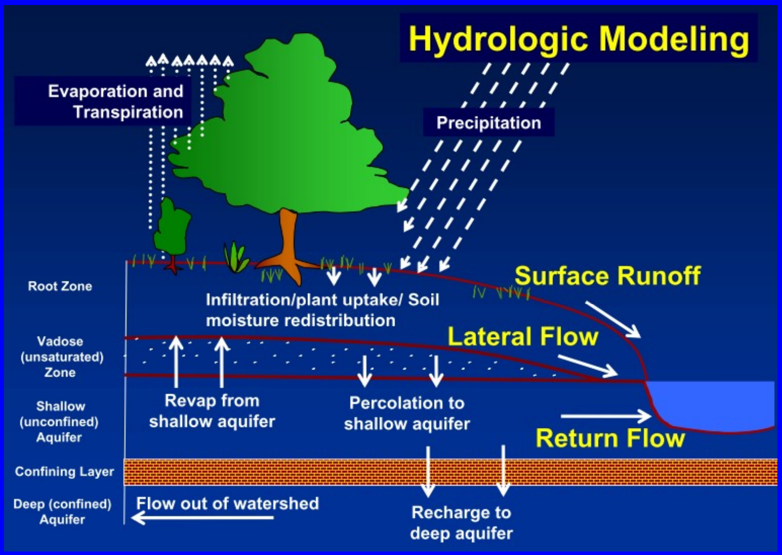
Evaluation of Swat for Modelling the Water Balance and Water Yield in Yerrakalva River Basin, A.P.



By

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INTRODUCTION

- Knowledge of water balance and water yield of a river basin is an indispensable prerequisite in the sustainable management of water resources at basin level.

- Components of water balance are influenced by climate & physical characteristics of the catchment such as morphology, LU and soil.

- Therefore, understanding the relationship between these physical parameters and hydrological components is necessary to assess the hydrologic response to climate and land cover variability in determining the water availability.

INTRODUCTION (contd…)

- Major hydrological processes can be quantified with the help of water balance equation
- Since the hydrologic processes are very complex, watershed models are widely used for proper comprehension of WB components.
- The watershed models partition rainfall into various hydrological processes such as surface runoff, ET, percolation, lateral flow and base flow etc. with the constraint to account for all water entering, leaving and being stored in a catchment.
- This adaptation of the principle of conservation of mass constrains the potential for error.
- Therefore, SWAT, a physically based model which uses water balance equation for simulation of hydrology, was applied in the present study for estimation of water balance components and water yield in Yerrakalva river basin, A.P.

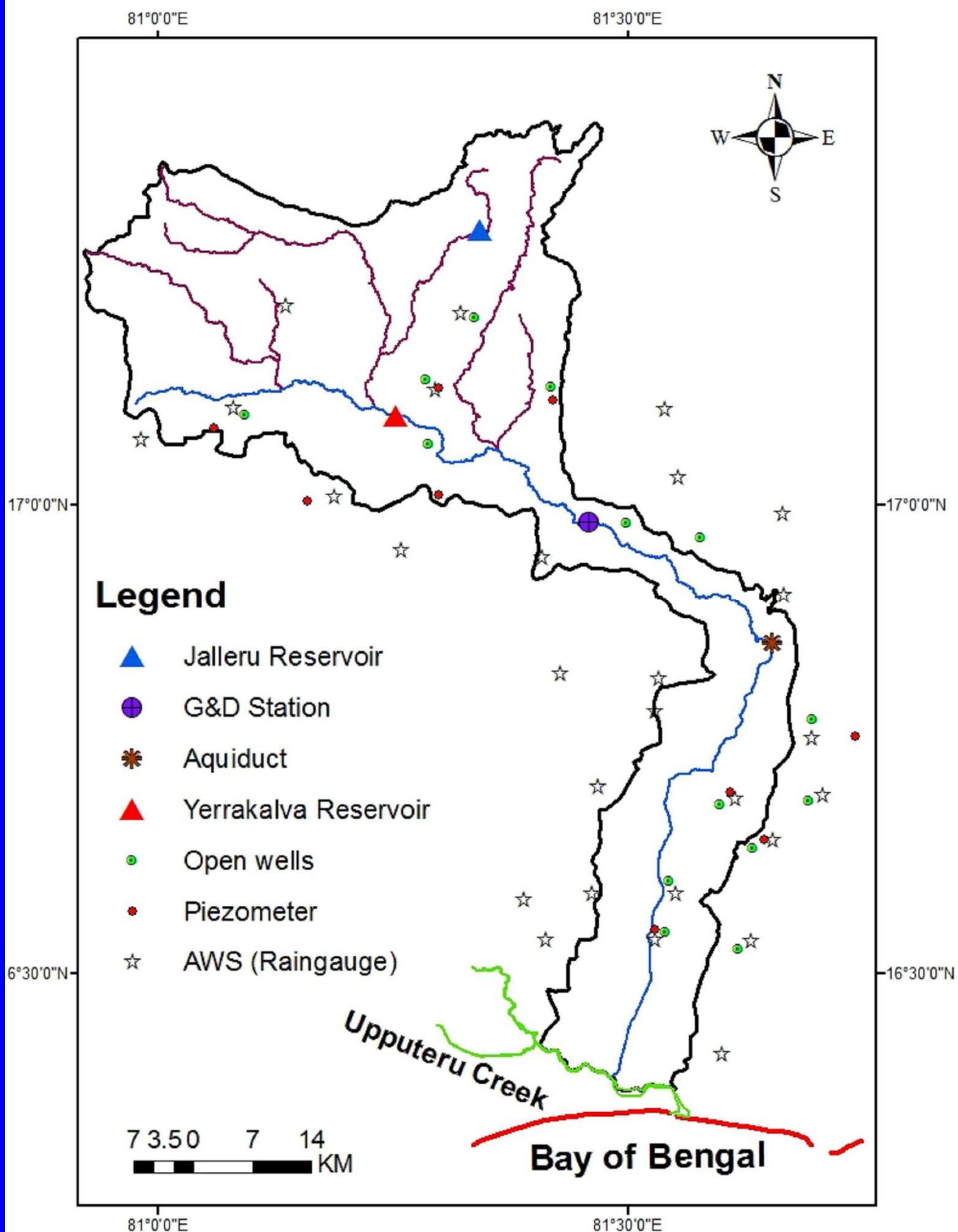
OBJECTIVES OF THE STUDY

- **To calibrate and validate SWAT model on Yerrakalva river basin**
- **To estimate water yield and water balance components of the hydrologic cycle in the basin**

SWAT MODEL

- SWAT has been chosen as it is an integrated river basin scale, physically based, continuous-time, long-term simulation, distributed model.
- Also, its suitability to different parts of the world has been well established.
- The hydrologic cycle simulated by SWAT is based on the water balance equation
- Model outputs all water balance components (surface runoff, evaporation, lateral flow, recharge, percolation, sediment yield, etc.) at the level of each watershed and are available at daily, monthly or annual time steps.

