Streamflow quantification using SWAT in a catchment of Coastal Odisha

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INTRODUCTION

- Odisha is a state which is liable to various natural disasters due to its geographic location. Large areas of coastal Odisha are affected by floods every year resulting in huge loss of life and property.

- Hence quantification of water resources in this area is a top priority to implement effective flood management practices.

- In the current study the SWAT (Soil and Water Assessment Tool) has been applied for assessment of streamflow at daily and monthly scale in the Budhabalanga river, a tributary of Subarnarekha river.

- The flood events have increased in the Subarnarekha river basin. The 2009 flash floods affected large parts of Bhograi, Jaleswar and Baliapal blocks and some parts of Balasore district as well. The year 2011 also witnessed tremendous variation in precipitation.

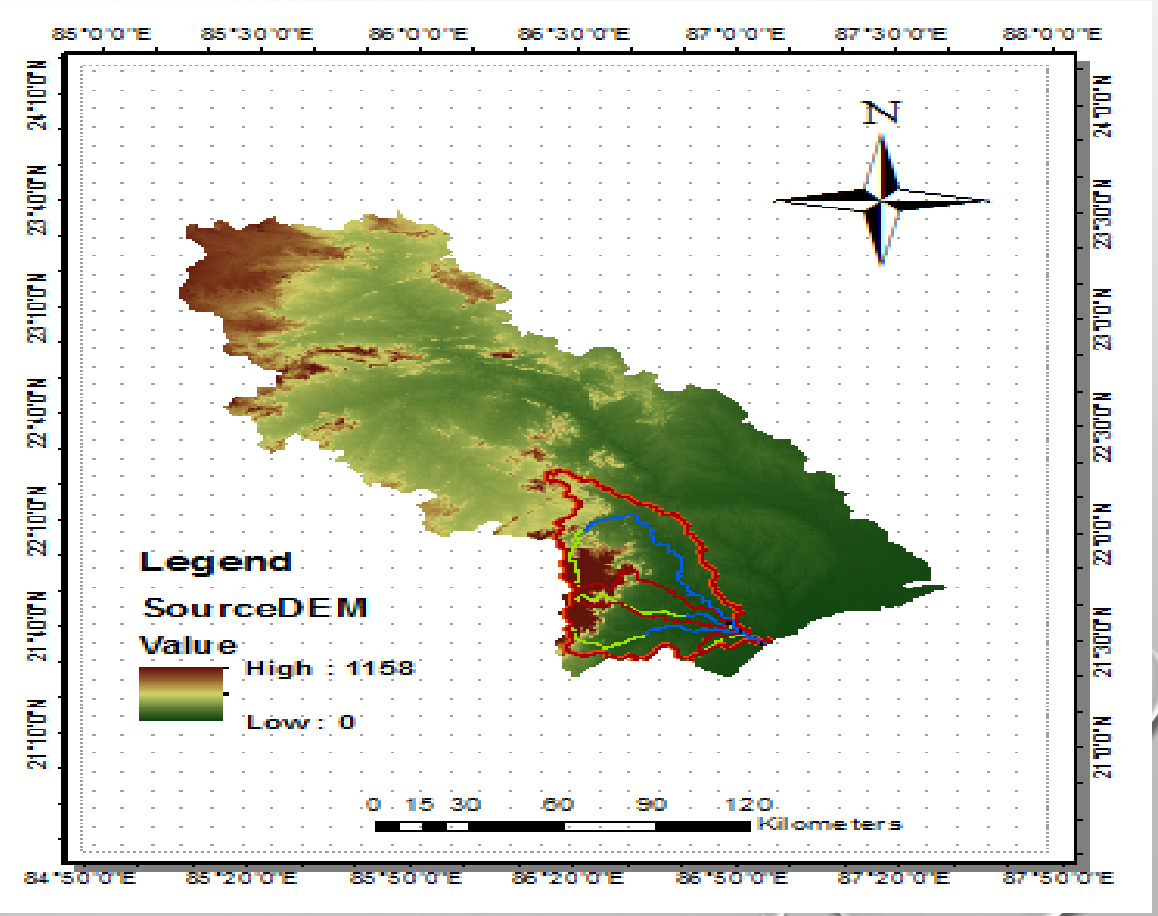
➢STUDY AREA

The Subarnarekha River Basin is an interstate basin which flows through the Indian states of Jharkhand, West Bengal and Odisha.

A catchment area of Subarnarekha River basin has been considered as our study area which covers the gauging station of Govindpur(NH5 Road Bridge) , situated in the Balasore district of Odisha with following characteristics.

- Area of the catchment: 4495 sqkm
- Location of the catchment: $86^{0}6'23''$E longitude $22^{0}18'48''$N latitude

  to $87^{0}5'36''$E longitude $21^{0}28'48''$N latitude
- Elevation of the catchment: maximum 610m minimum is 56m.
- Average annual rainfall: 1400mm
- Average temperature: maximum 32.4^{0} minimum 18.0^{0}C



OBJECTIVES OF THE STUDY

❖ To estimate the daily and monthly stream flow in Subarnarekha river basin by using SWAT model.

❖ To analyze the impact of land use/land cover and hydrologic changes on runoff in the basin for the time period 2004-2014.

