Climate Change Impact on Water Resources of Phakal Lake using SWAT model

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Introduction

- Climate change and its variability cause significant impacts on water resources of the region.
- The uncertainties in precipitation and increasing temperature in the semi-arid regions are posing a serious stress on the water resources.
- Minor Irrigation tanks play a significant role in managing water resources in semi-arid regions.
- Tank irrigation has a great significance in semi-arid regions, as the small scale farmers depend mainly on these resources.

- Tank irrigation is significant in arid and semi-arid regions due to the contribution to water resources development, agricultural production, livelihood security and environmental sustainability.
- This study was carried out for Phakal watershed, which is situated in the Krishna River Basin, India.
- This part of the basin is very important as the catchment provides water for Phakal lake – a medium irrigation project.
- So it is crucial to study and evaluate the potential impacts of climate change on the hydrology and water resources availability.
- The assessment of future climate change impacts on Phakal lake has been carried out using the Soil and Water Assessment Tool (SWAT).

Methodology

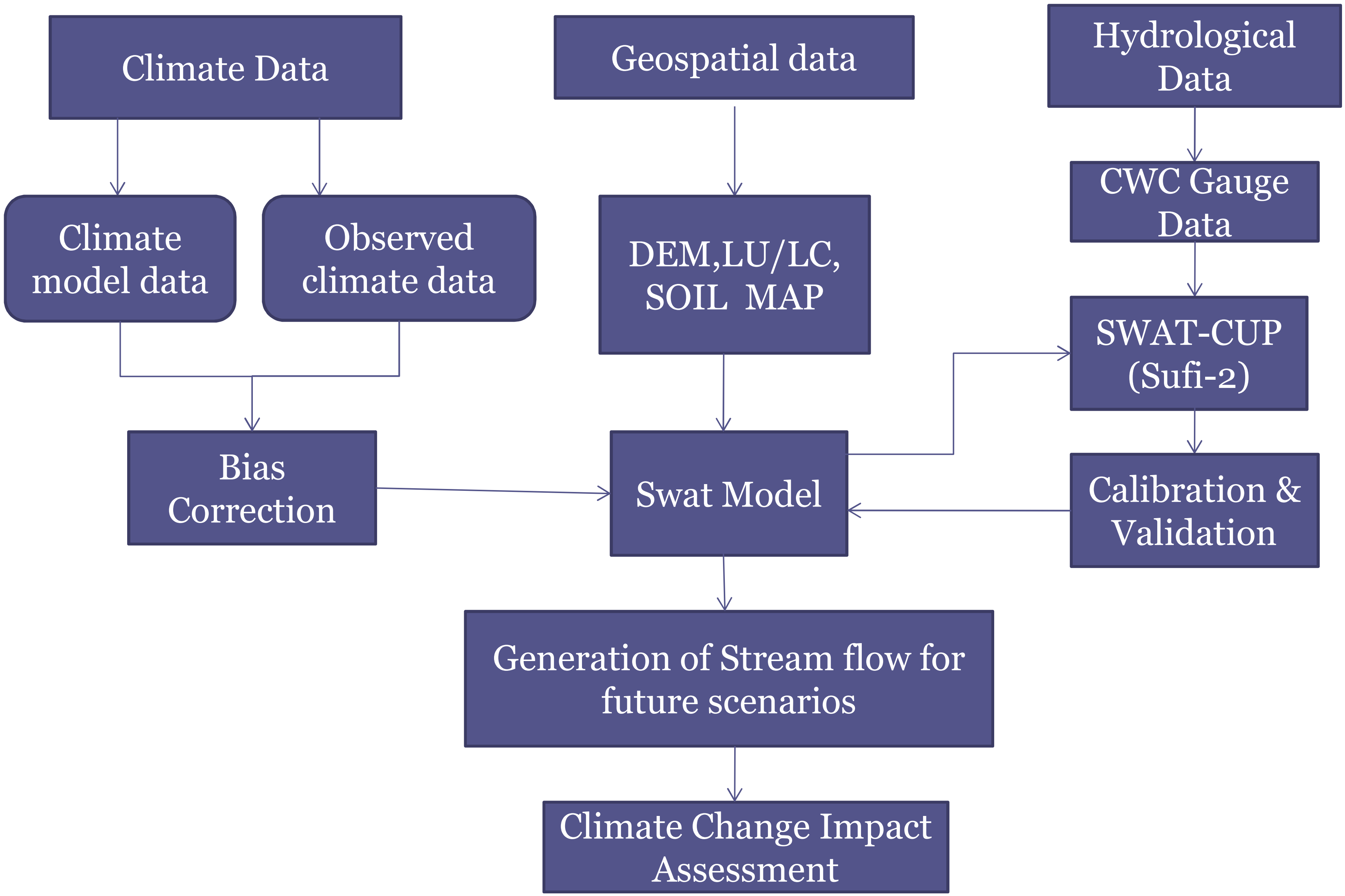

Fig. 1 Methodology followed in the present research study

Study Area

- Normal annual rainfall is about 1048mm
- Warangal District has an area of 12,846 km²
- **Location:** North Latitude $17^{o}19'$ and $18^{o}\,36'$

  East Longitude $78^{o}\,49'$ and $80^{o}\,43'$

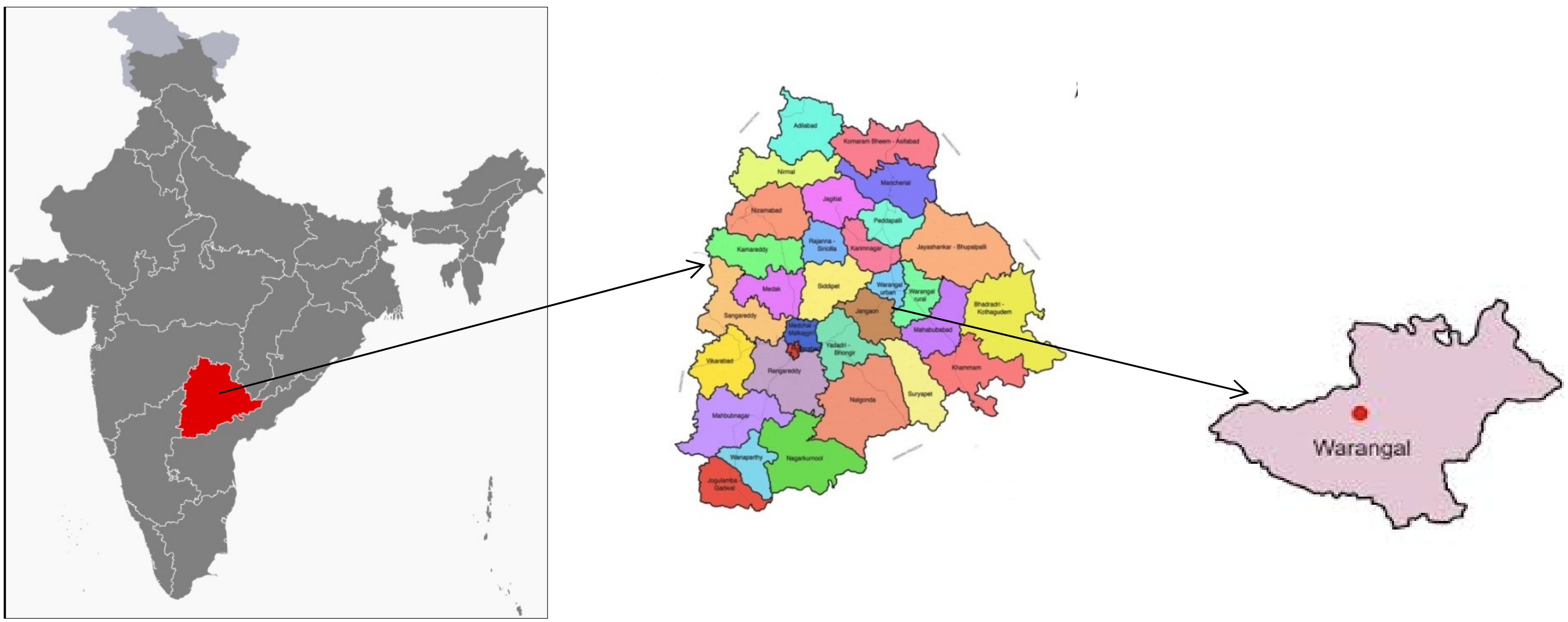

Fig 2 Study Area – Warangal district (Undivided)