APPLICATION OF SWAT MODEL



Yerrakalva Basin

- The Yerrakalva river rises in the eastern slopes of the eastern ghats at the boarder of West Godavari and Khammam districts.
- Runs in Khammam and West Godavari districts for about 6.4 km and 180 km
- joins the Upputeru river, which takes off from the Kolleru lake and falls into Bay of Bengal.
- Catchment area = 2725.03 sq km
- Annual rainfall received during both SW and NE monsoon = 1078mm

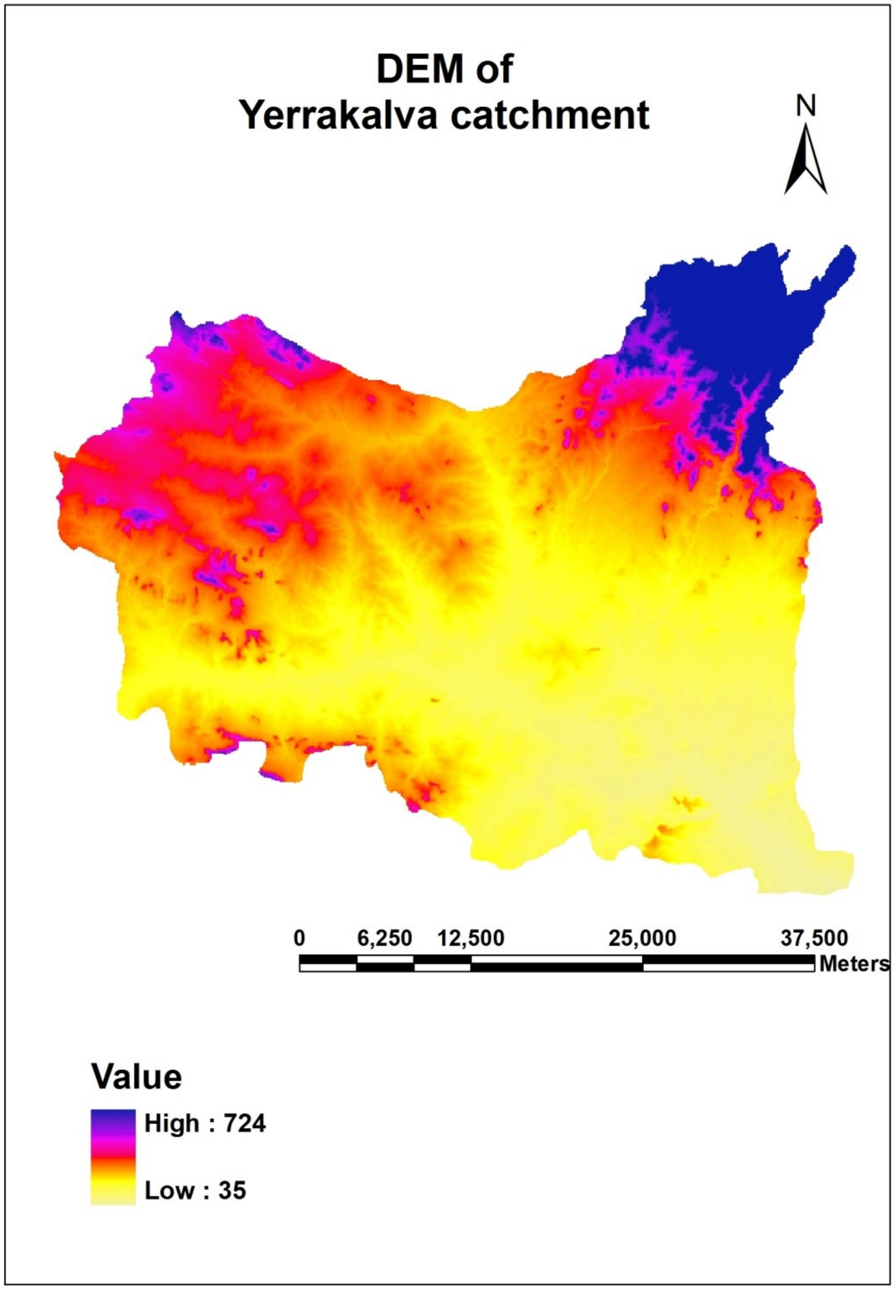
INPUT DATA USED IN SWAT MODELLING

- DEM
- Land use/cover map
- Soil map
- Attribute data for land use and soil types
- Daily weather data
- Elevation-area-capacity curve of Yerrakalva reservoir
- Daily river discharge at the Ananthapalli G-D site for calibration and validation of model

