EVALUATION OF ArcSWAT MODEL FOR STREAMFLOW SIMULATION

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By

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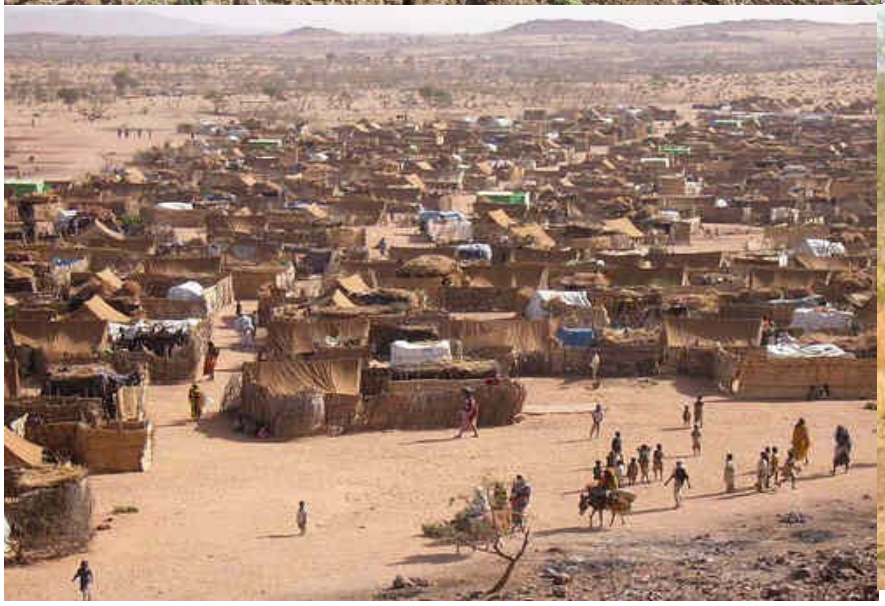
Introduction

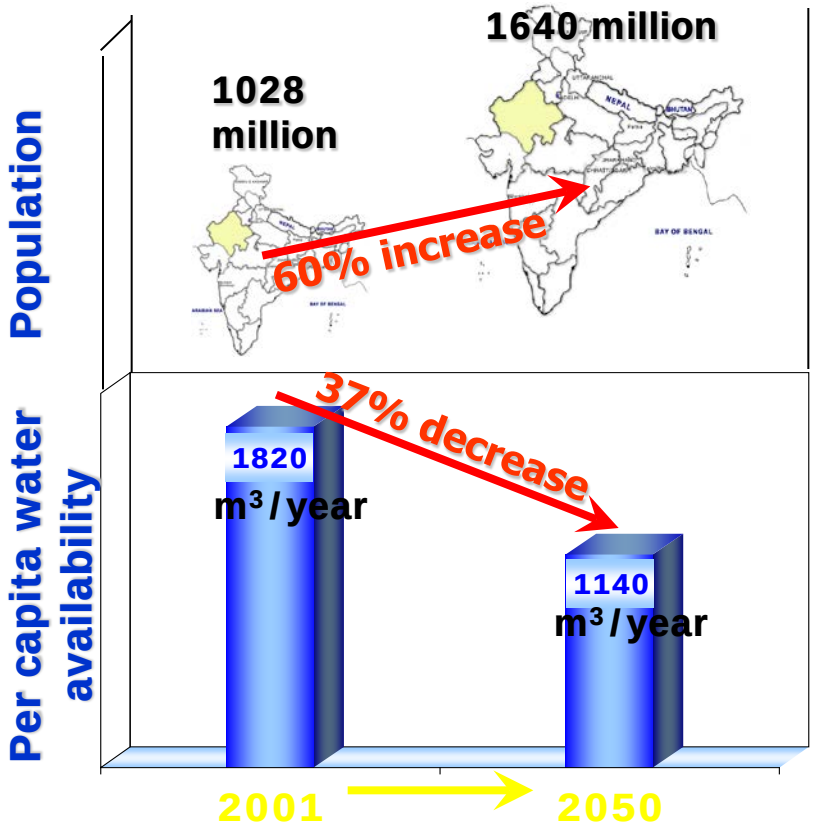


Introduction (Contd.)

Present and future per capita water availability in India

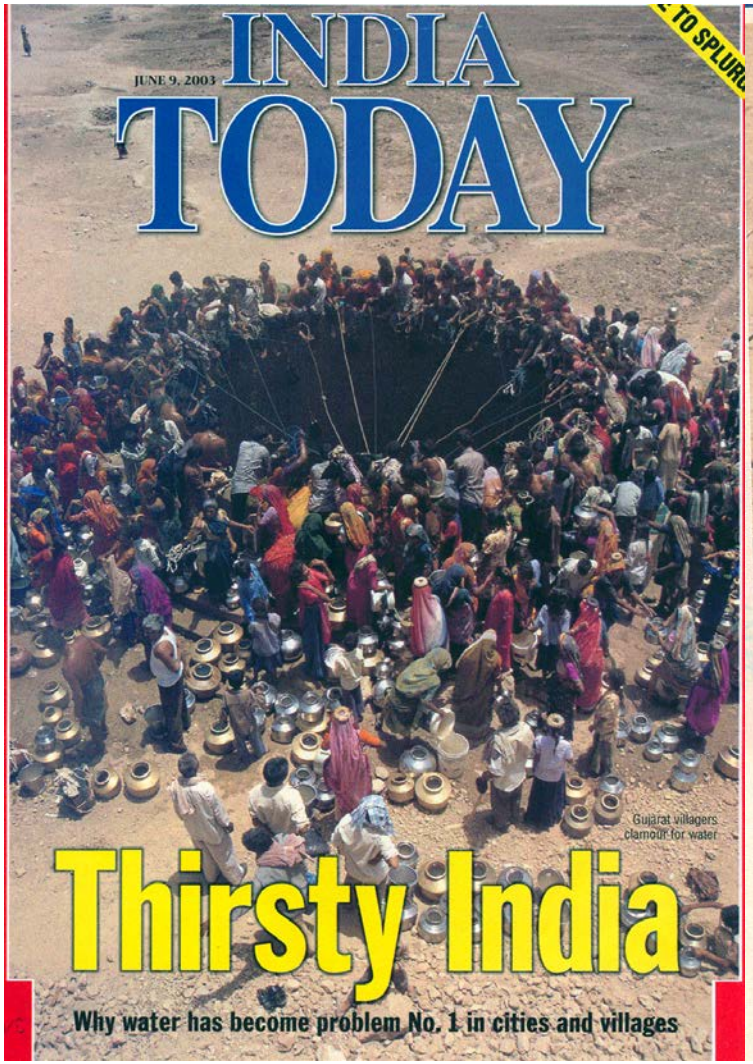
Water Availability m^3/person/year	Country's Status
>2000	Adequate
1000-2000	Water-stressed
<500	Water Scarce