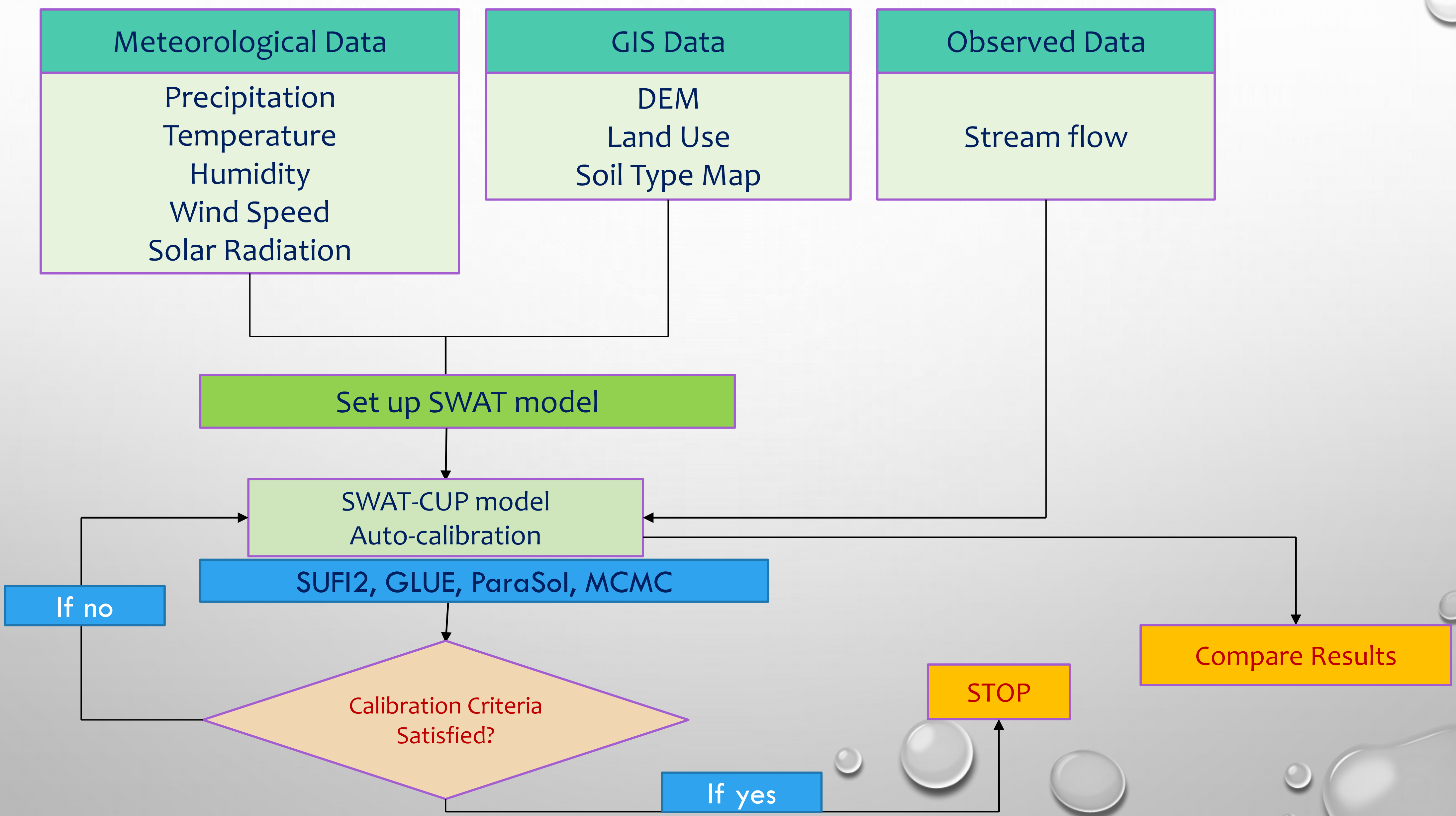
❖ To calibrate and validate the SWAT model against daily and monthly streamflow using SUFI-2 algorithm.

❖ To assess the model performance in terms of Nash-Sutcliffe efficiency (NSE), Coefficient of determination (R2) and Percentage Bias (PBIAS).

❖ To identify the sensitive flow calibration parameters and uncertainty associated with model performance in terms of p-factor and r-factor.

❖ To analyze the impact of land use/land cover and hydrologic changes on runoff in the basin for the time period 2004-2014.

METHODOLOGY



➢DATA SET FOR SWAT MODEL

DATA TYPE	SOURCE	SCALE/ PERIODS	DATA DESCRIPTION
TERRAIN	SRTM digital elevation data produced by NASA	30m x 30m	Digital elevation model
SOIL	ISRIC-World soil information website	1/25000	Soil classification and physical properties
LAND USE	NSRC, ISRO Hyderabad	2003-04, 2008-09, 2013-2014	Landsat land use classification(19 classes)
CLIMATE	Indian Meteorological Department (IMD)	2000-2014	Daily precipitation, minimum and maximum temperature
DISCHARGE	Central Water Commiss-Ion (CWC), Bhubaneswar	2000-2014	Daily discharge data at Govindpur (NH5 road)

- The model set-up is carried out using ArcSWAT interface package which runs under ArcGIS environment. In this case ArcSWAT 2012 is interfaced with ArcGIS 10.2.
- 5 subbasins were created using DEM and Gauges.
- 24 HRUs were created using multiple Landuse / Soil / Slope combinations.
- 15 Years data has been used to run the model.
- Number of years to skip (NYSKIP)

  i.e. Warmup period = 3 years (2000-2002)

  Calibration period = 8 years (2003-2010)