DEM

- One of the main inputs of SWAT

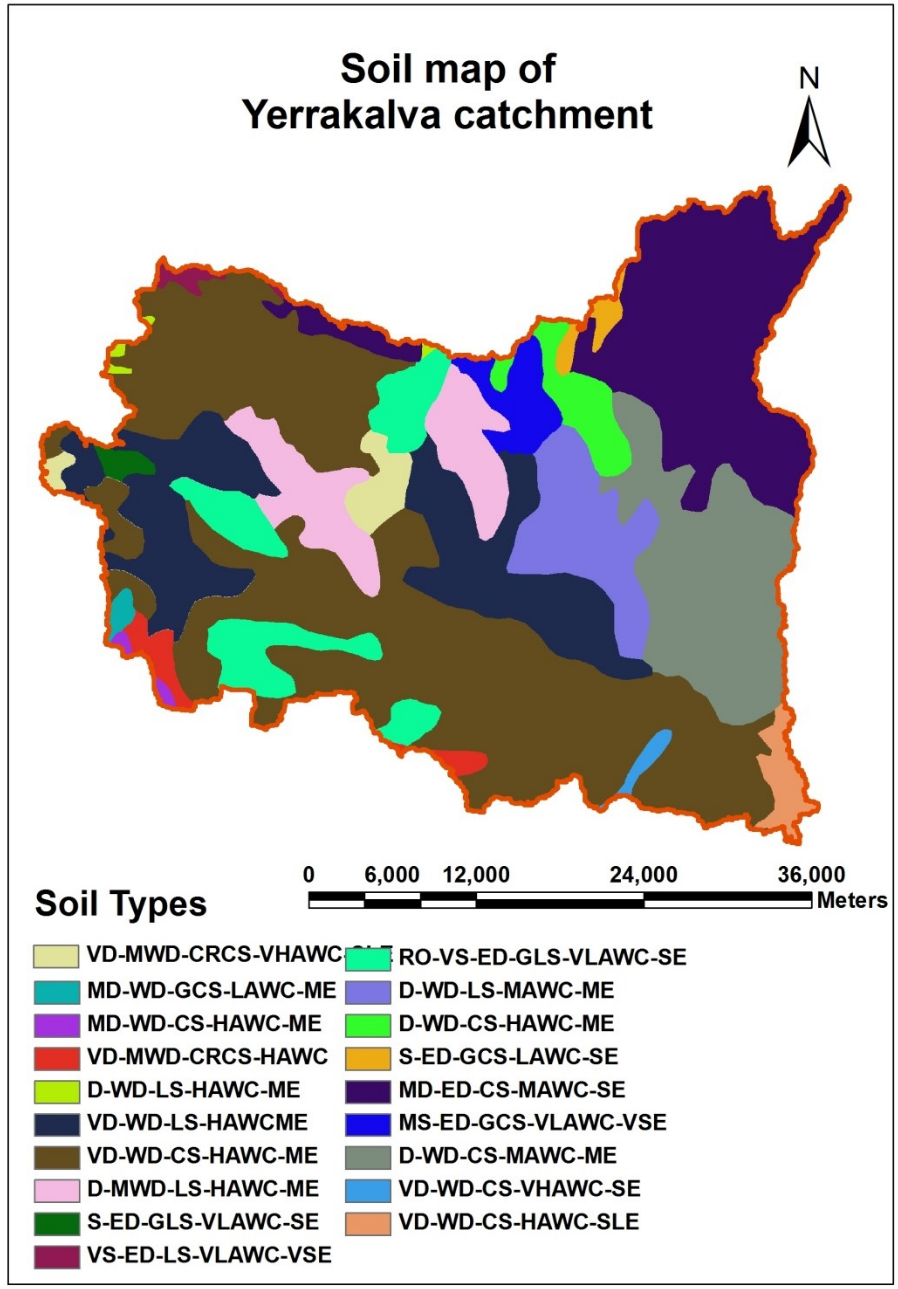
- ASTER DEM used



Soil Map

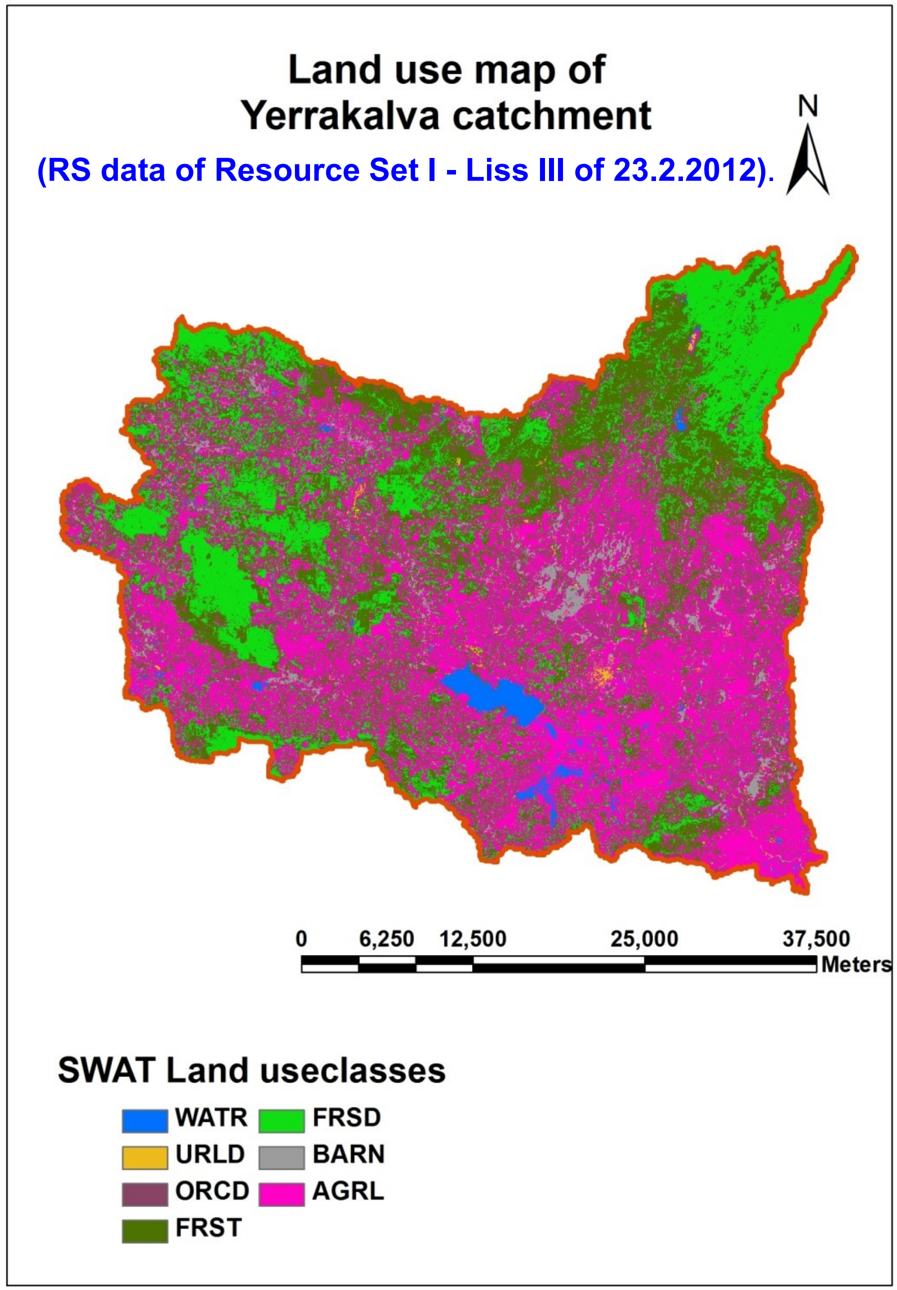
- Digitized using soil map of NBSS & LUP at 1:50,000 scale

