# ESTIMATION OF FLOW FOR UNGAUGED WATERSHEDS IN PRANHITA OF GODAVARI RIVER BASIN IN INDIA USING SWAT

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# Introduction

- The current study focuses on developing a model in SWAT that uses measured spatially and temporally varying inputs. It demonstrates that the comprehensiveness in the model's interrelationship after calibration at gauged locations, combined with incorporating the spatio-temporal heterogeneity of climate and landscape properties in a basin, can be used to predict flow at watershed scale ungauged locations.
- The finding of the study shows that, given appropriate spatial and temporal input, SWAT can provide a satisfactory simulation of the water budget at ungauged sites, when calibrated at a basin scale.

# Presentation Outline

Study Area : Pranhita River Basin

Soil and Water Assessment Tool (SWAT) Model set up

- DEM
- Soil
- Landuse
- Weather

Calibration and Validation data

Naturalisation : Approach

Water Balance

Results and discussion

Conclusion

Further prospects of the study

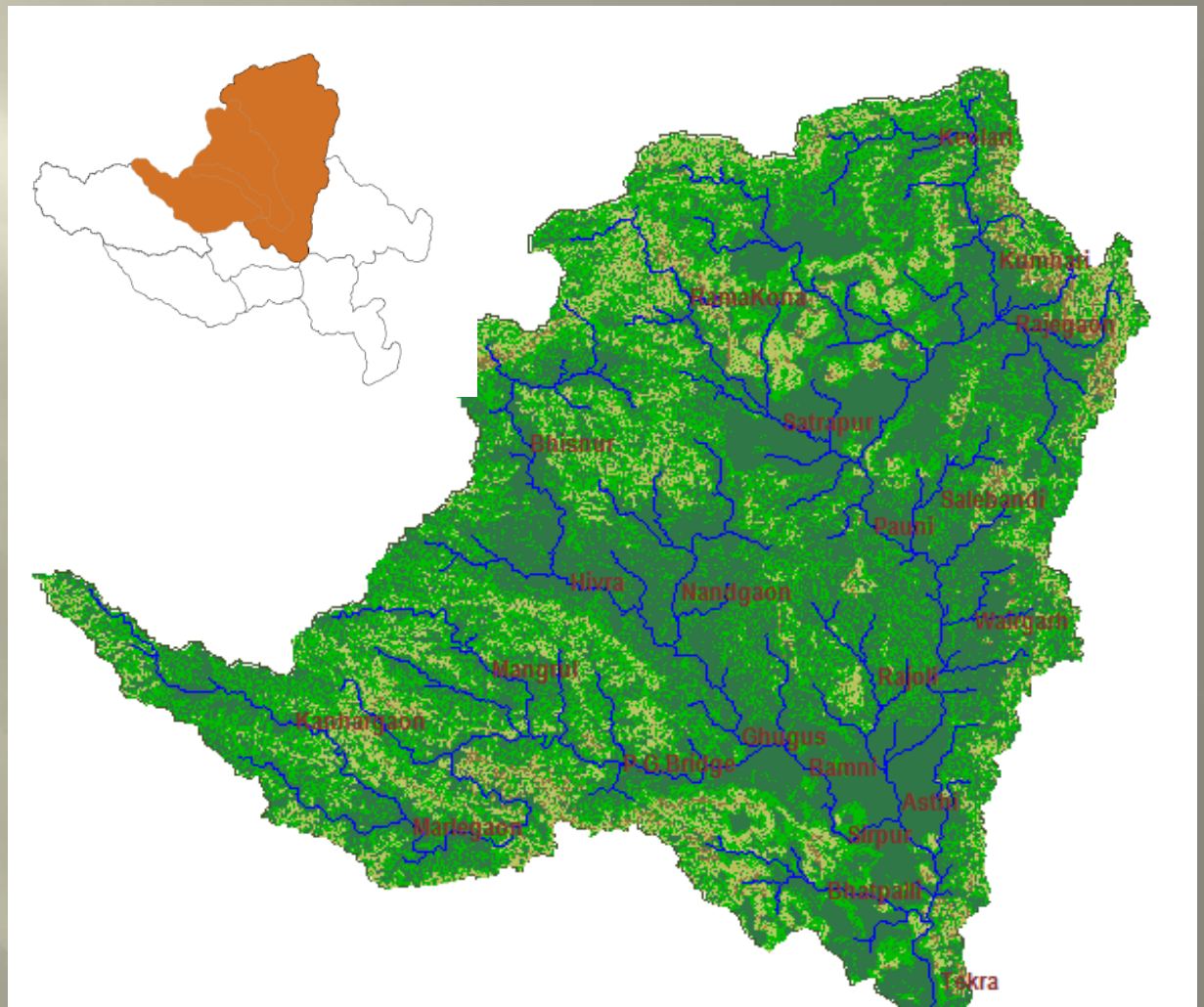
Acknowledgement

# Study area

Pranhita sub-basin
ngs to Godavari basin,
prising of rivers
ganga, Penganga and
lha draining an area
09,079 km$^2$.

fall :
ual rainfall variation is
nm - 1900mm

:
age 1063 cumec
mum 1.1 cumec
June 2005)
mum 38914 cumec



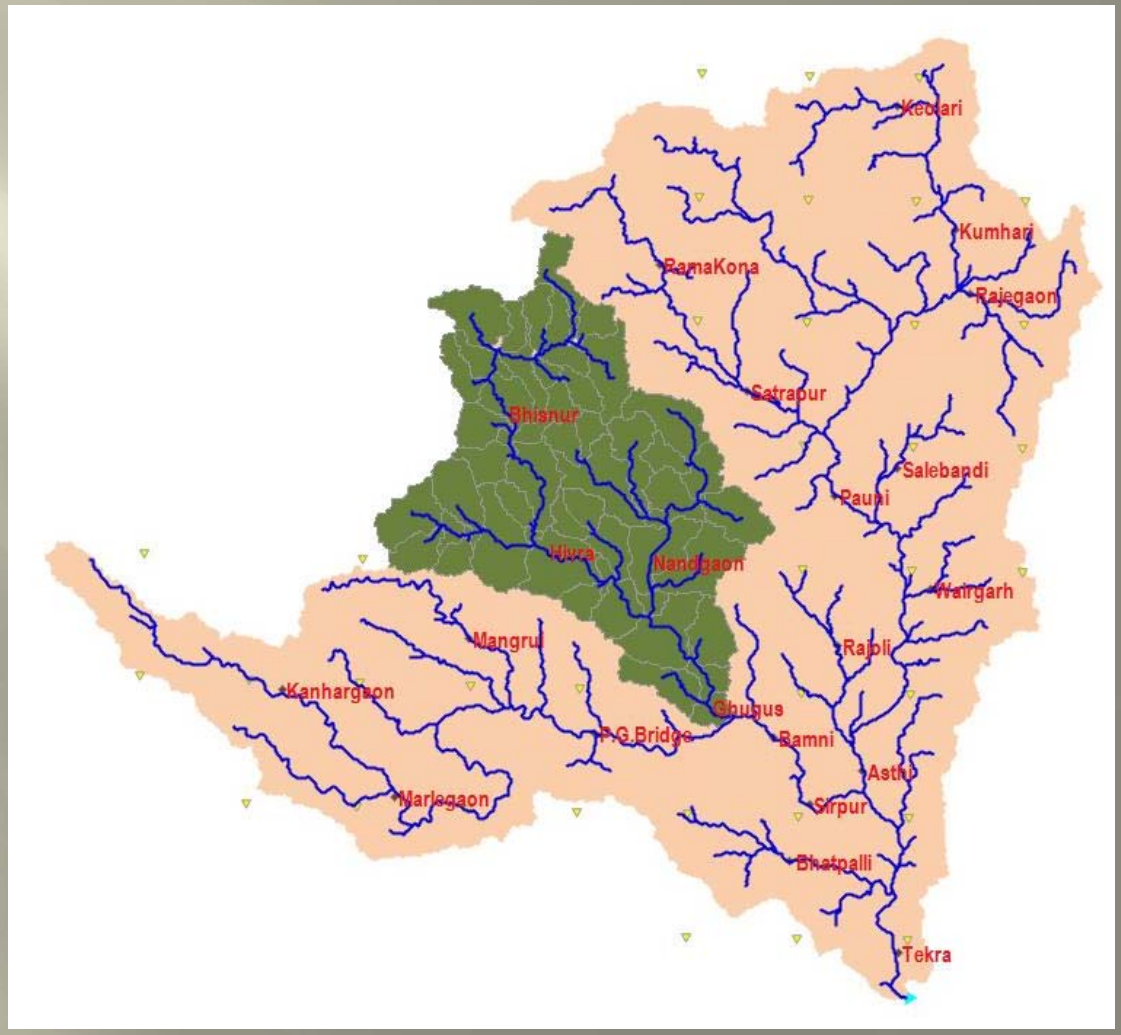
# Study area

Wainganga rises at an
e of 640m in the Satpura
u in Seoni district of
va Pradesh. Winding
the spurs of hills from
to east for a short
ce, it flows south and
west through Bhandara,
hat and Pauni area. The
catchment area of the
upto its confluence with
Wardha is 51,000 km$^2$.

