Application of SWAT for the modelling of sediment yield at Pong reservoir, India

A. R. Senthil kumar
Tanmoyee Bhattacharya
Suhas D Khobragade
Manohar Arora

National Institute of Hydrology
Roorkee-247667, India

- Many large reservoirs for spatial and temporal distribution of water
- High sediment inflow resulting from unpredicted activities (land use changes) reduces the performance of the reservoir during the designed life time
- Average sediment inflow 200 percent more than inflow assumed during the design

- Ichari diversion dam on Tons river got silted up to crest level in just two years
- Nizam Sagar Reservoir in Andhra Pradesh lost 60 percent capacity
- Estimation of sediment yield from watershed is very important for ascertaining the useful life of reservoir for meeting its intended purposes
- Sediment process in a watershed is highly random and depends upon the characteristics of basin and river

Study area

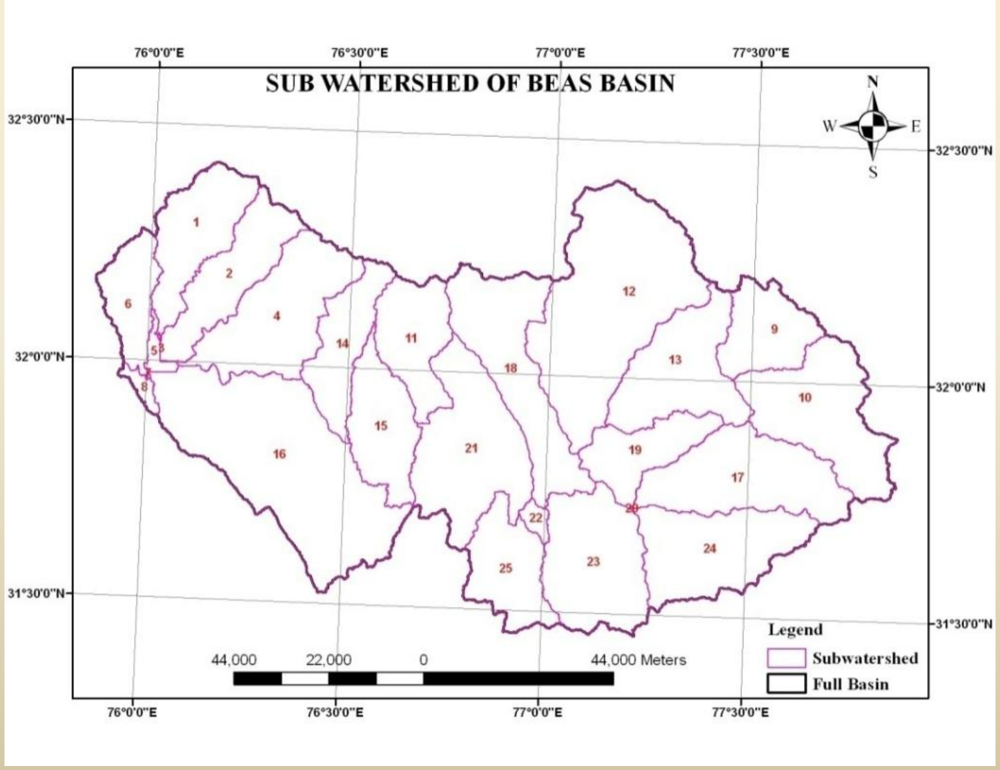
Catchment of Beas up to Pong Dam

Catchment area

12,562 sqkm

Water Spread area of the reservoir

260 sqkm



Study objectives

- Simulate the discharge and sediment yield at Nadaun Bridge (Pond Reservoir)

Methodology

ArcSWAT 2012.10.2.2 for simulating the discharge and Sediment yield

Conceptual, time continuous and physically based simulation model to model discharge and sediment yiled and water quality

Weather, soil properties, topography, vegetation and land management practices

Data Intensive

Data requirements

- DEM of the catchment
- LULC of the catchment
- Soil Map
- Rainfall
- Observed discharge and sediment yield

Simulation of discharge and sediment yield at Jwala Mukhi (Nadaun Bridge)

Data such as Land Use Land Cover, DEM, Soil Map, Aspect Map generated from NASA, National Bureau of Soil Survey and Land Use Planning (NBSSLUP) and NRSC

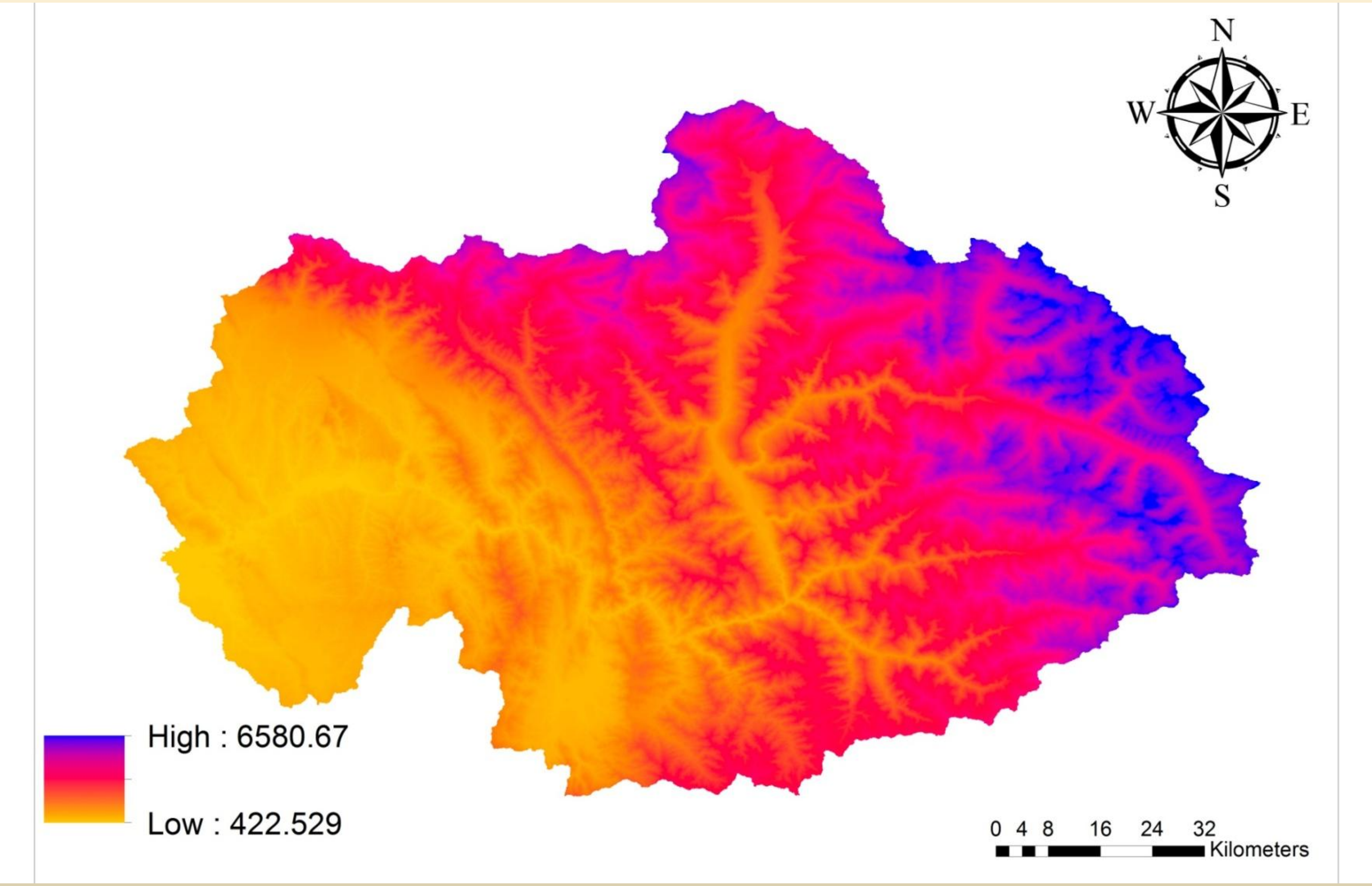
Grid based data such as daily rainfall, minimum and maximum temperatures obtained from Indian Meteorological Department (IMD) and European Centre for Medium-Range Weather Forecasts (ECMWF) (ERA Interim data)