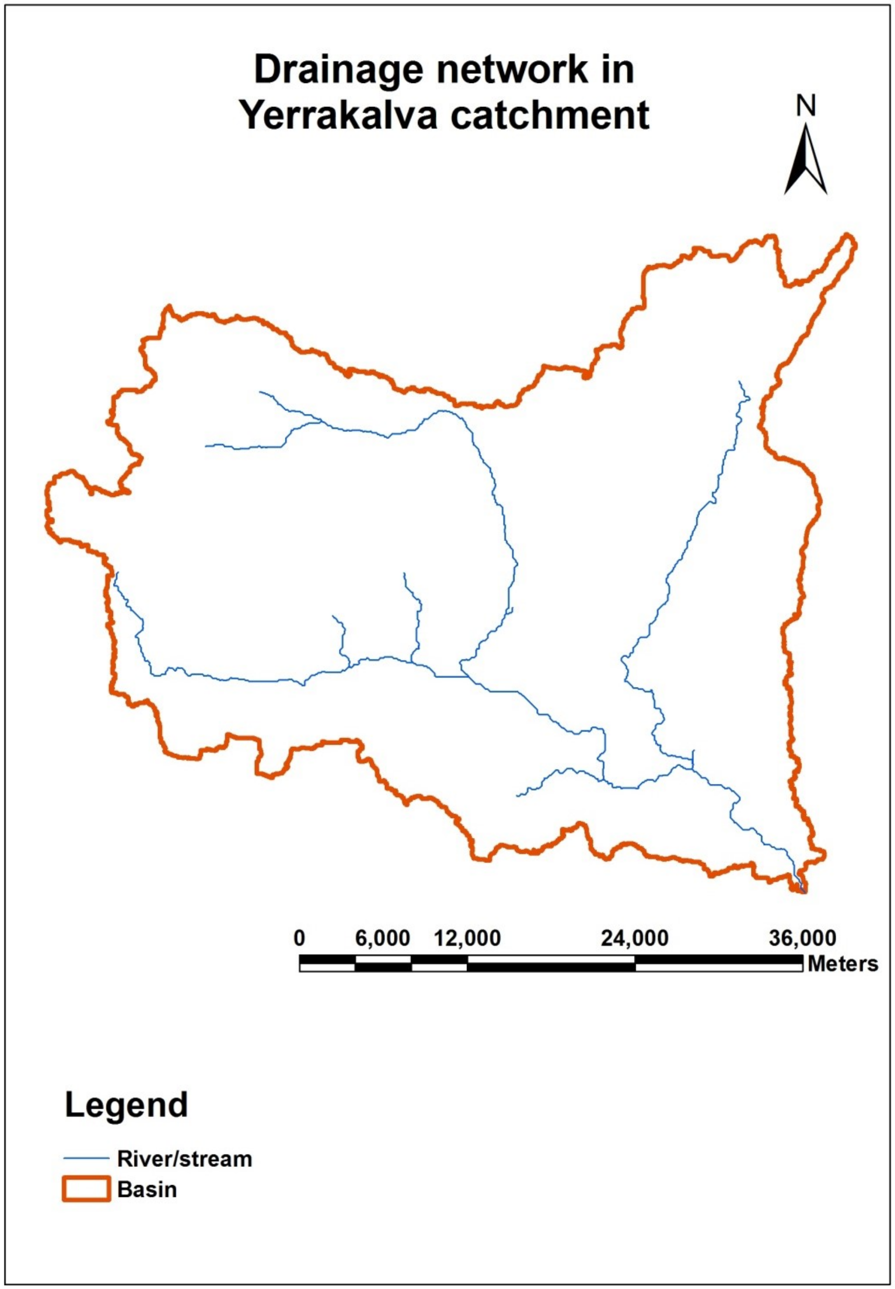
- Analysis revealed that the soils in the study area were mostly clayey soils falling in the HSG D with few polygons of loamy soils in the HSG of C.

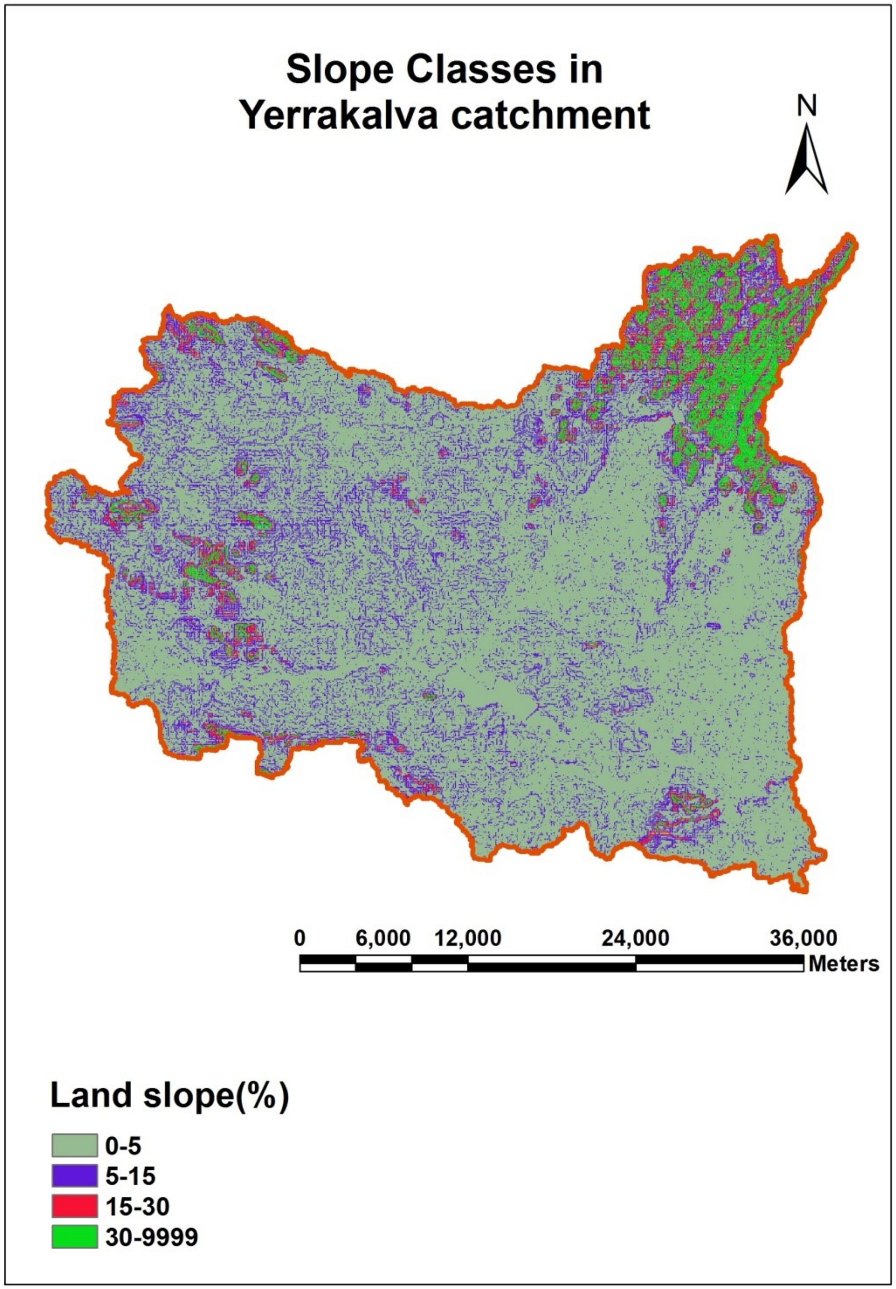


Land use/ cover Map

Land use	Area (km^2)	% to total
Agric. land	637.96	38.38
Agric. plantation / Orchards	168.0	10.10
Forests	351.60	21.15
Forest plantation	422.33	25.40
Residential	8.56	0.51
Barren land	46.64	2.81
Water	27.36	1.65
Total	1662.45	100.00




Drainage network in
Yerrakalva catchment
N
0
6,000
12,000
24,000
36,000
Meters
Legend
River/stream
Basin