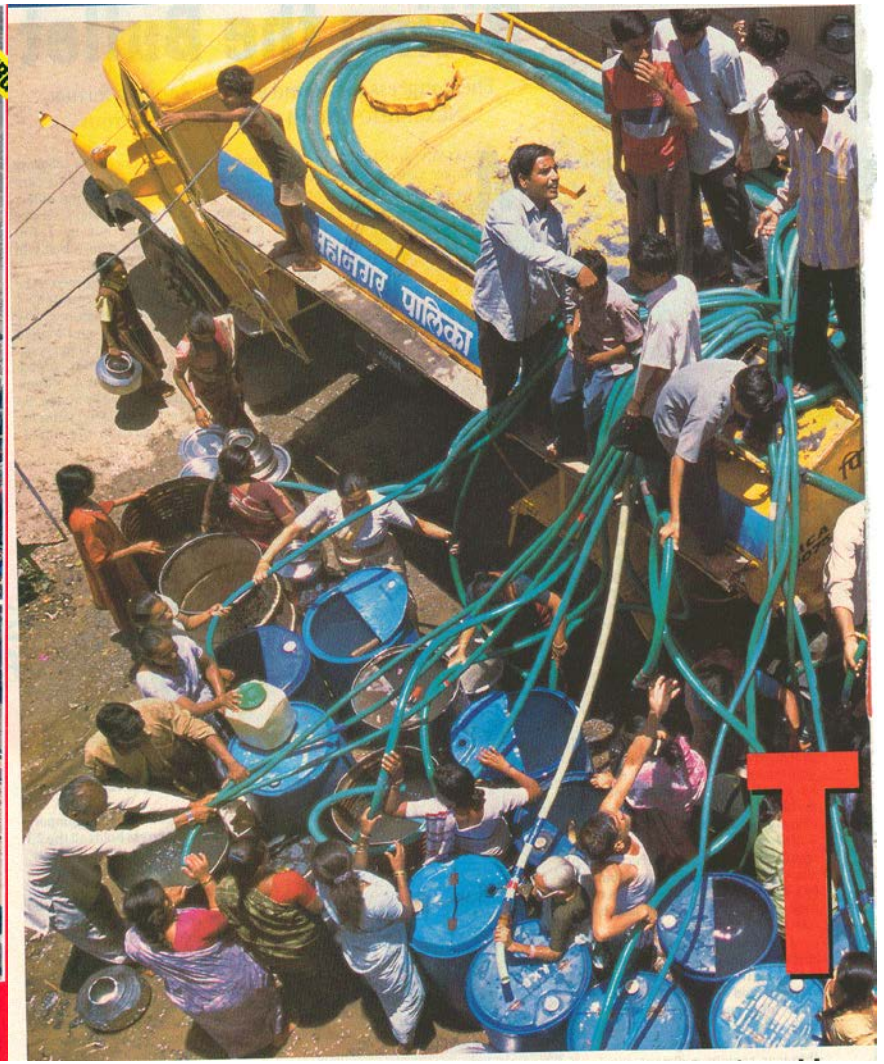
Source: Bouwer (2000)



Source: Gupta and Deshpande (2004)

Introduction (Contd.)





Introduction (Contd.)

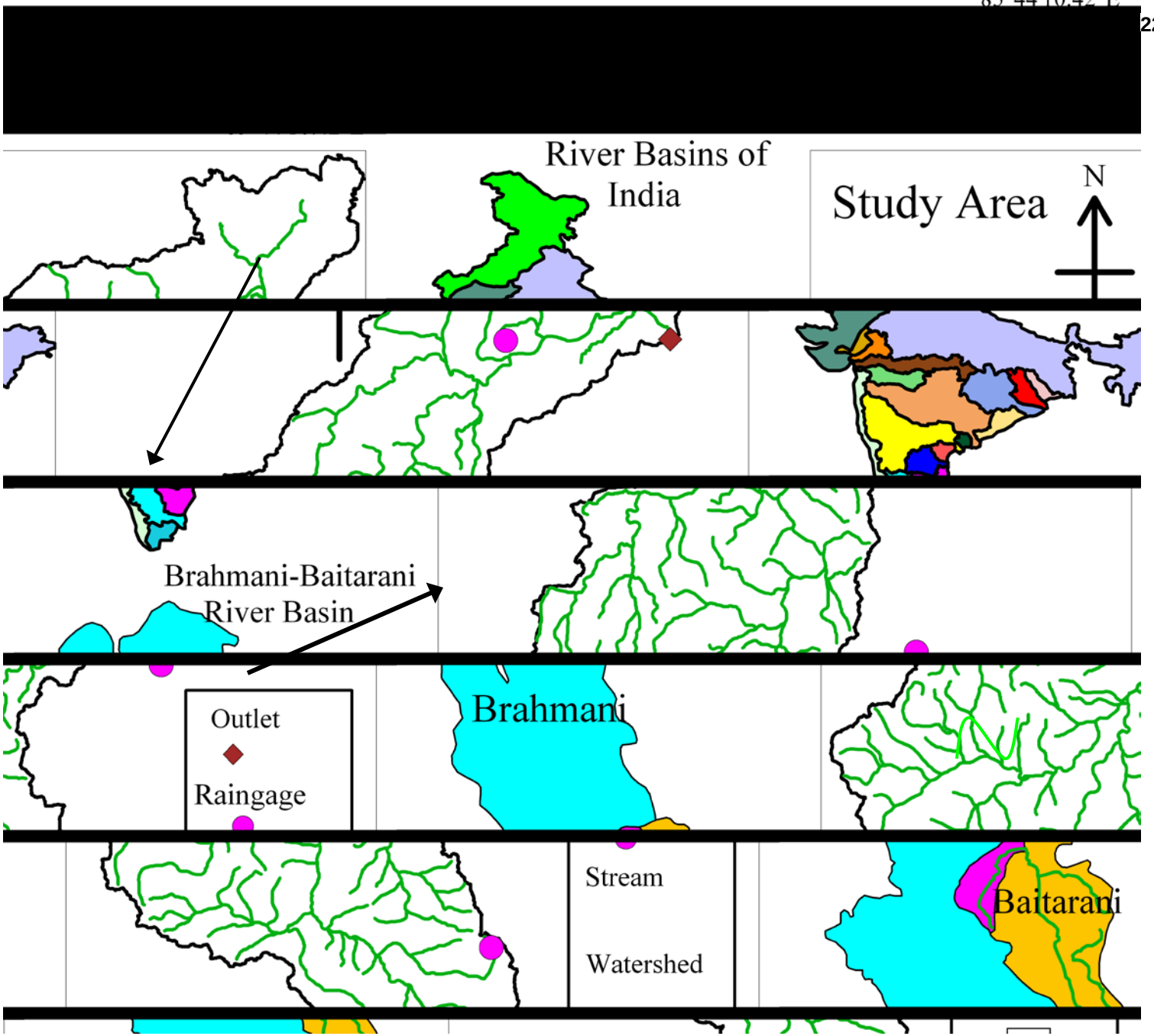
Watershed Hydrologic Models

SWAT	**GWLF**	**WAM**
HSPF	**WEPP**	**ANSWER**
MIKE SHE	**AGNPS**	**HEC-HMS**

Objectives

Calibration and validation of ArcSWAT watershed model for the simulation of streamflow.

Performance evaluation of the model for simulation of streamflow.