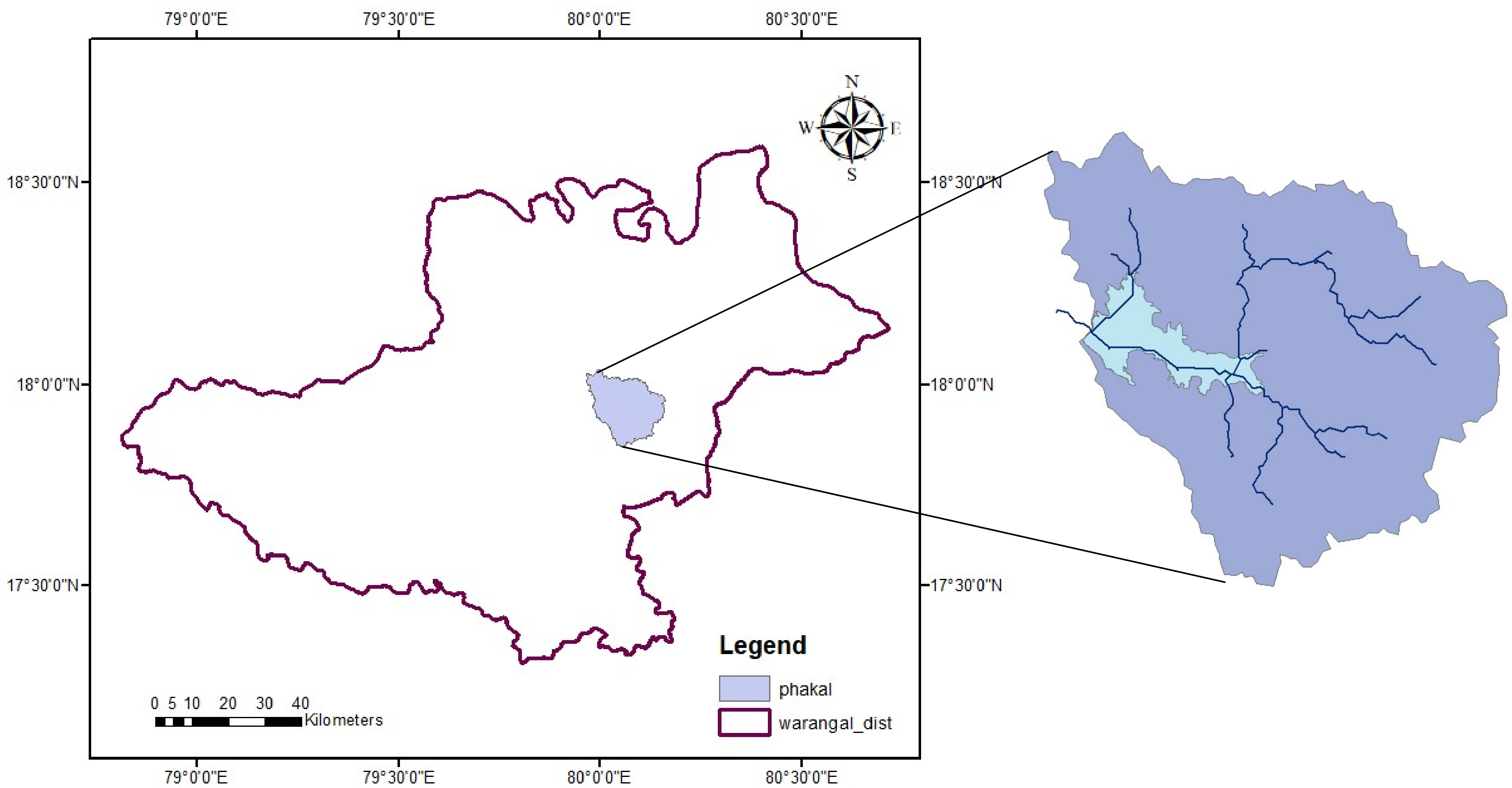

Fig. 3 Phakal Watershed

Climate Data

- **Observed climate data** provided by Indian Meteorological Department (IMD), Pune.
- Indian Meteorological Department has provided the rainfall data for the whole of India considering a grid with a cell size of 0.5°×0.5°.
- **Climate model data** –RCM available with grid cell size 0.5°×0.5°.
- Source: CORDEX (RCP 4.5)

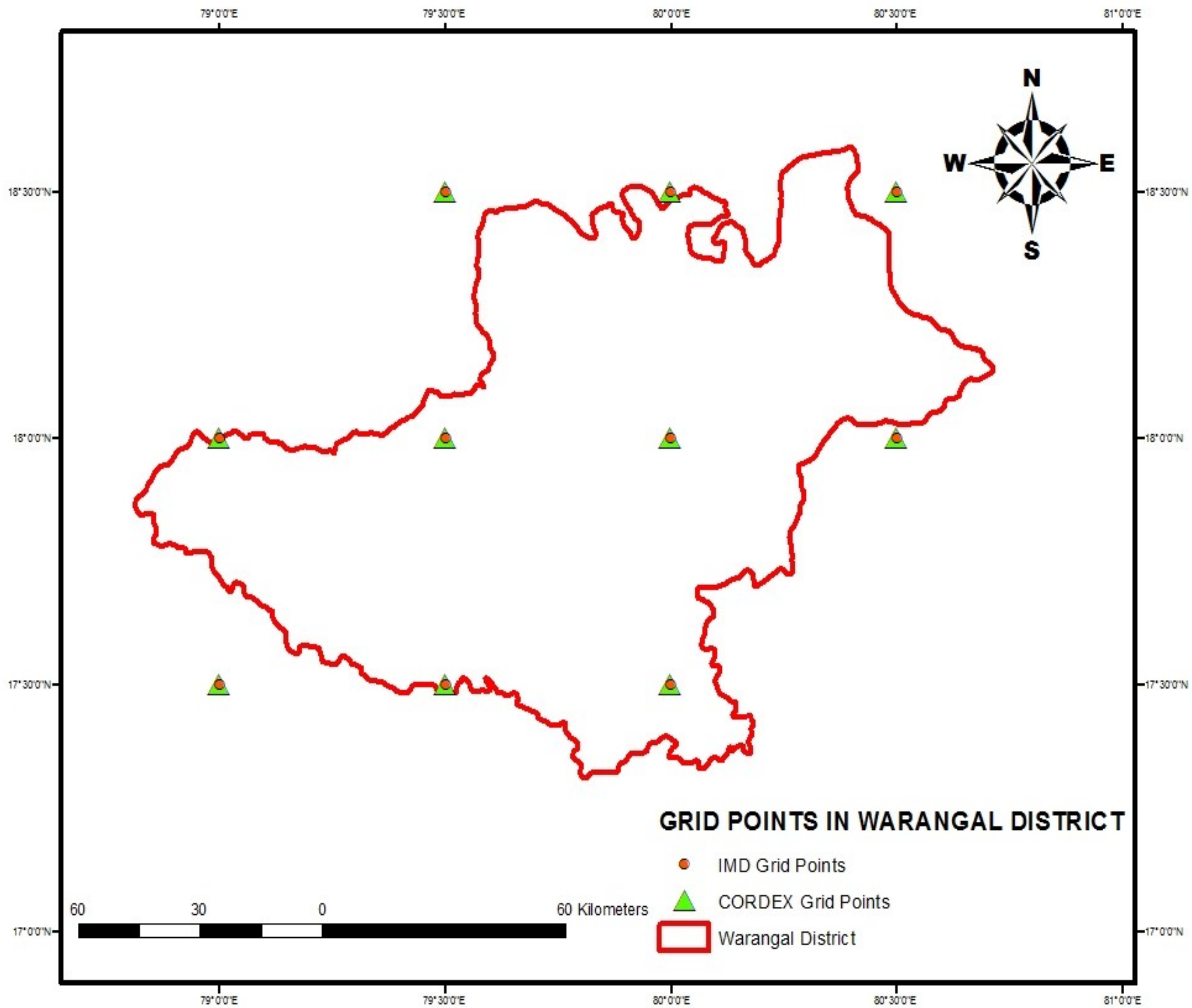

Fig.4 Climate model and IMD grid points of Warangal district

Table 1: List of RCMs used in the study

Source: http://cccr.tropmet.res.in/home/ftp_data.jsp

Experiment Name	RCM Description	Driving GCM	Contributing Institute
CCAM(ACCESS)	Commonwealth Scientific and Industrial Research Organisation (CSIRO), Conformal-Cubic Atmospheric Model (CCAM; McGregor and Dix, 2001)	ACCESS1.0	CSIRO Marine and Atmospheric Research, Melbourne, Australia
CCAM(CNRM)		CNRM-CM5	
CCAM(CCSM)		CCSM4	
CCAM(MPI)		MPI-ESM-LR	

Geospatial Data

- Digital Elevation Model – SRTM
- Landuse landcover map (LULC) -USGS
- Soil Map -FAO