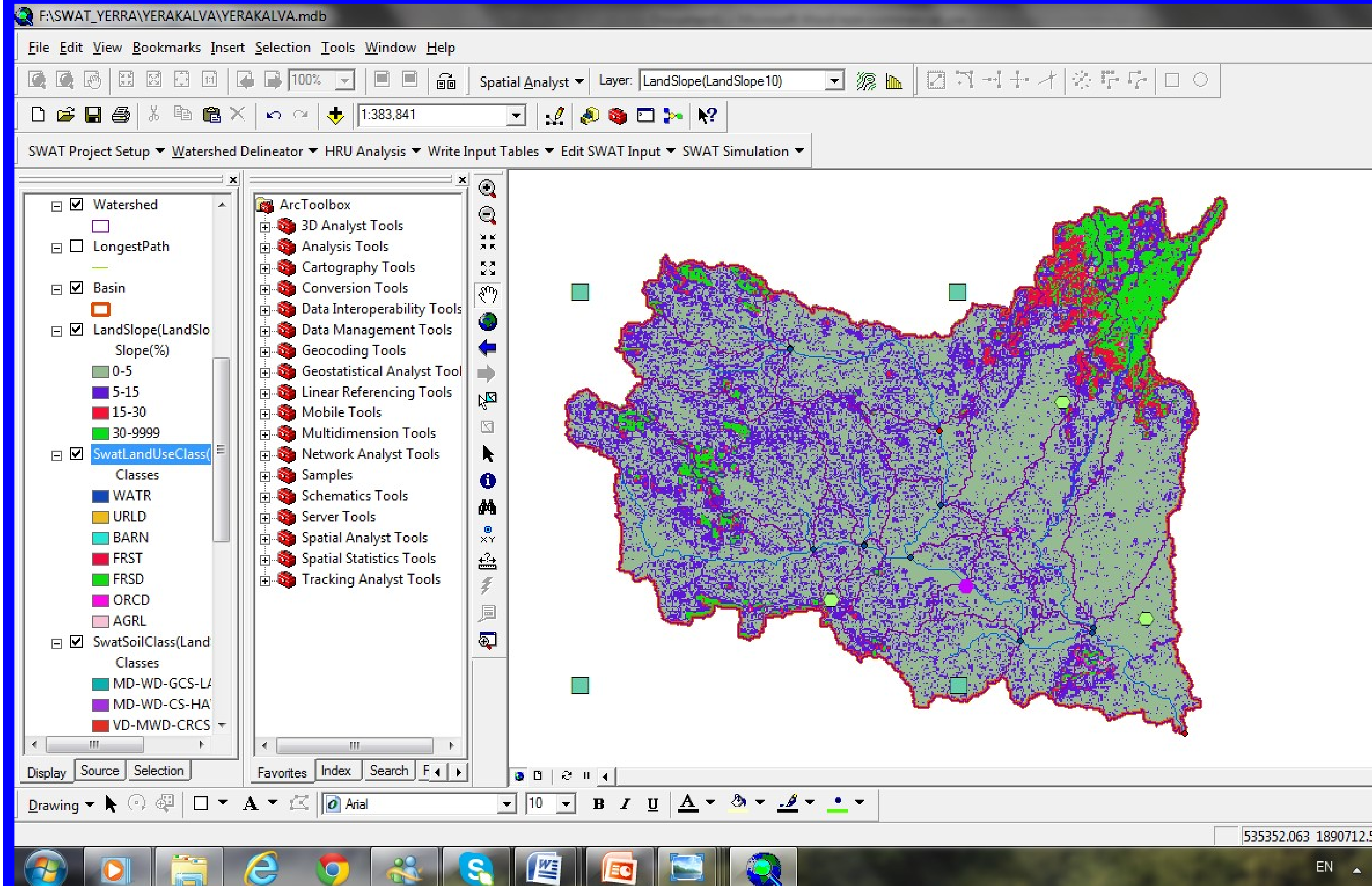

Slope Classes in
Yerrakalva catchment
N
0
6,000
12,000
24,000
36,000
Meters
Land slope(%)
0-5
5-15
15-30
30-9999

Data Availability

- **Daily rainfall data** of 5 rain gauge stations from 2005-2012 from Revenue Deptt.
- **Daily Max. & min. temperature, wind speed, RH and Solar radiation data** downloaded for the available stations in the study area from global weather data base from the website at URL:

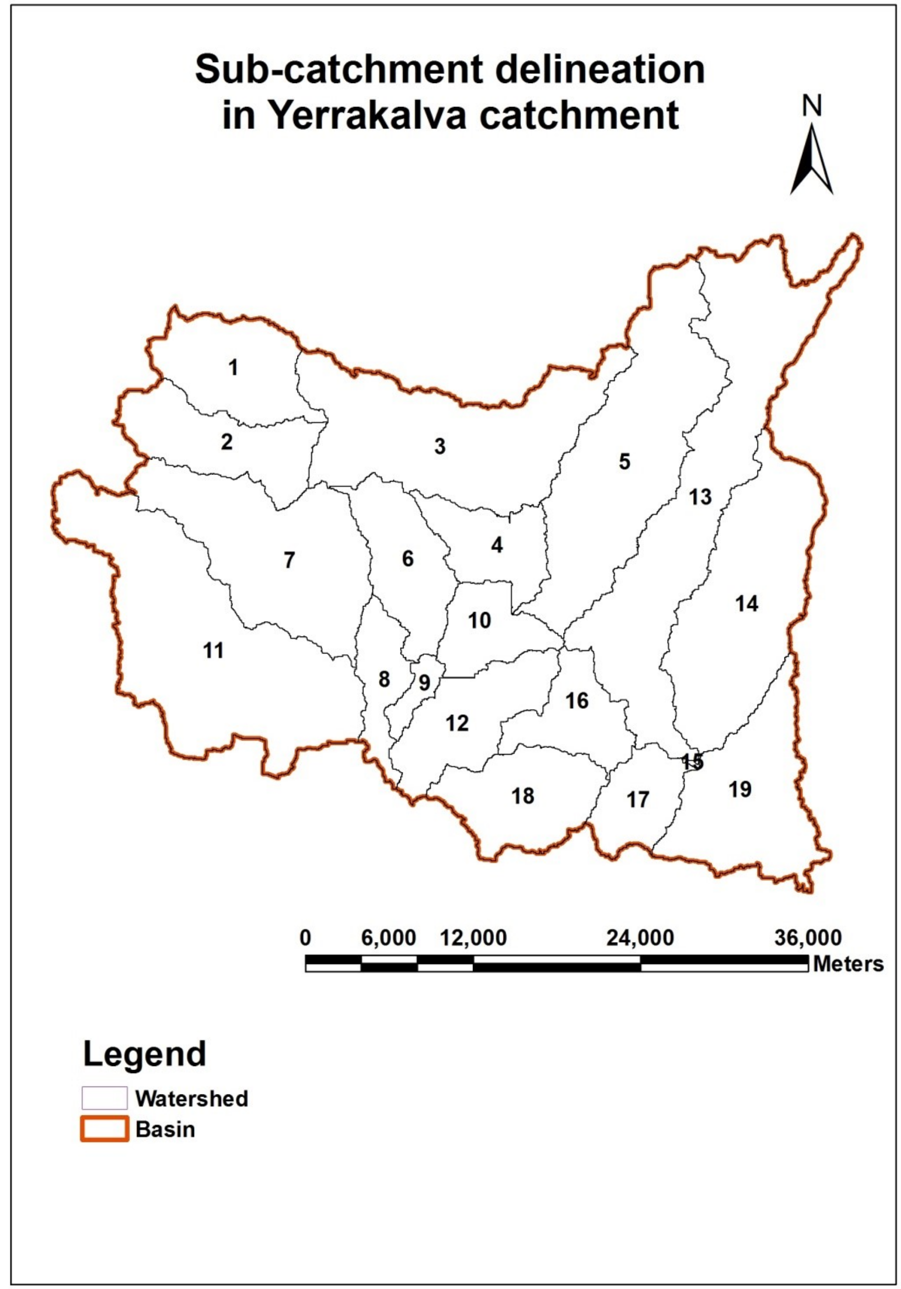
  http://globalweather.tamu.edu/home/view/3668
- **Daily discharge** at Ananathapalli G-D site collected for the period 2005-12
- **Details of Yerrakalva reservoir** collected from reservoir authorities.