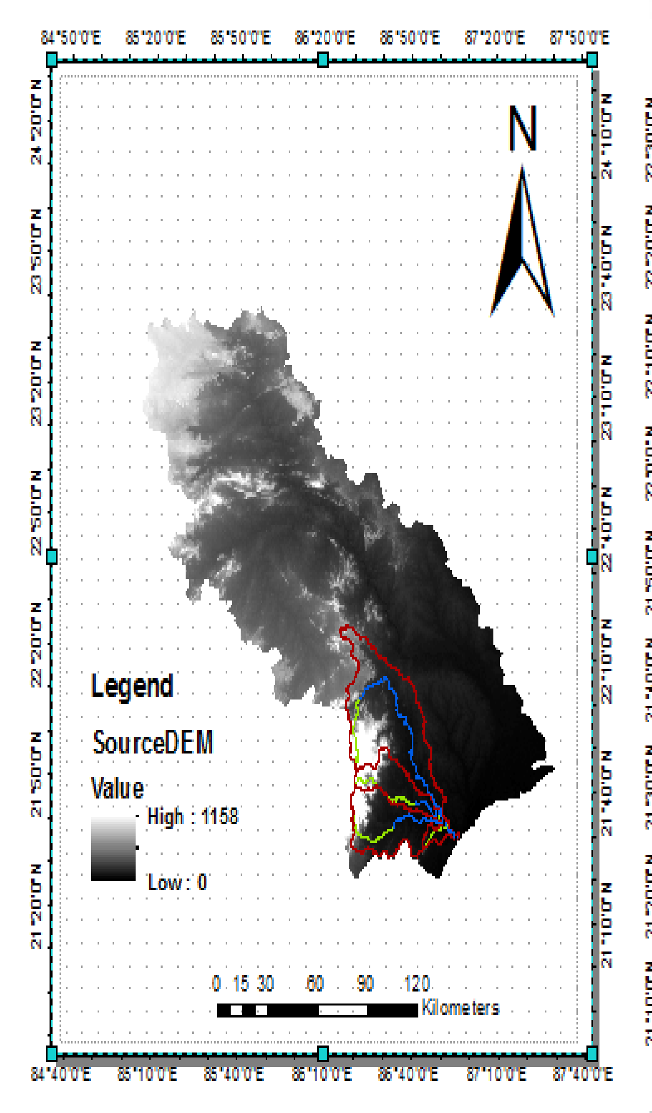
  Validation period =4 years (2011-2014)
- The **SUFI2** (Abbaspour, et al., 2007) **S**equential **U**ncertainty **Fi**tting ver.**2**, algorithm has been applied to calibrate the model considering 14 flow calibration parameters.

- The SCS-CN (Soil conservation services curve number) method has been implemented to calculate the runoff.

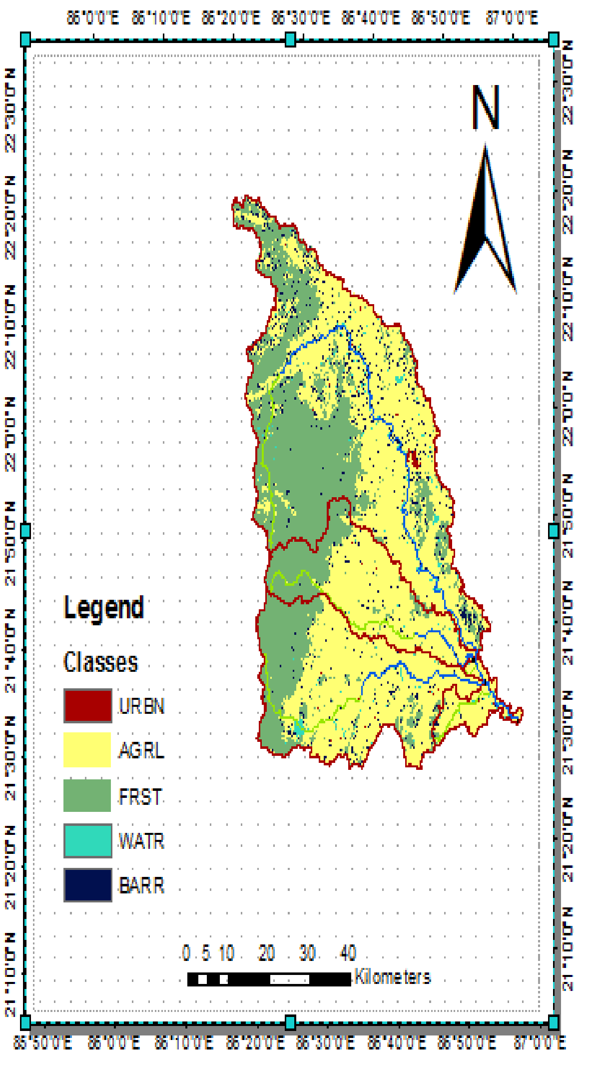
Performance of model

- The performance of model is acceptable and is considered satisfactory when coefficient of determination $R2 \geq 0.65$, Nash Sutcliffe efficiency $NSE \geq 0.5$ and PBIAS lies between -20 to +20 (Moriasi et al.,2007).
- **p-factor** : The percentage of observations covered by the 95PPU.
- **r-factor** : Relative width of 95% probability band.
- **A p-factor of 1 and r-factor of zero is a simulation that exactly corresponds to measured data.**
- **t-Stat** : Provides a measure of sensitivity, larger absolute values are more sensitive
- **P-Value** : Determined the significance of sensitivity. A value close to zero has more significance.