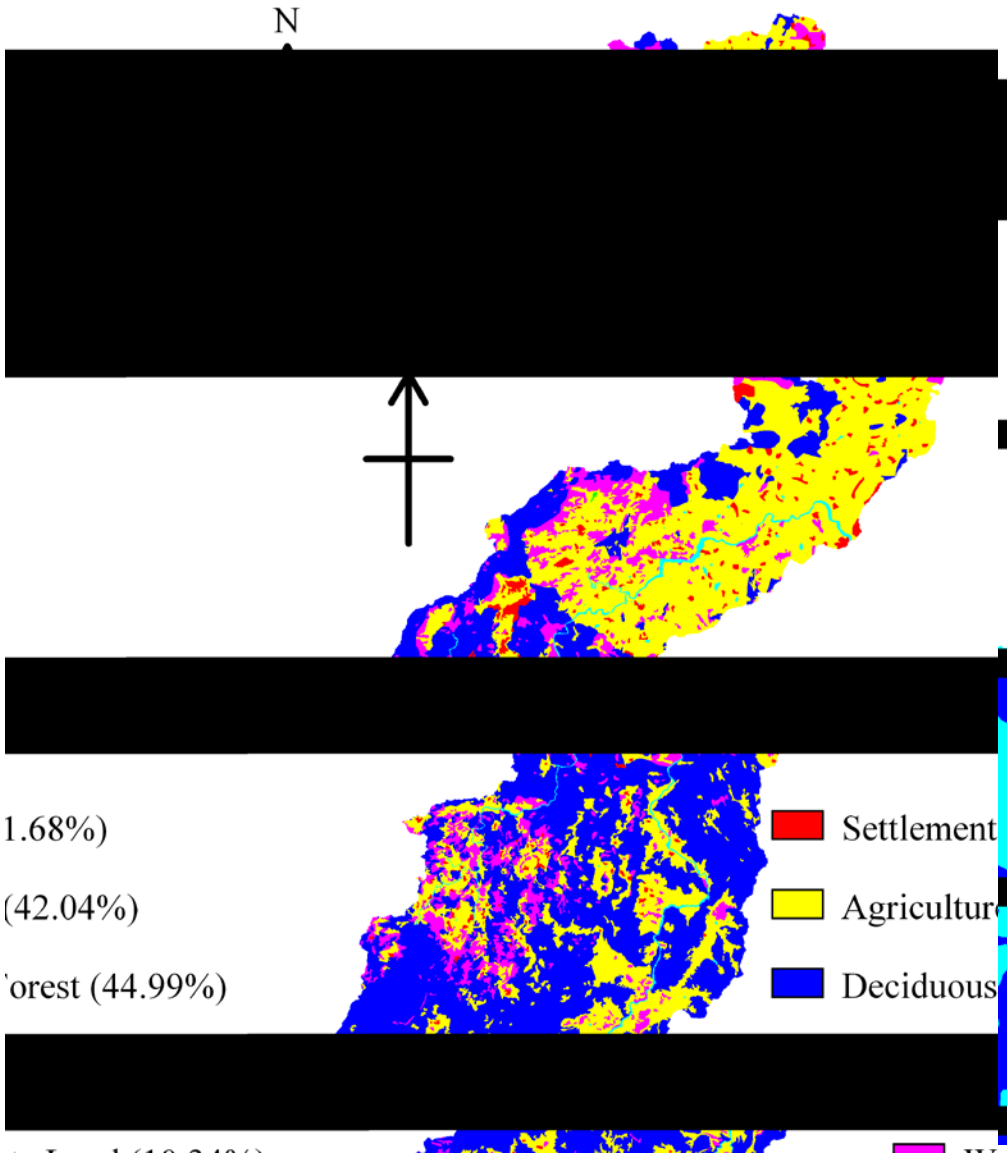

85°44'10.42"E
22°11'51.65"N
River Basins of India
Study Area
N
Brahmani-Baitarani River Basin
Outlet
Raingage
Brahmani
Stream
Watershed
Baitarani

METHODOLOGY

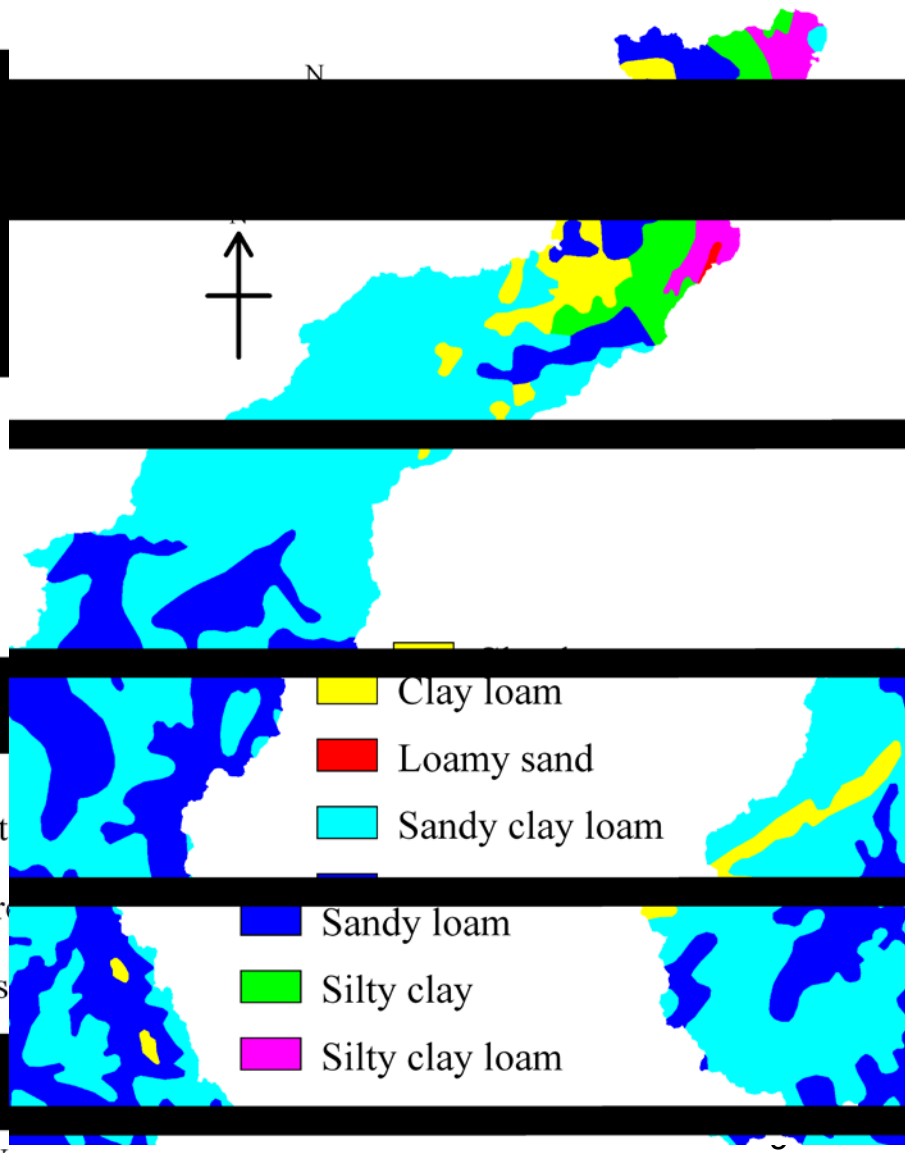
- **Pre Processing of Hydro-meteorological Data, Preparation of model specific weather input files** (Daily Rainfall and streamflow data of 8 years- 1998-2005)
- **Preparation of Spatial Data for the Study Area:**

