https://doi.org/10.46344/JBINO.2020.v09i06.19

MODELLING OF RUNOFF AND SOIL EROSION USING SWAT MODEL IN SALEBHATA CATCHMENT OF MAHANADI BASIN

BANOTH MOHAN*, DR. CH.RAJENDRA SUBUDHI & D.M.DAS*****

*Ex M.Tech student, **Professor, ***Ph.D.student Dept. of SWCE, CAET, OUAT, Bhubaneswar-751003,Odisha

ABSTRACT

This study was undertaken during the year 2019 for partial fulfilment of M.Tech thesis under the Dept. of SWCE, CAET, OUAT, Bhubaneswar. In the present study physical based, semi-distributed river basin scale Soil and Water Assessment Tool (SWAT) model interface with Geographical Information System (ArcGIS) tool was used to simulate the runoff, sediment yield and to understand the sensitivity of model input parameters in Salebhata catchment area Mahanadi river basin (4,588.9 km^2) Odisha, India. The study was conducted to calibrate, validate and parameter sensitivity analysis was performed using the semi-automated algorithm (SUFI-2) in SWAT-CUP package. The model was calibrated for 10 years of time period starting from 1997 to 2006 which include 3 years of the warm-up period from 1997 to 1999, where the validation was done for 4 year period starting from 2007 to 20010 using field measured flow and sediment yield data. Performance of the SUFI-2 in SWAT-CUP was evaluated using various statistical indices such as Nash–Sutcliffe coefficient (E_{NS}), coefficient of determination (R^2) and Percentage Bias (PBIAS) showed a good correlation between the measured and model-simulated data. Model sensitivity analysis was carried out by recognizing 11 stream flow and 18 sediment yield parameters. Out of which Base flow alpha factor (ALPHA_BF) and Sediment concentration in runoff (SED_CON)was found to be most influencing parameters for runoff and sediment yield respectively. The observed and model simulated monthly stream flow with R^2 of 0.74 and 0.77, NSE of 0.69 and 0.62 with varying PBIAS of 4.4 to 20.3 respectively, during calibration and validation period. While sediment yield computed with R^2 of 0.65 and 0.72, NSE of 0.65 and 0.69 with varying PBIAS of (-) 23.0 to (-) 24.50 respectively, during calibration and validation period. Also, an attempt has been made to identify the critical sub-basin based on both runoff and sediment yield rank combination and performed the best management practices priority in order to reduce the runoff and sediment yield. From the performance efficiency of the model to simulate runoff and sediment yield, it can be concluded that the SWAT model really a good tool for simulation of runoff and sediment yield and could be used for the implementation of best management practices on critical sub-basin sale level.

INTRODUCTION

Today, Food security and environment protection are the most challenging responsibility in the world. Due to continuous increasing the population growth, the optimum use of available land and water resources is crucial for improving food security. To meet the demand for food, the forest area brought under continuous intensive cultivation lead to deterioration of the quality in terms of functionally land use capability.

About 85% of land in the world is affected by soil erosion (Angima *et al*., 2003). In India, about 113.3 million hectares of land is subjected severely eroded to water erosion, while 69 million hectares are critically degraded due to shifting cultivation and water logging condition.

Used to assess the long-time impact of management practices and global climate changeon soil erosion, water movement, crop growth, nutrient, pesticide yield, and non-point source pollution control, etc. with varying soil, land use and management conditions over a long period of time in the large and complex watershed (Arnold *et al*., 1998).

Model provides the number of algorithms programs to perform the calibration process they are SUFI-2 (Sequential Uncertainty Fitting ver.2), MCMC (Markov Chain Monte Carlo), GLUE (Generalized Likelihood Uncertainty Estimation), and Parasol (Parameter Solution) for calibration and validation, the uncertainty analysis are performing using the un-certainty program (SWAT-CUP) (Abbaspour *et al*. 2007).The objective of the study is to calibrate and validate the soil water assessment tool (SWAT) model to simulate runoff and soil erosion from Salebhata catchment area.

METHODOLOGY

Description of the study area

Salebhata Catchment comprising of Ong river basin, a major tributary of Mahanadi River, situated in the middle reach of Mahanadi river basin of Odisha, India was selected for the study. It coversSalebhata gauging station of the Ong catchment, and part of Balangir, Bargarh, Nuapada, Sonpur districts in the Odisha and Mahasamund district of Chhattisgarh. The catchment extending over an area of 4588.9 km^2 and lies between 20^0 40' 12" N to 21^0 25' 08" N latitude and 82^0 33'24" E to 83^0 24'11" E longitude as shown in Fig. 1.