Progress during April 2016 to April 2017

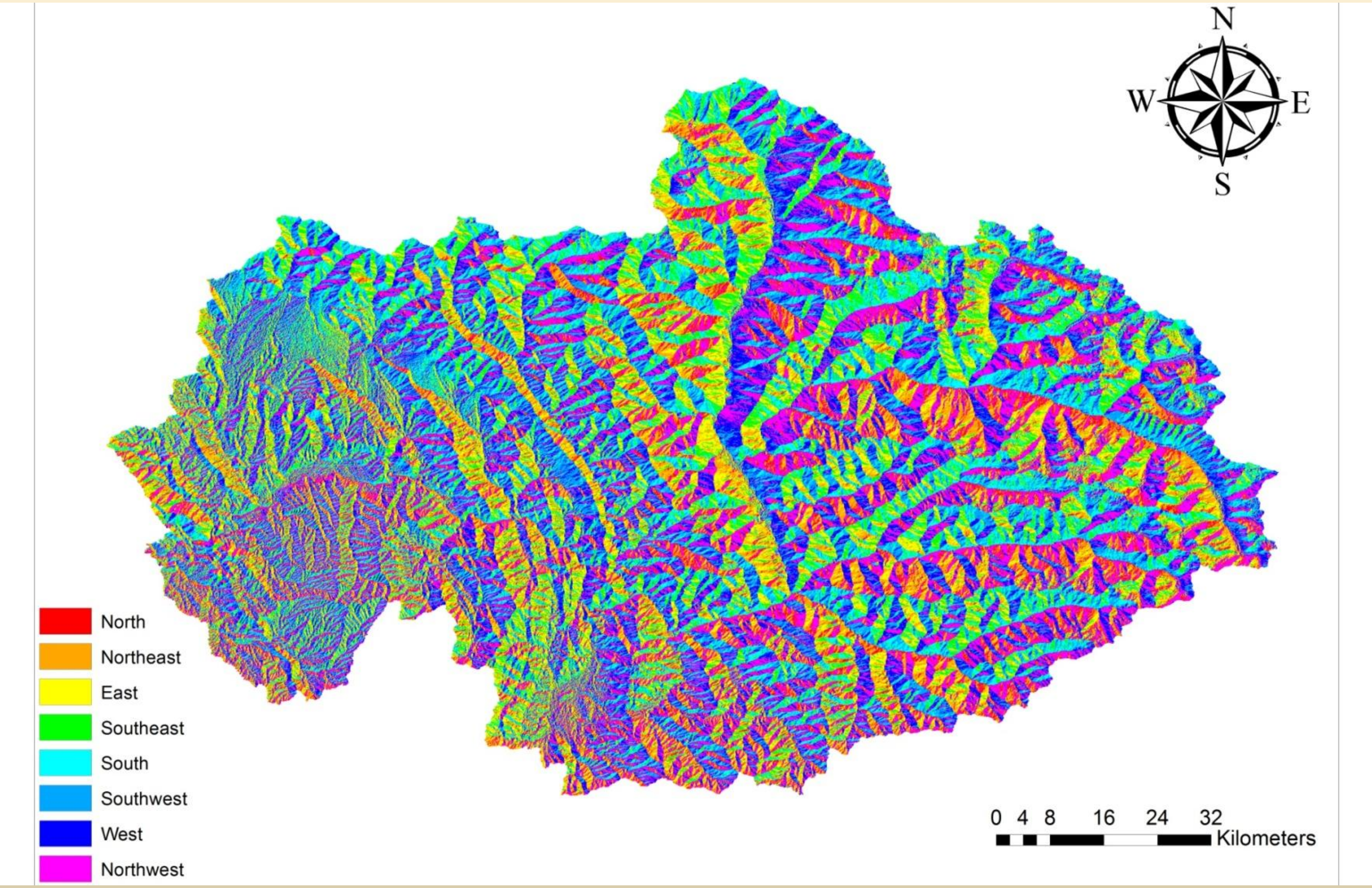
Parameters of ARCSWAT for discharge and sediment yield calibrated manually (trial and error method)

Calibration data – 1993 to 1996 (Daily data)
Validation data – 1999 to 2002 (Daily data)

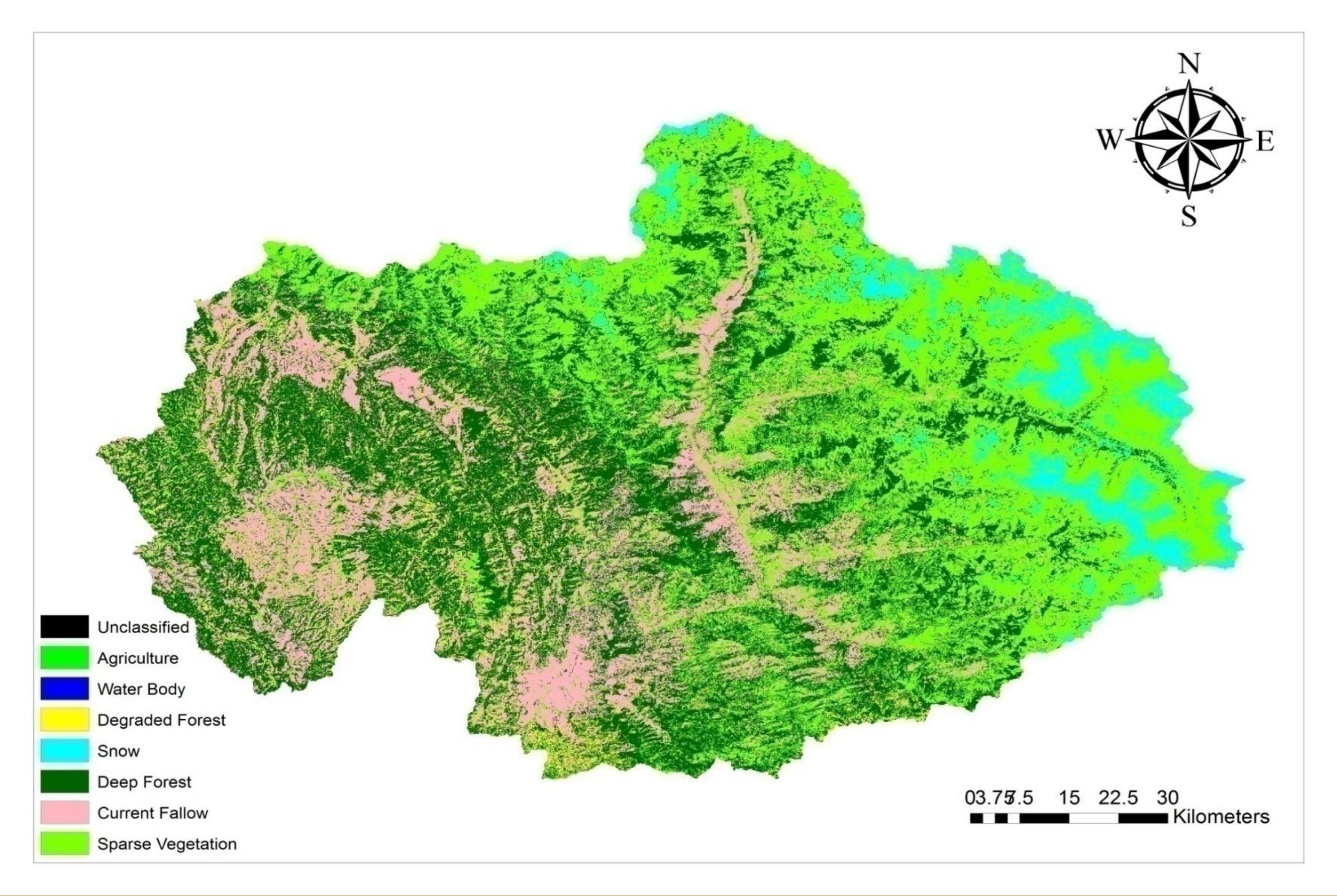
DIGITAL ELEVATION MODEL OF THE CATCHMENT UP TO NADAUN BRIDGE



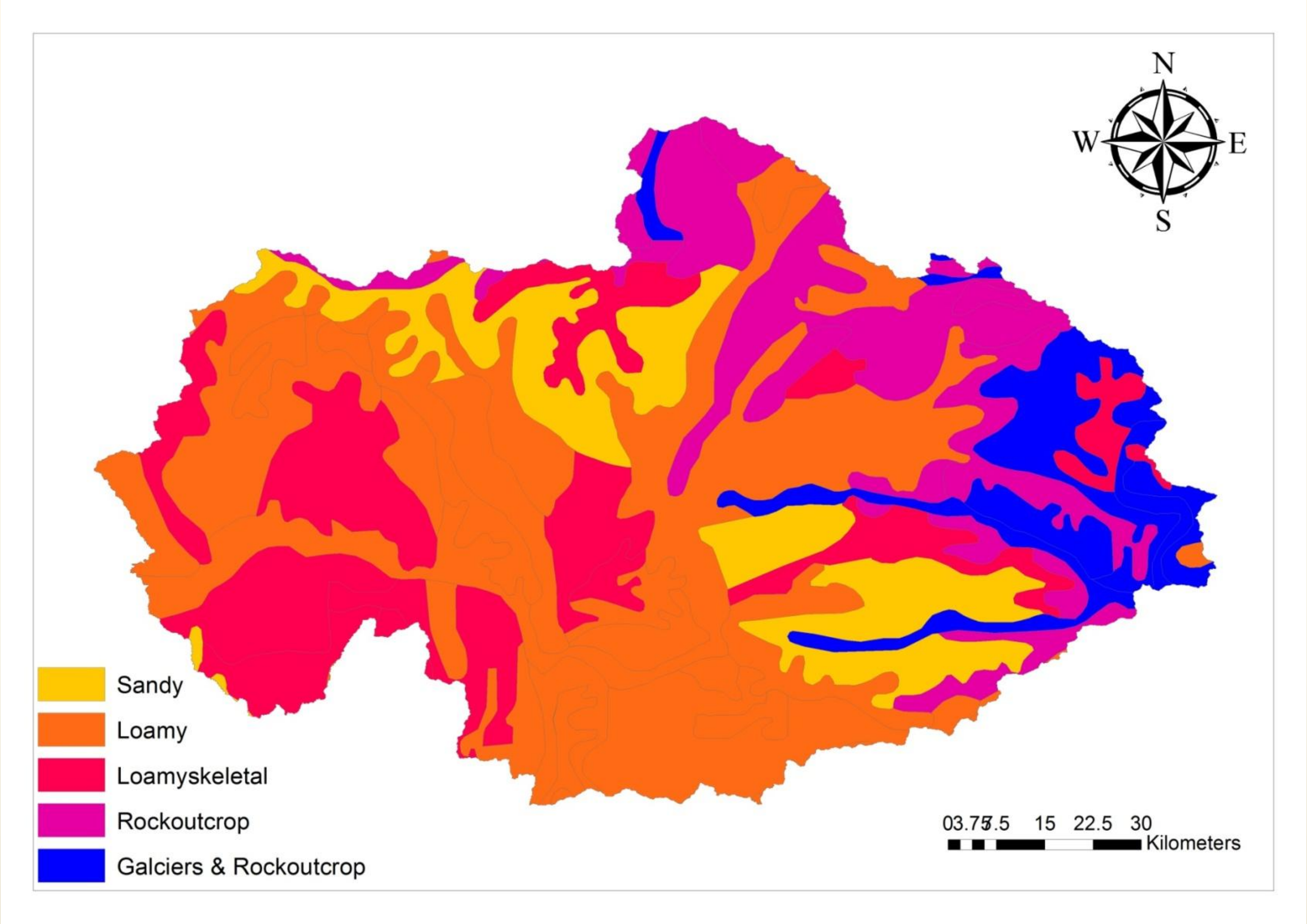
ASPECT MAP OF THE CATCHMENT UP TO NADAUN BRIDGE