  DEM, Land use/land cover map and Soil map

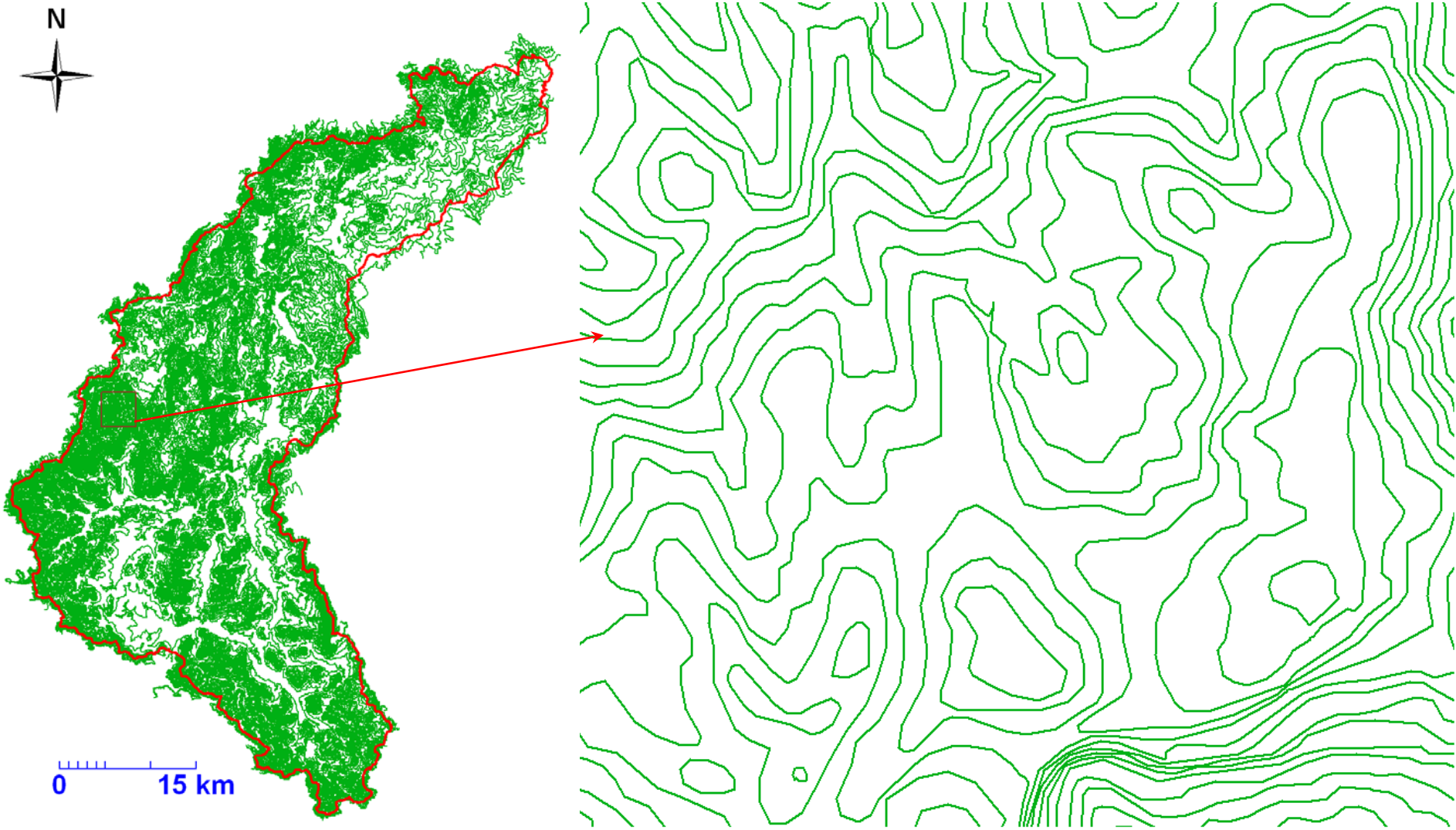
Land use/Land cover map



Soil map

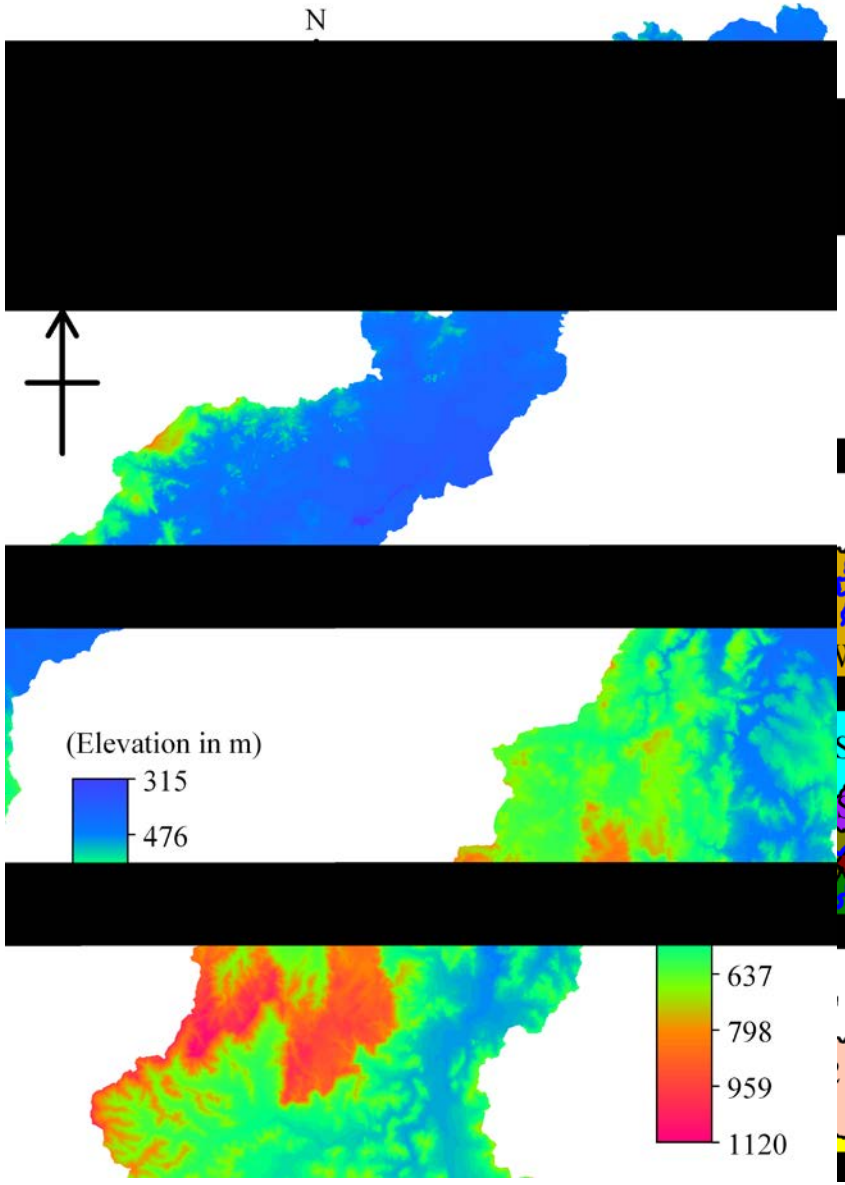


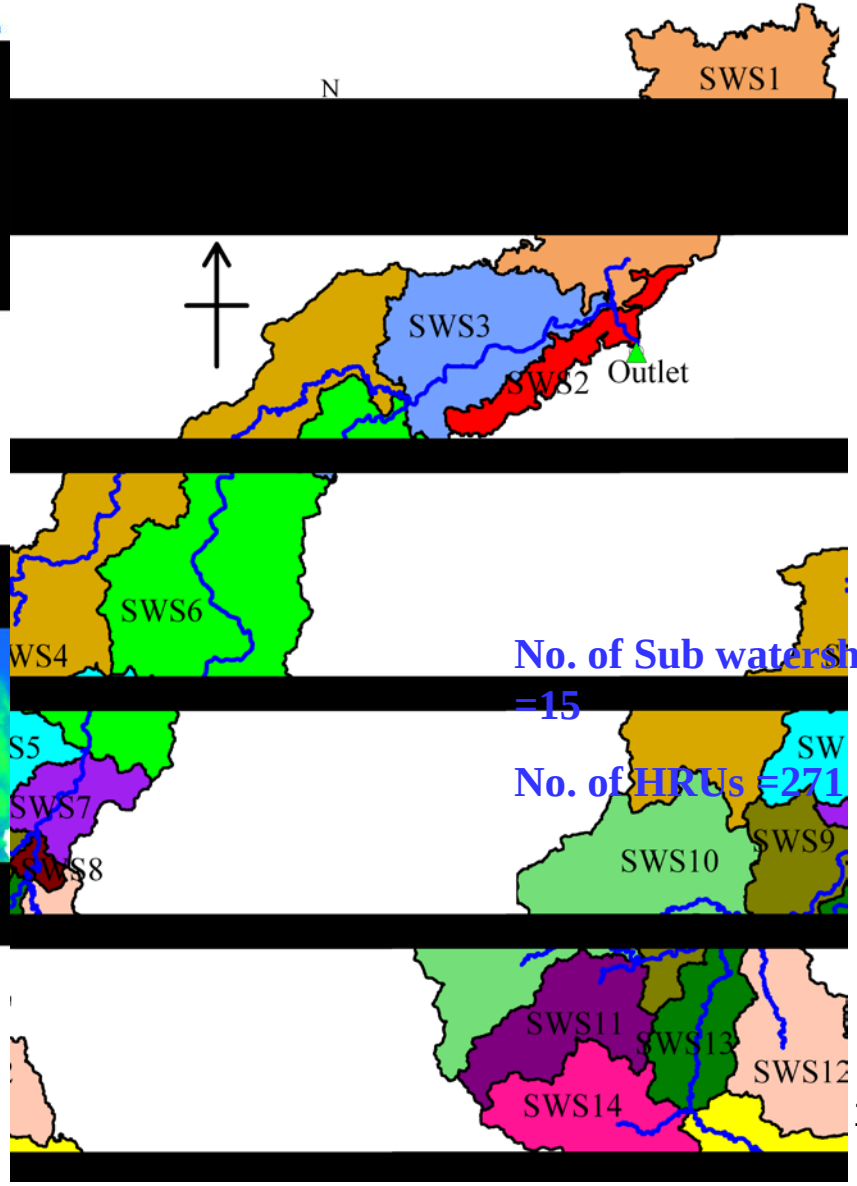
Contour Map



DEM

Sub watersheds and Stream reaches





No. of Sub watersheds =15

No. of HRUs =271

METHODOLOGY (contd.)