# Study area

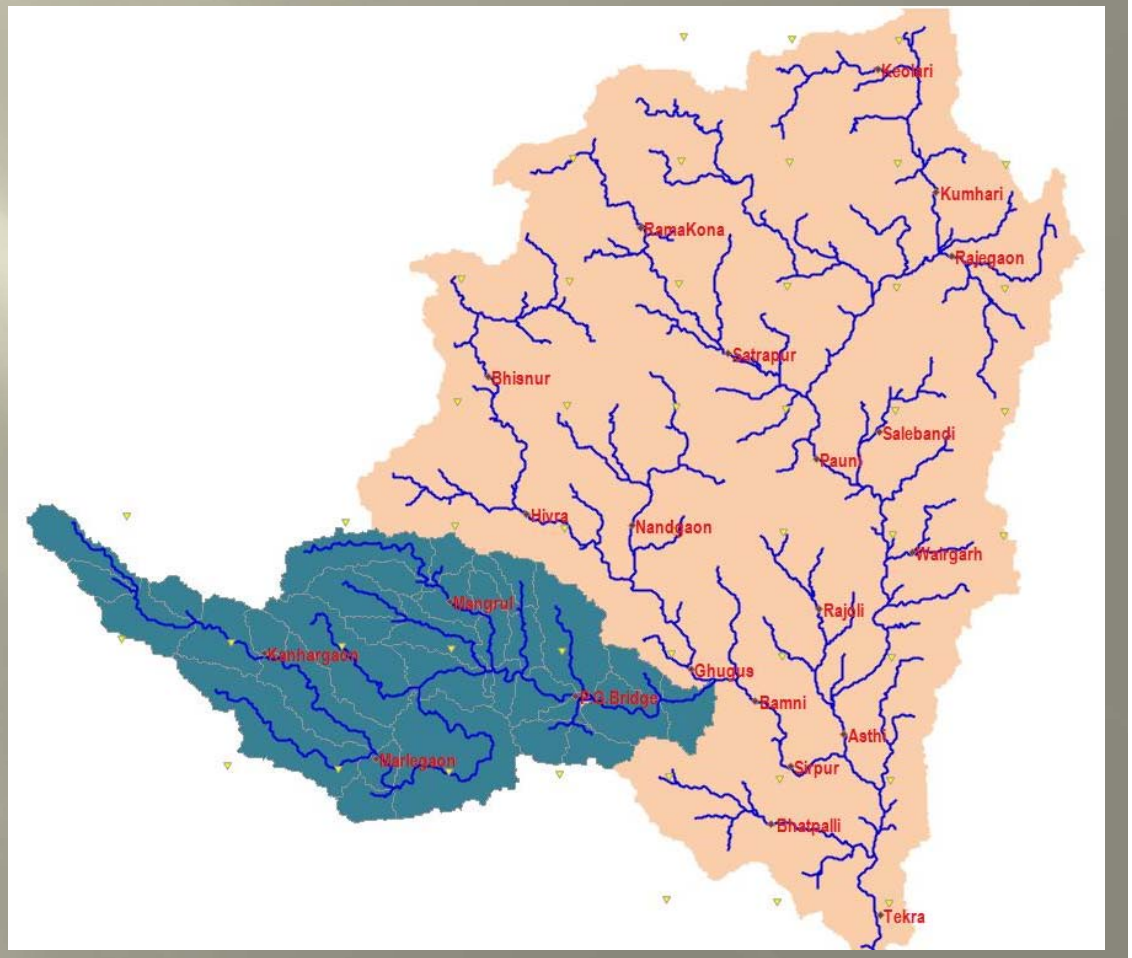
lha is the right bank tary of Pranhita with its n at Dahawadhna peak 777 m in the Satpura e in Betul district of nya Pradesh. After rsing 528 km, it joins ganga at Seoni, draining chment of 48,000 km$^2$.

combined water of ganga and Wardha d Pranhita flows joins vari near Kaleshwaram Andhra Pradesh arashtra border.

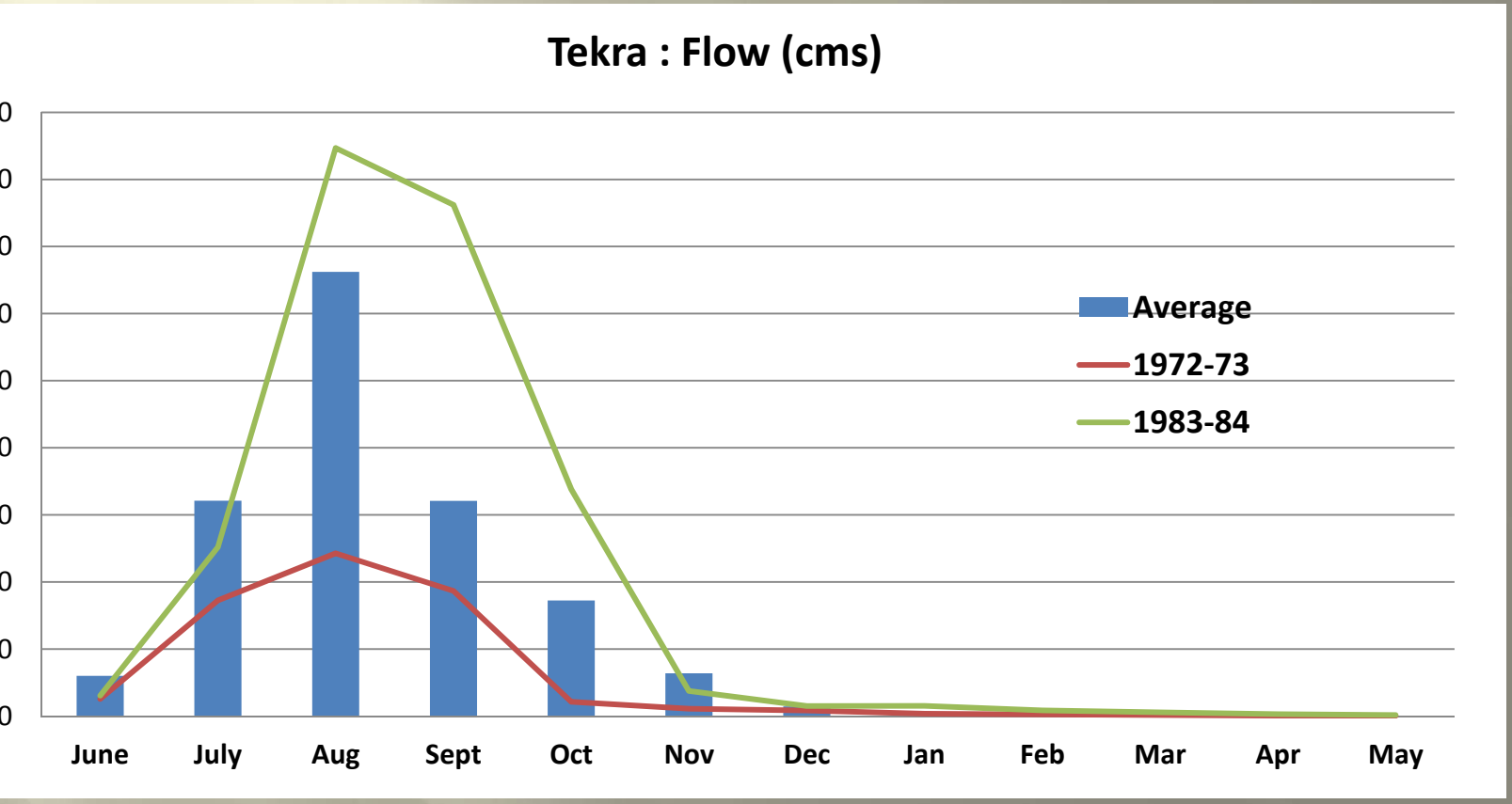


# Study area

major tributary of Wardha
enganga which originates
n Ajantha hills at an
ude of El 686m in
angabad district in Madhya
lesh. It flows along the
e border between
harashtra and Andhra
lesh along south-east and
nders along U shape twice
onverge into Wardha river
Wadhna village. The total
th of the river is 676 km
total catchment area up
s confluence with Wardha
,898 km$^2$.



# Study area


Tekra : Flow (cms)
Average
1972-73
1983-84
June
July
Aug
Sept
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May

# Soil Water Assessment Tool (SWAT)

SWAT is a river basin scale Long-term, continuous watershed simulation model (Arnold et al,1998)

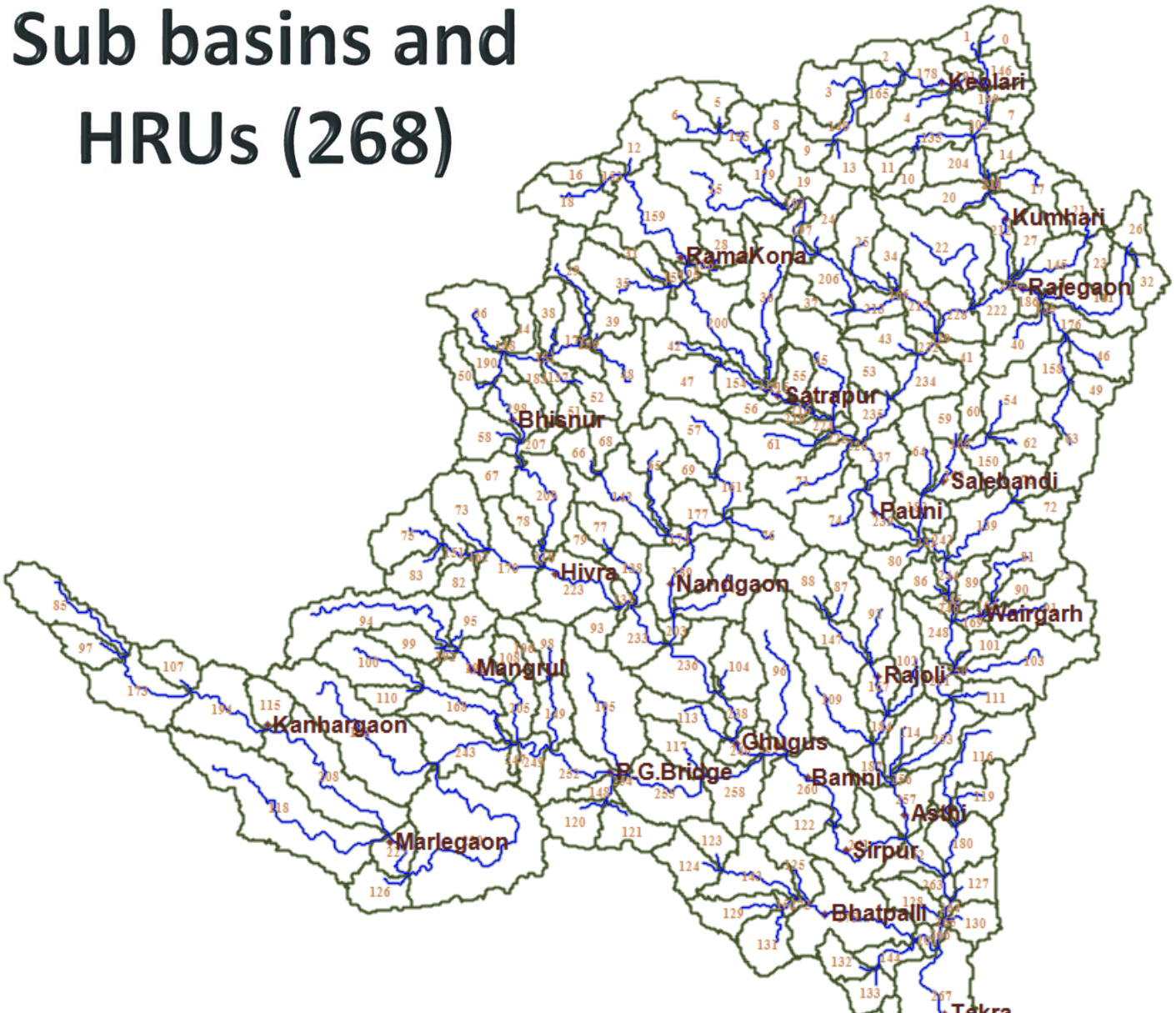
Assesses impacts of climate and land management on yields of water, sediment, and agricultural chemicals