LULC MAP OF THE CATCHMENT UP TO NADAUN BRIDGE



SOIL MAP OF THE CATCHMENT UPTO NADAUN BRIDGE



ARCSWAT

Conversion of classified LULC map(LISS-III) into SWAT LULC classes:

FRSD-Deciduous Forest(SWAT)-Degraded Forest

Snow-Snow

FRSE-Evergreen Forest(SWAT)-Deep Forest

SWRN-Bare rock(SWAT)-Current Fallow

PAST-Pasture/Hay(SWAT)-Sparse vegetation

WATR (SWAT)-Water

AGRR-Row crops(SWAT)-Agriculture

CONVERSION OF NBSSLUP SOIL CLASSIFICATION TO FAO SOIL CLASSIFICATION

Typic Udorthents-1-Sandy(FAO)

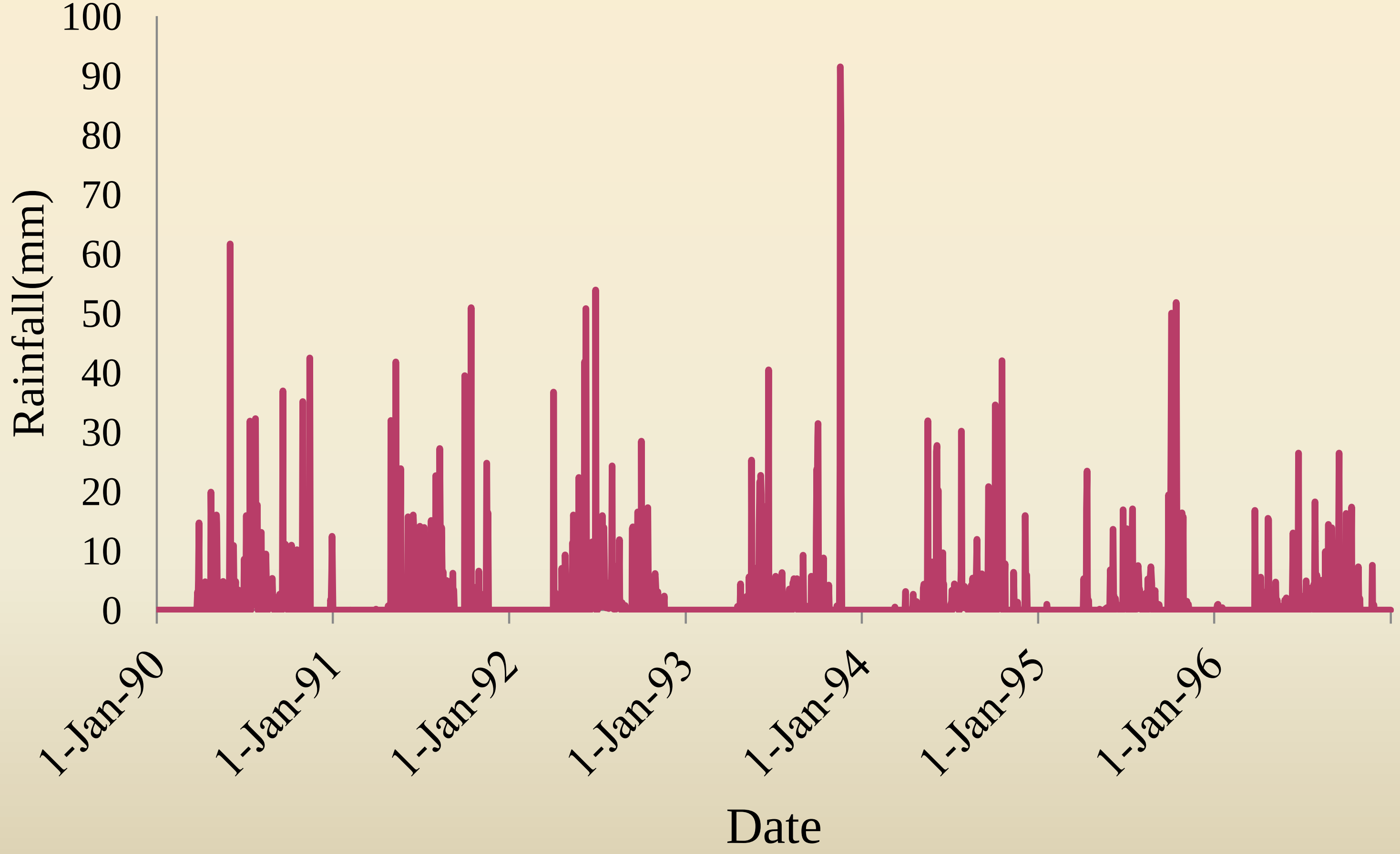
Typic Dystrudepts-2-Loamy(FAO)

Lithic Cryorthents-24-Loamy Skeletal(FAO)

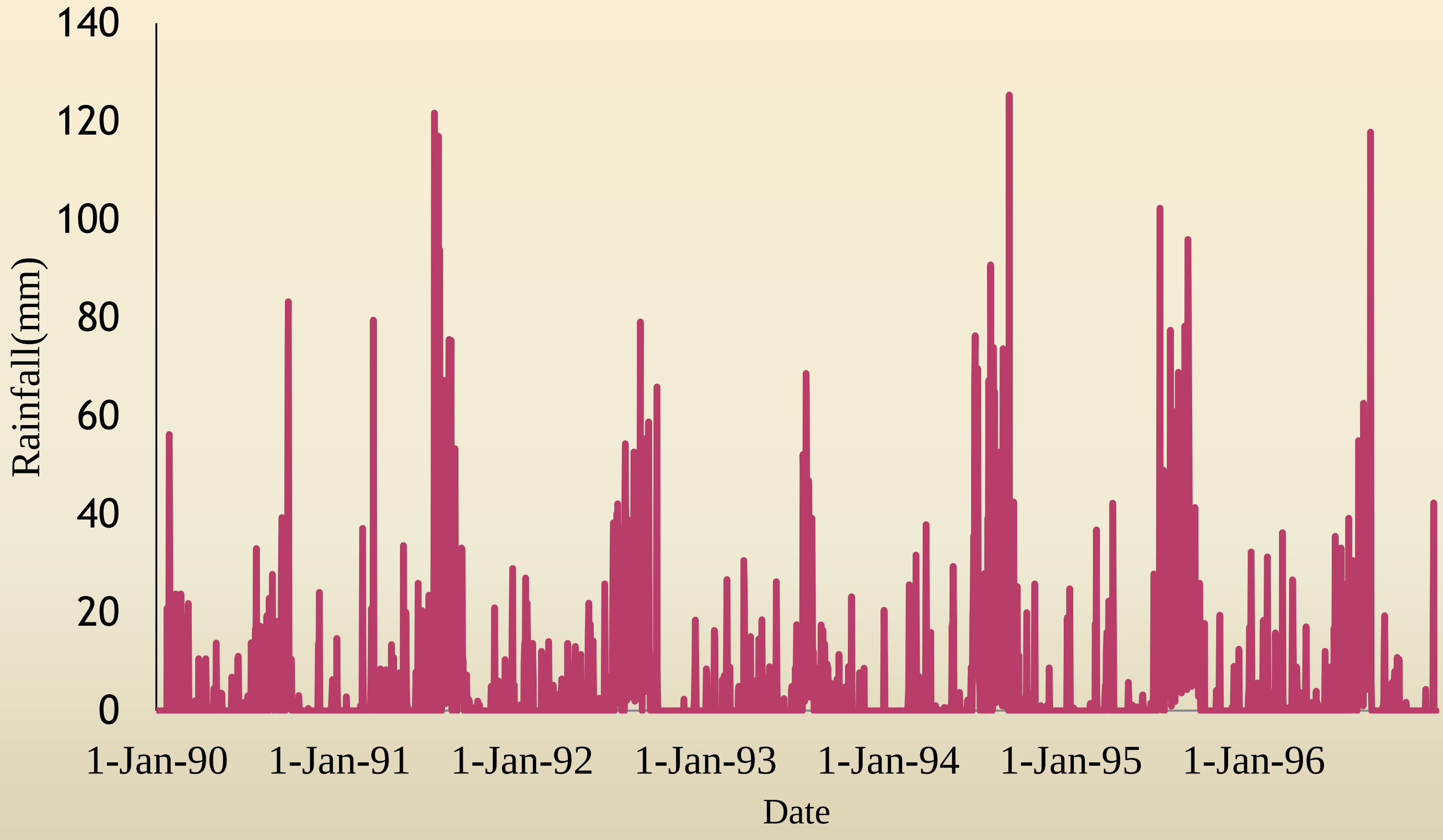
Rock Outcrop-100-Rock Outcrops(FAO)

Glacier and Rock Outcrop-104-Glaciers and Rock Outcrops(FAO)

