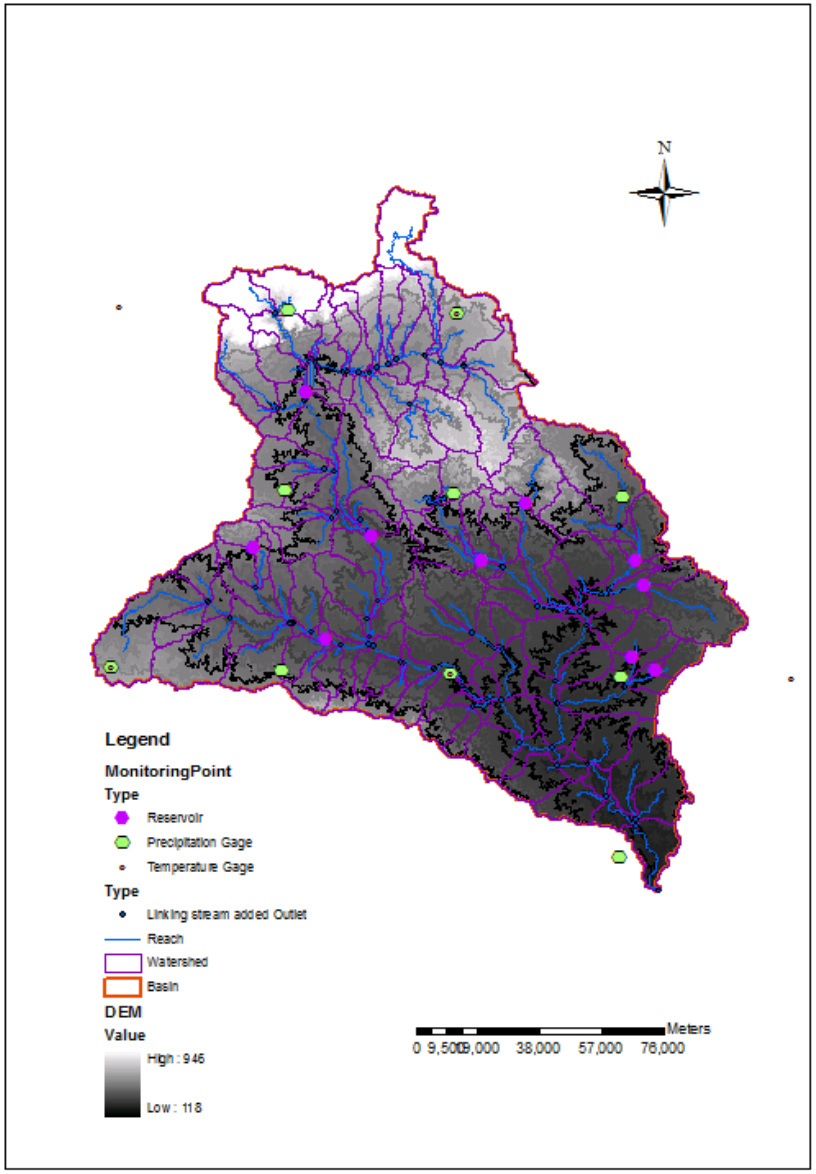
MODEL SET UP

- The Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM) of 90 m resolution was used for sub-basin definition (155 sub-basin)

- Daily climatic data for the period from January 1969 to December 2005 were used for the model simulations.

- The SWAT model was setup separately for three different developmental scenarios namely

i. *Virgin basin condition*,
ii. *Current developmental scenario*, and
iii. *Future (projected) developmental scenario.*



MODEL CALIBRATION

Simulation Periods :

i. Warm –up Period : January 1st ,2001 to December 31st , 2001.

ii. Calibration : January 1st ,2002 to December 31st , 2003.

iii. Validation : January 1st ,2004 to December 31st , 2004.

Observed Data :

i. Stream Flow : Daily Observed Data from January 1st , 1990 to December 31st , 2004 at Ghuggus G & D site.