Physically based, including hydrology, soil temperature, plant growth, nutrients, pesticides and land management

It is a public domain model actively supported by the USDA Agricultural Research Service at the Grassland, Soil and Water Research Laboratory in Temple, Texas, USA.

The SWAT system (ArcSWAT/MWSWAT) is embedded within geographic information system (GIS), and can integrate various spatial environmental data, including soil, land cover, climate, and topographic features.

# Sub basins and HRUs (268)



# SWAT model setup

M

tal Elevation dataset (DEMs) at 90m resolution was obtained from the NASA ttle Radar Topographic Mission (SRTM) website.

basin has medium topographic relief

ation in the basin 1086m-95m. Mean Elevation is 360m a.m.s.l

average slope of the sub-basin is 1.6%.

L

soil map by Food and Agriculture Organisation of the United Nations ,1995) with a spatial resolution of 10km as per AISLUS Classification, was d.

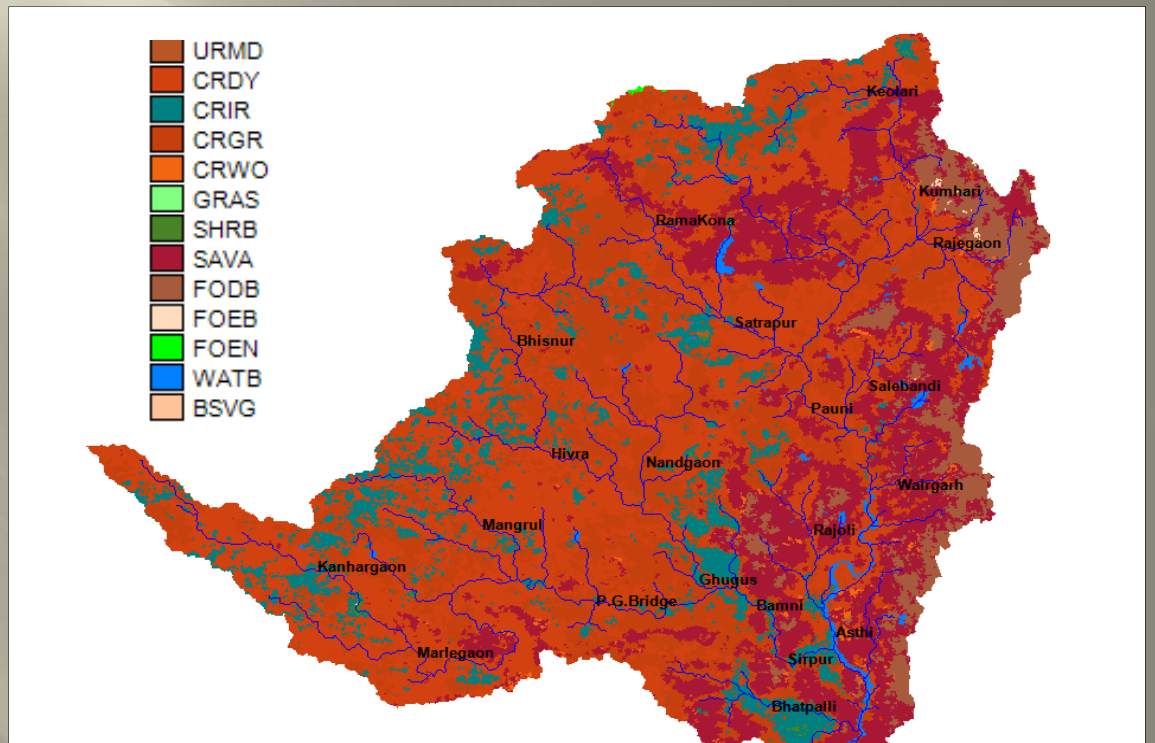
soil of Pranhita sub-basin is predominantly clay with clay loamy soil rspersed throughout the basin.

# Swat model setup

## ND USE

e Landuse map is from USGS Global Land Cover Characterisation (GLCC)
tabase (April 1992-March 1993)
p://edcsns17.cr.usgs.gov/glcc/glcc.html).

% agriculture
% pasture
% forest .



# Swat model setup

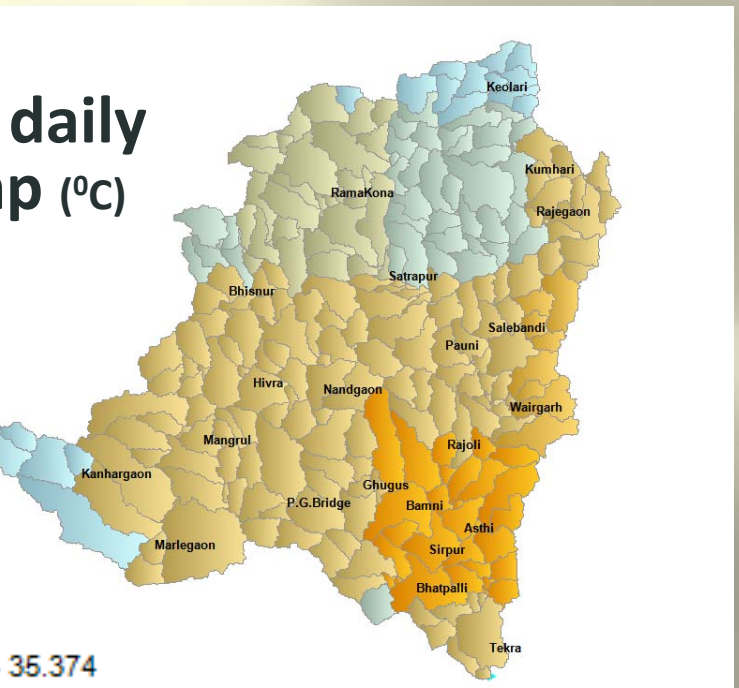
## VEATHER

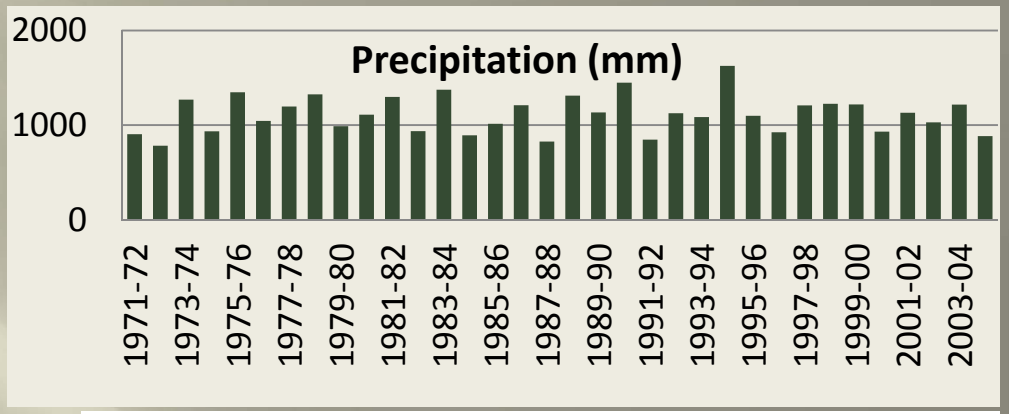
ational Climate Centre (NCC) of Indian Meterological Department (IMD) aily precipitation and temperature values at 0.5 and 1 degree interval espectively

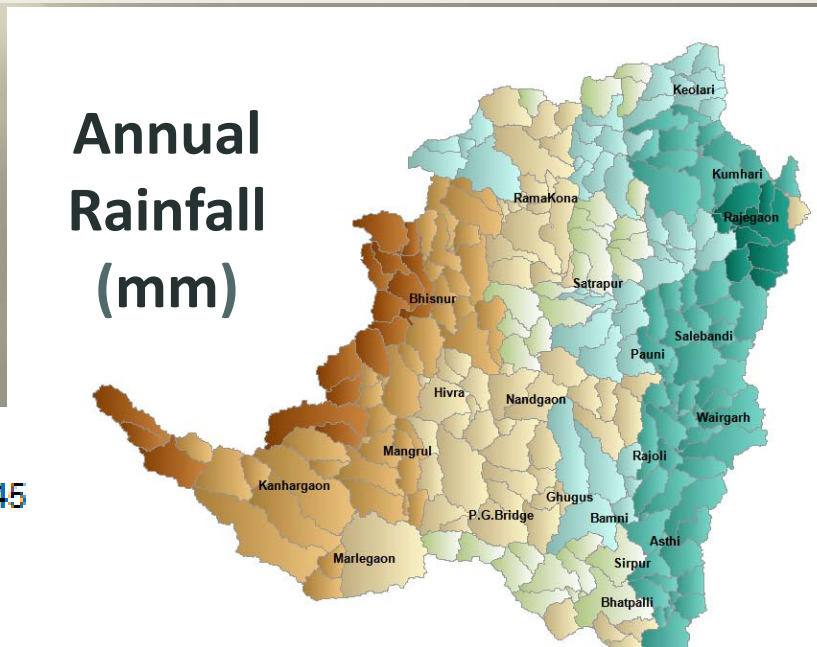
Vind speed and solar radiation were simulated from the nearest climate ation using the weather generator in SWAT.