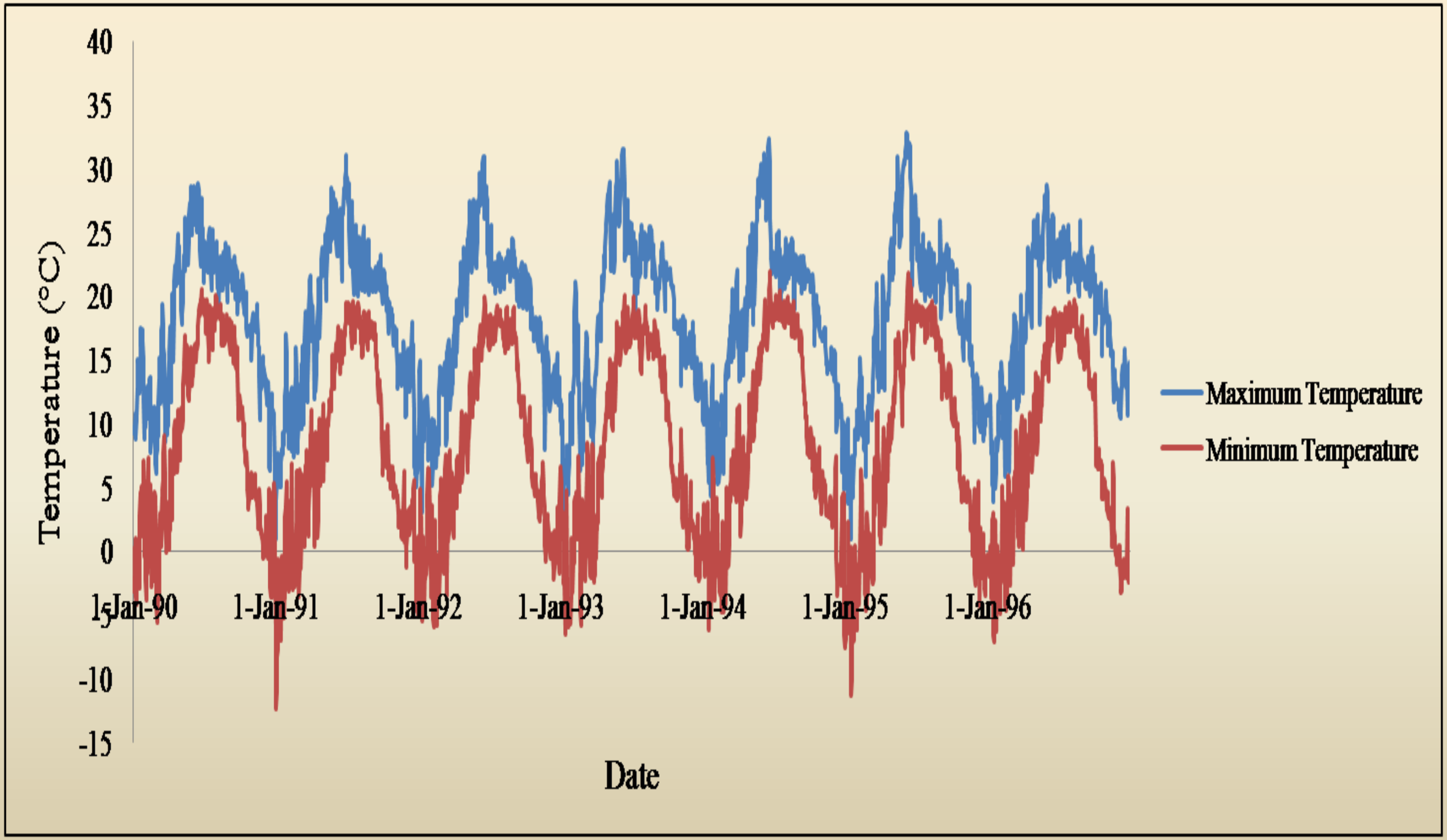
RAINFALL (INTERIM ERA)



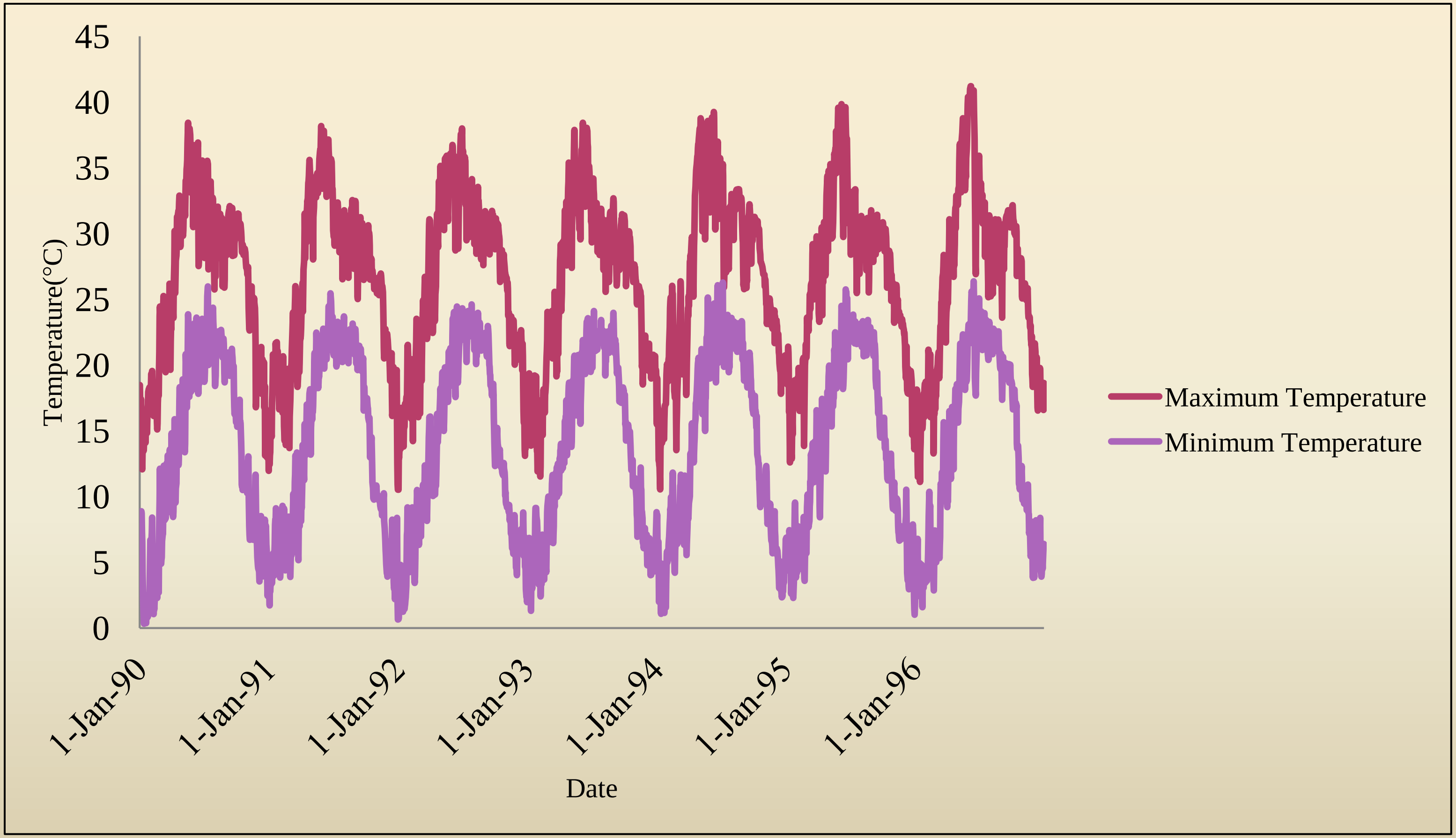
RAINFALL (IMD)



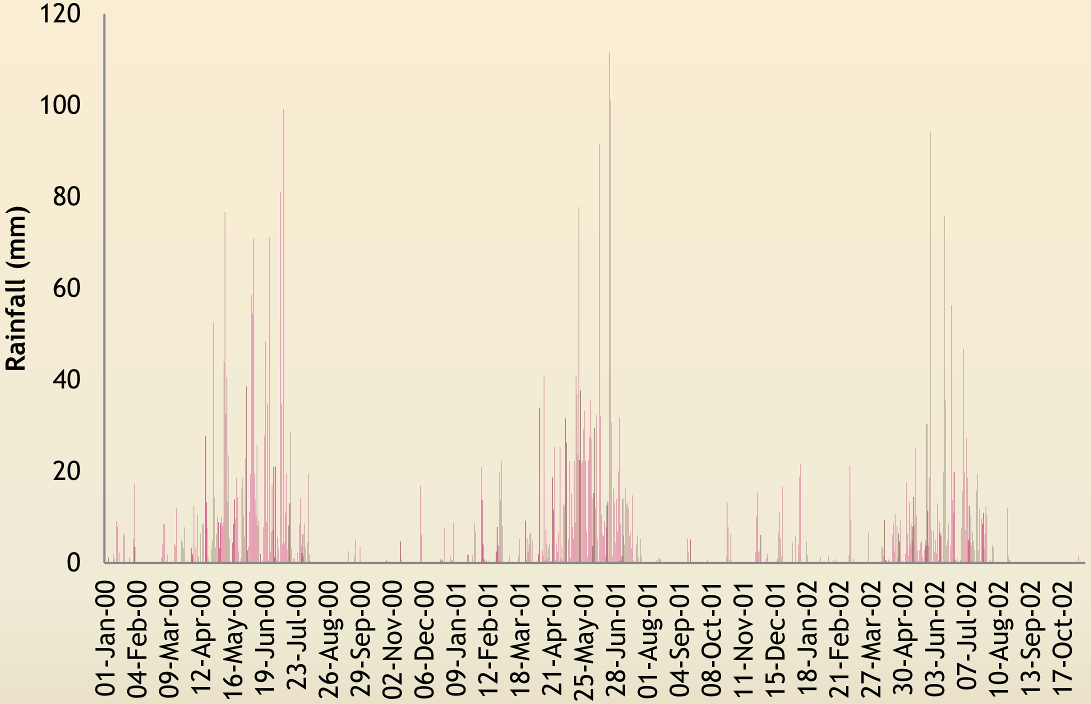
MAXIMUM AND MINIMUM TEMPERATURE (INTERIM ERA)