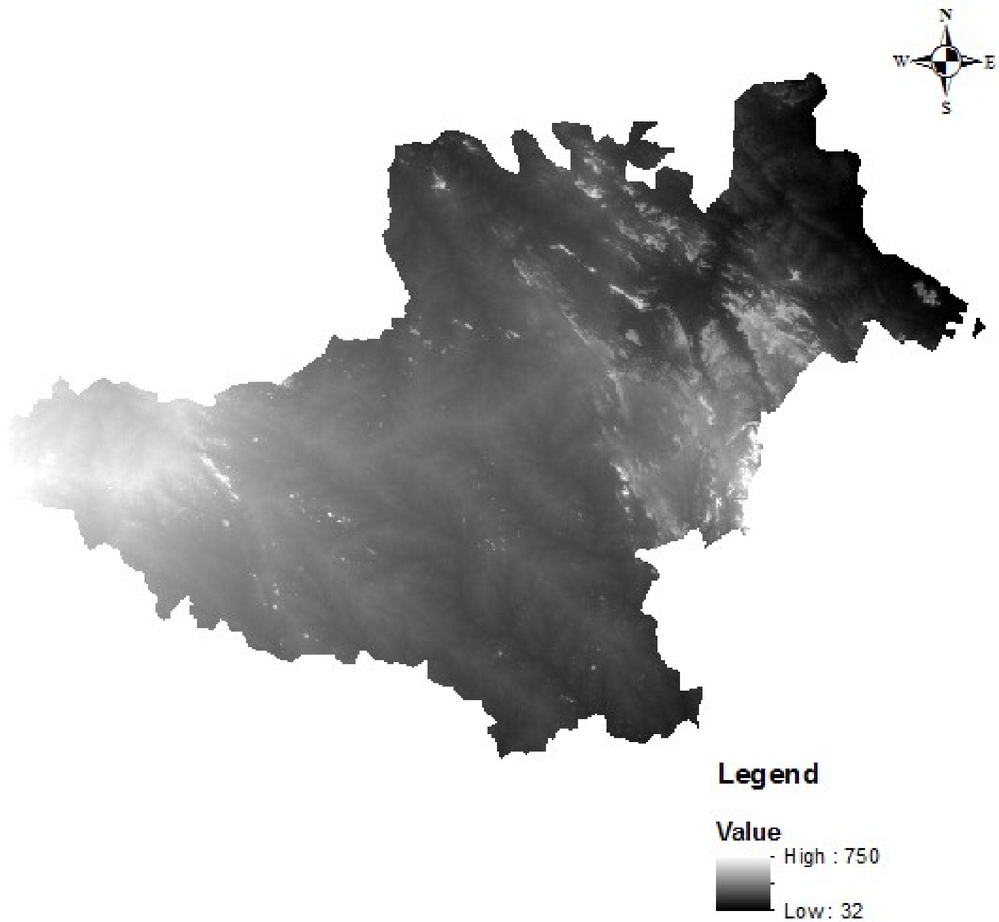

Fig 5 Digital Elevation Model

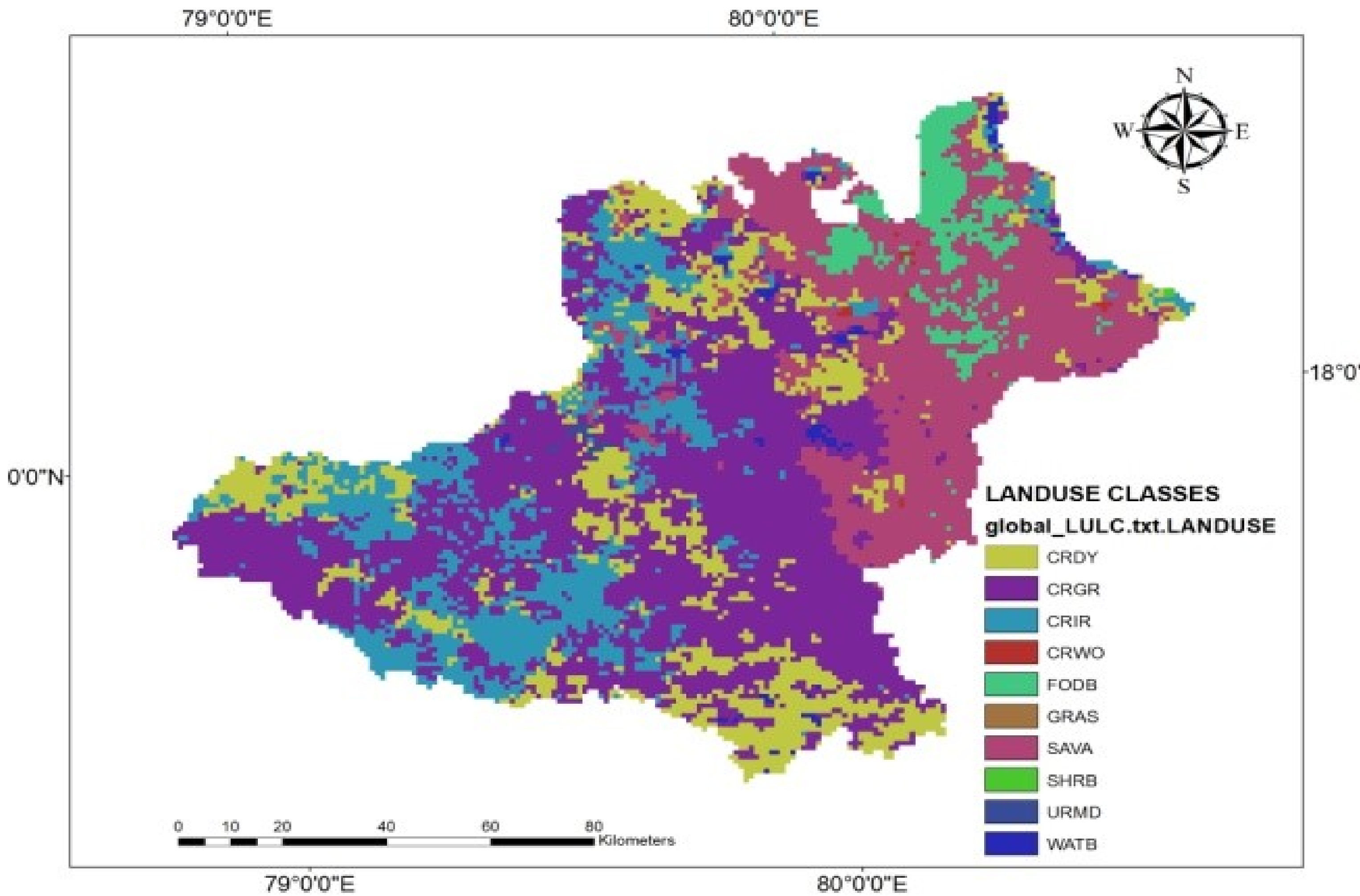

Fig 6 Landuse Landcover map

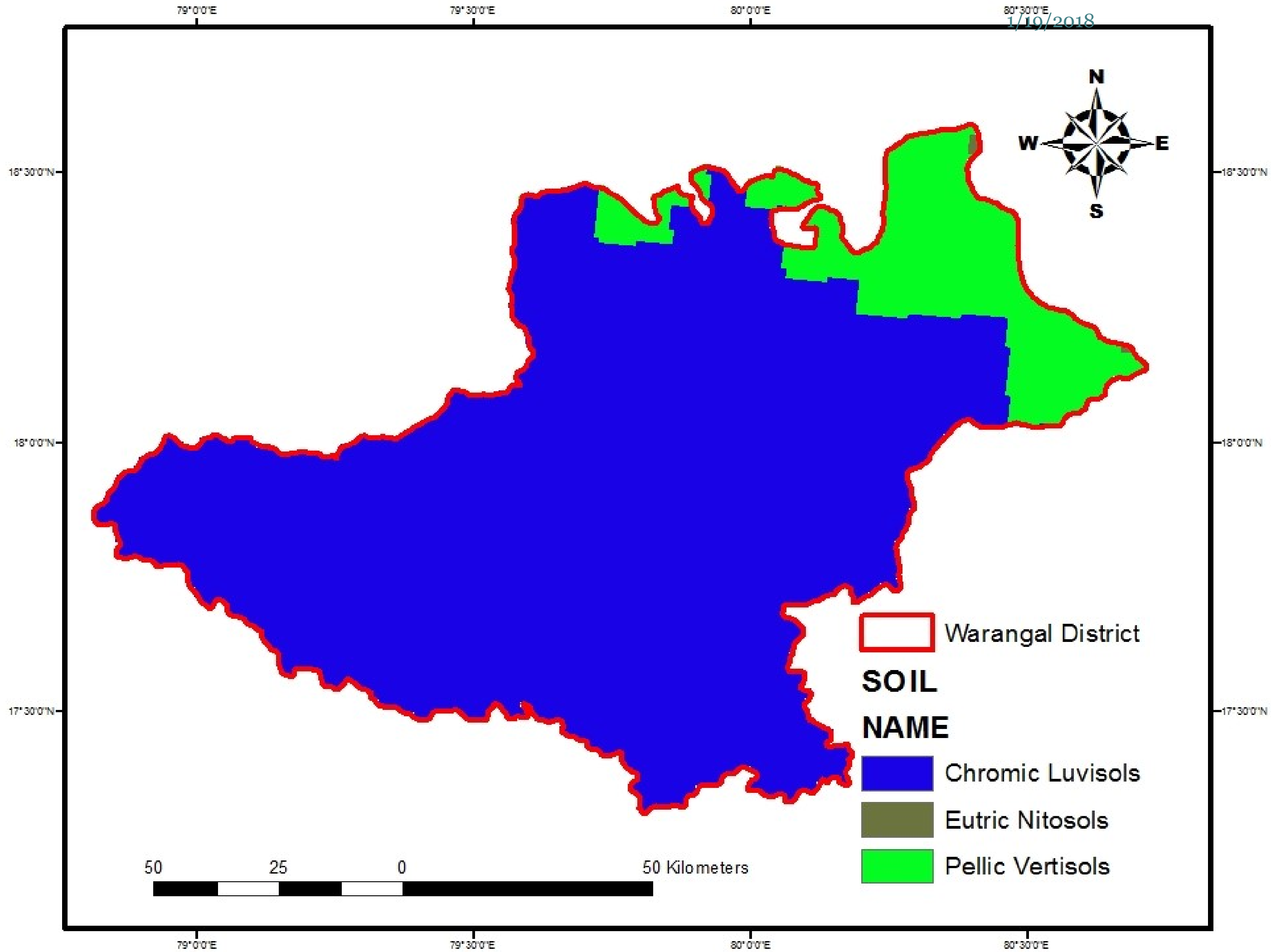

Fig. 7 Soil map of Warangal district

Hydrological Modelling

- Soil and Water Assessment Tool (SWAT) is selected for hydrological modelling.
- SWAT model run by using Observed weather data obtained from Indian Meteorological Department (IMD) from 1975-2005.
- SWAT model is run for Konduru watershed which is downstream of the study area due to the lack of gauge station at the Phakal lake.
- SWAT model calibration and validation is carried out for monthly simulated stream flow using observed stream flow data from the Purushothamagudem gauging station present in Konduru watershed.