Model Performance Evaluation :

i. Nash-Sutcliffe Efficiency (NSE)

ii. Coefficient Of Determination (R^2)

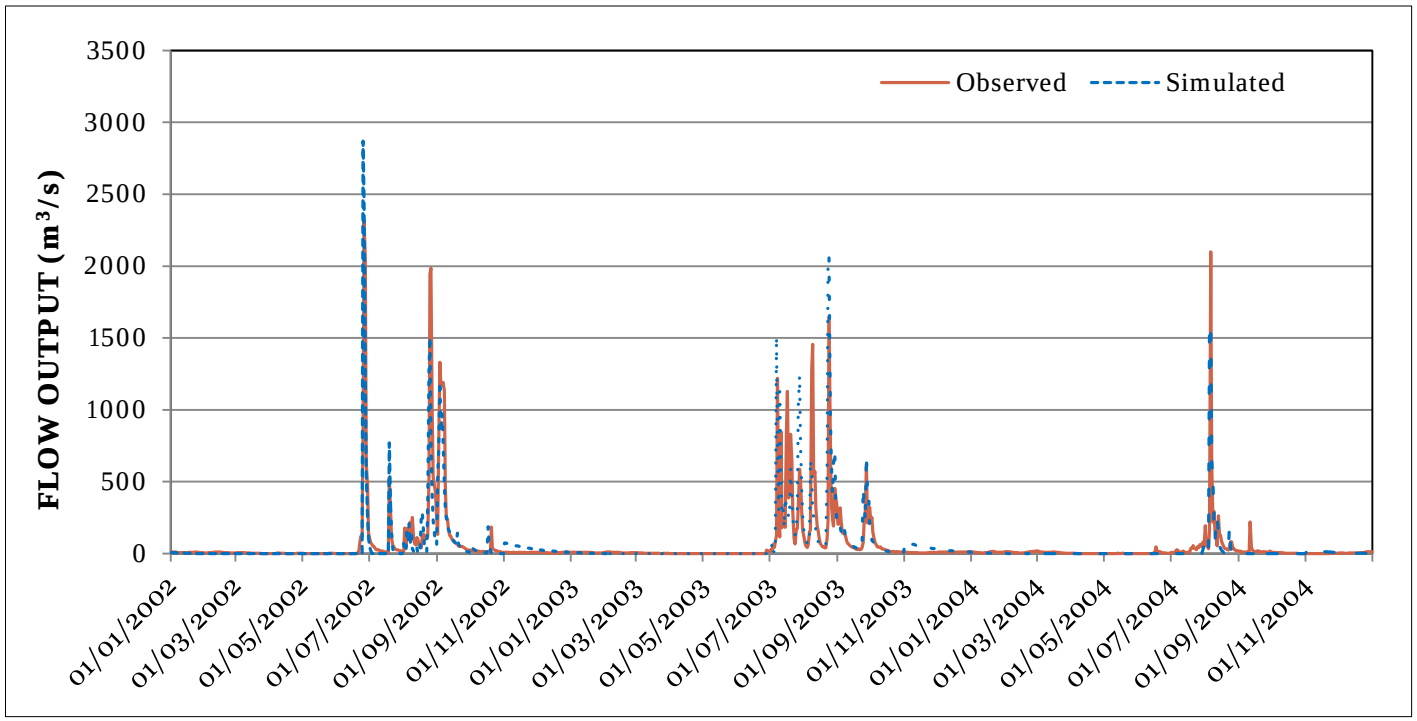
Model performance criteria :

i. Nash-Sutcliffe Efficiency (NSE) > 0.5

ii. Coefficient Of Determination (R^2)