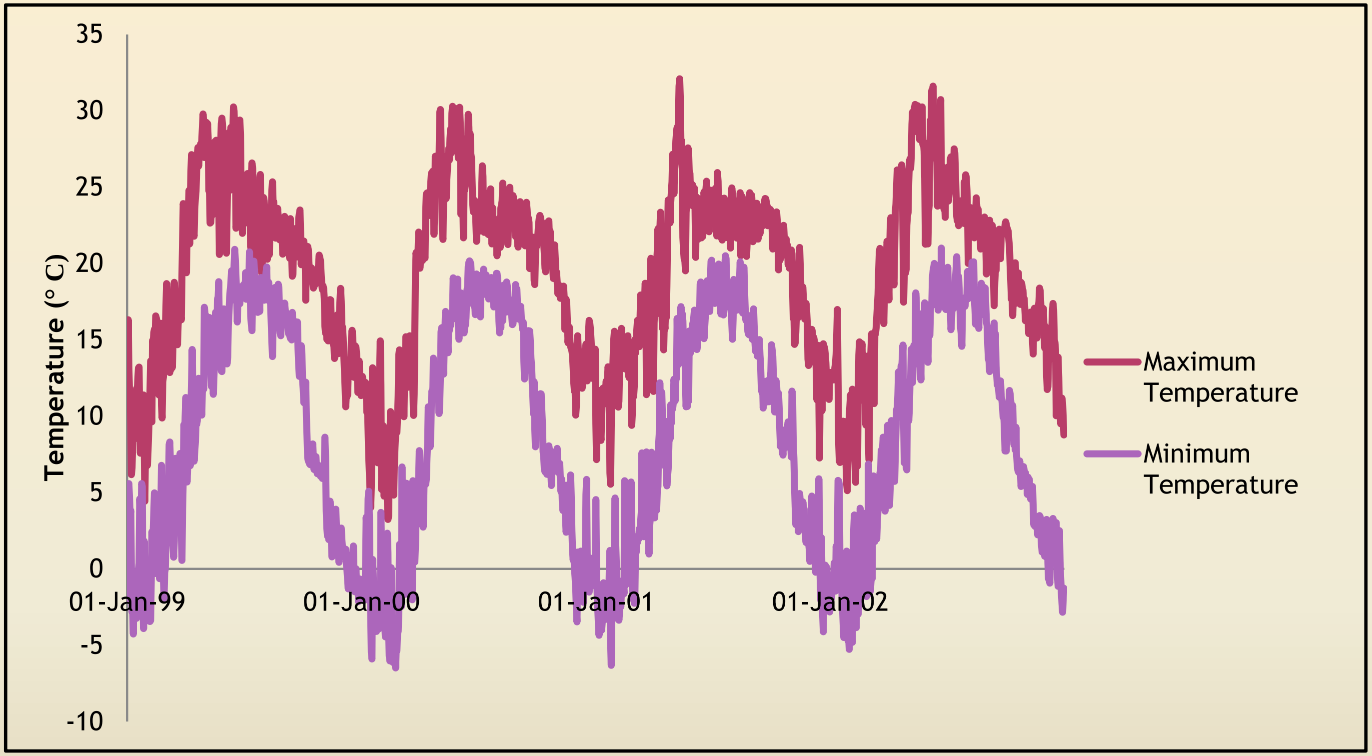
MAXIMUM AND MINIMUM TEMPERATURE (IMD)



RAINFALL (INTERIM ERA)



MAXIMUM AND MINIMUM TEMPERATURE (INTERIM ERA)



PARAMETERS SELECTED FOR STREAMFLOW CALIBRATION

Parameters	Description
CN2.mgt	SCS runoff curve number for moisture condition II
ALPHA_BF.gw	Base flow alpha factor
GW_DELAY.gw	Groundwater delay time
GWQMN.gw	Threshold depth of water in shallow aquifer required for return flow
SFTMP.bsn	Snowfall temperature
TIMP.bsn	Snowmelt temperature lag factor
SNOWCOVMX.bsn	Threshold depth of snow above which there is 100% cover
SOL_AWC.sol	Soil available water storage capacity
SOL_BD.sol	Soil bulk density
SOL_Z.sol	Depth from soil surface to bottom of layer

PARAMETERS SELECTED FOR STREAMFLOW CALIBRATION

Parameters	Description
SOL_K.sol	Soil hydraulic conductivity
REVAPMN.gw	Threshold depth of water in shallow aquifer for ‘revap’ or percolation to the deep aquifer to occur
GW_REVAP.gw	Groundwater ‘revaporation’ coefficient
RCHRG_DP.gw	Deep aquifer percolation fraction
ESCO.hru	Soil evaporation compensation factor
EPCO.hru	Plant uptake compensation factor
SURLAG.bsn	Surface runoff lag coefficient
SLSUBBSN.hru	Average slope length
OV_N.hru	Manning’s n value for overland flow
CANMX.hru	Maximum canopy storage

PARAMETERS SELECTED FOR SEDIMENT YIELD CALIBRATION

Parameters	Description
USLE_K	USLE equation soil erodibility (K) factor
USLE_P	USLE equation support conservation practice factor
SPCON	Linear parameter for calculating the maximum amount of sediment that can be reentrained during channel sediment routing
PRF	Peak rate adjustment factor for sediment routing in the main channel
SPEXP	Exponent parameter for calculating sediment reentrained in channel sediment routing
ADJ_PKR	Peak rate adjustment factor for sediment routing in sub basin (tributary channels)

ARCSWAT CALIBRATION OF PARAMETERS FOR STREAMFLOW

Parameters	Initial value		Fitted value
	Minimum value	Maximum value	
CN2.mgt	35	98	70
ALPHA_BF.gw	0	1	0.42
GW_DELAY.gw	30	450	50.54
GWQMN.gw	0	200	145.32
SFTMP.bsn	-20	20	4.56
TIMP.bsn	0	1	0.36
SNOWCOVMX.bsn	0	500	214.84
SOL_AWC.sol	0	1	0.25
SOL_BD.sol	0.9	2.5	1.52
SOL_Z.sol	-0.8	8.0	1.40

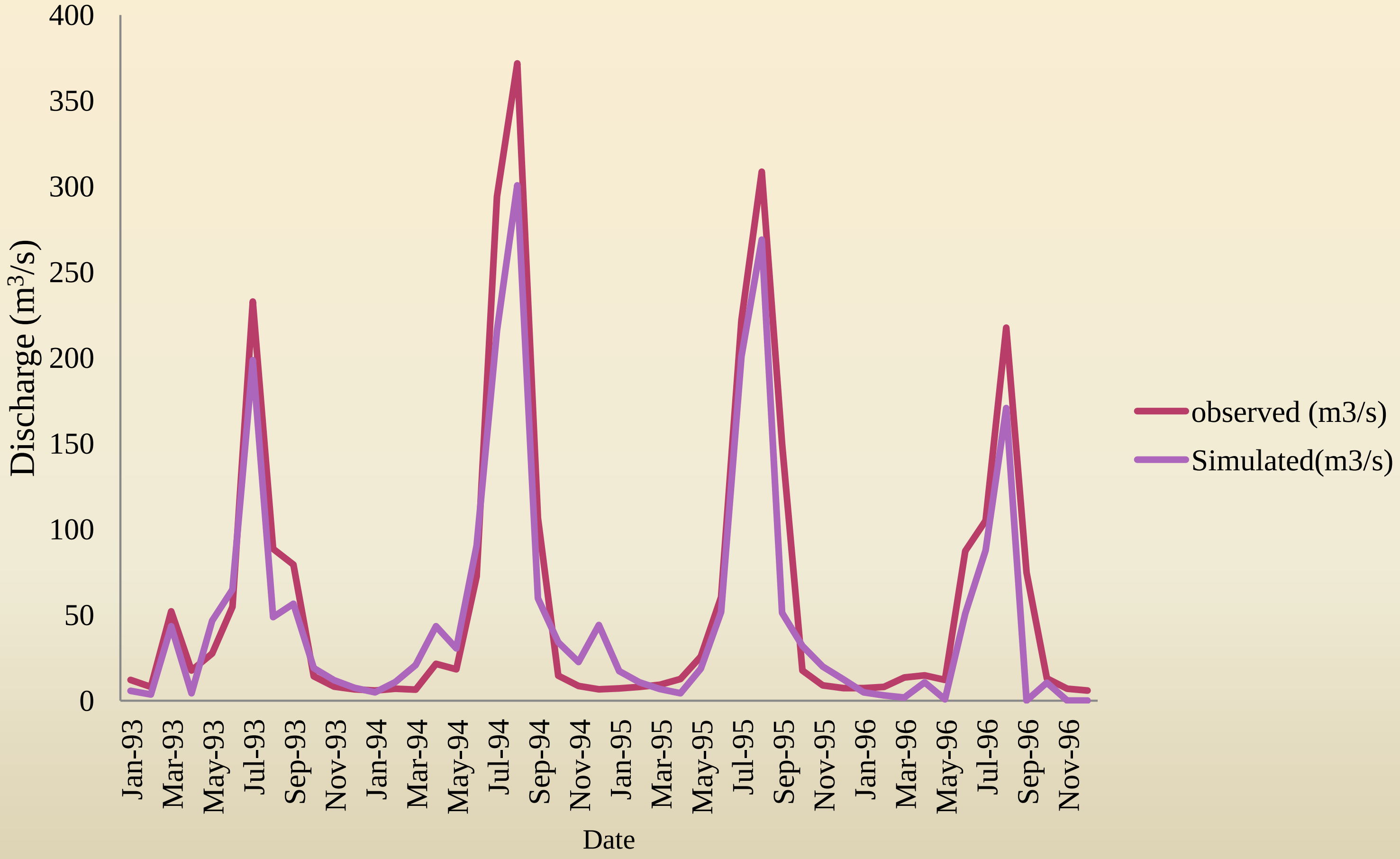
ARCSWAT CALIBRATION OF PARAMETERS FOR STREAMFLOW