Evapotranspiration was calculated within the model using Penman-Iontieth Method (Montieth, 1965).

# Swat model setup



# Calibration and validation Data

The daily and monthly streamflow observation data from CWC (Central Water Commission) maintained gauging stations viz. Ghugus (Wardha sub-basin), P G Bridge (Penganga) and Tekra (Pranhita) are used for calibration and validation.

Annual sub-basin level utilisation from National Water Development Agency (NWDA) sub-basin Reports of Godavari

# Utilisation

There are four major Projects, 37 medium Projects and minor projects of 1028 M cu m utilization capacity existing in truncated Pranhita.

In the Penganga sub-basin, two major projects and seven medium Projects and several Minor schemes existing which indicates utilization of about 18%

In the Wardha sub-basin, Sixteen medium projects and several *Minor schemes of 202 M cu m* capacity shows utilization percent of 12%.

Overall, there is over 12% utilization in Pranhita basin based on information collected upto 1992-93.

# Naturalisation : Approach

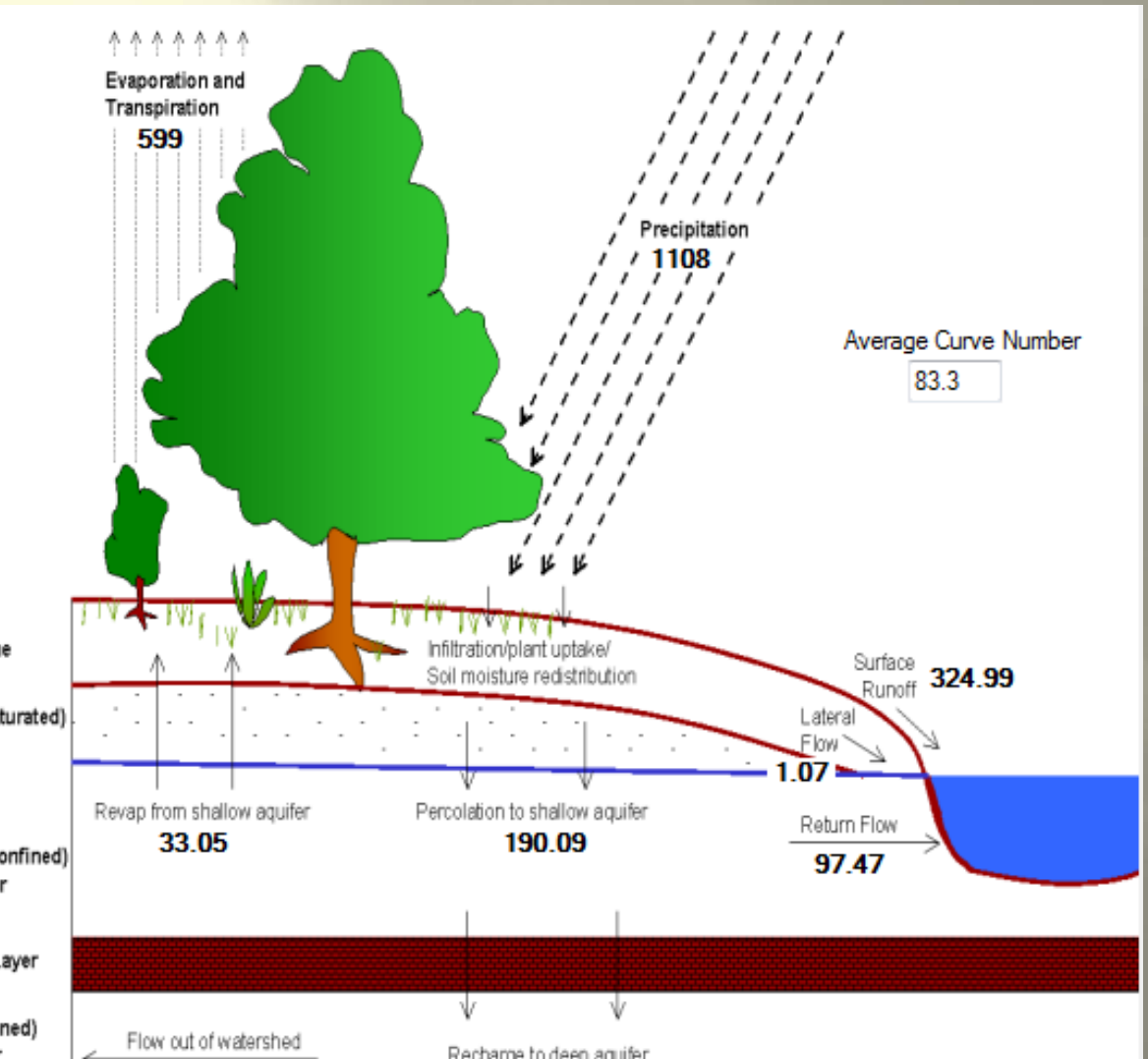
sin level Annual utilization collected from Reports. The lization comprises of irrigation, water supply, return flows, aporation loss.

aggregate into monthly utilization based on cropwater quirement.

n-Monsoon utilization is added to Monsoon months in portion to the rainfall received.

r gauging sites located inside the basin, the annual utilization derived on pro-rata basis from design capacity of projects cated in its catchment to the basin level design capacity.

# Water Balance




| Water Balance Ratios | |
|---|---|
| Streamflow/Precip | 0.38 |
| Baseflow/Total Flow | 0.23 |
| Surface Runoff/Total Flow | 0.77 |
| Perc/Precip | 0.17 |
| Deep Recharge/Precip | 0.05 |
| ET/Precipitation | 0.54 |

# Results and discussion

| meter | Description | Unit | Default value | Calibrated value |
|---|---|---|---|---|
| | | | | |
| | Soil Evaporation compensation factor | fraction | 0.95 | 0.7 |
| AWC | Available soil water capacity | mm $mm^{-1}$ | 0.1-0.18 | 0.18-0.32 |
| MN | Threshold water depth in shallow aquifer for return to occur | mm | 0 | 100 |
| RGE_DP | Deep aquifer percolation fraction | fraction | 0.05 | 0.3 |

# Results and discussion

| | Catchment Area ($km^2$) | | Period | Monthly | | Annual | | |
|---|---|---|---|---|---|---|---|---|
| | | | | $R^2$ | NSE | PBIAS | $R^2$ | NSE |
| kra | 108780 | Calib | 1971-72 to 1983-84 | 0.95 | 0.94 | -10 | 0.92 | 0.83 |
| Pranhita | | Valid | 1984-85 to 1993-94 | 0.97 | 0.95 | -16 | 0.98 | 0.84 |
| ugus | 21429 | Calib | 1971-72 to 1983-84 | 0.92 | 0.91 | -5 | 0.93 | 0.88 |
| Wardha | | Valid | 1984-85 to 1993-94 | 0.9 | 0.87 | -15 | 0.9 | 0.76 |
| G dge | 18441 | Calib | 1971-72 to 1983-84 | 0.95 | 0.95 | -7 | 0.94 | 0.93 |
| Penganga | | Valid | 1984-85 to 1993-94 | 0.93 | 0.92 | -9 | 0.96 | 0.95 |