Calibration and validation of ArcSWAT model for the simulation of stream flow

- ArcSWAT model set up
- Sensitivity analysis for 18 streamflow parameters (LH-OAT Sampling techniques),
- Calibration (SCEA-UA method) and Validation
- Performance evaluation of model for simulation of streamflow at daily and monthly time steps using statistical and graphical indicators

Model Performance Statistics

Moriasi et al. (2007)

Statistical Indicators	Mathematical Expression
RSR	$\frac{RMSE}{STDEV_{obs}}$
PBIAS	$\left[\frac{\sum_{i=1}^{n}\left(Q_o - Q_s\right)_i (100)}{\sum_{i=1}^{n}\left(Q_o\right)_i}\right]$
NSE	$\mathrm{NSE} = 1 - \frac{\sum_{i=1}^{n}\left(Q_o - Q_s\right)_i}{\sum_{i=1}^{n}\left(Q_o - \bar{Q}_o\right)_i}$

Performance Ratings of a Model for Monthly Time Step

Performance Rating	RSR	NSE	PBIAS (%)	
			Streamflow	Sediment
Very good	0.00 < RSR < 0.50	0.75 < NSE < 1.00	PBIAS < ±10	PBIAS < ±15
Good	0.50 < RSR < 0.60	0.65 < NSE < 0.75	±10 < PBIAS < ±15	±15 < PBIAS < ±30
Satisfactory	0.60 < RSR < 0.70	0.50 < NSE < 0.65	±15 < PBIAS < ±25	±30 < PBIAS < ±55
Unsatisfactory	RSR > 0.70	NSE < 0.50	PBIAS > ±25	PBIAS > ±55

Moriasi et al. (2007)

RESULTS

Streamflow Simulation

Sensitivity Analysis Results for ArcSWAT Streamflow Parameters

Sl.No.	Parameters	Unit	Mean Sensitivity Index	Assigned Rank
1	Baseflow alpha factor (Alpha_Bf)	days	1.4722	1
2	Manning coefficient for channel (CH_N)		1.3714	2
3	Surface runoff lag coefficient (Surlag)		0.2512	3
4	SCS curve number for moisture condition II (Cn2)		0.2141	4
5	Effective hydraulic conductivity in main channel (Ch_K2)	mm/hr	0.1877	5
6	Threshold depth of water in the shallow aquifer required for return flow to occur (Gwqmn)	mm	0.0921	6
7	Soil evaporation compensation factor (Esco)		0.0346	7
8	Groundwater delay (Gw_Delay) (days)		0.0249	8

Sensitivity Analysis Results (contd.)

Sl.No.	Parameters	Unit	Mean Sensitivity Index	Assigned Rank
9	Soil conductivity (Sol_K)	mm/h	0.0150	9
10	Available water capacity of the soil layer (Sol_Awc)	mm/mm	0.0110	10
11	Soil depth (Sol_Z)		0.0077	11
12	Groundwater ‘revap’ coefficient (Gw_Revap)		0.0070	12
13	Plant evaporation compensation factor (Epco)		0.0066	13
14	Threshold depth of water in the shallow aquifer for ‘revap’ to occur (Revapmin)	(mm)	0.0061	14
15	Maximum canopy index (Canmx)		0.0041	15
16	Soil albedo (Sol_Alb)		0.0000	17
17	Leaf area index for crop (Blai)		0.0000	17

Initial and Calibrated Parameter Values for Streamflow Simulation

Parameter	Lower boundary	Upper boundary	Initial Value	Calibrated Parameter value
Alpha_Bf	0	1	0.048	**0.99947**
Canmx	0	100	0	**91.80400**
Ch_K2	0.01	500	0.01	**76.476000**
Ch_N	0.01	0.3	0.014	**0.01003**
Cn2*	**-25**	**25**	Soil /LULC data	**-17.18700**
Epco	0	1	0	**0.97161**
Esco	0	1	0.95	**0.02797**
Gw_Delay	0	500	31	**28.69900**
Gw_Revap	0.02	0.2	0.02	**0.03377**
Gwqmn	0	5000	0	**65.50400**
Rchrg_Dp	0	1	0.05	**0.00034**
Revapmin	0	500	1	**1.80870**
Sol_Awc*	**-25**	**25**	Soil data	**20.47100**
Sol_K*	**-25**	**25**	Soil data	**24.94900**
Sol_Z*	**-25**	**25**	Soil data	**23.26100**
Surlag	1	24	4	**17.92800**

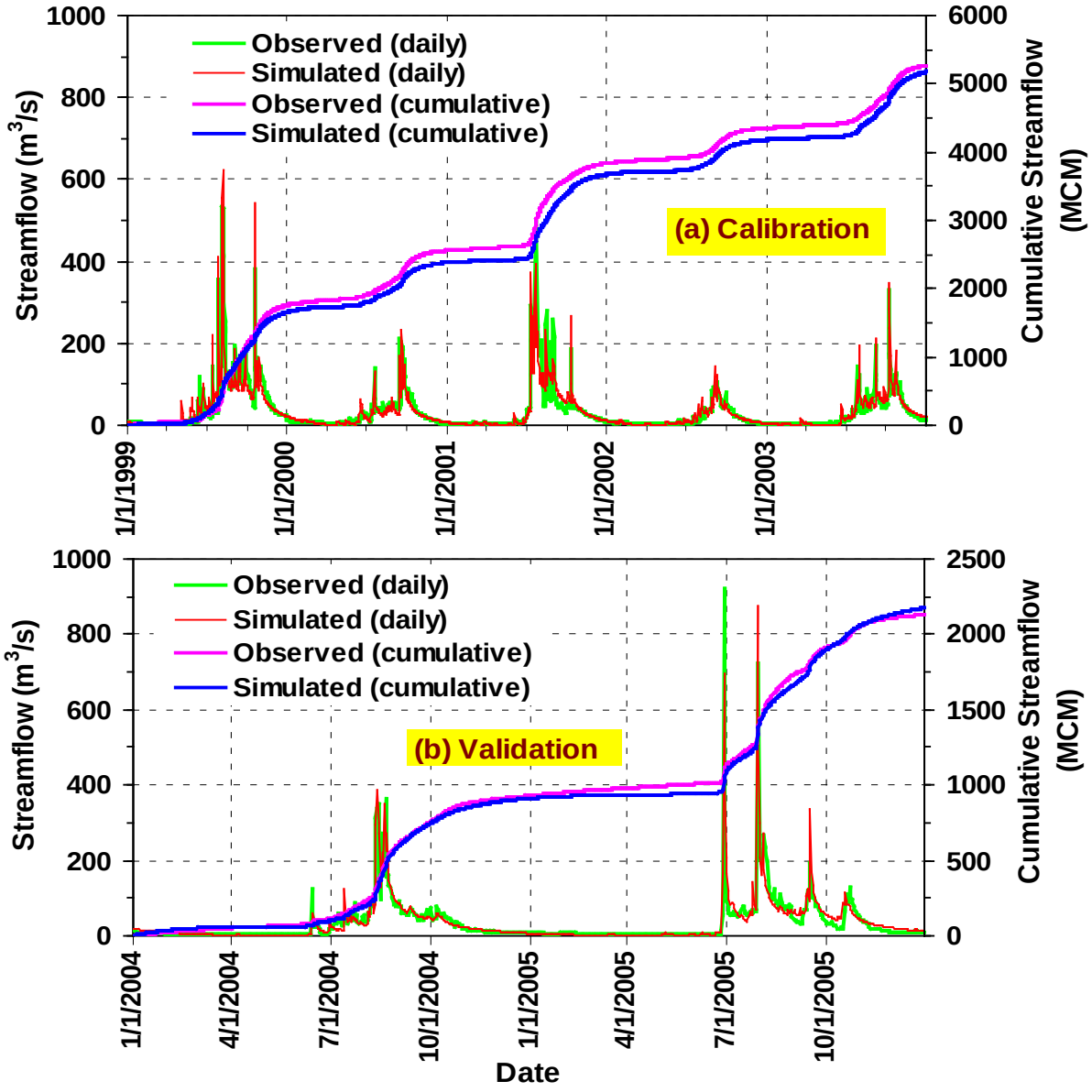
ArcSWAT Model Performance Statistics for Simulation of Daily Streamflow