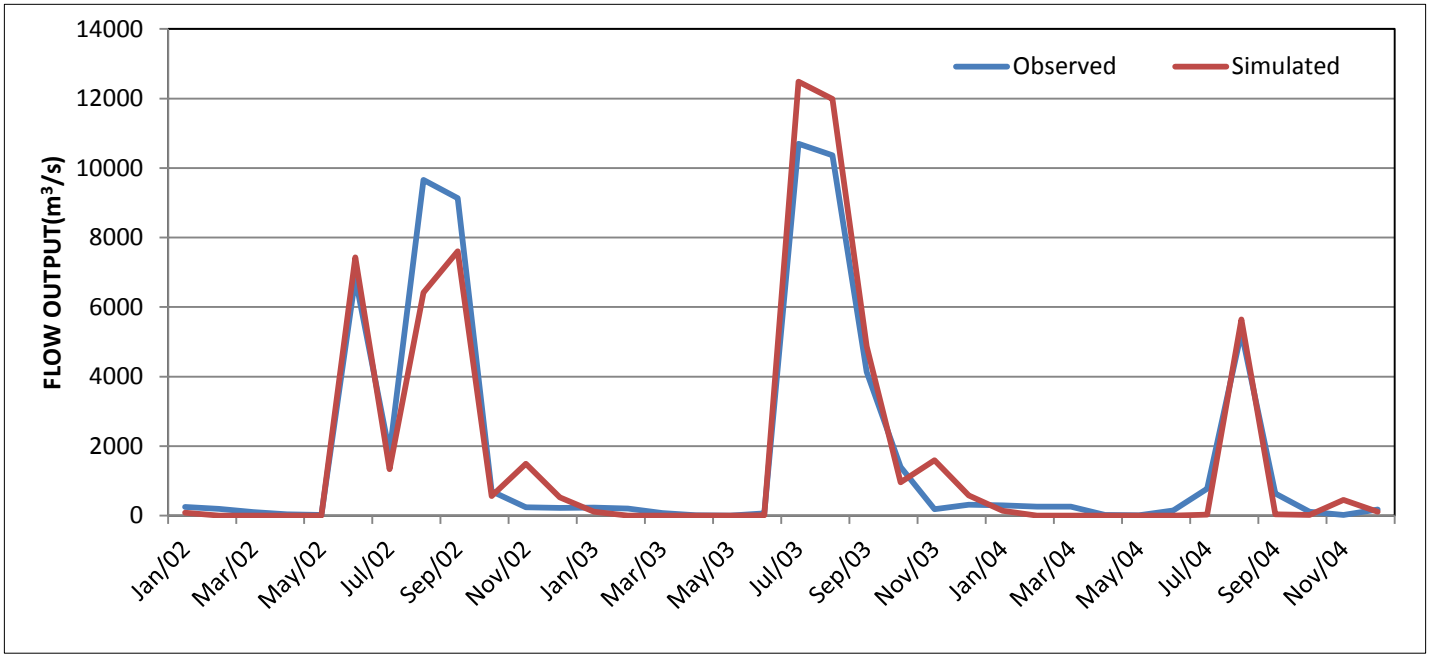
	R^2			
	Poor	**Fair**	**Good**	**Very Good**
Daily Flows	< 0.60	0.60 – 0.70	0.70 – 0.80	0.80 – 0.90
Monthly Flows	< 0.65	0.65 – 0.75	0.75 – 0.85	> 0.85

MODEL CALIBRATION

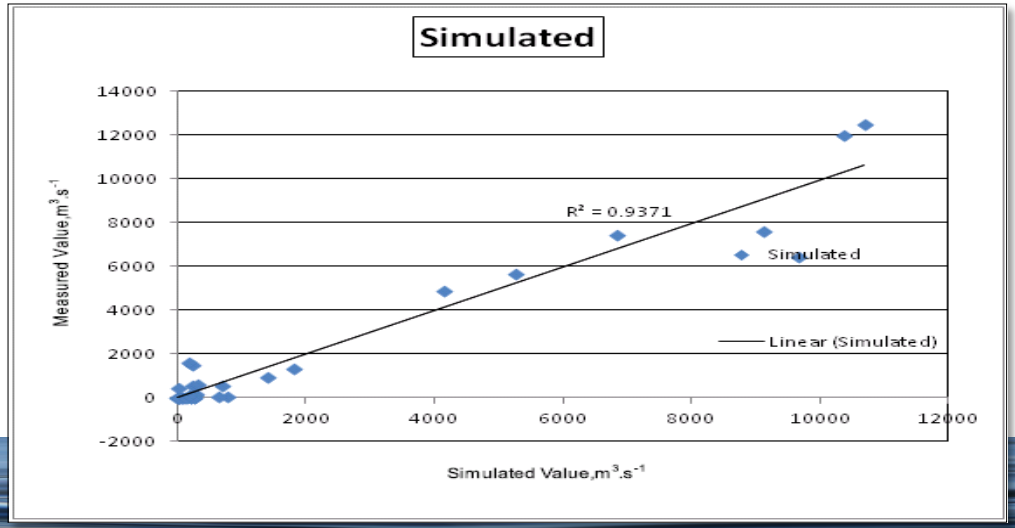


Comparison of SWAT simulated and measured monthly flow for daily time-scale calibration

MODEL CALIBRATION



Comparison of SWAT simulated and measured monthly flow for Monthly time-scale calibration