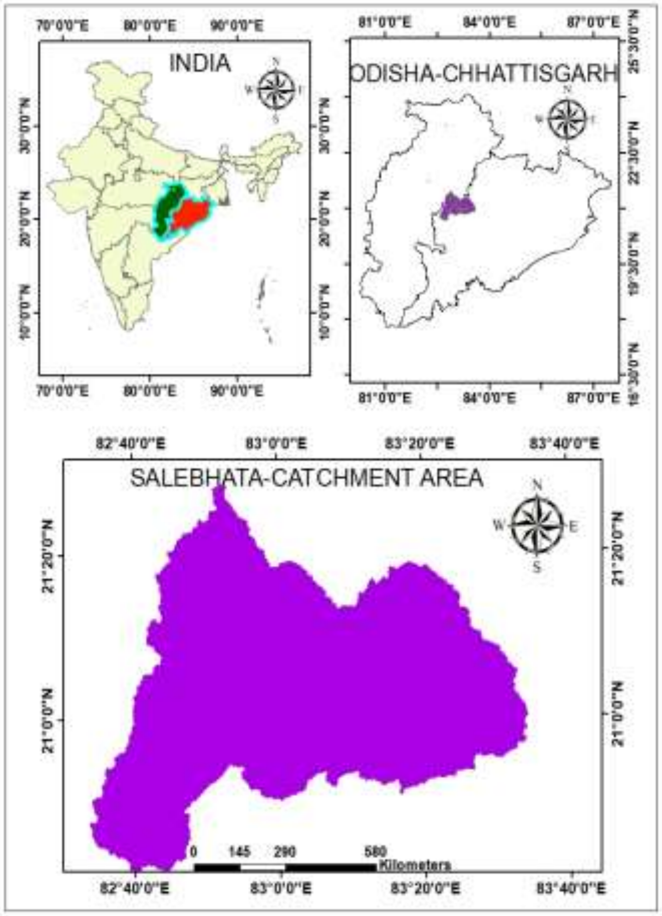


Fig. 1-Study area

It flows all across Odisha and joins Mahanadi in Sambalpur 11 km upstream of Sonpur where Tel River is merged.The river rises at an elevation of 457 m and runs 204 km before it meets Mahanadi. A major part of the study area under agricultural practices (75%), followed by forest, paddy is the main crop grown in the cultivable land. Fig.1 shows the Location of Salebhata catchment in Mahanadi basin at Odisha and Chhattisgarh.

SWAT Model

Srinivasan *et al*., (1994) develop the integration of a basin-scale model (SWAT) with GIS to automates inputs, to predict the effect of alternative management practices on water, sediment, and chemical yields from un-gaged rural basins. The model was developed by modifying the SWRRB model for application to large, heterogeneous rural basins.

Data required for the SWAT model

1 Meteorological data

The observed climatic data of the study area were collected from the Indian Meteorological Department (IMD) Bhubaneswar, from the period of 1997-2010. It is one of the important datasets for analysis of the watershed hydrology. The climatic parameters include daily precipitation, maximum and minimum temperature, relative humidity, wind speed, and sunshine hour.

2 Hydrological data

The hydrological flow and sediment yield data were required for calibration, uncertainty, performing sensitivity analysis and validation of the model. The hydrological data of the study area ware collected for a period of 1997-2010 from Water Resources Information System (India-WRIS). In this study, the model was calibrated from the period of 1997-2006 including 3 years warm-up period and validation carryout from the period of 2007-2010 done by using SWAT CUP tool SUFI-2 algorithm.

3. GIS data

A geographic information system (GIS) data are used to detailed analysis and mapping of the watershed topography, soil and land use/ land cover is important for proper hydrological modeling. In the present study SRTM GLOBAL digital elevation data ware acquired from USGS Earth Explorer, land use/ land cover (LULC) map ware collected from NRSC, ISRO Hyderabad and soil map ware obtained from *FAO World soil database*. The source and description of the data have been present in Table3.1.

Table 1 Data required for the SWAT model

Data Type	Source	Scale/Period	Data Description
DISCHARGE	India WRIS	1997-2010	Daily discharge data
SEDIMENT	India WRIS	1997-2010	Daily sediment data
SOIL MAP	FAO World soil database	1:500000	Soil type and classification
LAND USE	NRSC, ISRO, Hyderabad	1:250000	LISS III Land use classification
WEATHER	Indian Metrological Department, BBSR	1997-2010	Daily rainfall, maximum/minimum temperature, Wind speed and Sunshine hour
DEM/TERRAIN	SRTM Global file from USGS Earth Explorer	30m ×30m	Digital elevation model

4. Software used

1 ArcGIS 10.3

RESULT AND DISCUSSION

Table 2 Performance evaluation of sediment yield during calibration and validation period

Performance evaluation	Statistical parameters		
	R^2	NSE	PBIAS%
Calibration (2000-2006)	0.65	0.64	-24.5
Validation (2007-2010)	0.72	0.69	-25.0