Statistical Indicators	Daily Streamflow			
	Calibration Period (1999-2003)		**Validation Period (2004-2005)**	
	Observed	Simulated	Observed	Simulated
Mean(m^3/s)	33.41	32.82	34.34	34.90
STDEV(m^3/s)	53.61	50.84	65.56	66.09
ME (m^3/s)	0.59		-0.66	
MAE (m^3/s)	9.72		10.84	
RMSE (m^3/s)	20.10		25.93	
PBIAS	**1.14**		**-1.94**	
RSR	**0.37**		**0.39**	
NSE	**0.86**		**0.84**	
R^2	0.86		0.85	

ArcSWAT Model Performance Statistics for Simulation of Monthly Streamflow

Statistical Indicators	Monthly Streamflow			
	Calibration Period (1999-2003)		**Validation Period (2004-2005)**	
	Observed	Simulated	Observed	Simulated
Mean(mm)	49.07	48.52	50.04	51.01
STDEV(mm)	64.15	60.12	61.95	63.55
ME (mm)	0.56		-0.97	
MAE (mm)	8.09		9.88	
RMSE (mm)	13.52		15.07	
PBIAS	**1.14**		**-1.94**	
RSR	**0.21**		**0.24**	
NSE	**0.95**		**0.93**	
R^2	0.96		0.94	

Observed and SWAT Simulated Daily and Cumulative Streamflow Hydrographs



Total Streamflow (MCM)

Obs.=5217.38

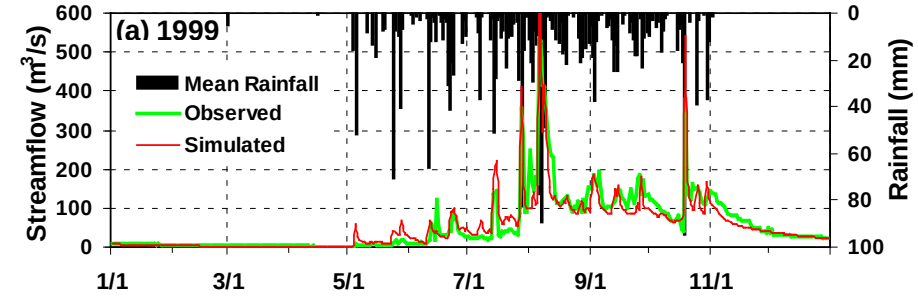
Sim.=5178.41

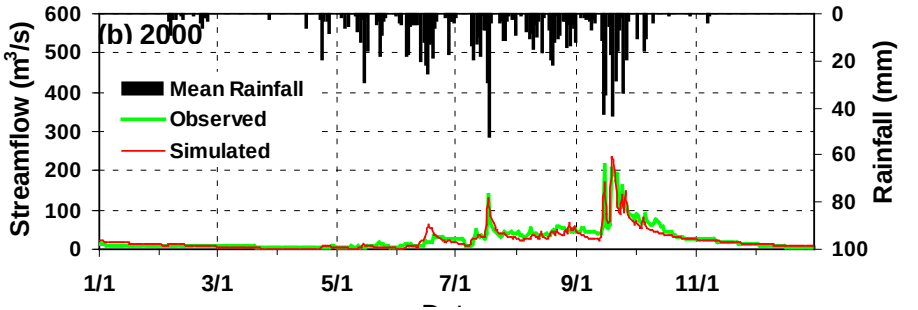
Total Streamflow (MCM)

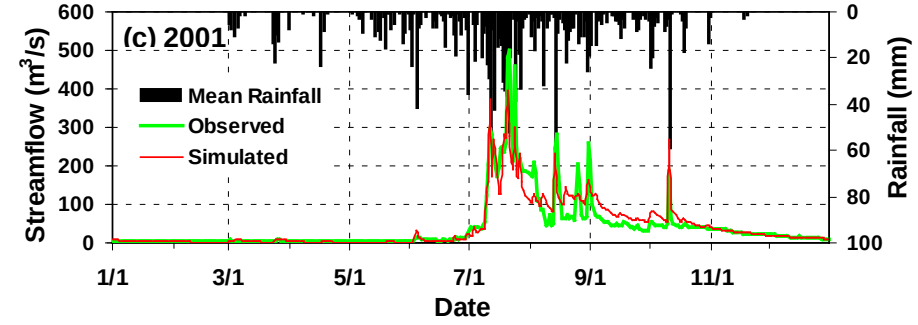
Obs.=2134.57

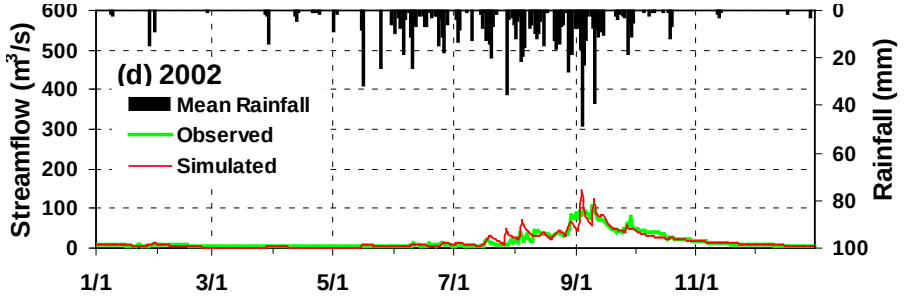
Sim.=2176.05

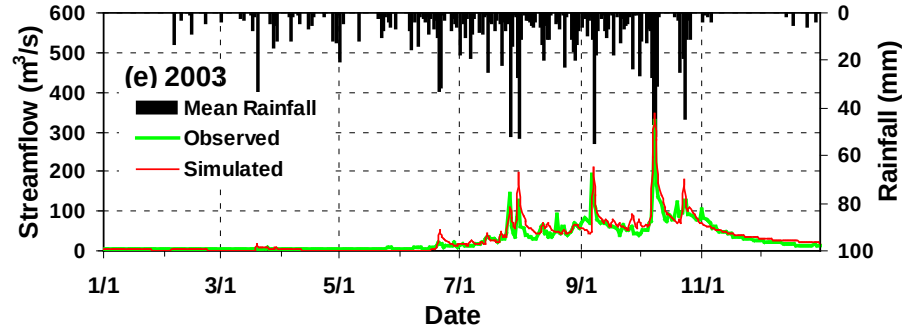
Comparison of Observed and SWAT Simulated Daily Streamflows Hydrographs for Calibration Years 1999-2003