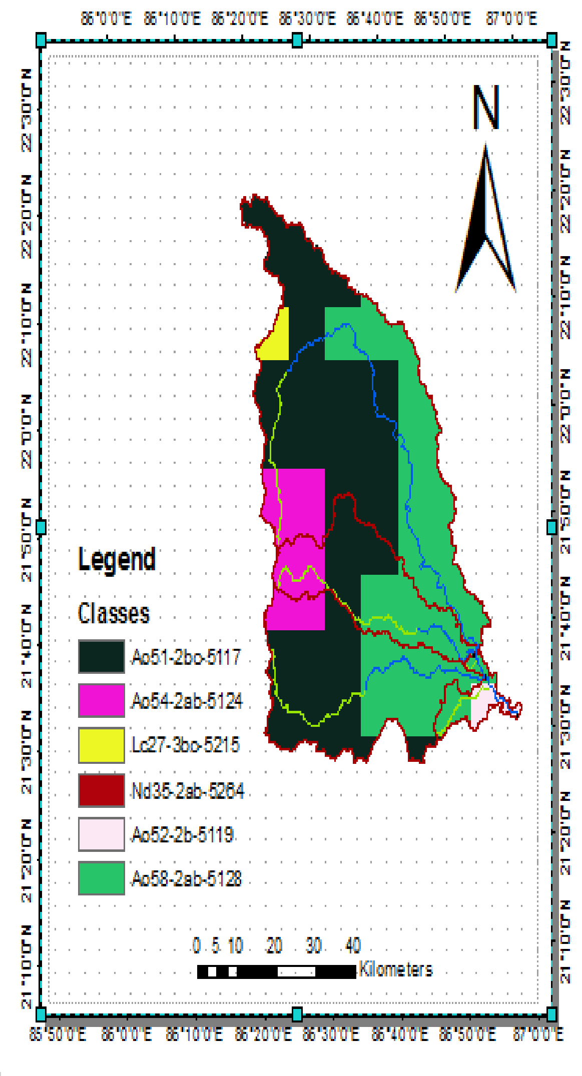
➢GIS INPUTS



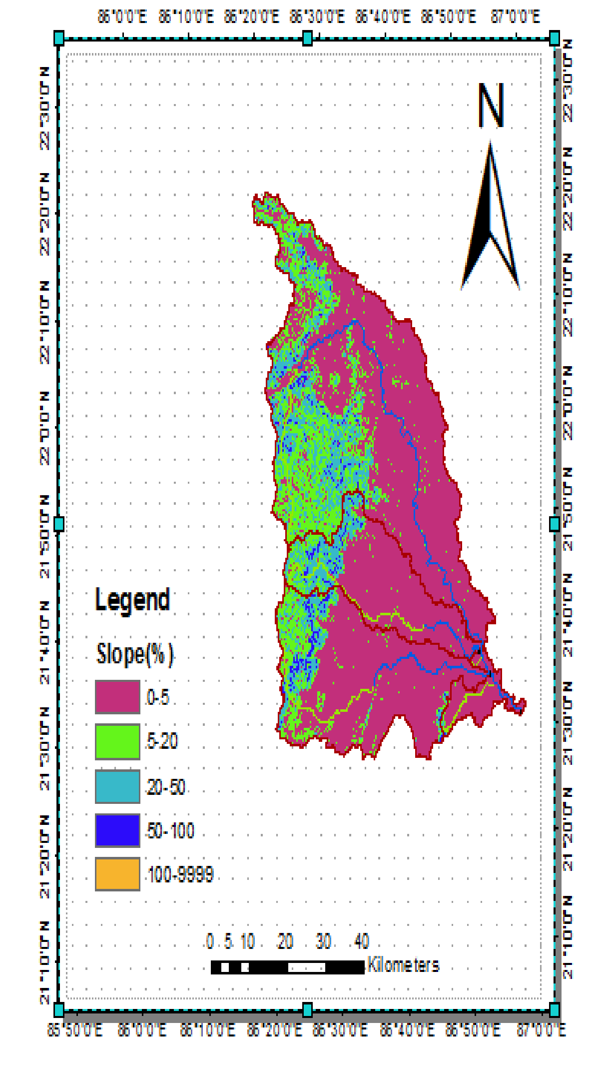
1) SOURCE DEM



2) SWAT LAND USE CLASS



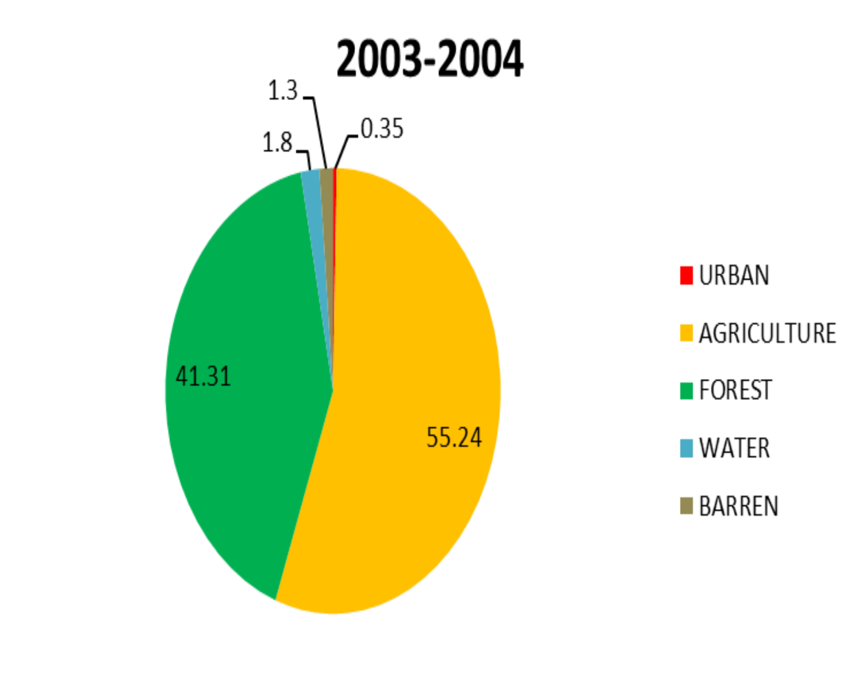
3) SWAT SOIL CLASS