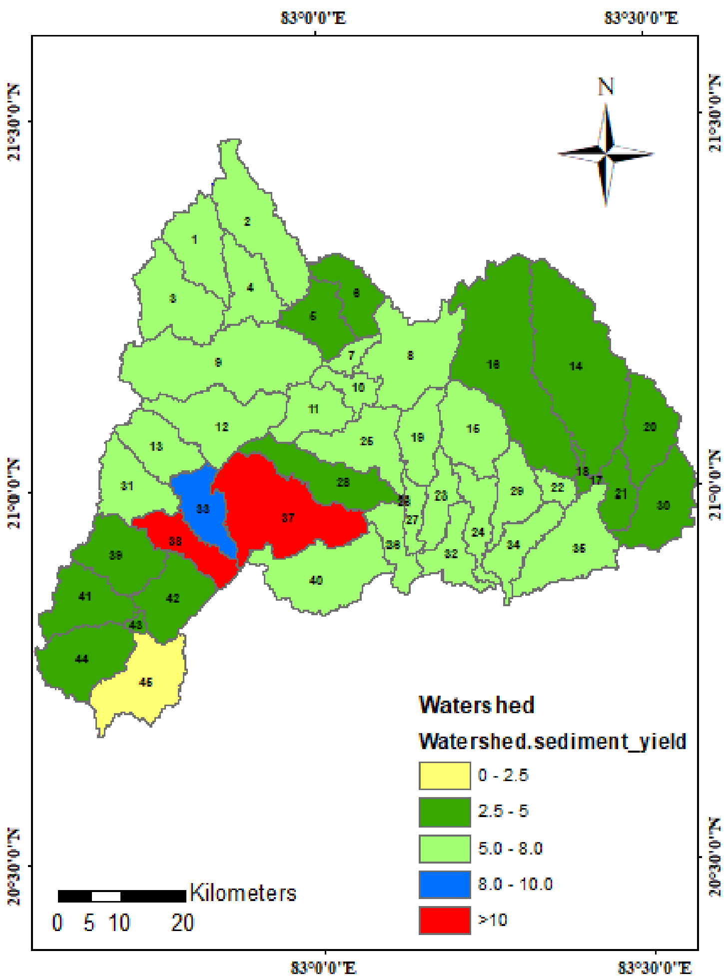
Table 3 Sub-basin wise distribution of sediment yield

Sl. No	Sub-basin	Surface runoff (mm)	Sediment yield (ton/year)
1	1	62.654	5.674
2	2	62.644	6.086
3	3	62.652	6.813
4	4	62.65	5.325
5	5	39.943	3.467
6	6	39.942	3.638
7	7	58.032	6.066
8	8	45.846	5.242
9	9	71.553	7.125
10	10	48.776	6.045
11	11	51.962	5.680
12	12	67.895	6.592

13	13	71.618	7.013
14	14	66.287	3.445
15	15	56.204	6.819
16	16	61.02	4.008
17	17	66.285	3.945
18	18	66.286	3.812
19	19	52.139	7.361
20	20	66.288	3.126
21	21	66.29	4.783
22	22	60.603	6.670
23	23	59.044	6.732
24	24	56.786	6.099
25	25	55.605	6.155
26	26	59.062	4.499
27	27	58.784	6.223
28	28	57.004	4.770
29	29	59.115	5.848
30	30	63.453	4.666
31	31	69.73	5.307
32	32	53.74	5.768
33	33	70.366	8.986
34	34	56.3	7.778
35	35	59.787	7.549
36	36	53.262	6.082
37	37	67.005	10.518
38	38	67.351	11.101
39	39	27.092	2.980
40	40	52.075	7.845
41	41	27.361	2.792
42	42	23.937	3.192
43	43	27.394	2.822
44	44	27.357	3.517

45	45	24.755	2.401

From the table 3 it is clear that sub-basin 37 and 38 contribute high rate of sediment yield 10.518 and 11.101 (ton/year) respectively, and majority (62%) of the sub-basins comes under moderate rate of sediment yield varies from 5.242 to 8.986 (ton/year), those sub-basin are 1, 2, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 19, 22, 23, 24, 25, 27, 29, 31, 32, 33, 34, 35, 36, and, 40 respectively.



CONCLUSION

From the performance efficiency of the model to simulate runoff and sediment yield, it can be concluded that the SWAT model really a good tool for simulation of runoff and sediment yield and could be used for the implementation of best management practices on critical sub-basin sale level.

REFERENCES

Abbaspour, K.C., Yang, J., Maximov, I., Siber, R., Bogner, K., Mieleitner, J. and Srinivasan, R. (2007). Modeling hydrology and water quality in the pre-alpine/alpine Thur watershed using SWAT. *Journal of Hydrology*, **333(2)**: 413-430.Angima, S., Stott, D, O neill, M., Ong, C. and Weesies, G. (2003).Soil erosion prediction using RUSLE for central Kenyan highland conditions. Agriculture, Ecosystems and Environment, 97: 295-308.

Arnold, J.G., Srinivasan, R., Muttiah, R.S. & Williams, J.R. (1998). Large area hydrologic modeling and assessment. *Journal of the American Water Resources Association*, **34(1)**: 73–89.

Srinvasan, R. and J. G. Arnold, J.G. (1994). Integration of a basin-scale water quality model with GIS. *Water resources bulletin,* Vol. **30(3)**: pp. 453-462.