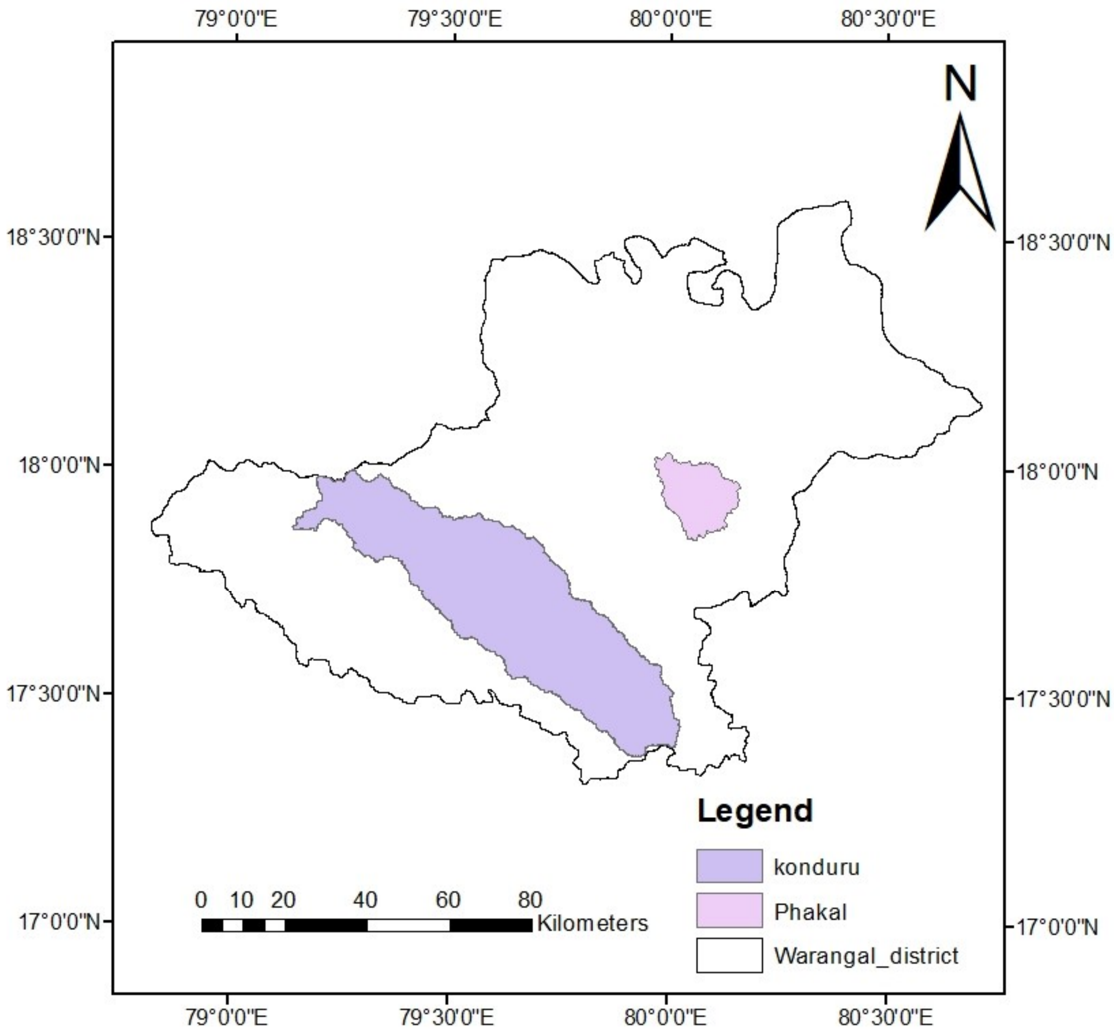

Fig. 8 Watersheds of Warangal district

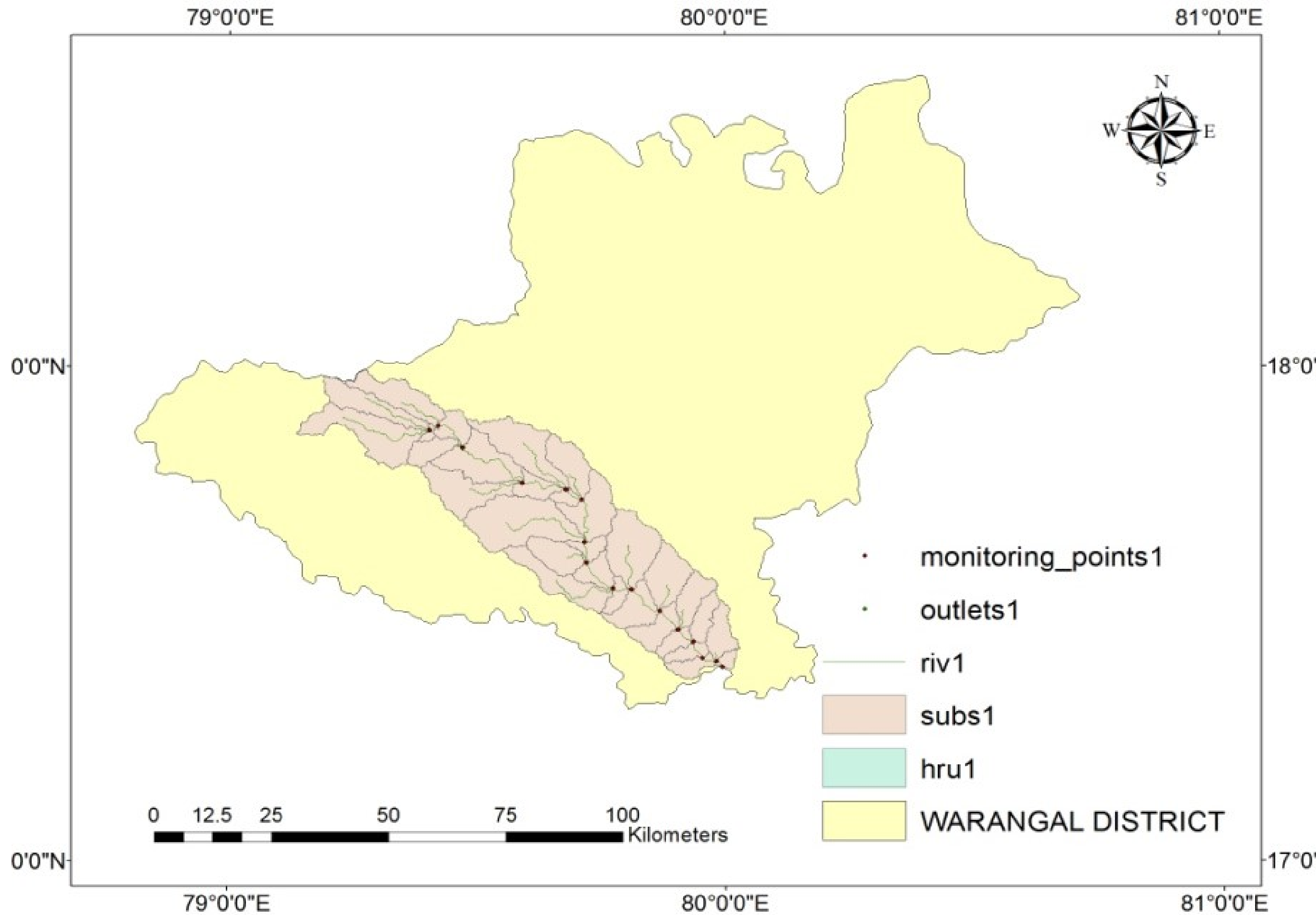

Fig. 9 Hydrological Modelling of Konduru Watershed

Calibration and Validation of Konduru Watershed using SWAT- CUP

- Observed data available at Purushothamgudem
- Data available for the period of 1988 to 2005
- SUFI-2 is used calibration and validation of the Model

Table 2 Calibration and validation results of Konduru watershed

Objective functions	Calibration	Validation
R^2	0.7	0.39
NSE	0.67	0.35

Sensitivity Analysis

Table -3 The most sensitive parameters and their best parameter values and intervals

Parameter Name	Description	Best Parameter Value	Minimum Value	Maximum Value
V__ALPHA_BNK.rte	Base flow alpha bank factor for bank storage (days)	0.045	0.000	1.000
V__CH_K2.rte	Effective channel hydraulic conductivity, mm/hr	14.141	5.00	22.00
R__CN2.mgt	Curve Number	-0.000852	-0.007	0.007
A__OV_N.hru	Manning's N	0.191	0.18	0.2
A__REVAPMN.gw	Threshold depth for revaporation to occur, mm	265.37	0.00	500
V__ESCO.bsn	Soil evaporation compensation factor	0.812	0.8	1.0
V__CH_N2.rte	Manning's N	0.183	0.15	2.0
R__SOL_K (...).sol	Saturated hydraulic conductivity	-0.594	-0.6	-0.57
V__GW_DELAY.gw	Ground water delay, days	42.445	42	60
A__GWQMN.gw	Threshold depth for ground water flow to occur, mm	1385.84	1350	1390
V__GW_REVAP.gw	Ground water revaporation coefficient	1.857	1.8	1.9
V__EPCO.bsn	Plant uptake compensation factor	0.69	0.00	1.00
V__ALPHA_BF.gw	Base flow recession factor, days	0.138	0.00	1.0
R__SOL_AWC (...).sol	Available water capacity, m/m	0.338	0.33	0.4
R__SOL_BD (...).sol	Moist bulk density ($Mg/ m^{3)}$)	-0.023	-0.04	-0.1