SET UP OF SWAT MODEL



Delineation of sub-watersheds & HRUs

- Delineated into 19 sub-basins.
- The sub-basins were further subdivided into 280 HRUs by overlaying land use map, slope map and the soil map.



SENSITIVITY ANALYSIS

- Distributed models involve too many parameters
- Dealing with all these parameters at calibration stage is not feasible
- So, to ensure efficient calibration, sensitivity analysis was carried out for filtering out less influential parameters using a built-in SWAT sensitivity analysis tool.

Sensitivity ranking of flow parameters

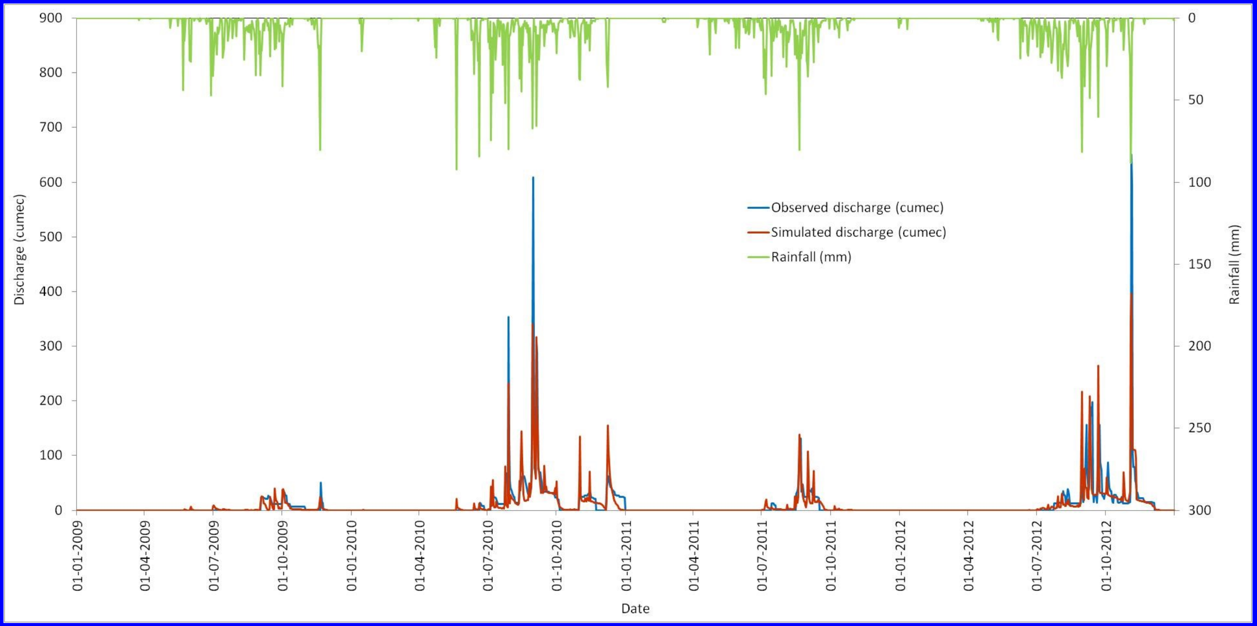
Ranking	Parameter	Explanation
1	Cn2	SCS CN II value
2	Sol_K	Saturated hydraulic conductivity (mm/hr)
3	Sol_Awc	Available water capacity of soil (mm H_2O/mm)
4	Alpha_Bf	Baseflow alpha factor (days)
5	RCHRG_DP	Deep aquifer percolation factor
6	ESCO	Soil evaporation compensation factor
7	Sol_Z	Soil depth (mm)
8	Ch_K2	Channel effective hydraulic conductivity (mm/hr)
9	Gw_Delay	Groundwater delay (days)
10	Gw_Revap	Groundwater 'revap' coefficient
11	Gwqmn	Threshold water depth in the shallow aquifer for flow
12	Ch_N2	Manning's 'n' for main channel
13	Revapmn	Threshold water depth in the shallow aquifer for 'revap'
14	Canmx	Maximum canopy storage (mm)
15	Slope	Average slope steepness (m/m)
16	EPCO	Plant uptake compensation factor
17	Biomix	Biological mixing efficiency
18	Blai	Maximum potential LAI
19	Surlag	Surface runoff lag time (days)
20	Slsubbsn	Average slope length

MODEL CALIBRATION AND VALIDATION

- **Model calibration :**
  - ✓ Using daily observed discharges of 2009-12 at Ananathapalli G-D site (1662 sq km) which is located downstream of Yerrakalva reservoir.
  - ✓ Since discharges at G-D site are regulated by the reservoir, the reservoir is also incorporated in the model to take into account the effect of reservoir on flows at G-D site.
  - ✓ Auto calibrated for sensitive parameters CN, Manning’s n, and GW parameters (Soil K, Ch_K, Alpha BF, REVAP, ESCO, soil AWC, GW delay, Recharge_DP, Soil Z) based on the ranking of sensitive parameters
- **Model validation:**
  - ✓ Using an independent set of discharge data of four years from 2005 to 2008.
- **Model evaluation:** Using E_{NS}, R^2 and PBIAS