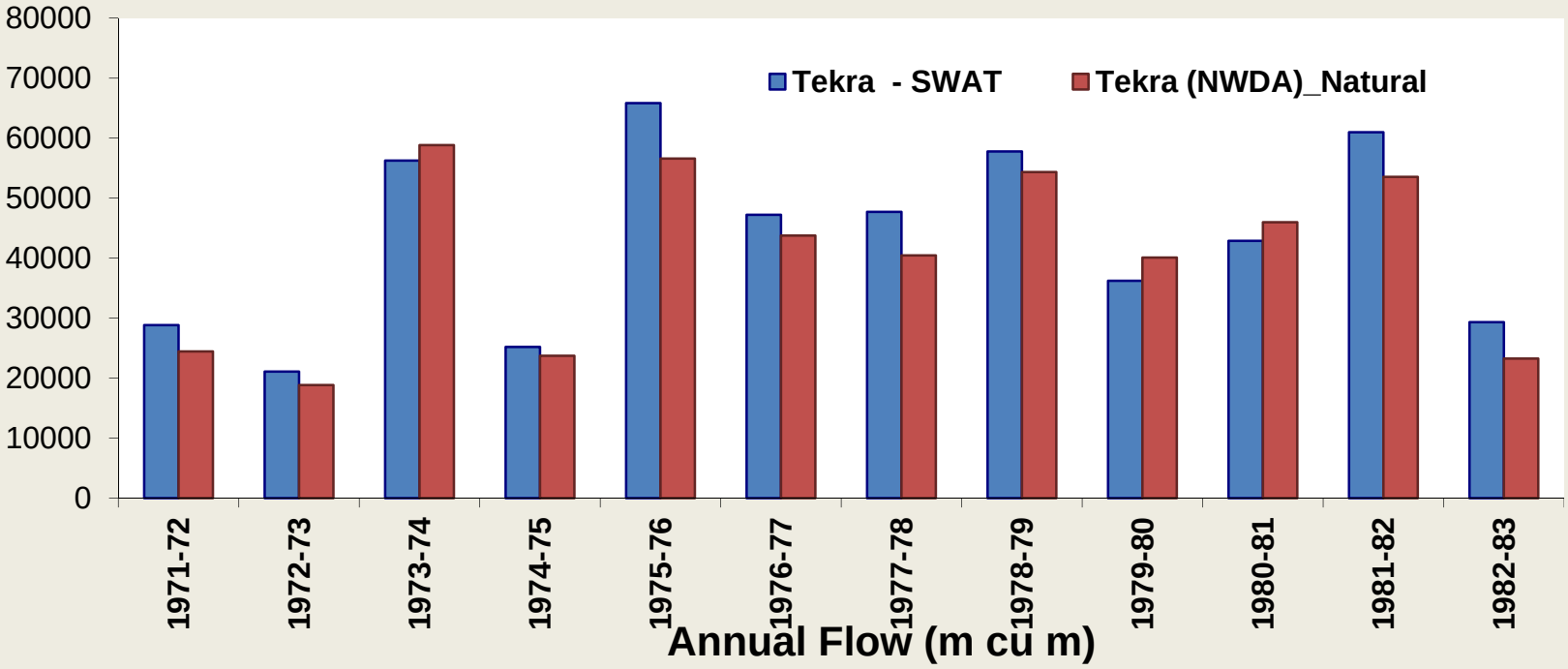
# Results and discussion

| | Catchment Area (km2) | Average | | | Standard deviation | |
|---|---|---|---|---|---|---|
| | | Observed | Naturalised | Simulated | Observed | Simulated |
| Asthi | 50990 | 680 | 784 | 893 | 389 | 346 |
| Bamni | 46020 | 335 | 362 | 426 | 206 | 192 |
| Bishnur | 5000 | 20.1 | 20.2 | 29.8 | 16 | 18.6 |
| Ghugus | 21429 | 146 | 154 | 211 | 88.5 | 90.6 |
| Hivra | 10240 | 44.6 | 46 | 71.9 | 34 | 38.3 |
| Kanhargaon | 3515 | 16 | 20 | 24.1 | 14.3 | 19 |
| Keolari | 2970 | 33.8 | 34.3 | 44.9 | 21.2 | 20.5 |
| Kumhari | 8070 | 111.2 | 114.9 | 138.6 | 69.2 | 58 |
| Marlegaon | 7410 | 35.9 | 39.9 | 58.9 | 31.6 | 38.9 |
| Nandgaon | 4580 | 26.7 | 34.6 | 49.2 | 17.9 | 24 |
| Pauni | 35520 | 347 | 440.7 | 617.6 | 210 | 252.1 |
| P G Bridge | 18441 | 132.3 | 144.4 | 168.6 | 86.3 | 91.9 |
| Rajegaon | 5380 | 111.8 | 121.1 | 141.6 | 79.8 | 56.4 |
| Rajoli | 1900 | 21 | 25.3 | 30.1 | 12 | 16.1 |
| Satrapur | 11100 | 81.2 | 111.2 | 129.1 | 55.7 | 60.4 |
| Sirpur | 47500 | 370.3 | 415.5 | 476.4 | 230.8 | 199.6 |

# Results and discussion

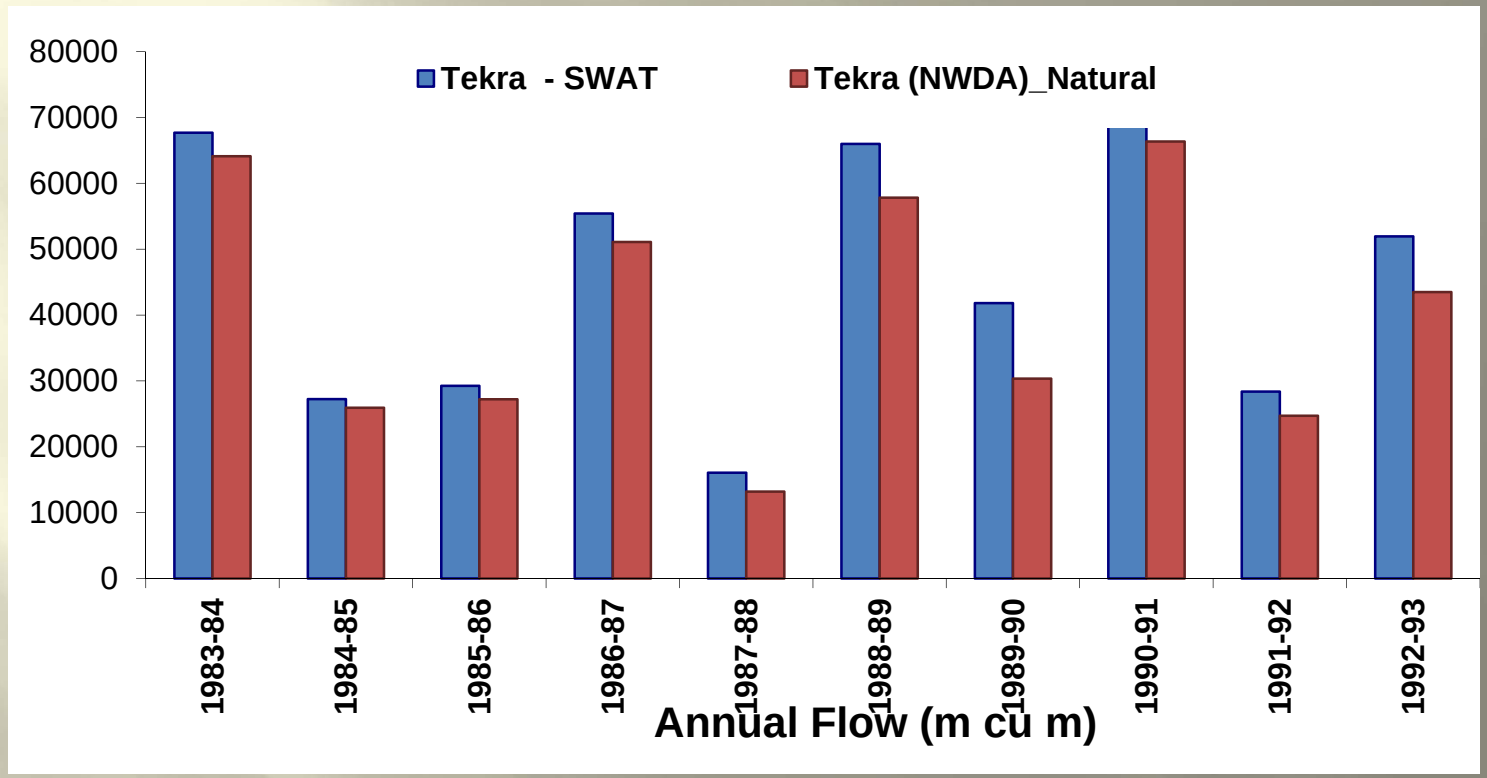
| | Catchment Area (km2) | Annual | | | Monthly | |
|---|---|---|---|---|---|---|
| | | $R^2$ | NSE | PBIAS (%) | $R^2$ | NSE |
| Asthi | 50990 | 0.97 | 0.92 | -8.3 | 0.94 | 0.94 |
| Bamni | 46020 | 0.95 | 0.86 | -16.8 | 0.93 | 0.9 |
| Bishnur | 5000 | 0.79 | 0.09 | -44 | 0.71 | 0.3 |
| Ghugus | 21429 | 0.98 | 0.63 | -37.4 | 0.81 | 0.62 |
| Hivra | 10240 | 0.89 | 0.15 | -56 | 0.82 | 0.59 |
| Kanhargaon | 3515 | 0.97 | 0.94 | -7 | 0.82 | 0.81 |
| Keolari | 2970 | 0.91 | 0.69 | -24.5 | 0.9 | 0.85 |
| Kumhari | 8070 | 0.97 | 0.85 | -15.7 | 0.92 | 0.91 |
| Marlegaon | 7410 | 0.99 | 0.57 | -41 | 0.91 | 0.81 |
| Nandgaon | 4580 | 0.94 | 0.33 | -38 | 0.94 | 0.71 |
| Pauni | 35520 | 0.97 | 0.54 | -29.1 | 0.93 | 0.73 |
| P G Bridge | 18441 | 0.97 | 0.89 | -16.7 | 0.94 | 0.88 |
| Rajegaon | 5380 | 0.71 | 0.62 | -16.9 | 0.77 | 0.76 |
| Rajoli | 1900 | 0.93 | 0.72 | -15 | 0.93 | 0.91 |
| Satrapur | 11100 | 0.85 | 0.71 | -16.1 | 0.81 | 0.66 |
| Sirpur | 47500 | 0.98 | 0.9 | -14.7 | 0.93 | 0.91 |

# Result and discussion : Tekra - Calibration



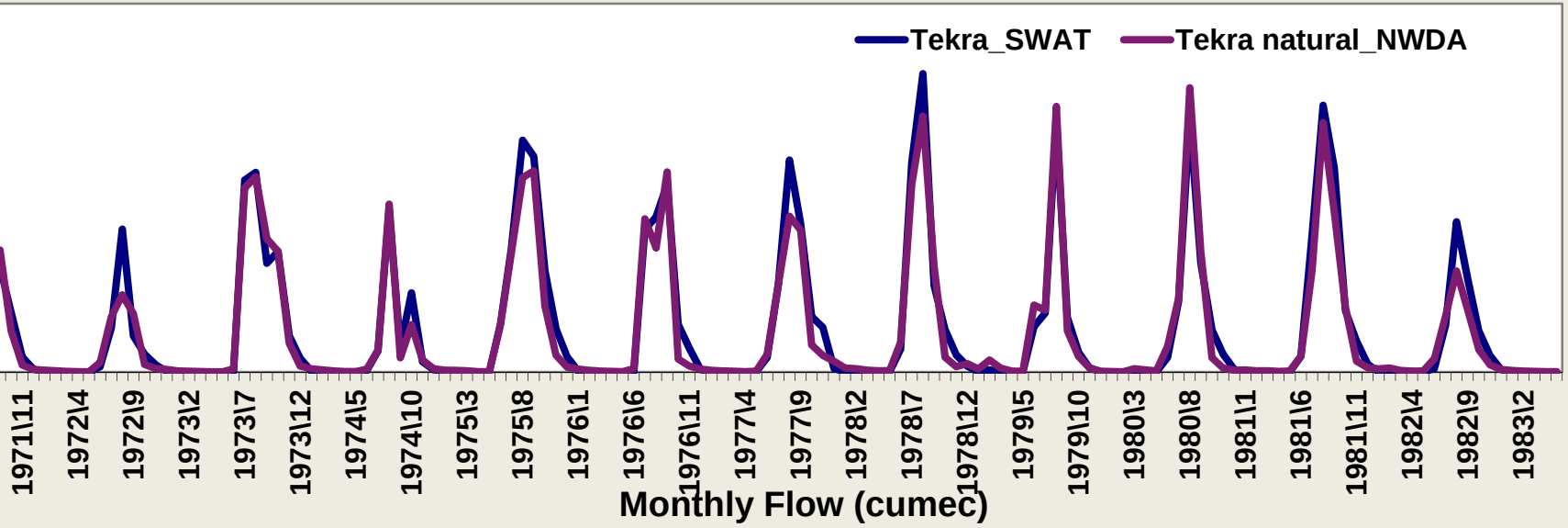

| | Catchment Area ($km^2$) | | Period | Monthly | | Annual | | |
|---|---|---|---|---|---|---|---|---|
| | | | | $R^2$ | NSE | $R^2$ | NSE | PBIAS |
| ekra | 108780 | Calib | 1971-72 to 1982-83 | 0.95 | 0.94 | 0.92 | 0.88 | -6 |
| | | | | | | | | |