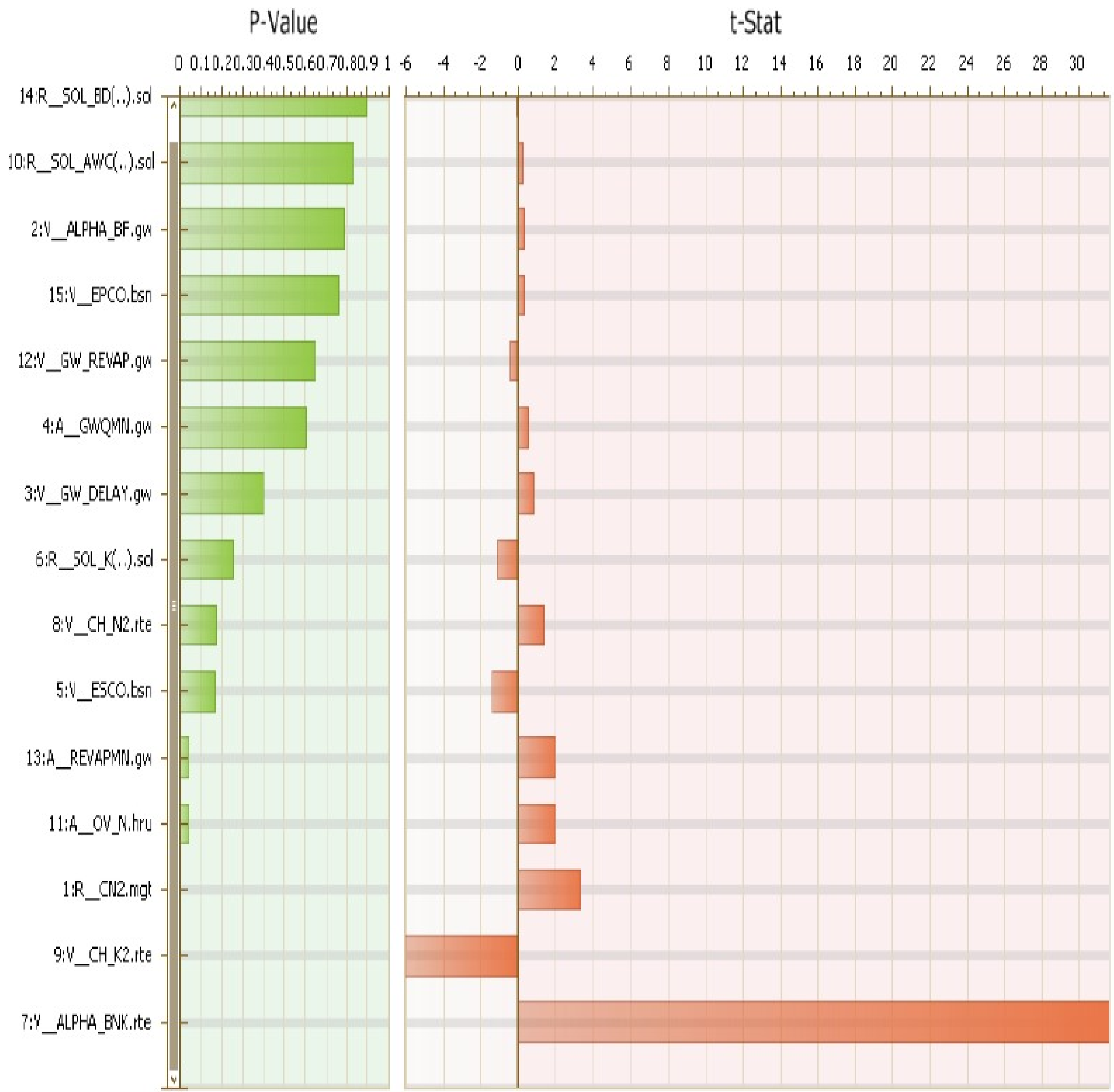

Fig. 10 Global Sensitivity Analysis

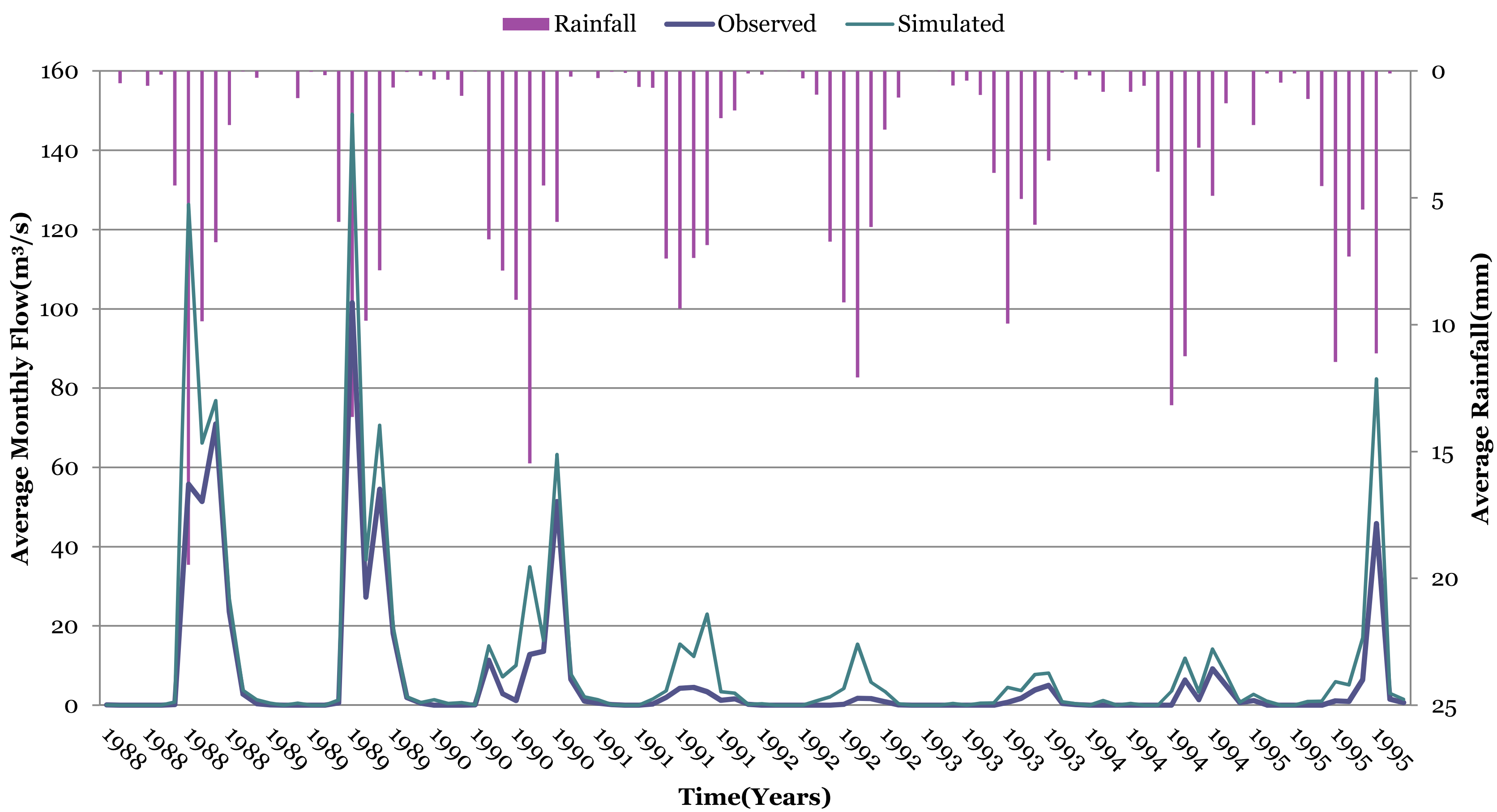

Fig. 11 Calibration of Konduru Watershed

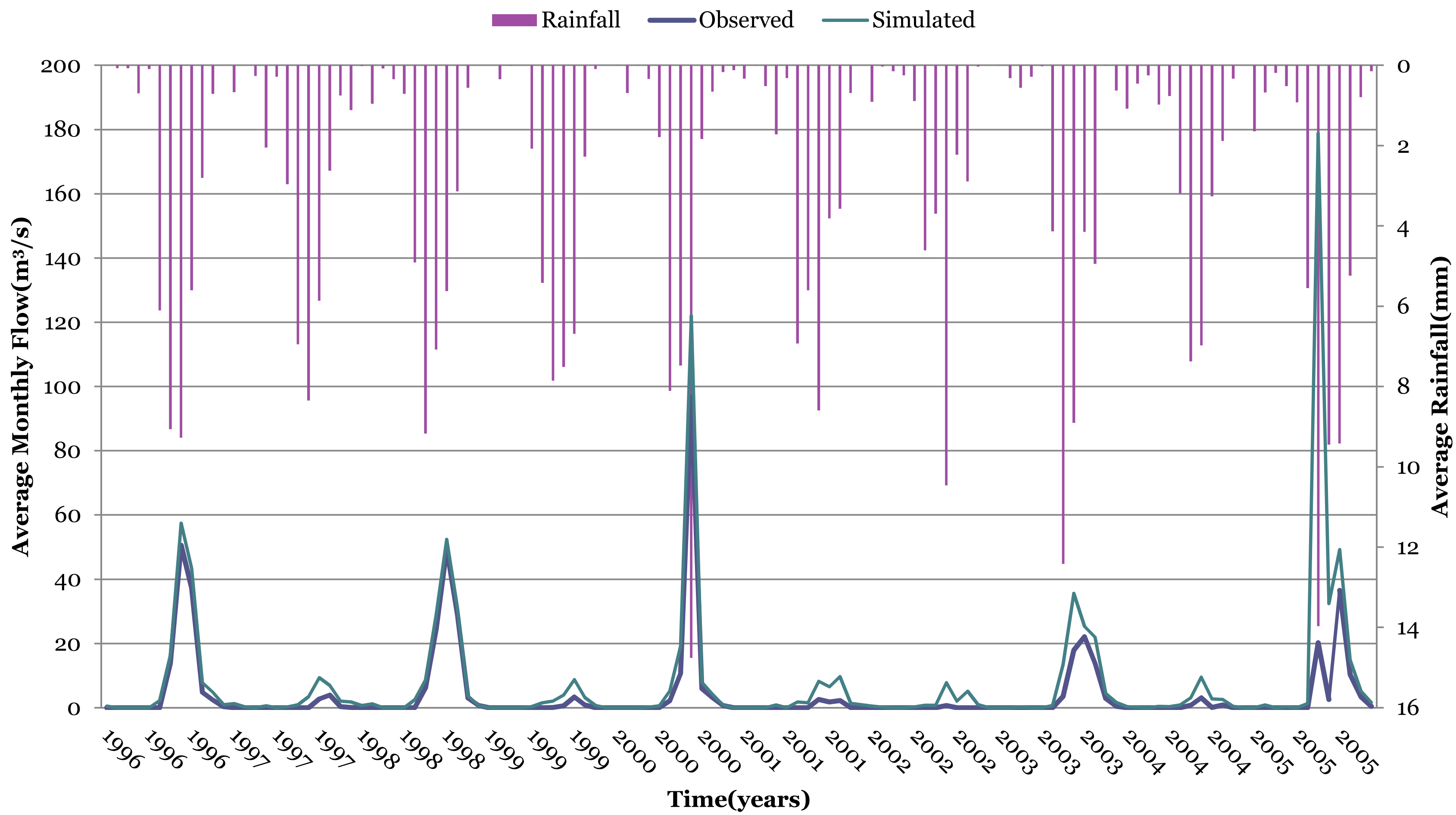

Fig. 12 Validation of Konduru Watershed

Simulation of Konduru Watershed Water resources