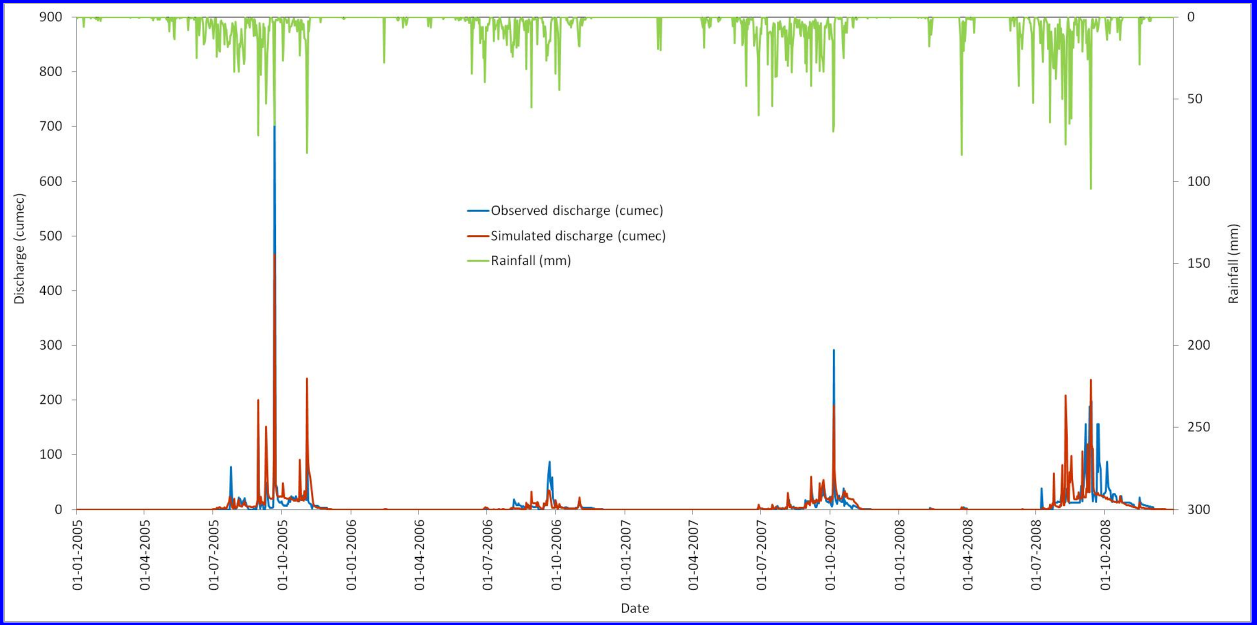
RESULTS

CALIBRATION AND VALIDATION RESULTS FOR DAILY DISCHARGES



CALIBRATION

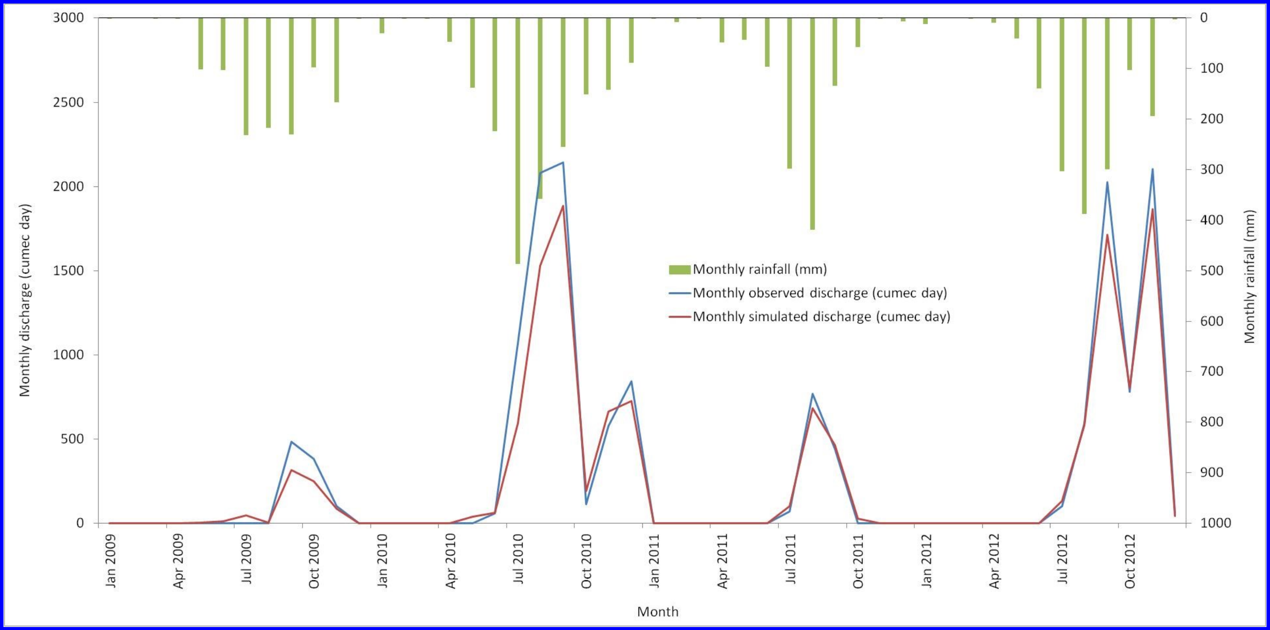
Statistical criteria	Values
E_{NS}	0.64
R^2	0.65
PBIAS	13.32



VALIDATION

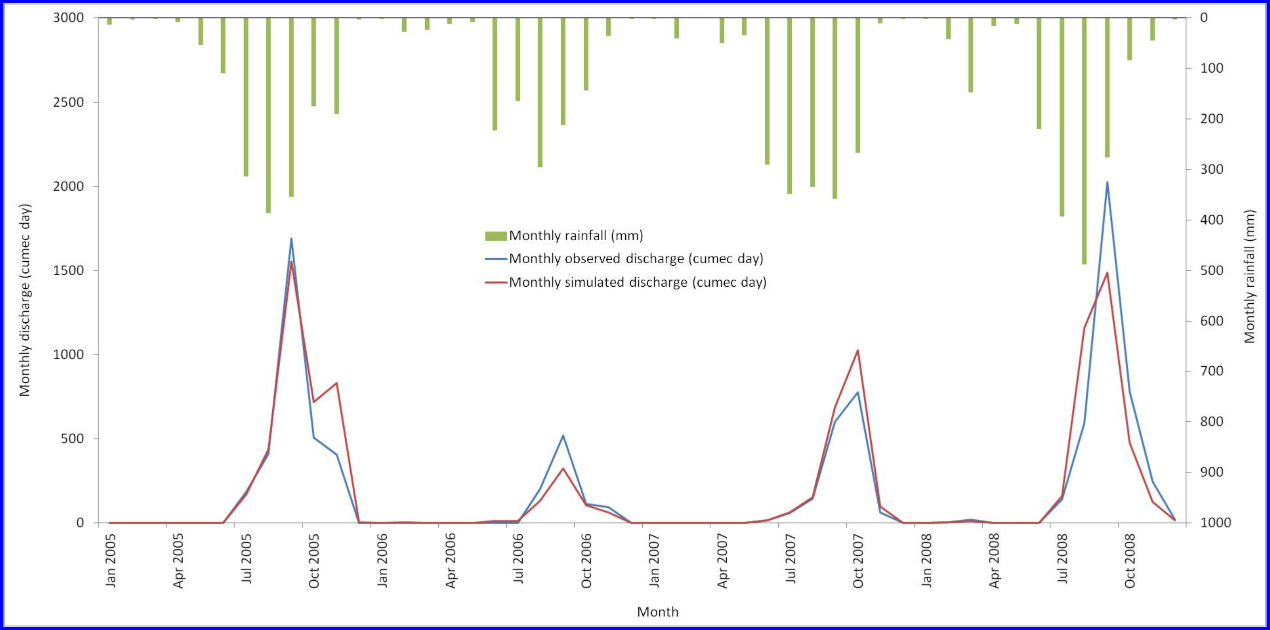
Statistical criteria	Values
E_{NS}	0.62
R^2	0.62
PBIAS	-2.58