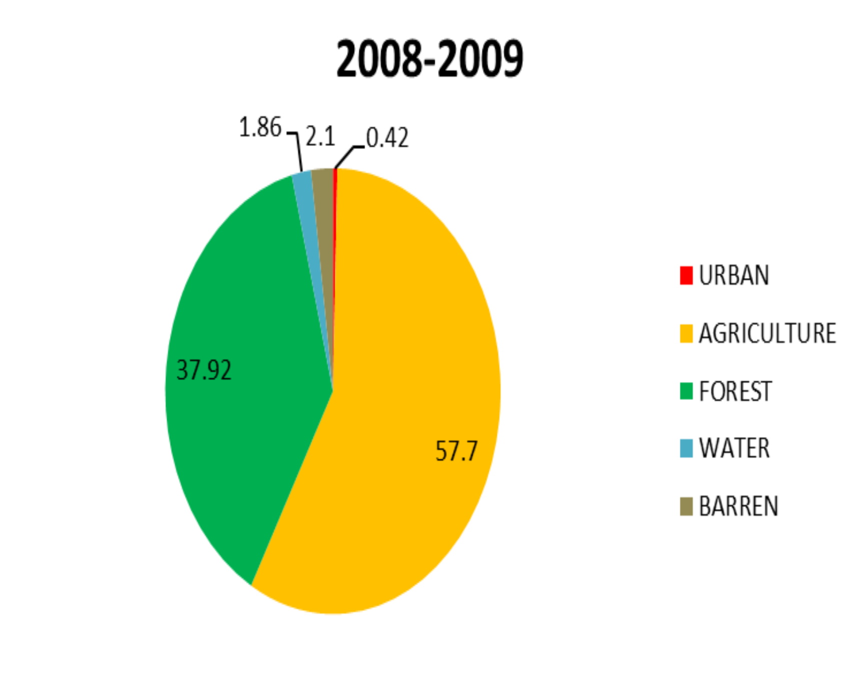


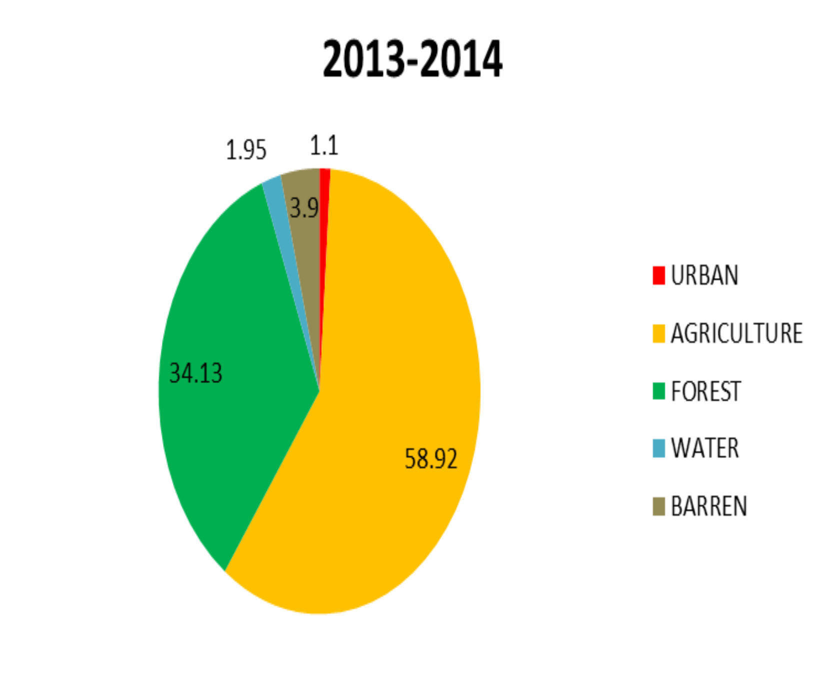
4) LAND SLOPE

RESULTS AND DISCUSSION

➢ ***IMPACT OF LAND USE CHANGES ON RUNOFF:***

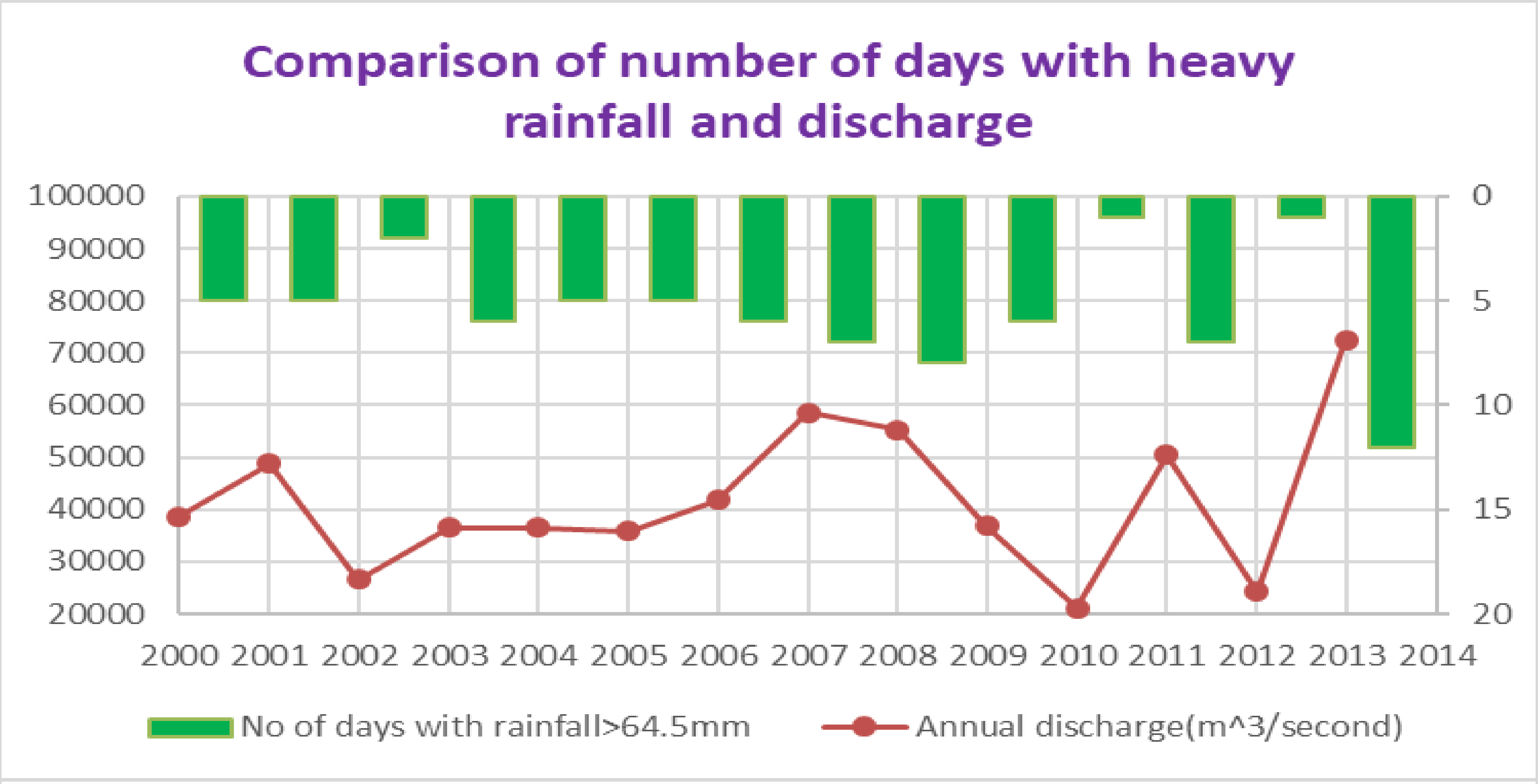