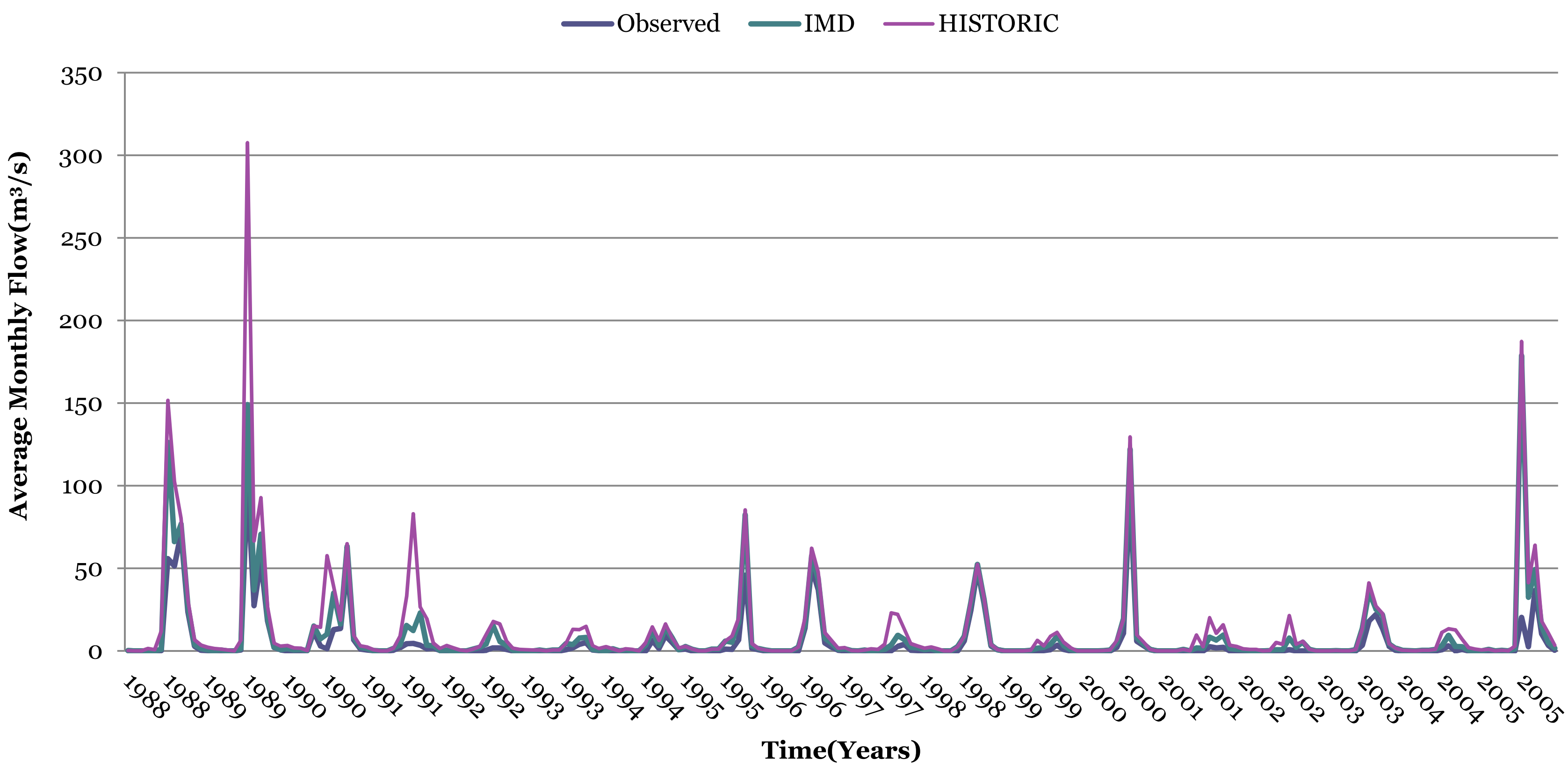

Fig. 13 Average Monthly flow Variations of Konduru Watershed between observed, IMD and Historic

Simulation of Phakal Watershed Water resources

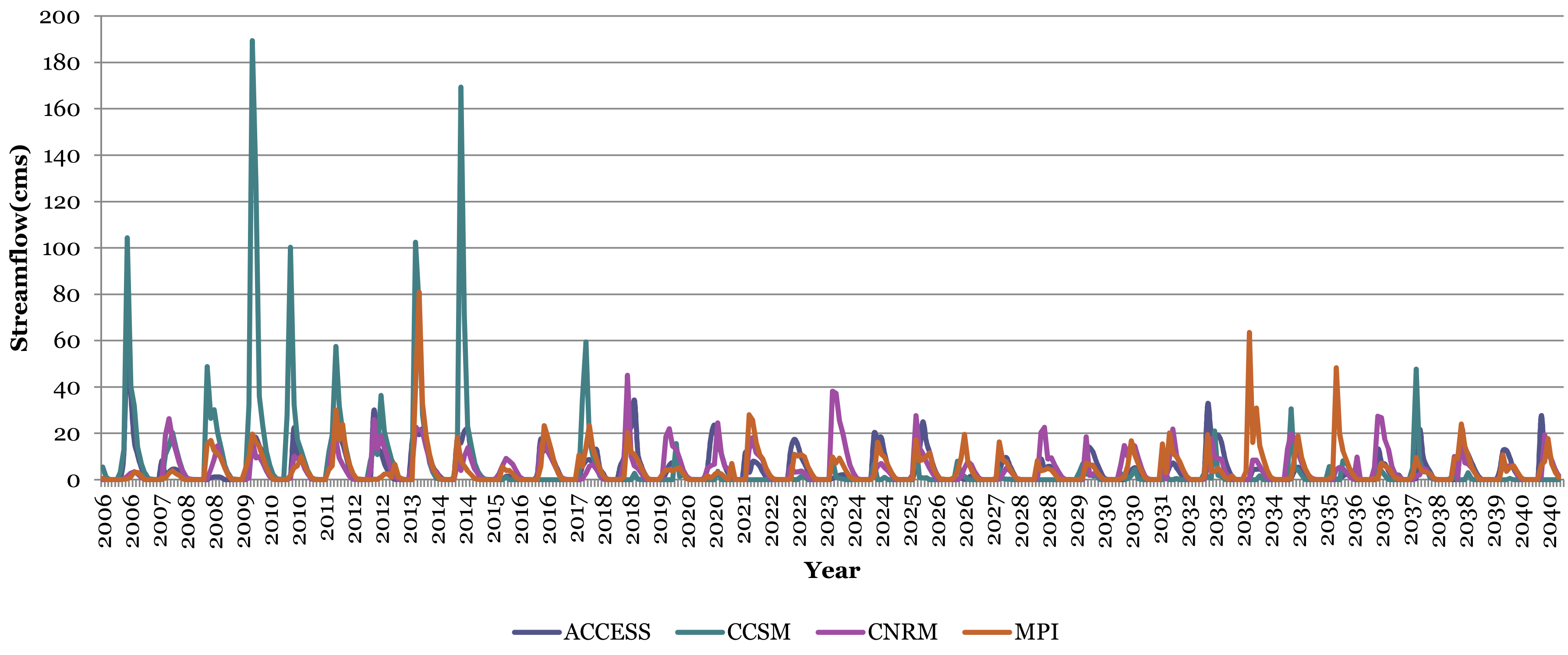

Fig. 14 Average Monthly flow Variations of Phakal Watershed for different climate models for 2006-2040