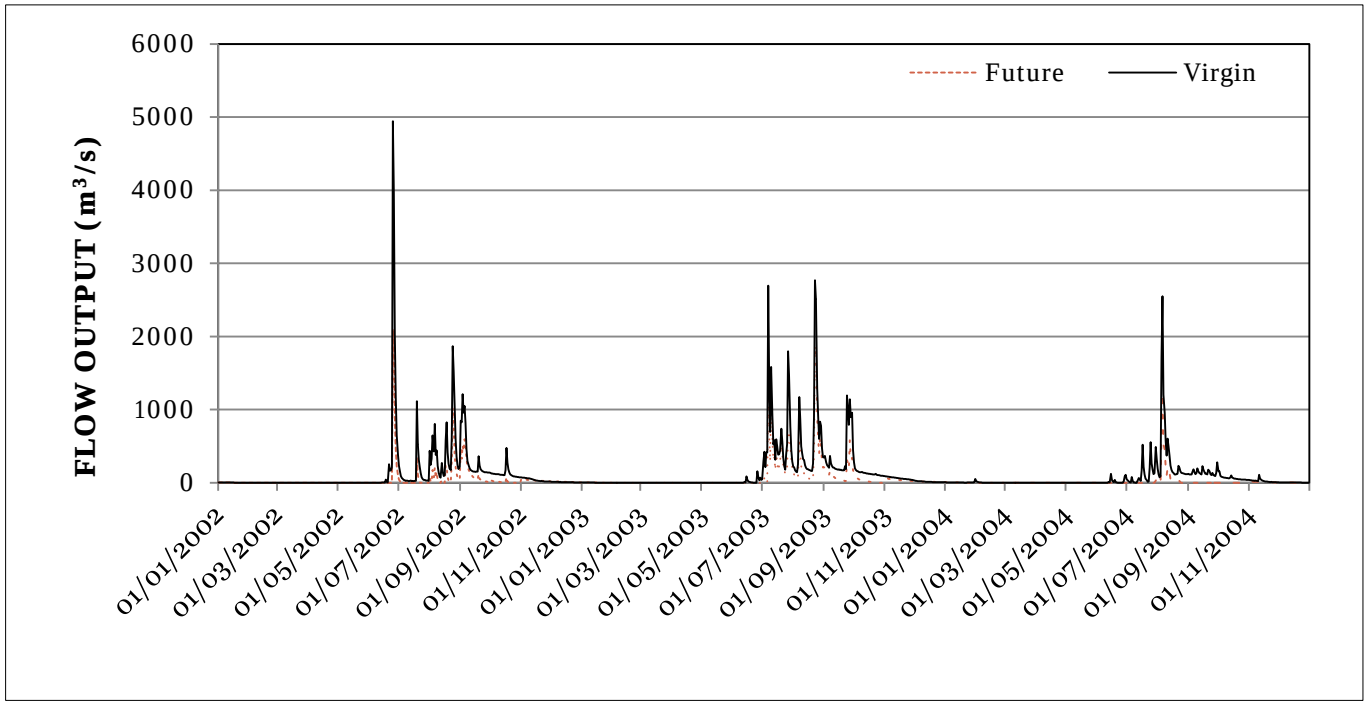


Scatter plot of SWAT simulated and observed flow at monthly time-scale (SMC) .

- The E_{NS} and R^2 of monthly runoff were 0.93 and 0.93, respectively at the Ghuggus Gauge & Discharge station.