Parameters	**Initial value**		**Fitted value**
	Minimum value	Maximum value	
SOL_K.sol	1	10	1.31
REVAPMN.gw	0	20	10.23
GW_REVAP.gw	0.02	0.2	0.05
RCHRG_DP.gw	0	1	0.60
ESCO.hru	0	1	0.56
EPCO.hru	0	1	0.45
SURLAG.bsn	0.05	24	10.05
SLSUBBSN.hru	10	150	30.56
OV_N.hru	0.01	30	12
CANMX.hru	0	100	59.56

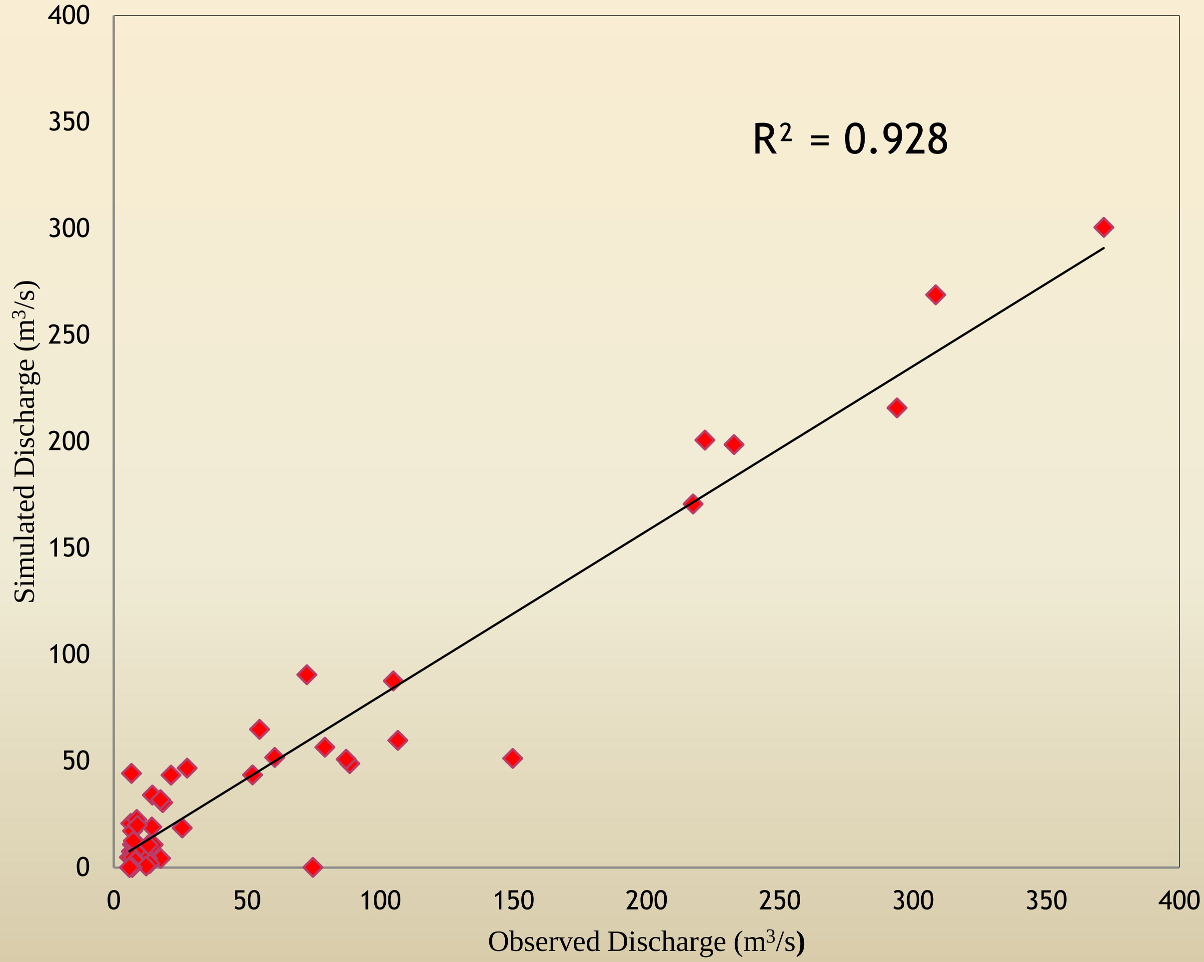
ARCSWAT CALIBRATION PARAMETERS FOR SEDIMENT YIELD

Parameters	Initial value		Fitted value
	Minimum value	Maximum value	
USLE_K	0	0.65	0.17
USLE_P	0	1	1
SPCON	0.0001	0.01	0.0001
PRF	0	2	1
SPEXP	1	1.5	1
ADJ_PKR	0.5	2	1

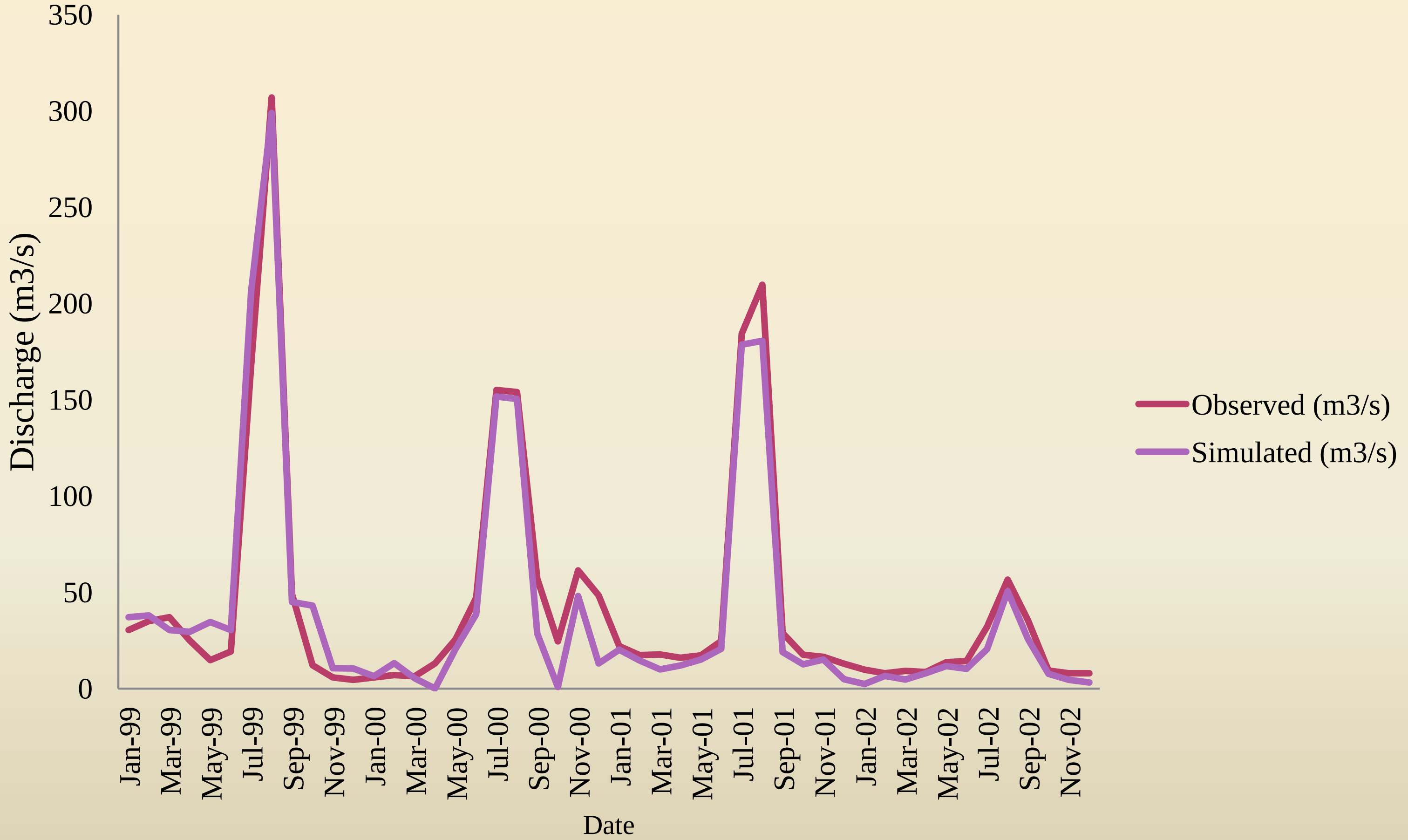
ARCSWAT - CALIBRATION (4YR) RESULTS OF DISCHARGE