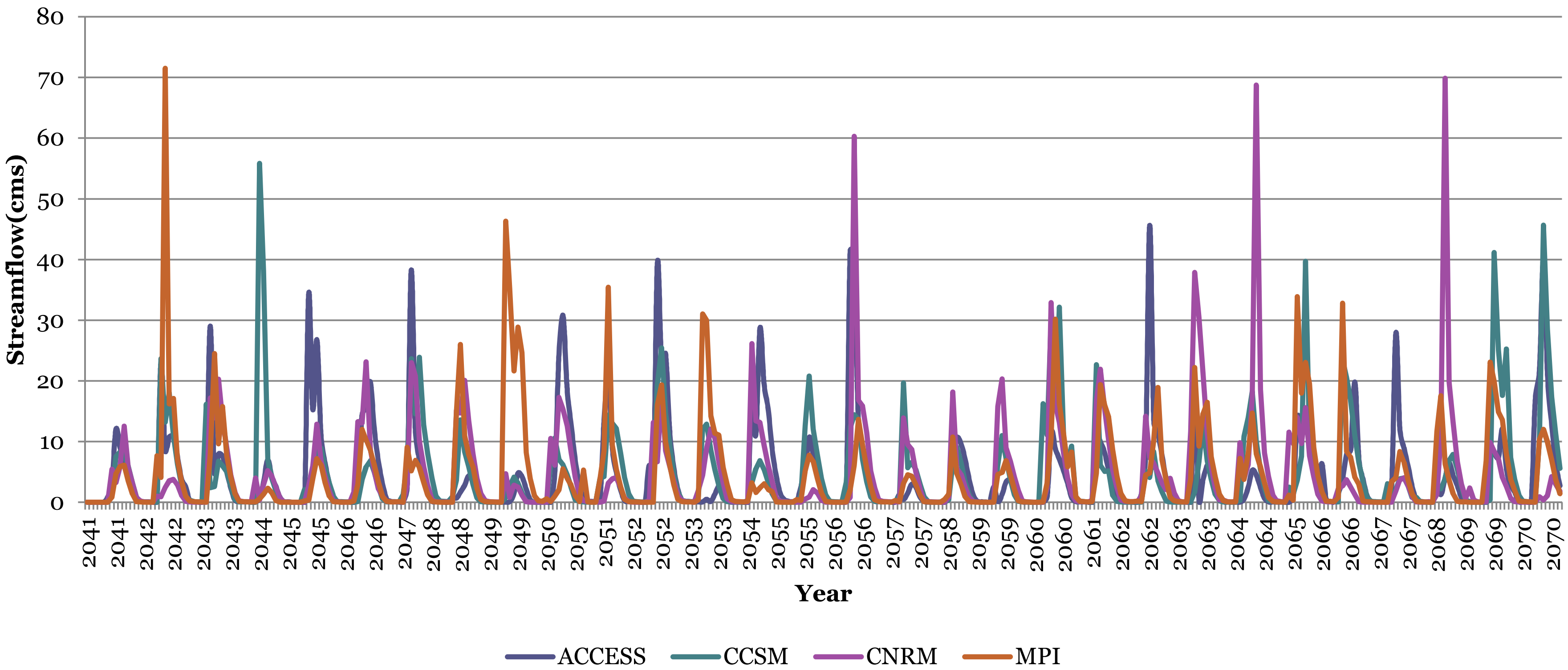

Fig. 15 Average Monthly flow Variations of Phakal Watershed for different climate models for 2041-2070

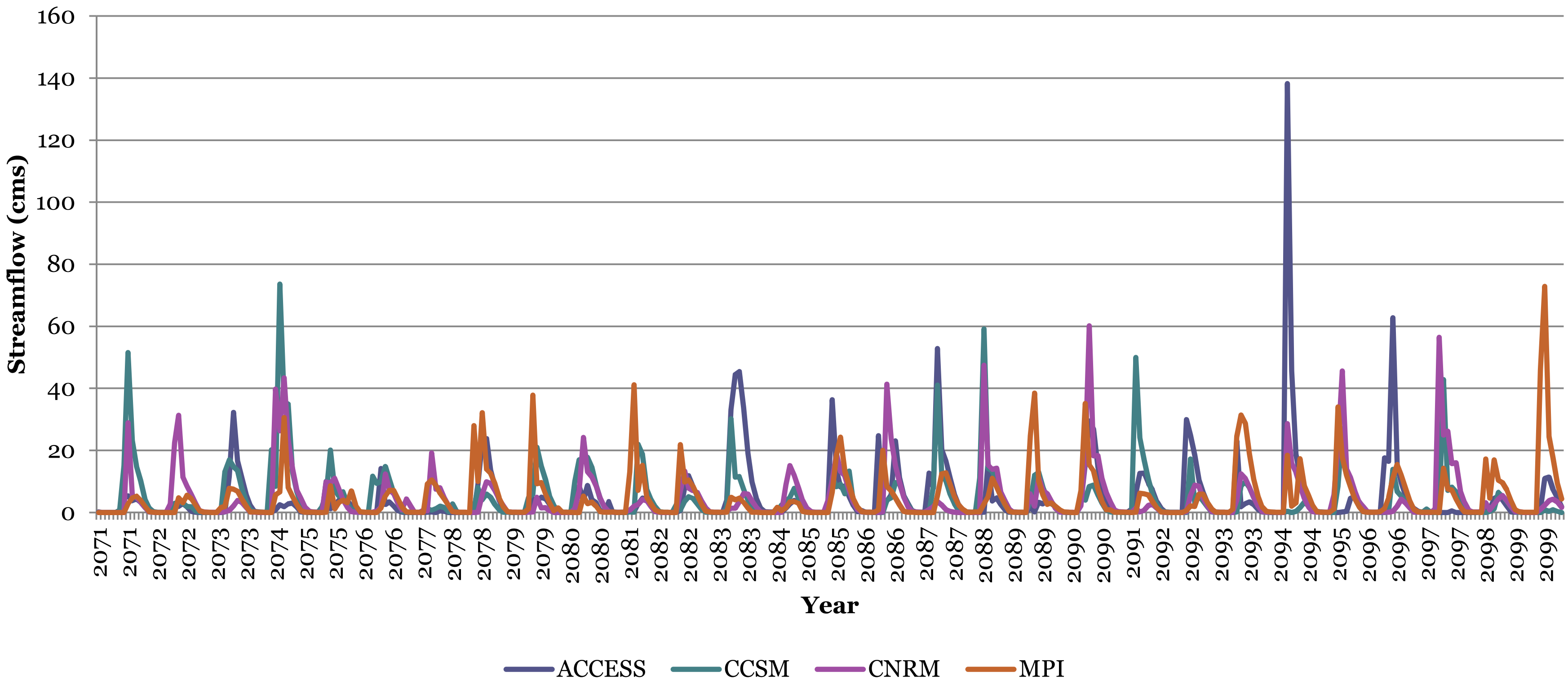

Fig. 16 Average Monthly flow Variations of Phakal Watershed for different climate models for 2071-2099

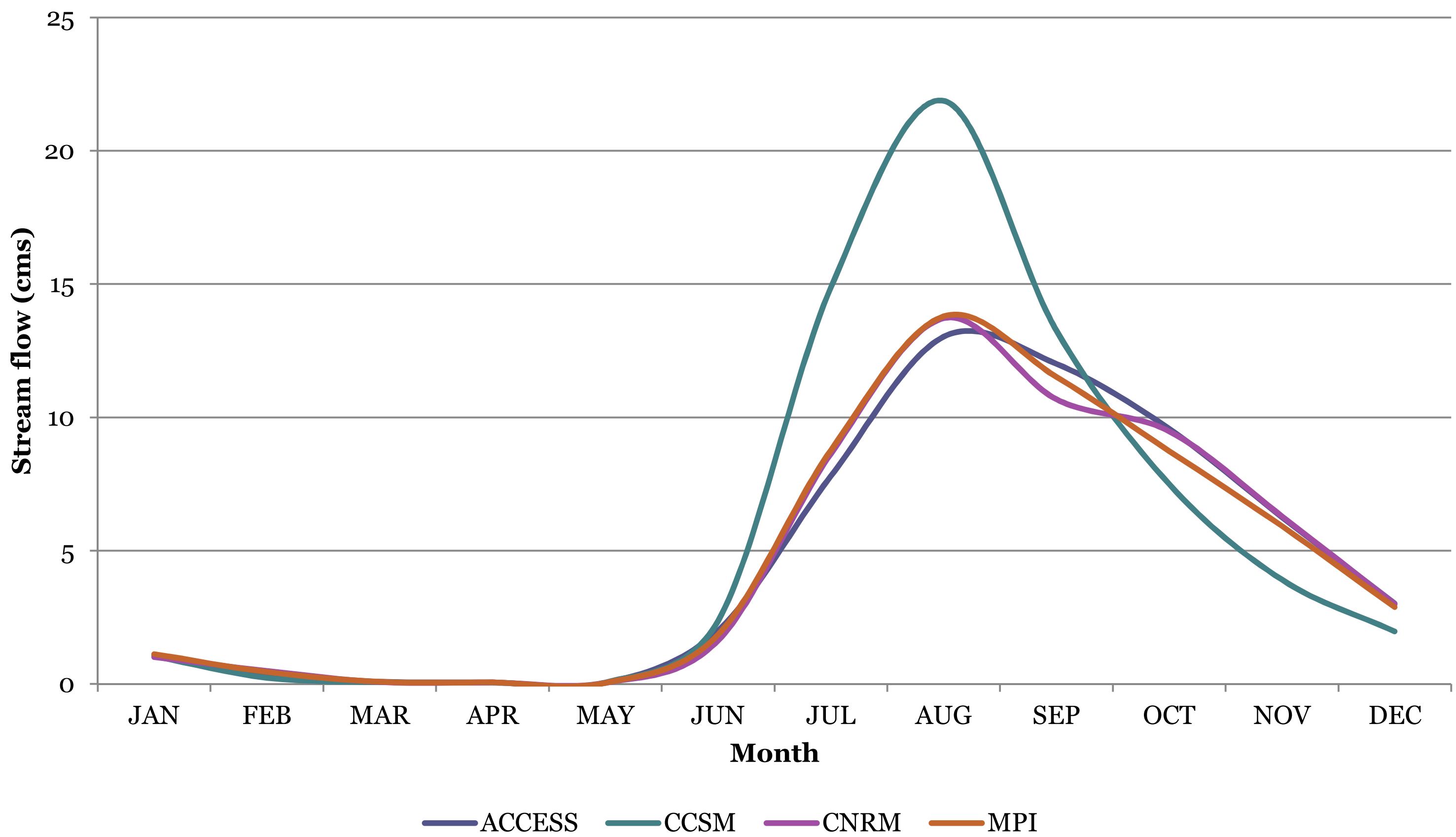

Fig 16: Monthly flow variation of the stream flow and rainfall for all scenarios for 2006-2040