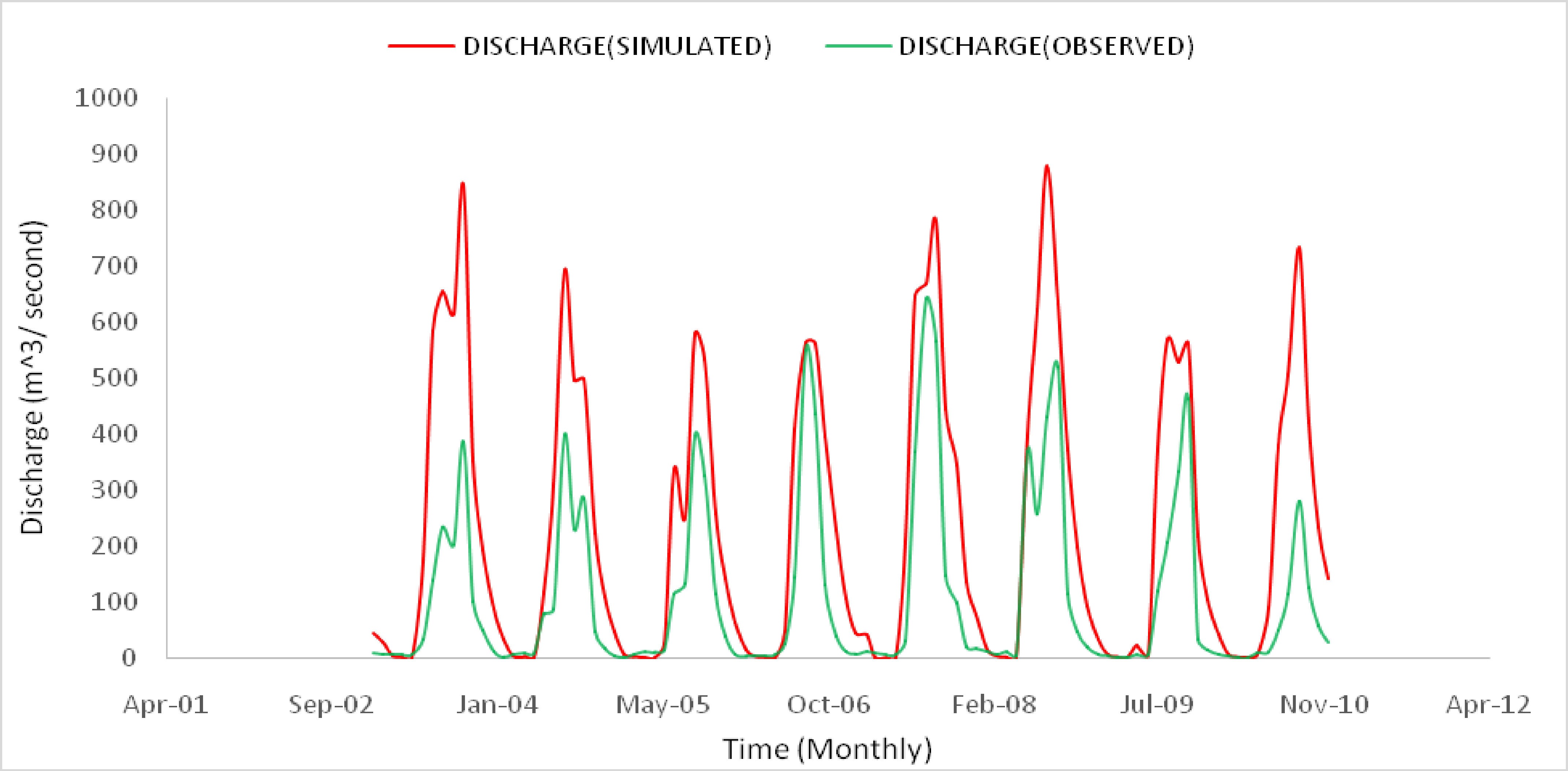


LAND USE	2003-2004	2008-2009	2013-2014
URBAN	0.35	0.42	1.1
AGRICULTURE	55.24	57.7	58.92
FOREST	41.31	37.92	34.13
WATER	1.8	1.86	1.95
BARREN	1.3	2.1	3.9