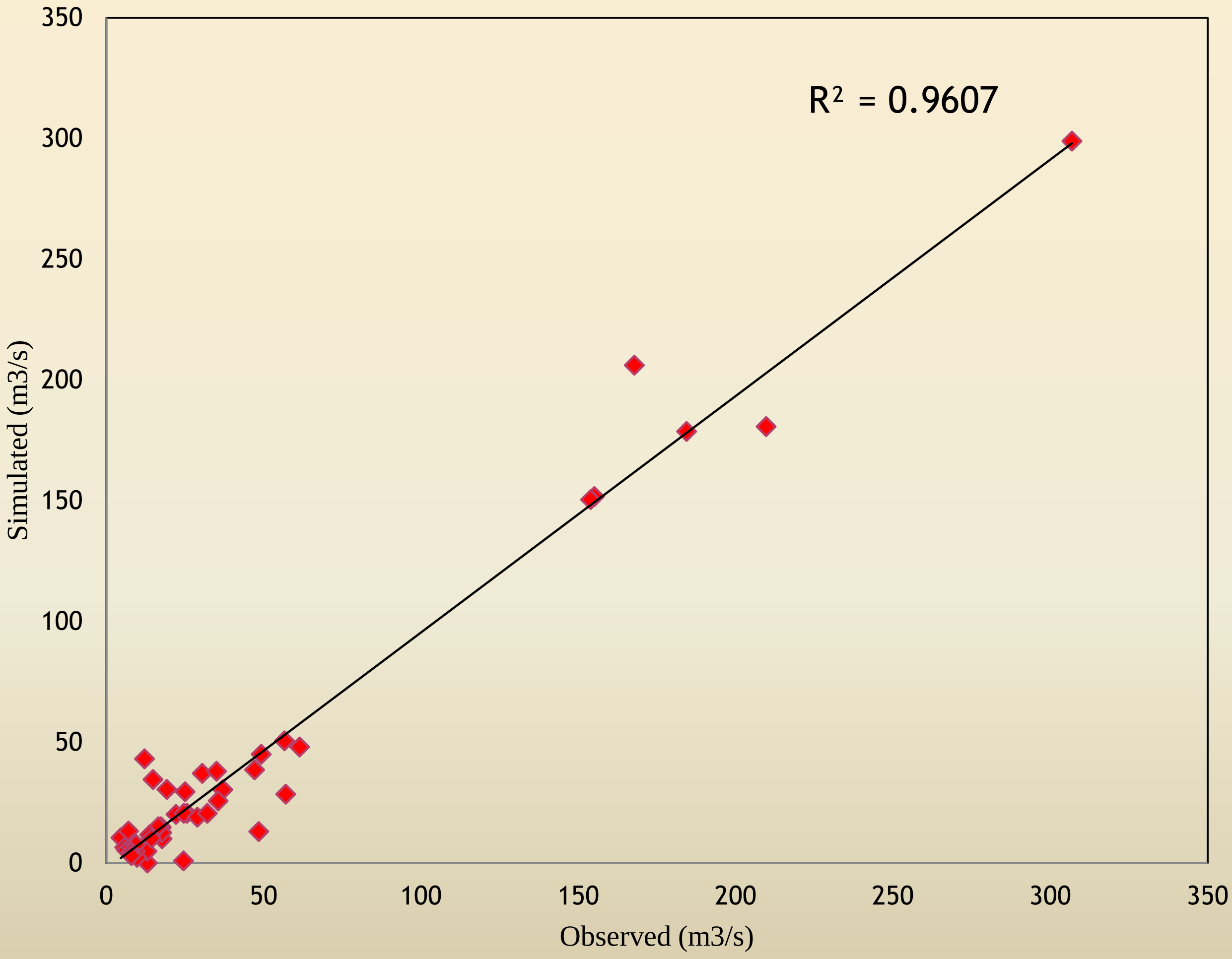
SIMULATED DISCHARGE Vs OBSERVED DISCHARGE (CALIBRATION)



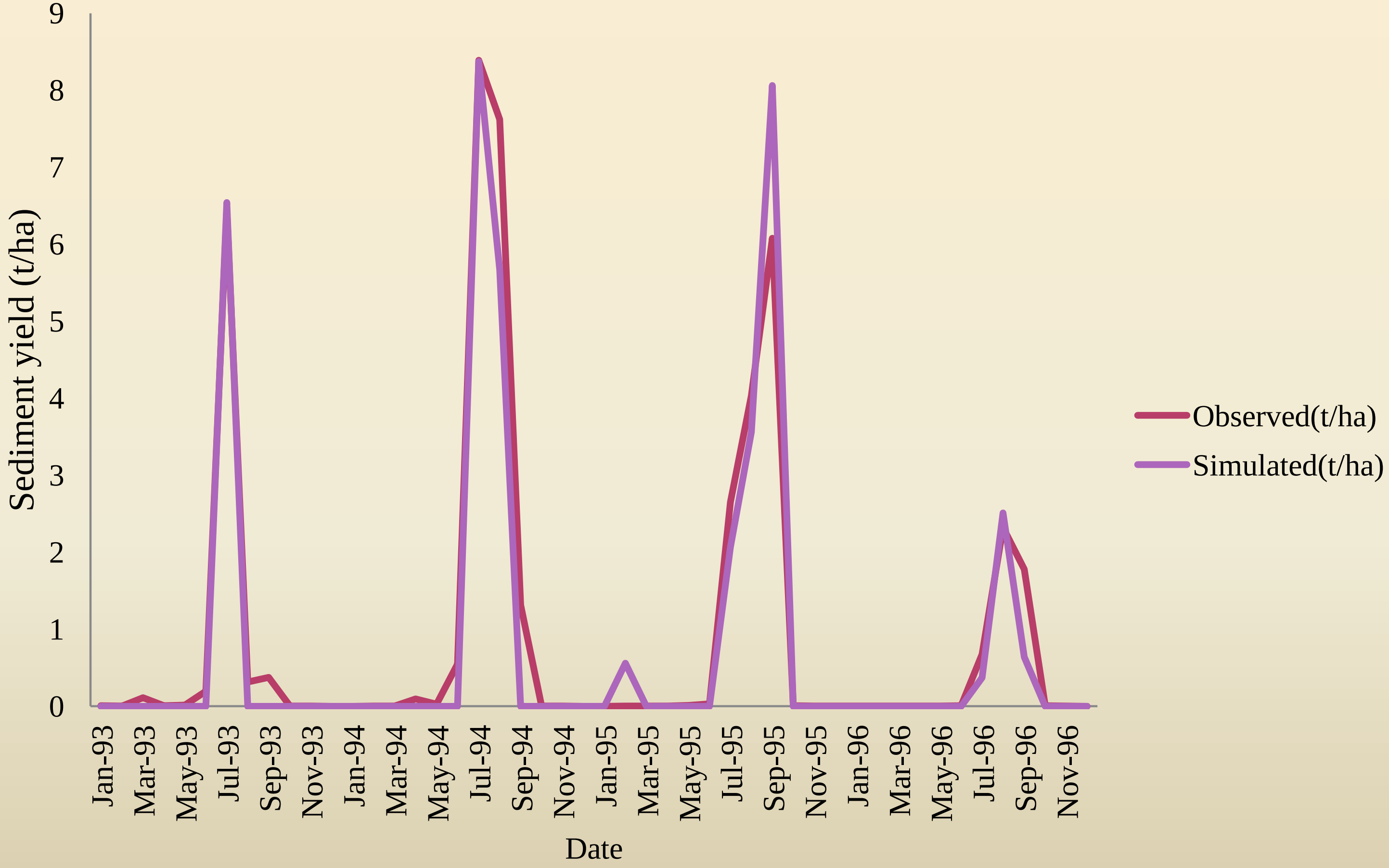
ARCSWAT - VALIDATION (4 YR) RESULTS OF DISCHARGE



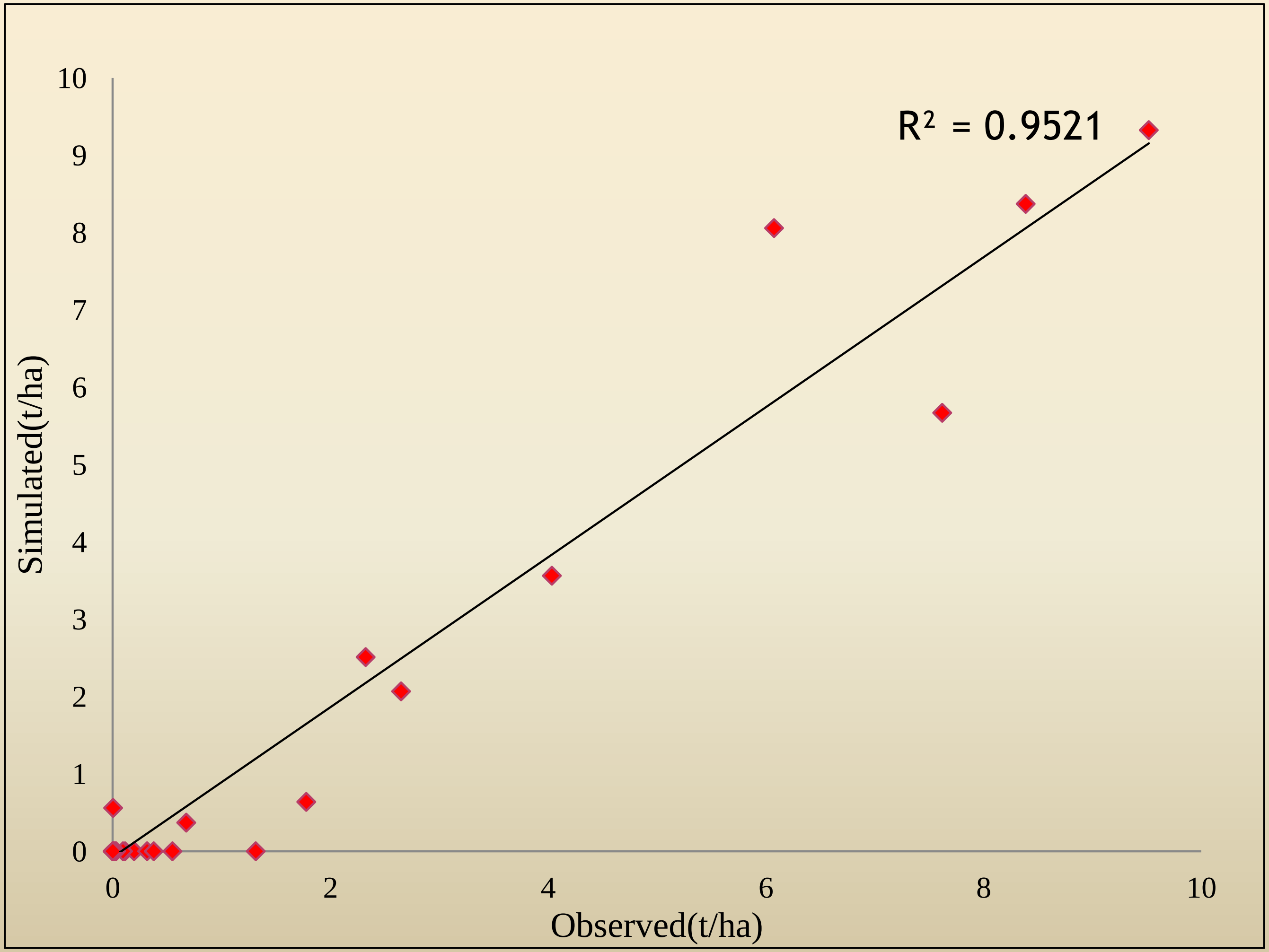
SIMULATED DISCHARGE Vs OBSERVED DISCHARGE (VALIDATION)