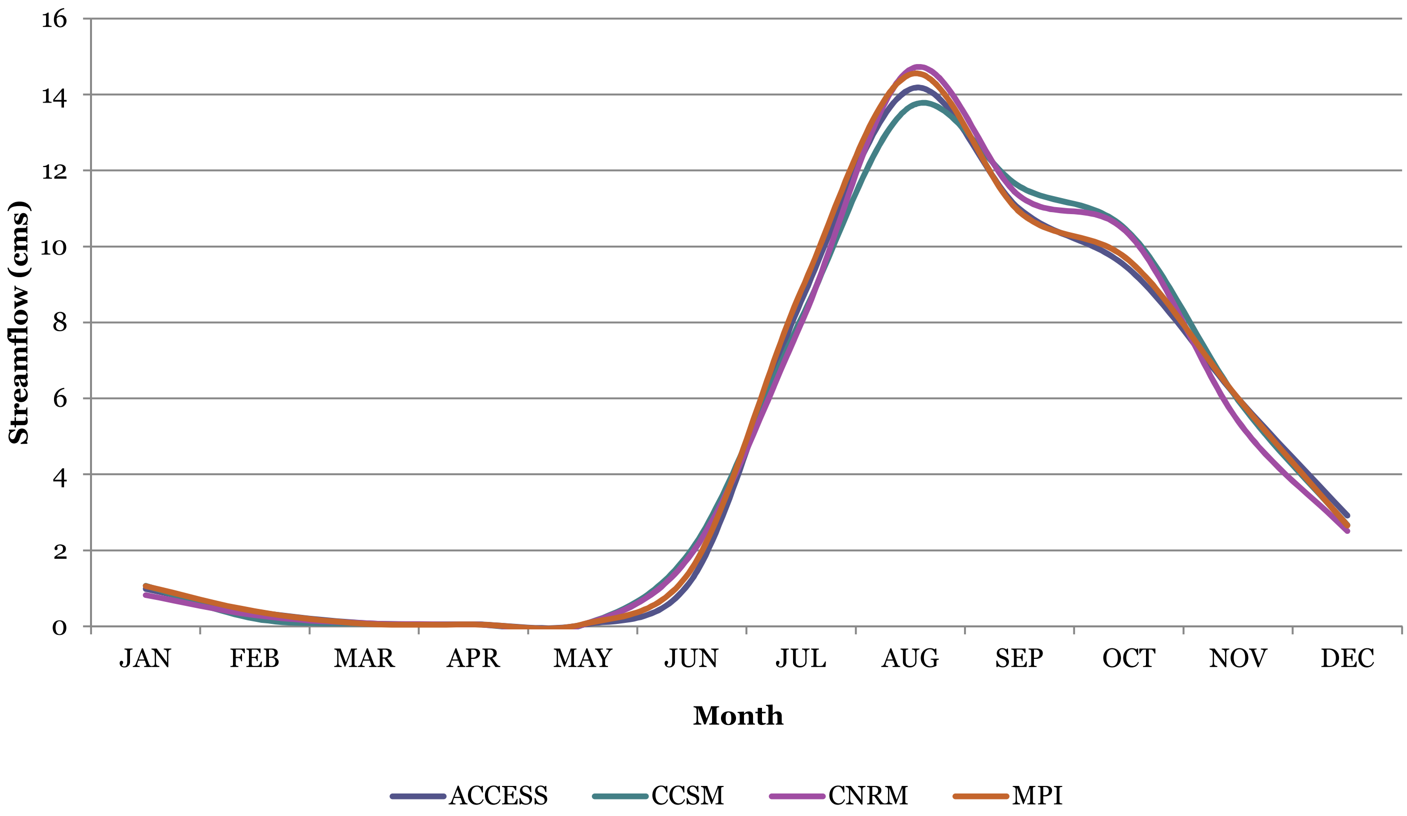

Fig 17: Monthly flow variation of the stream flow and rainfall for all scenarios for 2041-2070

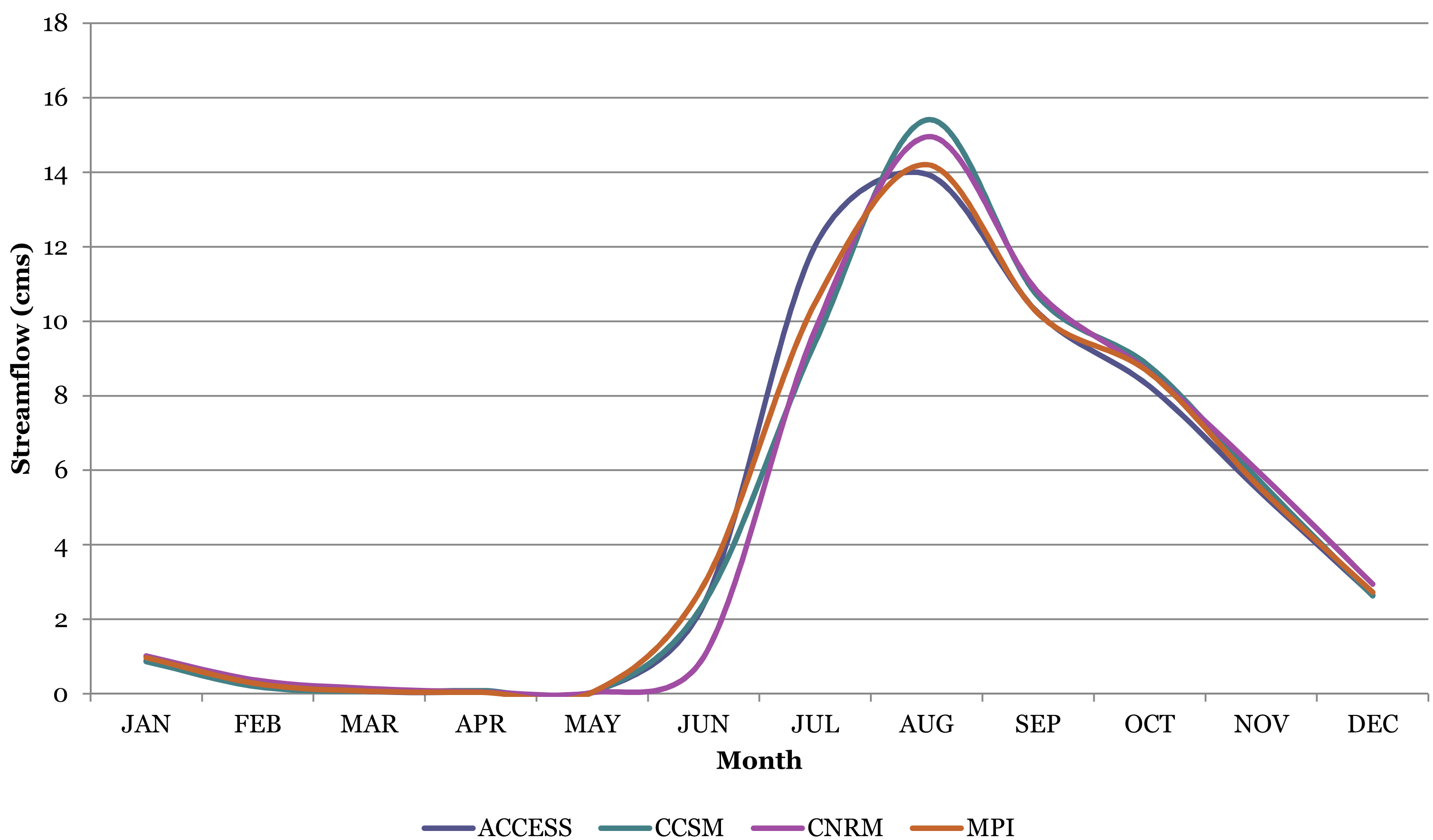

Fig 18: Monthly flow variation of the stream flow and rainfall for all scenarios for 2071-2099

Summary and Conclusions

- The study reveals that SWAT model works well in semi-arid regions like Warangal district.
- The calibration and validation of the SWAT model indicate good results
- The climate model (CCSM4) predict very well on overall and even the rainfall is increased by 4.5% overall still the stream flow generated by model decreed by 31% percent this indicates model error.
- For the beginning of the century (2006-2040) rainfall is decreased by 58.3% but stream flow is decreases by 72.5%.

- For the mid-century (2041-2070) rainfall is decreased by 13.4% but the stream flow is decreased by 37.4%.
- For the end century (2071-2099) rainfall is decreased by 14.4%, the stream flow is decreased by 23%
- As the results of this study reveal, surface runoff amounts are going to be affected by the impact of climate change.
- The rainfall and stream flow follows decreeing trend in the Warangal district.

- In light of this, it is necessary to revise the water budget of Tanks in Warangal District to consider these changes in the budget.
- It is necessary for Telangana Government to think about policies and strategies to help the District to adapt for impacts of climate change and to plan the water resources of the district.
- Tanks revival is one of the major works needed by district to take care about impact of climate change on water resources.

Future Work

- SWAT Model should be run using the Phakal Tank daily water level data.
- SWAT Model run using RCP 8.5 scenario.
- Further, various regionalization approaches should be considered for calibration and validation.
- Development of Adaptation Tool with the water budgets available at the study area for present and future conditions.

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