➢ *TREND ANALYSIS OF RAINFALL AND RUNOFF:*

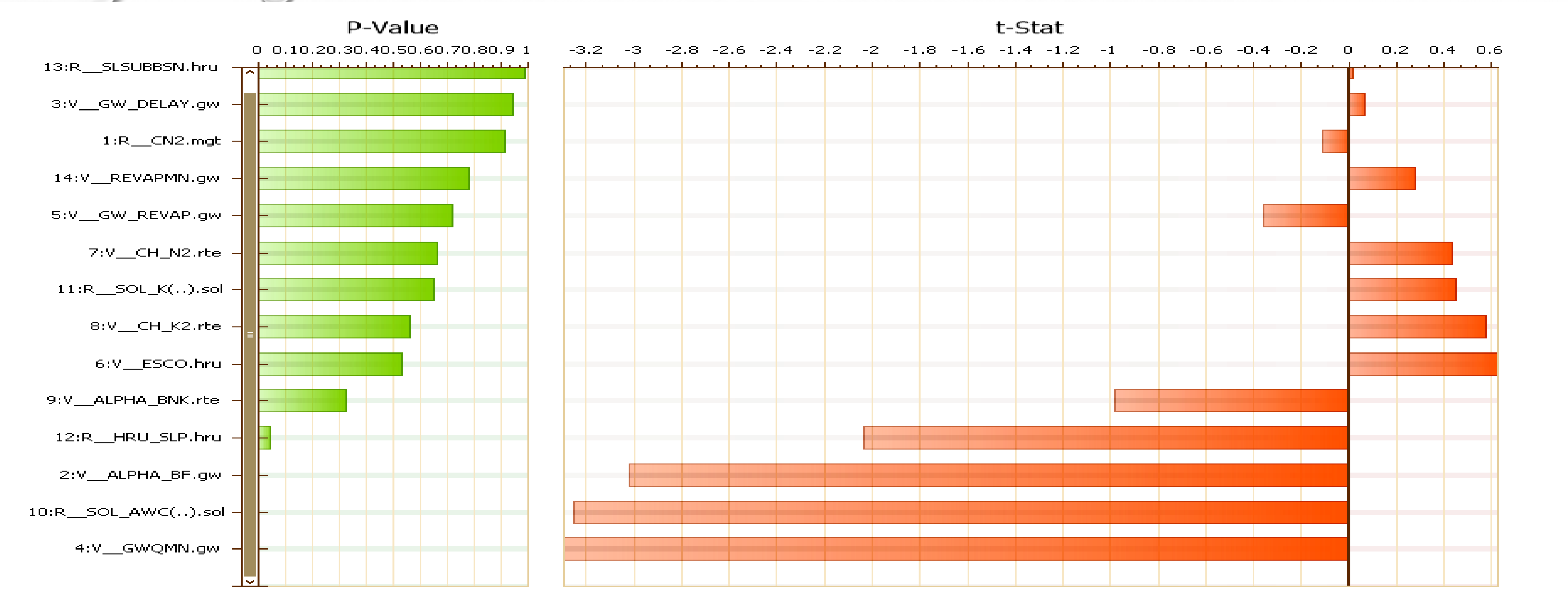


➢*Simulated Results*



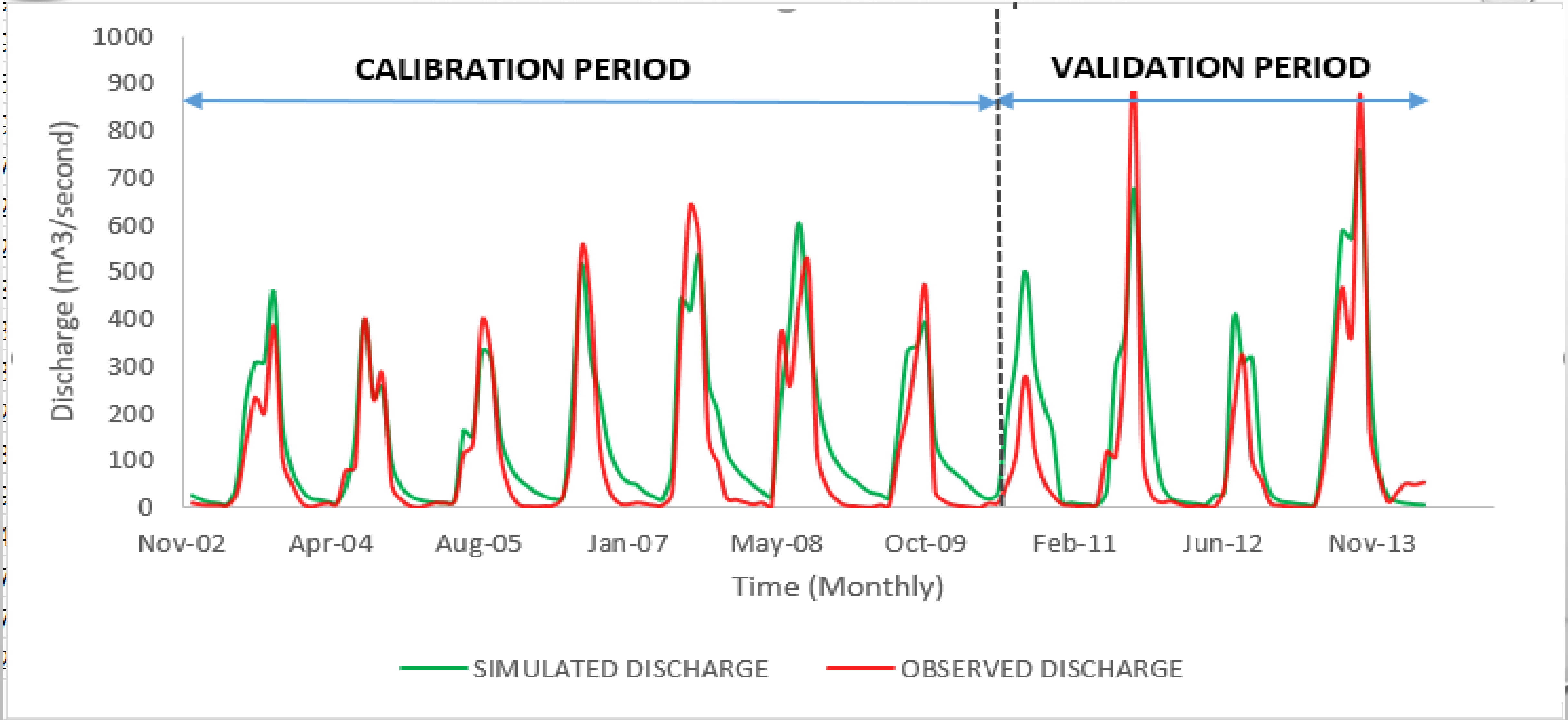
Sl.	Flow Calibration Parameters		Minimum	Maximum	Fitted Value
1.	Curve Number	r_CN2.mgt	-0.5	0.5	-0.035375
2.	Base flow alpha factor	v_ALPHA_BF.gw	0	1	0.119868
3.	Groundwater delay(days)	v_GW_DELAY.gw	30	350	199.57
4.	Threshold depth of water(mm)	v_GWQMN.gw	0	5000	4316.364
5.	Groundwater revap coefficient	v_GW_REVAP.gw	0.02	0.3	0.272723
6.	Soil evaporation compensation factor	v_ESCO.hru	0.01	1	0.589846
7.	Manning's n value for main channel	v_CH_N2.rte	0.01	0.5	0.440980
8.	Effective hydraulic conductivity	v_CH_K2.rte	-70	100	-59.991
9.	Base flow alpha factor for bank storage	v_ALPHA_BNK.rte	-0.5	0.5	0.34742
10.	Available water capacity of the soil	r_SOL_AWC.sol	-0.5	0.5	1.205750
11.	Saturated hydraulic conductivity	r_SOL_K.sol	-0.8	0.8	-0.218733
12.	Average slope steepness	r_HRU_SLP.hru	0	0.6	0.435079
13.	Average slope length	r_SLSUBBSN.hru	10	150	82.262680
14.	Threshold depth of water for revap to occur	v_REVAPMN.gw	8	14	8.398216

➢SENSITIVITY ANALYSIS:



- Sensitivity analysis of the flow calibration parameters was done.
- Out of the 14 parameters considered for calibration , 7 parameters were found to be most sensitive namely, **threshold depth of water, available water capacity, base flow alpha factor, average slope steepness, base flow alpha factor for bank storage, soil evaporation compensation factor and effective hydraulic conductivity.**

➢*Calibrated and validated results*



DATA SETS (Daily)	R^2	NASH-SUTCLIFFE	PBIAS	p-Factor	r-Factor