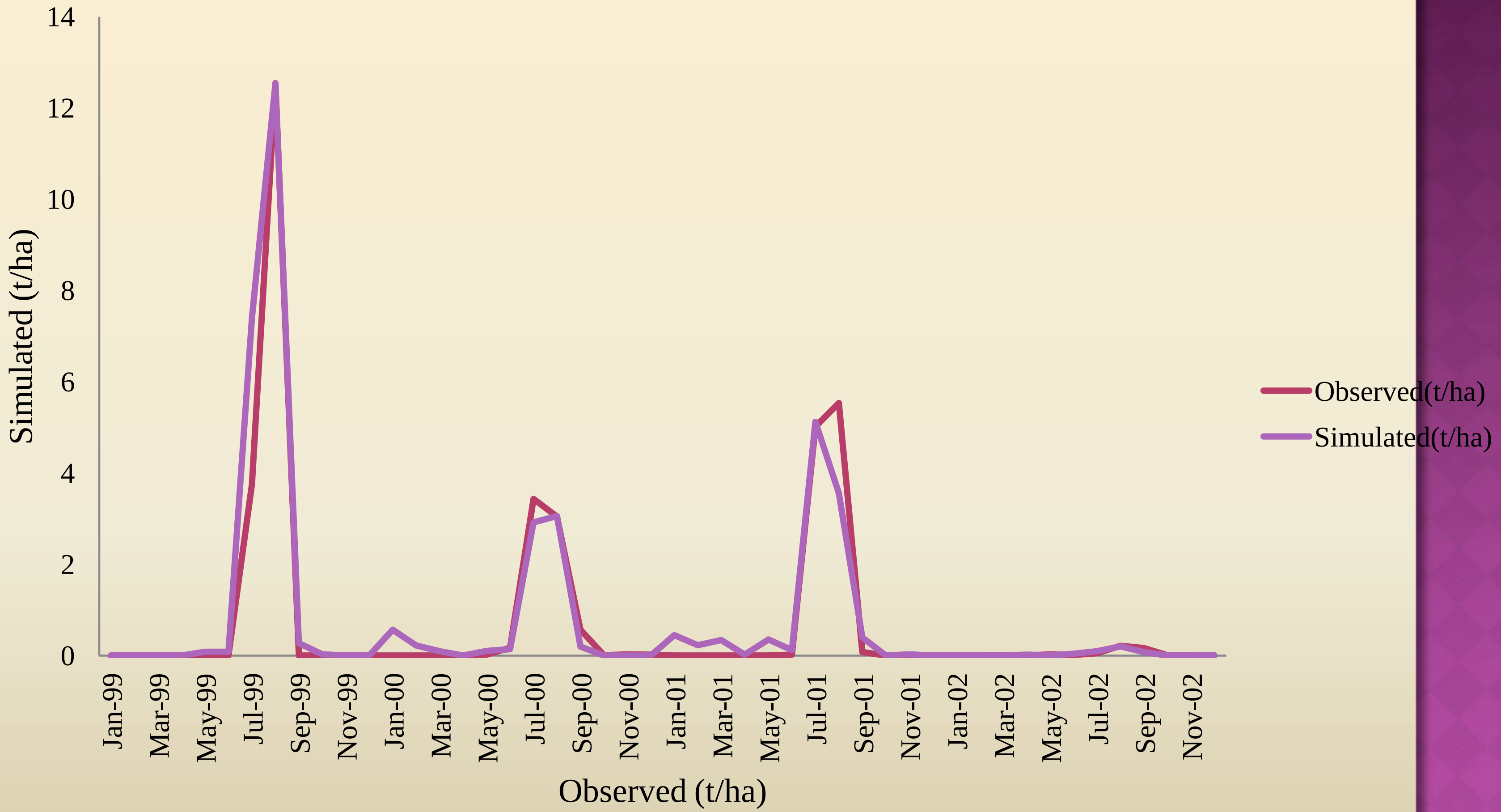
ARCSWAT – CALIBRATION (4YR) RESULTS OF SEDIMENT YIELD



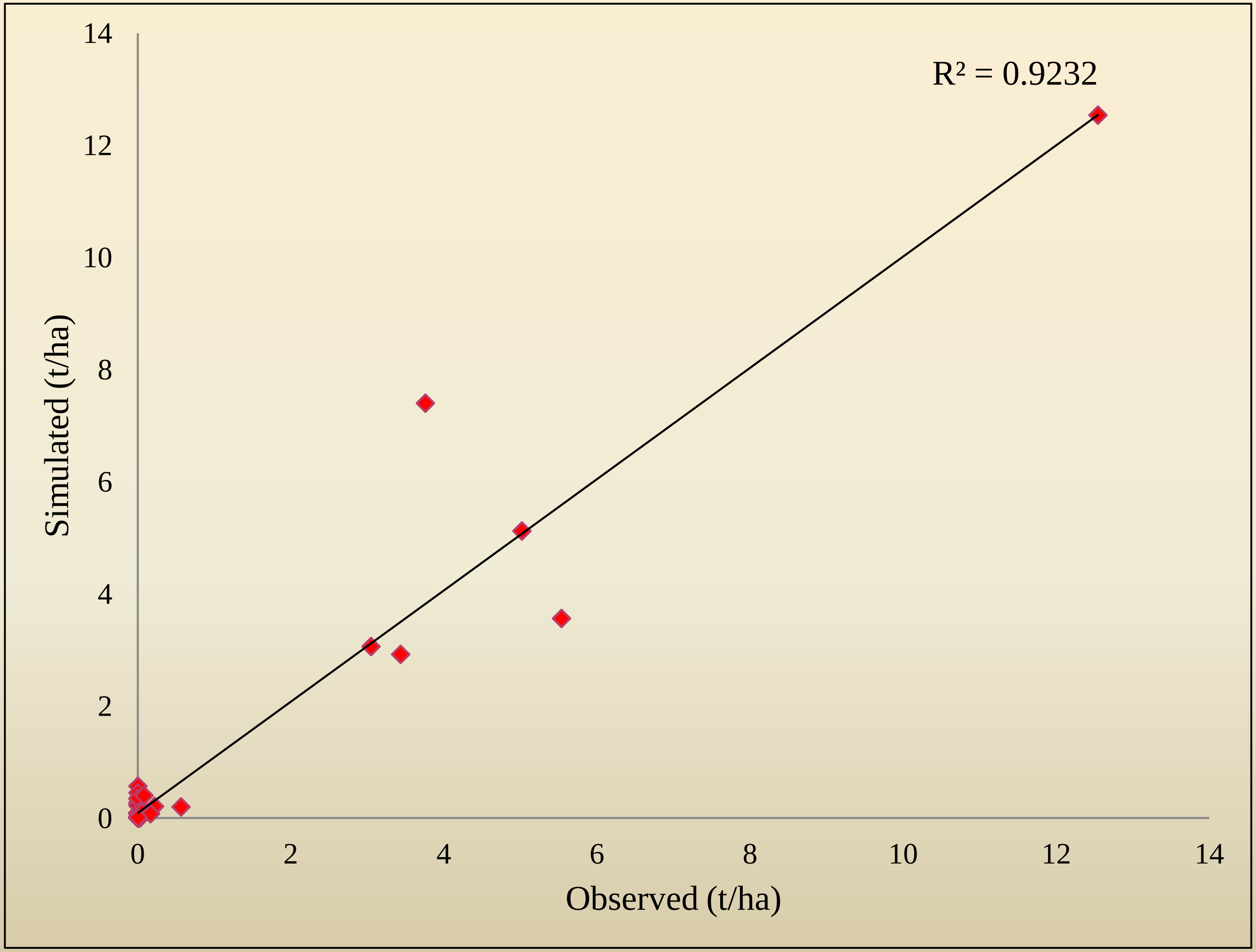
SIMULATED SEDIMENT YIELD Vs OBSERVED SEDIMENT YIELD (CALIBRATION)



ARCSWAT - VALIDATION (4 YR) RESULTS OF SEDIMENT YIELD



SIMULATED SEDIMENT YIELD Vs OBSERVED SEDIMENT YIELD (VALIDATION)



CONCLUSIONS

The coefficient of determination for simulation of sediment yield during calibration and validation are 0.95 and 0.92 respectively

The results clearly demonstrate the capability of SWAT for simulating the sediment yield at Pong reservoir.

Thank you