# Result and discussion : Tekra - Validation



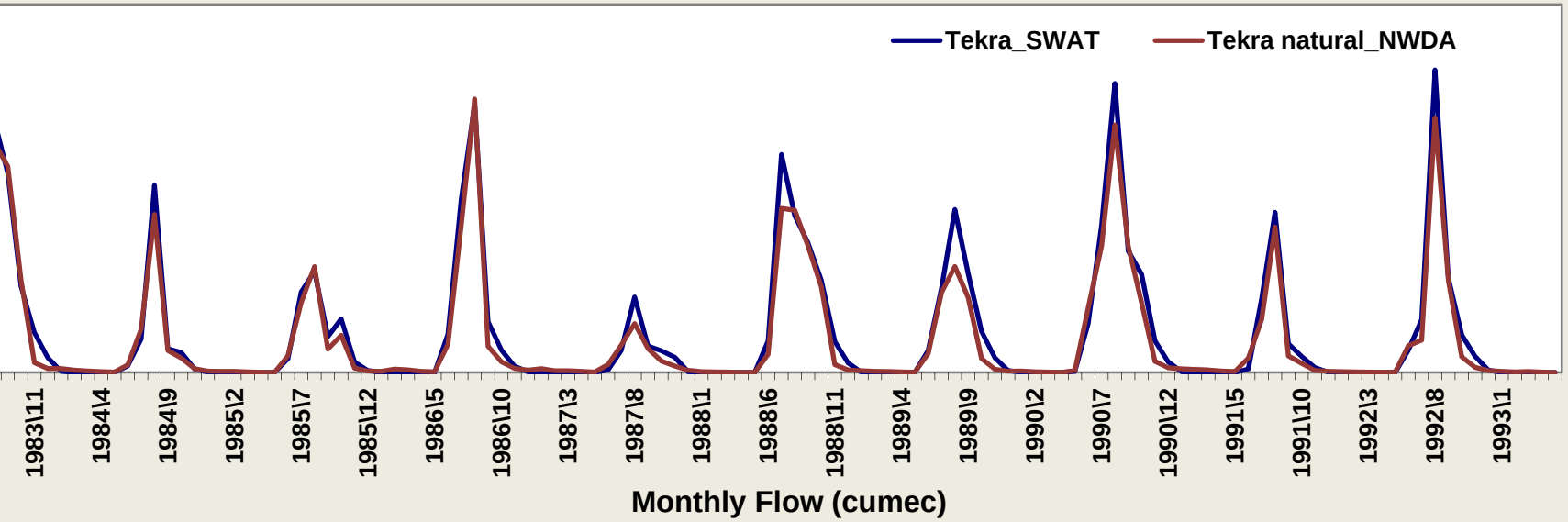

| | Catchment Area ($km^2$) | | Period | Monthly | | Annual | | |
|---|---|---|---|---|---|---|---|---|
| | | | | $R^2$ | NSE | $R^2$ | NSE | PBIAS |
| ekra | 108780 | Calib | 1971-72 to 1982-83 | 0.95 | 0.94 | 0.92 | 0.88 | -6 |

# Result and discussion : Tekra - Calibration




| | Catchment Area (km²) | | Period | Monthly | | Annual | | |
|---|---|---|---|---|---|---|---|---|
| | | | | $R^2$ | NSE | $R^2$ | NSE | PBIAS |
| kra | 108780 | Calib | 1971-72 to 1982-83 | 0.95 | 0.94 | 0.92 | 0.83 | -10 |
| | | | | | | | | |

# Result and discussion : Tekra - Validation



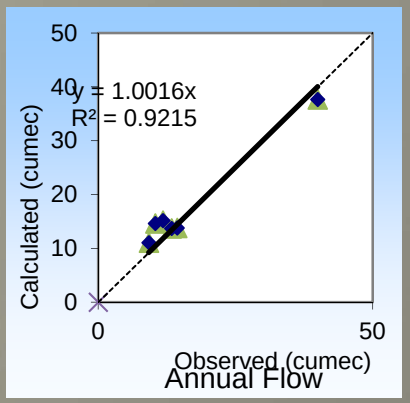

| | Catchment Area ($km^2$) | | Period | Monthly | | Annual | | |
|---|---|---|---|---|---|---|---|---|
| | | | | $R^2$ | NSE | $R^2$ | NSE | PBIAS |
| kra | 108780 | Calib | 1971-72 to 1982-83 | 0.95 | 0.94 | 0.92 | 0.83 | -10 |
| | | | | | | | | |

# Validation Results

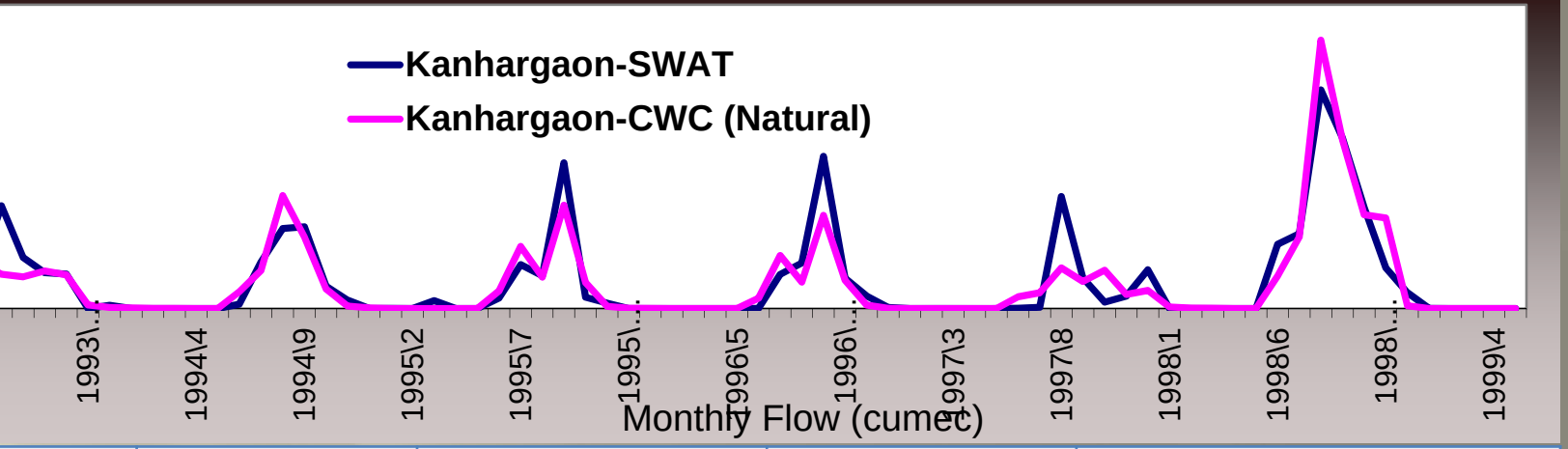
# Result and discussion : Kanhargaon

CA -3515 sq km

Sub-basin -Penganga



Annual Flow



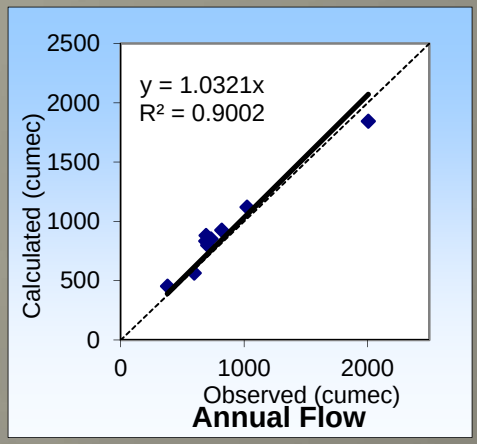
Monthly Flow (cumec)