RESULTS

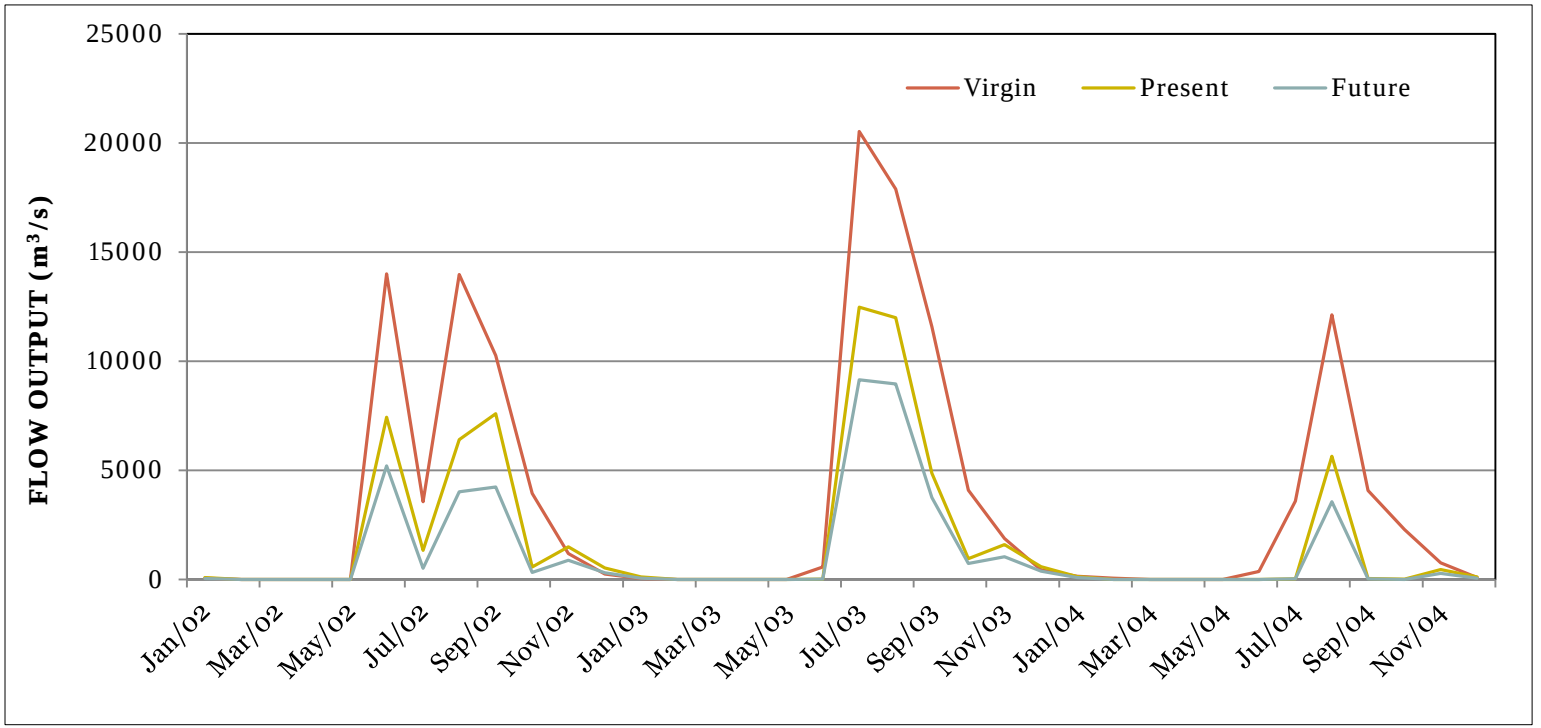
SWAT simulations of runoff have been derived for the period 1969 to 2005 after carrying out an elaborate calibration process .



Daily outflow variation for the Wardha basin in *Virgin* and *Future* condition

Above figure presents a comparison between generated daily scenarios for three years from 1st January, 2002 to 31st December, 2004 and correspond to (i) the virgin (black trace) and (ii) the future (red trace) conditions.

RESULTS



Monthly outflow variation for the Wardha basin in Virgin, Present and Future condition

Similarly, above figure presents a similar comparison on a monthly scale between (i) the virgin (blue trace), (ii) present baseline (red trace) and (iii) the future (green trace) conditions.

RESULTS & DISCUSSIONS

The above figures show a comparison between stream flow regimes for the three indicated developmental scenarios. With the commissioning of projects the annual mean flow at the basin outlet has shown a reduction .

	Virgin Condition	Present Scenario	Future Condition
Annual Mean Flow	3679.19 MCM	1857.01 MCM	1419.42 MCM

	Average Volume for 1991-2000		Average Volume for 2001-2004	
	MAX (Mm^3)	**MIN (Mm^3)**	**MAX (Mm^3)**	**MIN (Mm^3)**
Virgin Condition	11860	3122	5001	1916
Present Scenario	8398	1464	2692	556
Future Condition	4678	355	2380	387

These results indicate that the simulation horizon from 2001-2004 has been particularly severe in terms of the deficiency in available water resources.

Further, with an additional projected demand for 552.52 MCM of water expected to be made by the various Thermal Power Plants that are at various stages of the approval process, there would be practically very little water available .

CONCLUSION

•The main objective of the water resources management is to regulate the stream flow within the basin in relation to various industrial and irrigation requirements and domestic usages.

•The study of the hydrosystem of the Wardha basin was achieved using the SWAT model to define the operation of each hydraulic structure within the basin. The obtained results show that the annual stream flow decreases at the outlet.

•The derived results suggest that there is a substantial reduction in overall water resources availability in the study basin on account of the current level of development and further, future developments, as are being proposed, may require a careful study of their potential impact on currently sanctioned water use.

•Hence, the managers and decision makers should take into account the water resource shortage and irregularity between the significant inflow, occurring in the wet period and the significant outflow (needs), that occurs, in opposite, in dry period.


Thanks for your Attention