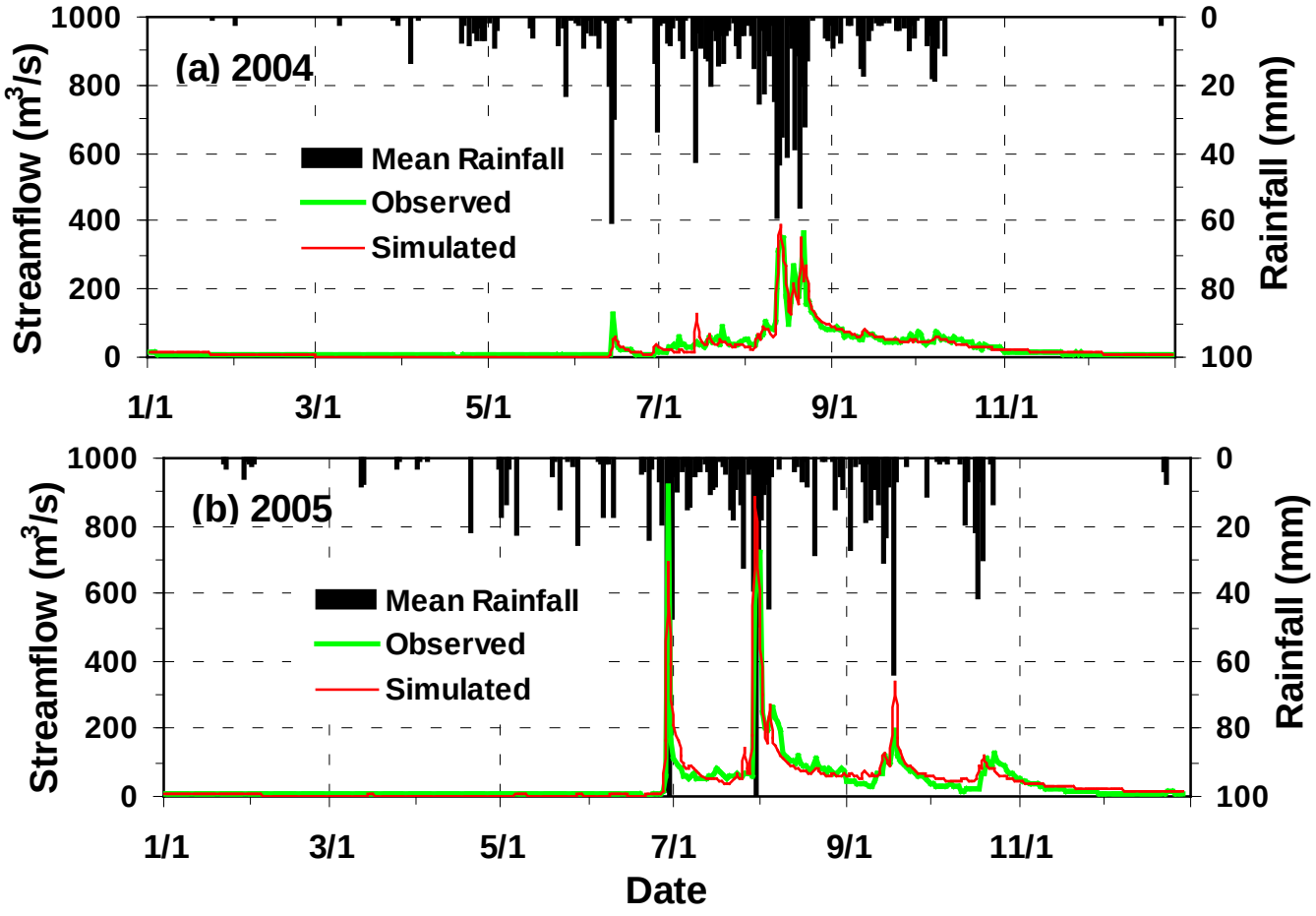




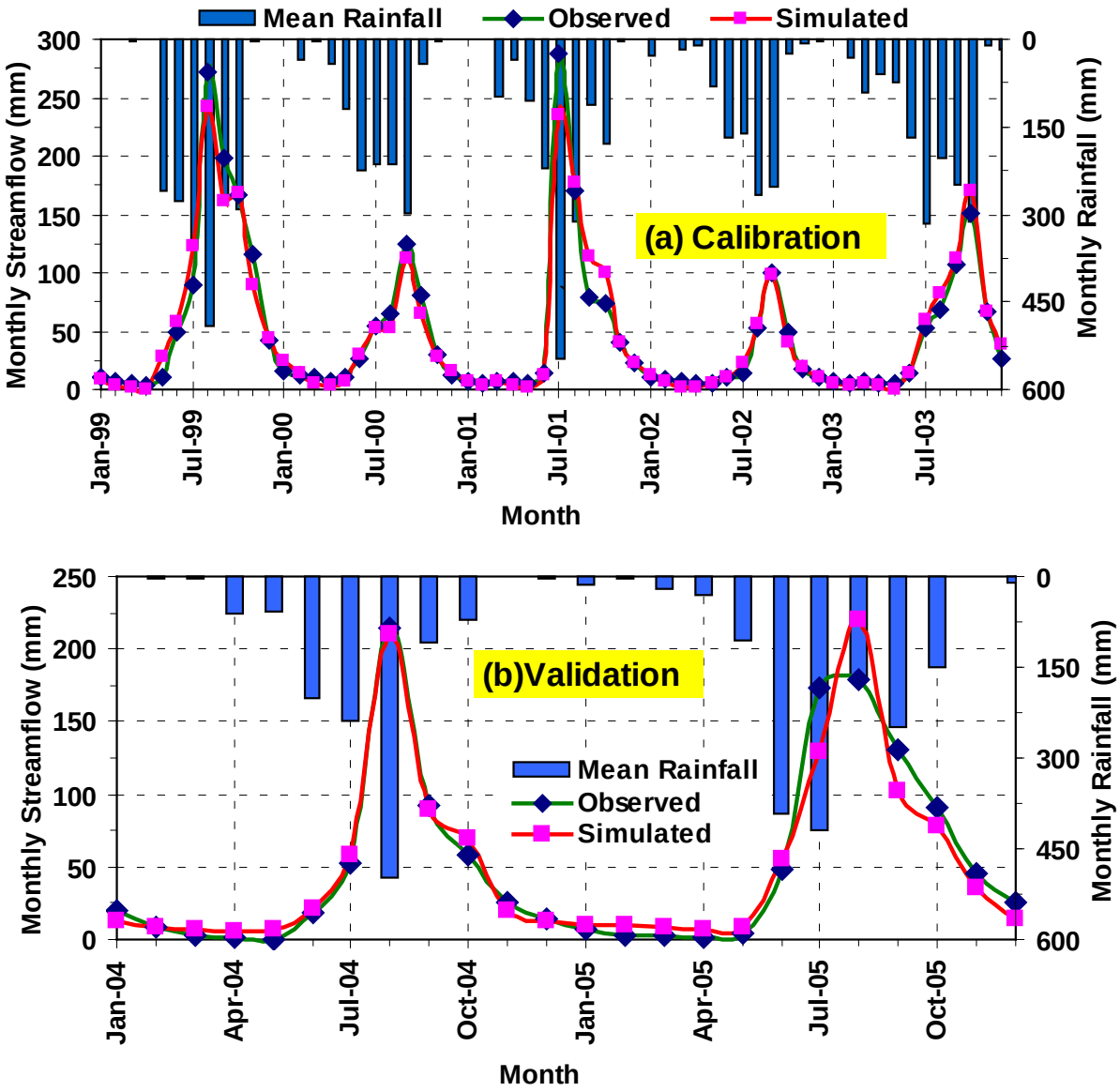




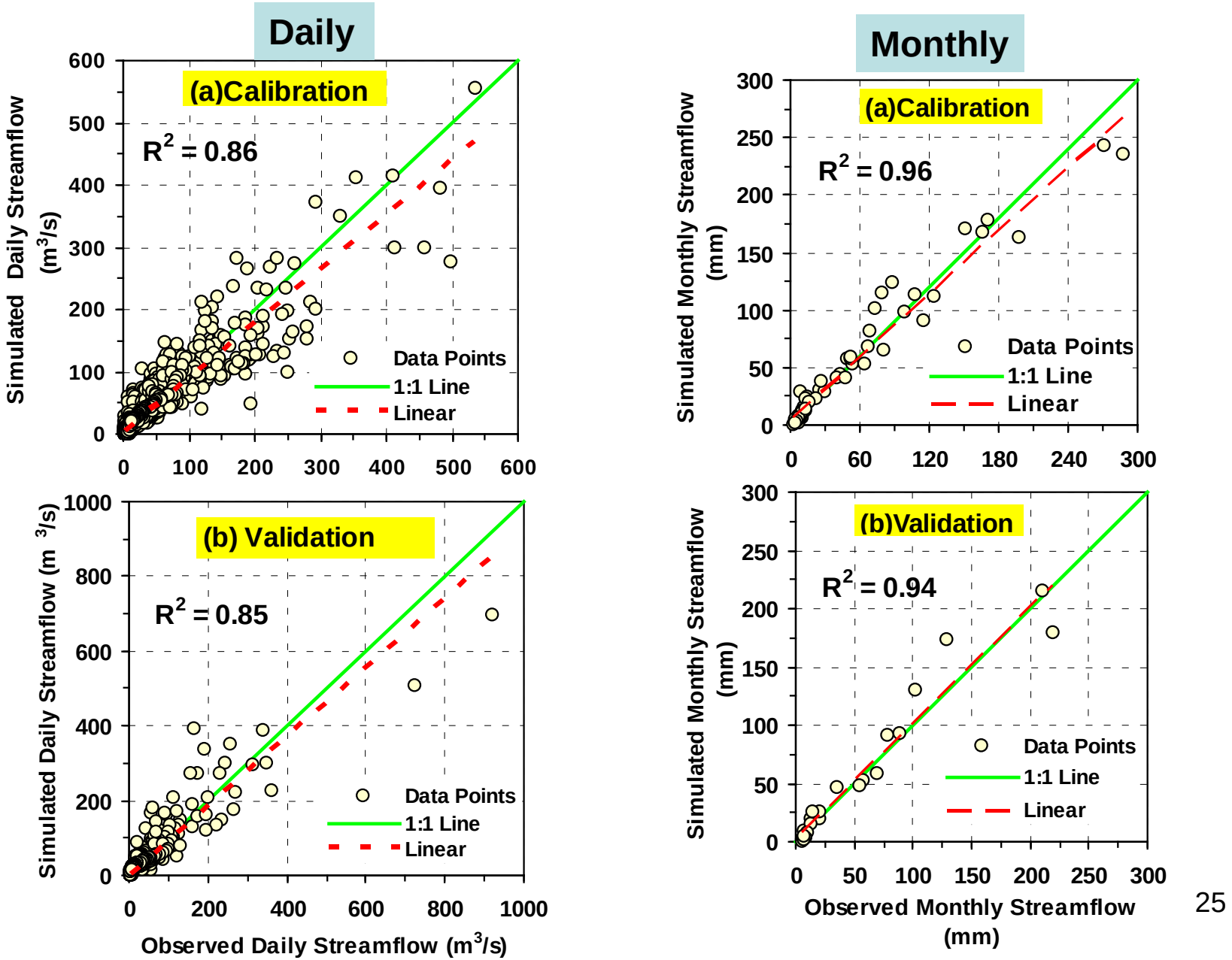
Comparison of Observed and SWAT Simulated Daily Streamflows Hydrographs for Validation Years 2004-2005



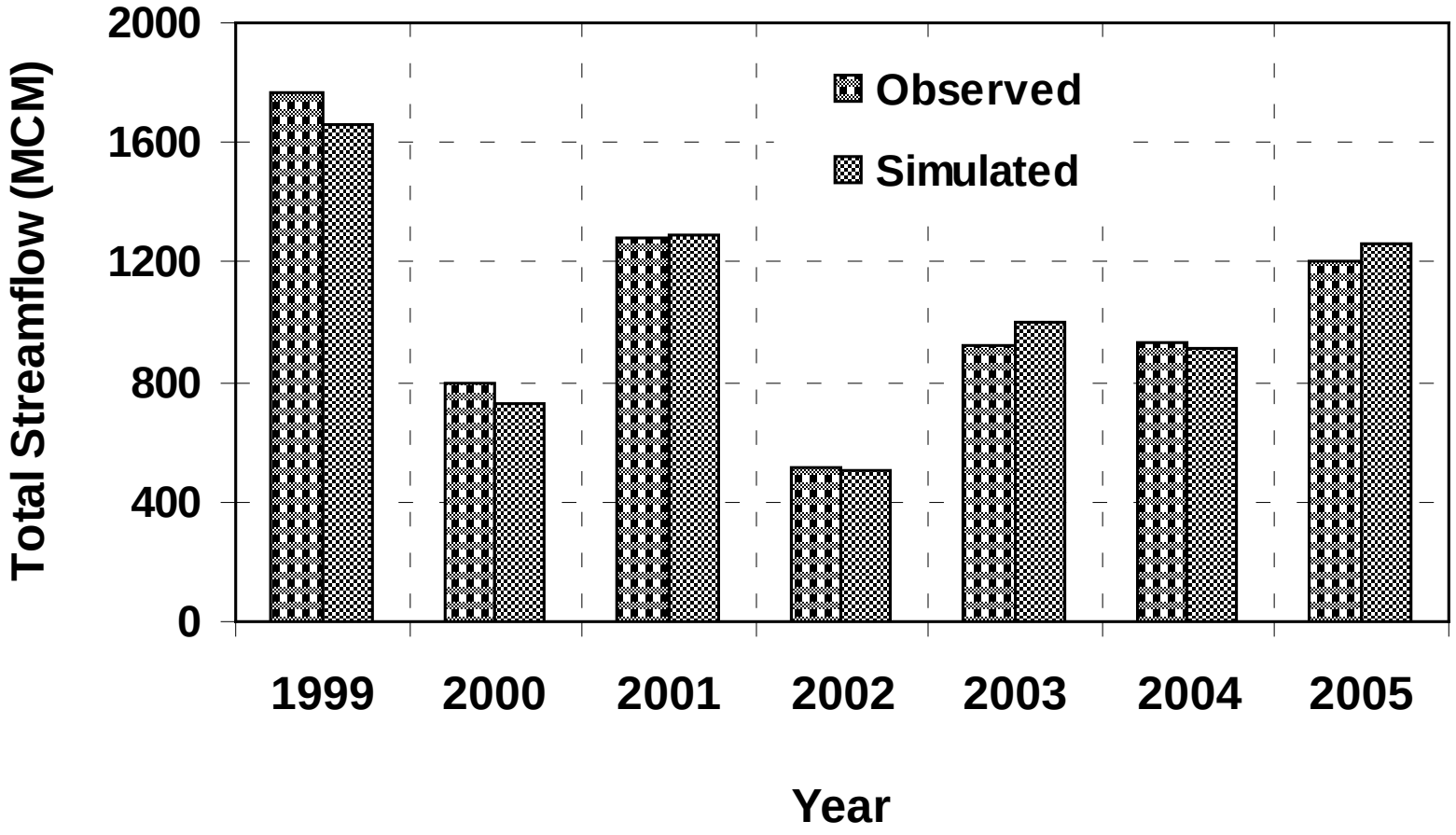
Observed and SWAT Simulated Monthly Streamflow Hydrographs



Scatter Plots of Observed and Simulated Streamflow



Bar Plots of Observed and Simulated Annual Streamflow



Conclusion

Based on the analysis of the results obtained in this study, the following conclusions could be drawn

- **Alpha_Bf was found to be the most sensitive parameters followed by Ch_N, Surlag, Cn2, Ch_K2, Gwqmn, Esco, Gw_delay, Sol_k, Slope, Sol_Awc, Sol_Z, Gw_revap, Epco, Revapmin, Canmax, Slsubbsn, and Biomix.**

- **Values of PBIAS, NSE, and R^2 during model calibration and validation at daily and monthly time steps were found to vary from -1.94 to 1.76, 0.84 to 0.95, and 0.86 to 0.96 respectively.**

Conclusion (contd.)

- **Lower values of PBIAS and RSR coupled with higher values of NSE and R^2 indicated that the SWAT model simulated streamflow within accepatable level of accuracy.**

- **Diffrerent graphical techniques used to evaluate model performance showed that there is a reasonably good agreement between observed and simulated daily and monthly streamflows as well as observed and simualted annual streamflow volumes for both calibration and validation period of model simulation.**

- **Overall, it can be concluded that the ArcSWAT model simulated streamflow satisfactorily. Therefore, ArcSWAT model can be used for future studies on wtershed modeling in the Upper Baitarni river basin.**

THANK YOU