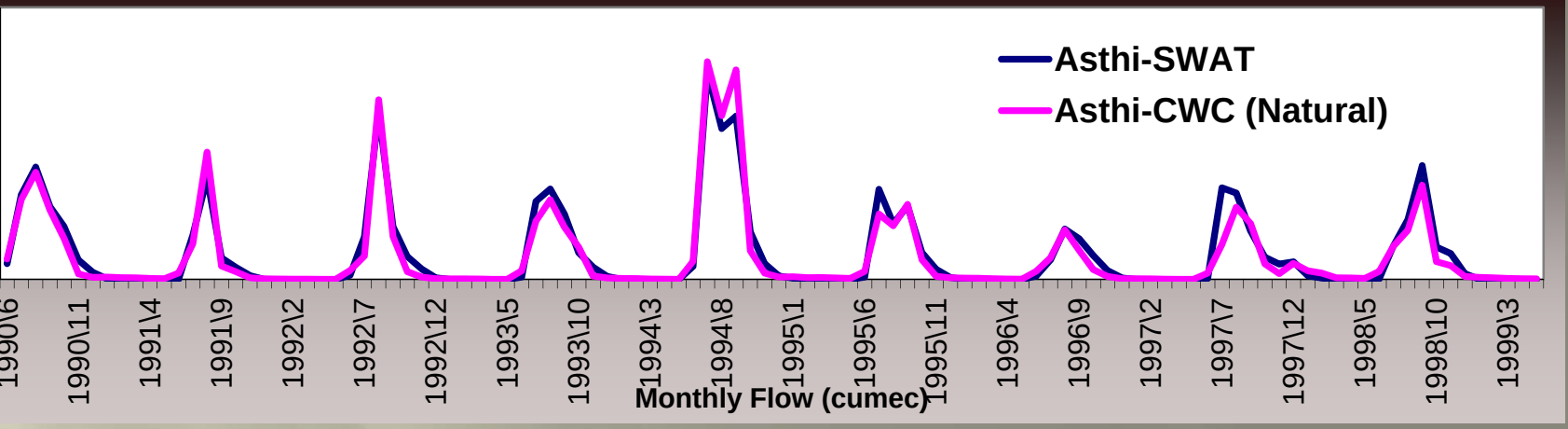
| | Catchment Area ($km^2$) | Period | Monthly | | Annual | | |
|---|---|---|---|---|---|---|---|
| | | | $R^2$ | NSE | $R^2$ | NSE | PBIAS |
| Bridge | 18441 | 1971-72 to 1982-83 | 0.95 | 0.95 | 0.94 | 0.93 | 7 |

# Result and discussion : Asthi

CA -50990 sq km

Sub-basin - Pranhita

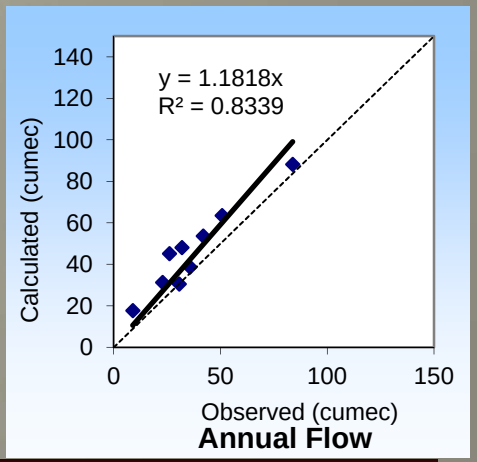




| | Catchment Area (km²) | | Period | Monthly | | Annual | | |
|---|---|---|---|---|---|---|---|---|
| | | | | $R^2$ | NSE | $R^2$ | NSE | PBIAS |
| Tekra | 108780 | Calib | 1971-72 to 1982-83 | 0.95 | 0.94 | 0.92 | 0.83 | -10 |

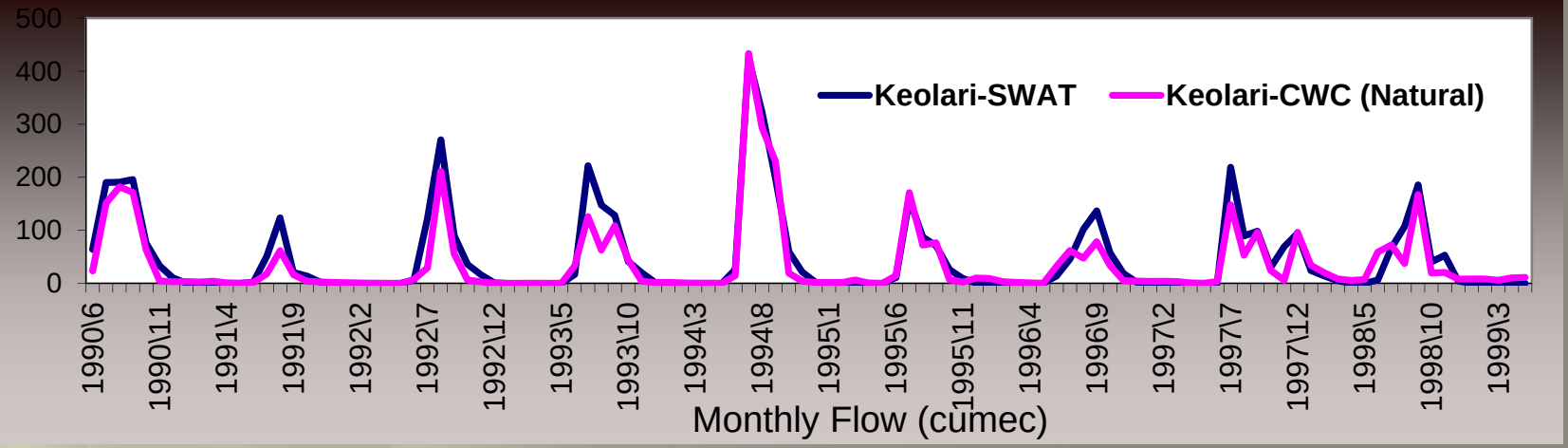
# Result and discussion : Keolari

CA – 2970 sq km

Sub-basin - Wainganga


**Annual Flow**



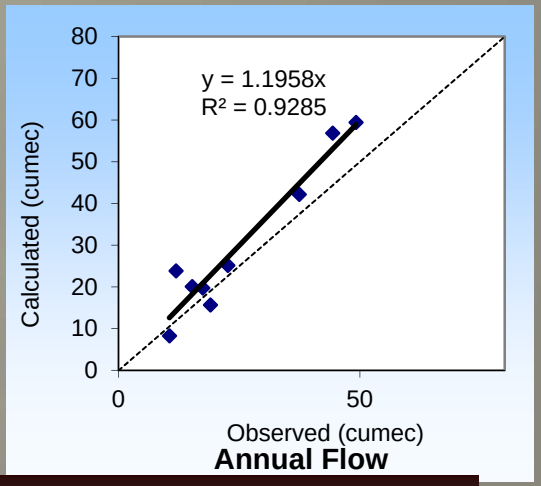

Monthly Flow (cumec)

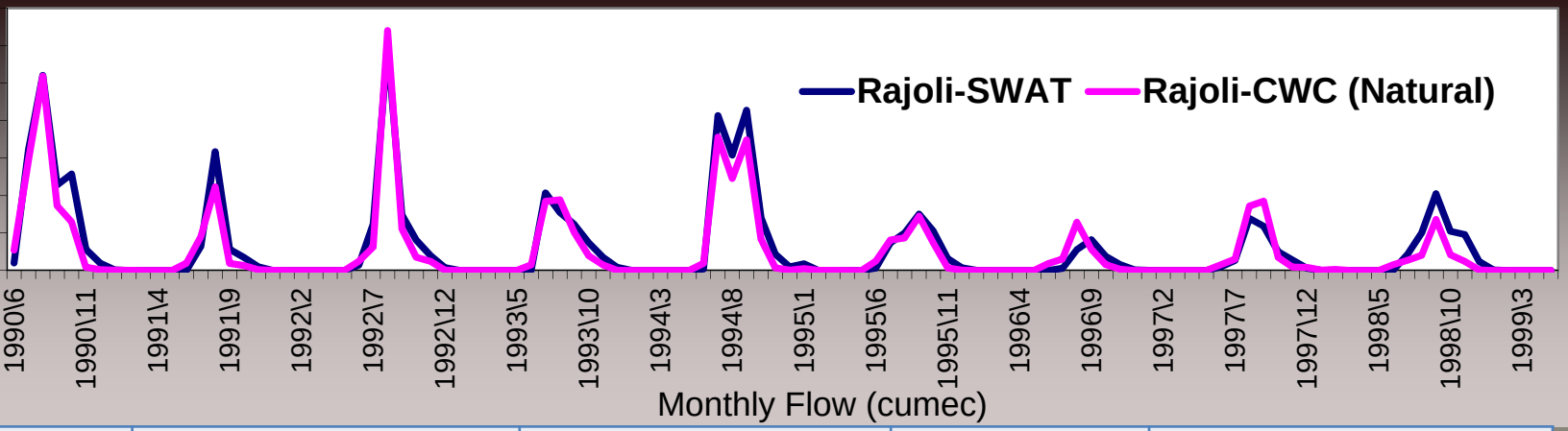
| | Catchment Area ($km^2$) | Period | Monthly | | Annual | | |
|---|---|---|---|---|---|---|---|
| | | | $R^2$ | NSE | $R^2$ | NSE | PBIAS |

# Result and discussion : Rajoli

CA – 1900 sq km

Sub-basin - Pranhita

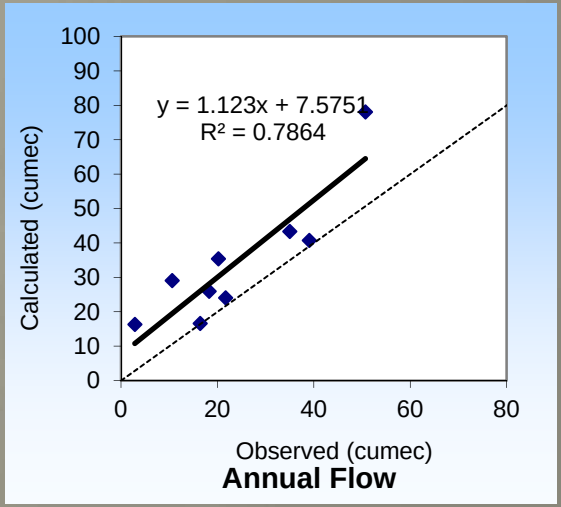

| | Catchment Area ($km^2$) | | Period | Monthly | | Annual | | |
|---|---|---|---|---|---|---|---|---|
| | | | | $R^2$ | NSE | $R^2$ | NSE | PBIAS |
| | | | | | | | | |