SIMULATED DATA (2003-2010)	0.469	0.186	39.9	0.97	1.21
CALIBRATED DATA (2003-2010)	0.6367	0.61	-12.0	0.7	0.53
VALIDATED DATA (2011-2014)	0.602	0.57	14.2	0.61	0.59

DATA SETS (Monthly)	R^2	NASH-SUTCLIFFE	PBIAS	p-Factor	r-Factor
SIMULATED DATA (2003-2010)	0.77	0.355	-33	0.81	0.97
CALIBRATED DATA (2003-2010)	0.81	0.76	9.2	0.7	0.39
VALIDATED DATA (2011-2014)	0.83	0.79	10.4	0.73	0.45

CONCLUSION

- Five sub-basins and twenty four HRUs are found to exist for the region from the delineation result.
- SWAT model has given satisfactory results for daily as well as monthly time step. However the results improved for monthly time step as the flows are averaged and smoothened out.
- No significant land use changes have been observed for the region in the past decade and groundwater flow does not have very prominent influence on the runoff for the region.
- The rainfall influences the runoff in this region mostly specially the number of days with high rainfall has a significant influence on the runoff for this region.
- As the model has given successful results for this area this model can be implemented in similar hydrologic conditions where streamflow data are not available.
- The SCS-CN curve number method has been used to calculate runoff. The SWAT model will be run with the muskinghum routing method and the difference in results will be compared in the future.
- The study can be extended to compare the influence the impact of future land use changes and climate changes on the runoff.

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THANK YOU