CALIBRATION AND VALIDATION RESULTS FOR MONTHLY DISCHARGES



CALIBRATION

Statistical criteria	Values
E_{NS}	0.95
R^2	0.98
PBIAS	13.32

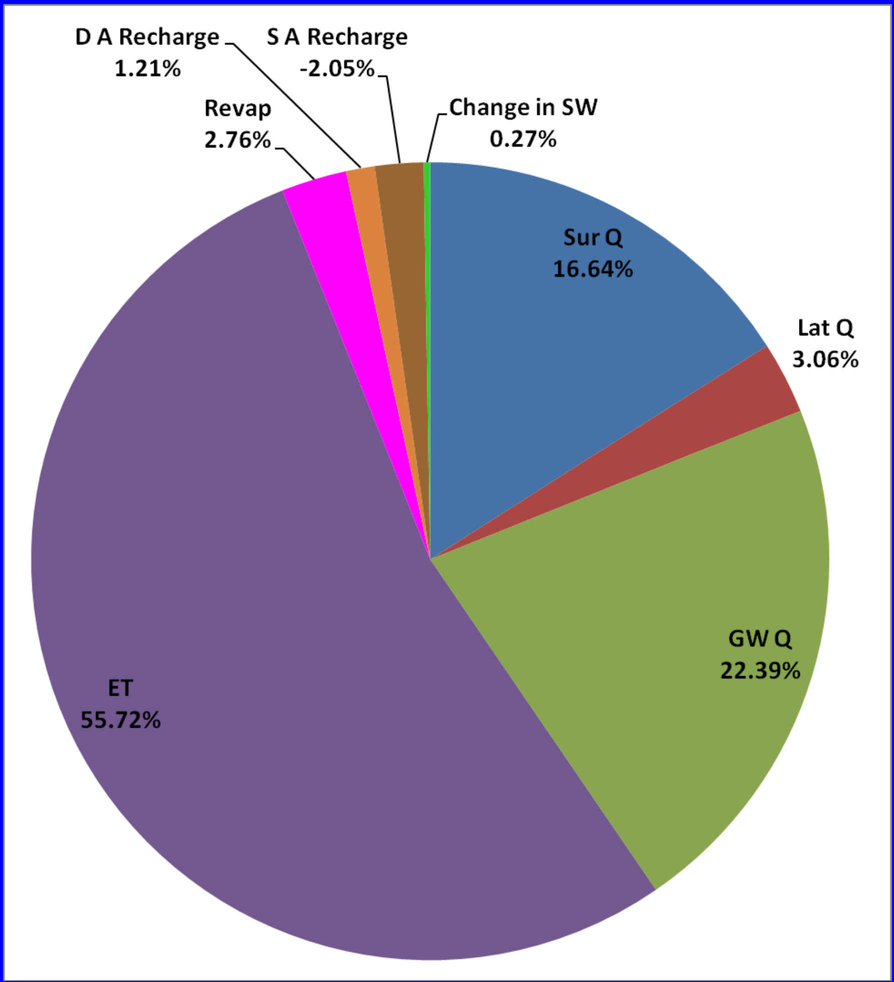


VALIDATION

Statistical criteria	Values
E_{NS}	0.87
R^2	0.87
PBIAS	-2.58

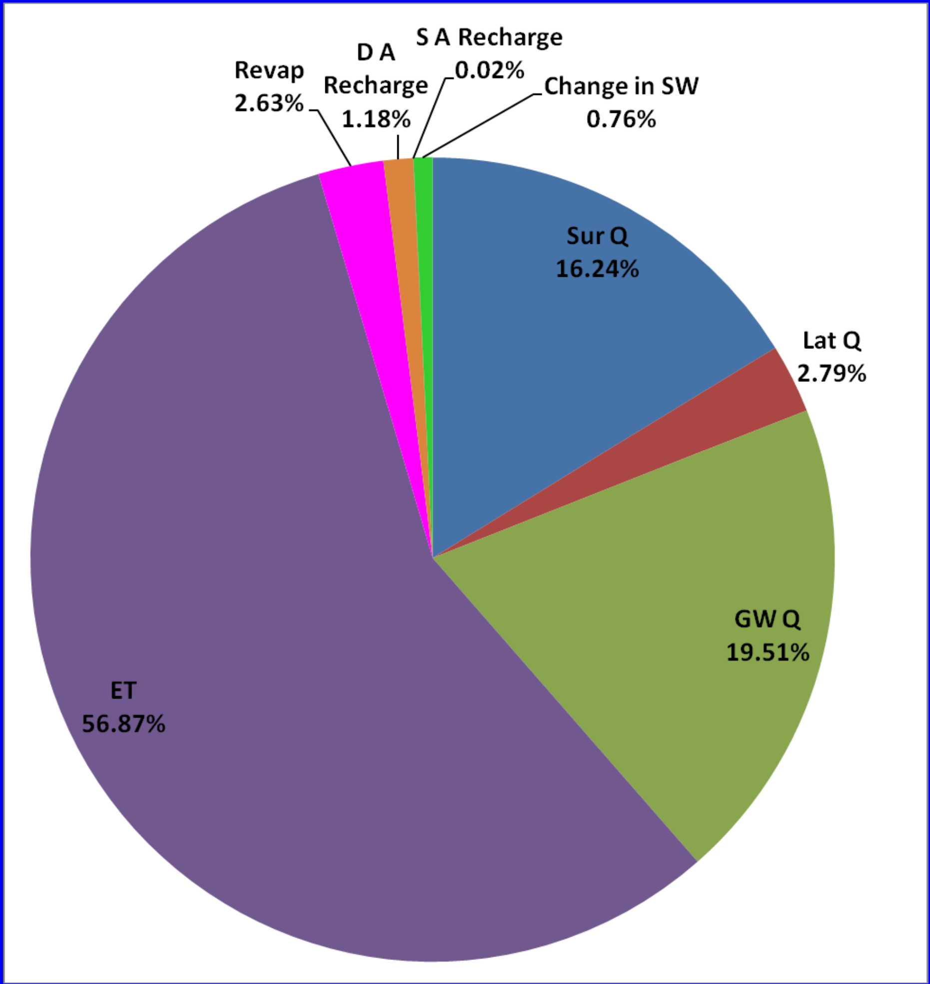
WATER BALANCE COMPONENTS

CALIBRATION



Average Annual Rainfall = 1387.10 mm
Av. Annual Water yield= 580.8 mm (41.8%)

VALIDATION



Average Annual Rainfall = 1398.20 mm
Av. Annual Water yield = 536.0 mm (38.3%)

CONCLUSIONS

- Overall, SWAT demonstrated good performance in capturing the patterns and trend of the daily observed flow series.
- Model was found to produce a reliable estimate of aggregated monthly runoff which was demonstrated by E_{NS} and R^2 superior to 0.85 for both calibration and validation periods.
- High values of R^2 and E_{NS} for monthly stream flows both for calibration and validation period indicate the predictive ability of the model and suggest its appropriateness for estimation of water balance components and water yield in the study basin.
- Water balance components simulated by SWAT provided baseline understanding of the hydrologic processes to deal with water management issues in the basin.
- The study suggests that SWAT model could be a promising tool to predict water balance & water yield to support policies & decision making for sustainable water management at basin level.

THANK YOU