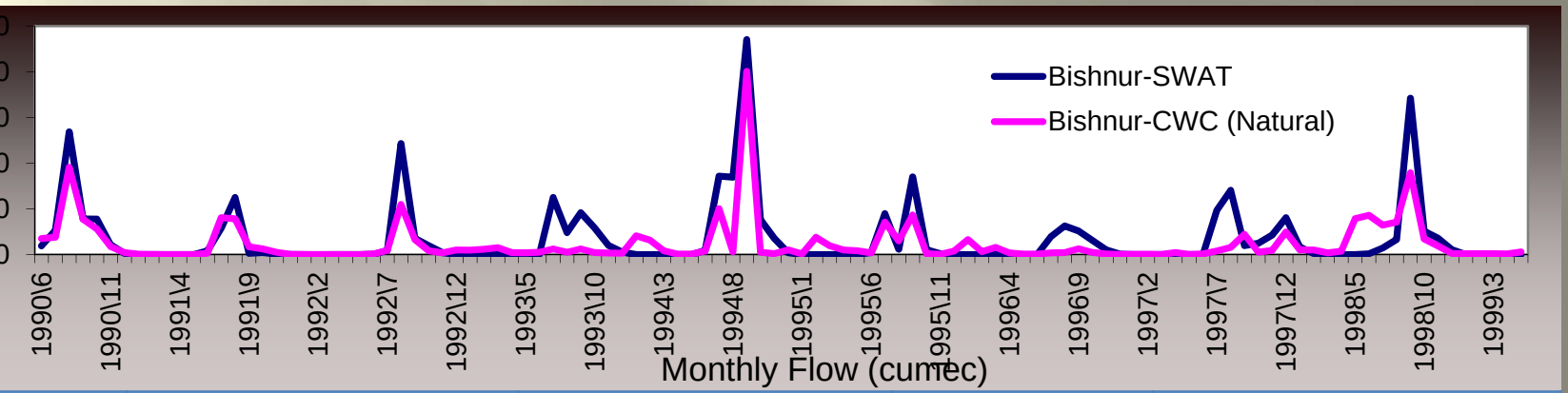
# Some low Statistics

# Result and discussion : Bishnur

CA – 5000 sq km

Sub-basin - Wardha

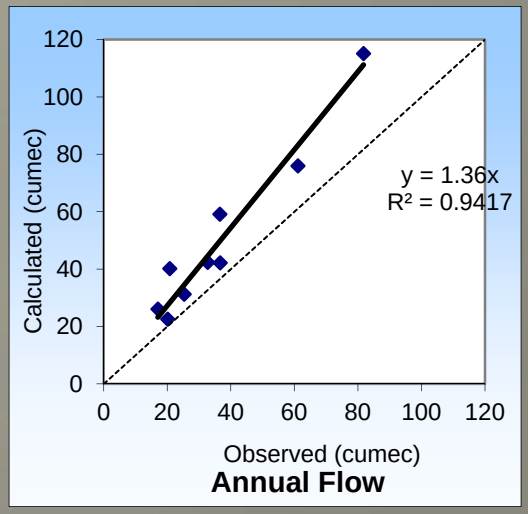



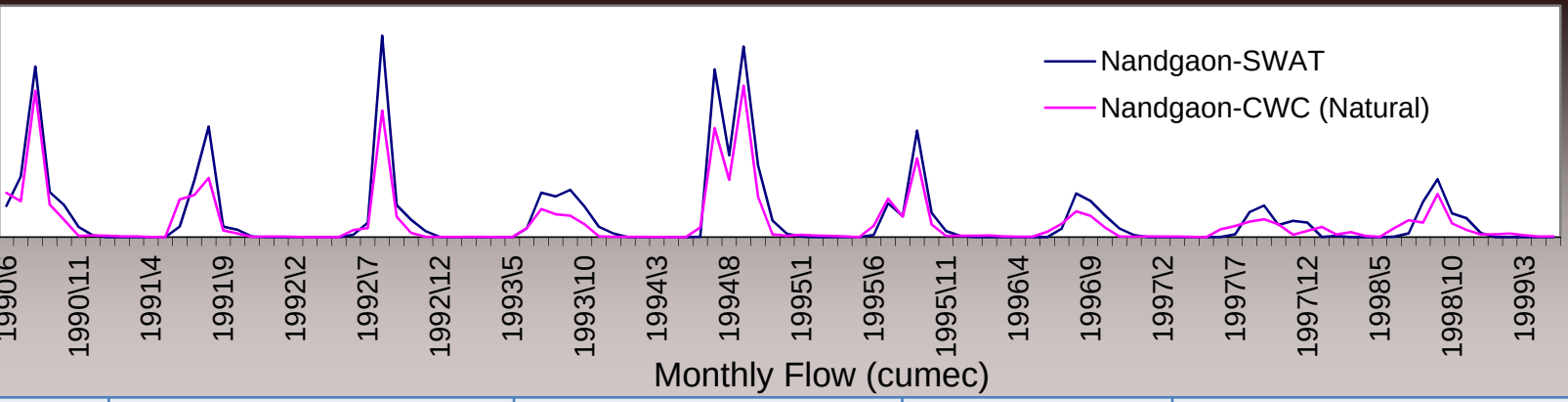




| | Catchment Area ($km^2$) | Period | Monthly | | Annual | | |
|---|---|---|---|---|---|---|---|
| | | | $R^2$ | NSE | $R^2$ | NSE | PBIAS |

# Result and discussion : Nandgaon

- CA – 4580 sq km
- Sub-basin - Wardha

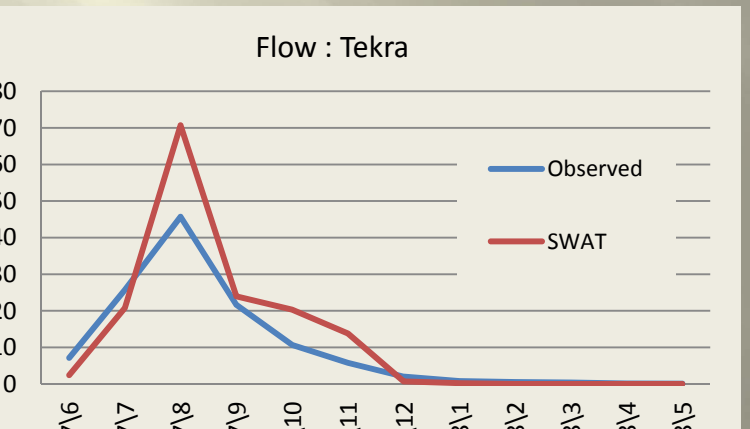

| | Catchment Area (km²) | | Period | Monthly | | Annual | | |
|---|---|---|---|---|---|---|---|---|
| | | | | $R^2$ | NSE | $R^2$ | NSE | PBIAS |
| ghus | 21249 | Calib | 1971-72 to 1983-84 | 0.92 | 0.91 | 0.93 | 0.88 | -5 |

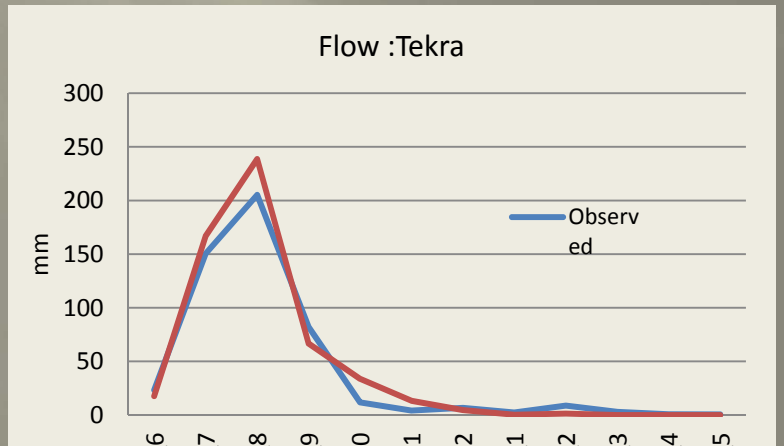
# Result and discussion

analysis of wetter than normal years and drier than normal years
ws that the model gives better results in wetter years than drier years.

e monthly NSE's for TWYLD are 0.95 for the three wet years and 0.67
the four drier years.

omparison of the monthly observed and simulated streamflow for the
year with highest peak and dry year with the lowest peak reveal that
model tended to overpredict streamflow during the monsoon period
he year.



# Conclusion

The SWAT model developed in the study validates how well spatially distributed models are able to produce acceptable results using readily available, physically based input parameters in watersheds ranging from small to very large. Given further information about the watershed's physiographic characteristics, better simulation results would be obtained, especially on a monthly temporal scale.

The calibrated SWAT model is tested for streamflow. We used annual and monthly streamflow from 16 CWC monitoring gauges to test SWAT and found that SWAT can capture the amount and variability of annual streamflow acceptably well ($R^2$ values range between 0.72 and 0.99 and NSE ranges between 0.94 and 0.54).

# Conclusion

The low statistics of Bishnur/Nandgaon may be attributed to :

- Lack of sufficient information about the utilization details from minor irrigation projects in the upper reaches of Wardha basin, in particular.
- Major change in Water utilization due to projects in Wardha post 1990 for which data is not available

Overall, the SWAT model can satisfactorily predict hydrologic budget for the ungauged basins in Pranhita with calibration at basin scale. The results further emphasize the importance and prospects of using accurate spatial input data for ungauged flow assessment using the physically based SWAT model .

The Simulation is being tested on utilization of time line 1972 to 1993 which is dynamic in nature.

# Further prospects of the study

- The study also highlights the prospect of simulation of effect of change in landuse on ungauged catchments and their combined effect on basin scale.
- The effect of climate change on small ungauged basins

# Disclaimer

- The views expressed by the authors in the presentation are purely individual and do not reflect the views of the organization in any way.

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GODAVARI BASIN
MADHYA PRADESH
CHHATTISGARH
ORISSA
MAHARASHTRA
KARNATAKA
ANDHRA PRADESH
BAY OF BENGAL
NAGPUR
HYDERABAD
PUNE
Legend
State Capital
Forecast Station
GD
GQ
GDS
GDSQ
Dam/ Weir/ Barrage
Divisional Office
CE / CO / DO
River
Basin Boundary
State Boundary
International Boundary
* All sites are not shown at this map scale
* For International/State boundaries and Coast-Line refer to Survey of India maps

# Thank You