Journal of Agrometeorology 20 (4) : 325-328 (December 2018)

Short Communication

Prediction of climate change impact on streamflow and evapotranspiration in Baitarani basin using SWAT model

J. PADHIARY[1], D. M. DAS[2], K. C. PATRA[1], B.C.SAHOO[2], K. K. SINGH[3]

[1]*Department of Civil Engineering, NIT, Rourkela*

[2] *SWCE, CAET, OUAT, Bhubaneswar*

[3]*India Meteorological Department, New Delhi*

Email: jagadishpadhiary@gmail.com[1]

dwarika.dmd@gmail.com[2]

Global warming driven emission of greenhouse gases has been the main cause of climate change leading to increase in atmospheric temperature. Consequent changes in rainfall due to increase in air temperature over a long period of time are two main indicators of climate change. Climate change associated with variation in precipitation pattern, distribution of floods and droughts over time and space across the world has enhanced the uncertainty in availability of water for agriculture and other uses (Frederick and Major, 1997; Ficklin *et al*., 2012; Dar *et al.,* 2017). Achievement of sustainable crop production depends upon meeting the water demand of crops using the available water resources. Streamflow and evapotranspiration (ET) are two hydrological processes of paramount importance to be considered for assessing surface water availability and water demand for agricultural production system in river basin scale. Hence, to study the impact of climate change on streamflow and evapotranspiration is imperative to examine the sustainability of the current agricultural production system and to plan accordingly for the future.

Hydrologic models are very prominent tools for mathematical representation of the interactions among hydrologic processes, soil properties, land use and climate (Gosain *et al.*, 2006; Saharia and Sarma, 2018). Therefore, it is very much emphasized to simulate the hydrologic responses to climate change. The SWAT model is an effective modelling tool for simulating streamflow and other hydrological parameters at watersheds scale (Praskievicz and Chang, 2009). In the present study, SWAT model has been used to predict future changes in streamflow and evapotranspiration commensurate with climate change in the Baitarani river basin of Odisha.

Baitarani river is one of the major east flowing rivers of Odisha. It originates from the hilly tracts of Keonjhar district of Odisha. The geographical extent of the river basin spreads through 85°10' to 87°03' E longitude and 20°35' to 22°15' N latitude. The annual rainfall over the basin ranges from 750 to 1400 mm with a normal rainfall of 1185 mm. The maximum temperature over the basin is recorded to be 48.5°C during summer and the minimum temperature is 6°C during winter.Odisha and Jharkhand shares 93.3 per cent and 6.7 per cent area of the total basin, respectively. The basin extends over Keonjhar, Mayurbhanj, Balasore, Cuttack, Sundergarh and Dhenkanal districts of Odisha. Rice-pulse system describes the major cropping system of the basin in addition to maize, wheat, and vegetables like brinjal, tomato, cole crops which are the existing cropping scenarios in various topo-sequences.

SWAT has been calibrated and validated for monthly streamflow by comparing the observed streamflow at Anandapur outlet of Baitarani basin. The model was run for a period of 24 years (1987–2010) out of which first 3 years (1987 – 1990) considered as the warm-up period. Streamflow data from 1990 to 2000 were used for calibration whereas; the remaining 10 years of the data (2001–2010) were used for validating the model.The regional climate model(RCM) HadGEM3-RA (http://cordex-ea.climate.go.kr) has been used to project future precipitation, maximum and minimum temperatures of the basin. Two representative concentration pathway (RCP) scenarios: RCP 4.5 and RCP 8.5 that represent future medium and high emissions of carbon, respectively, were taken into consideration for predicting the future rainfall and temperature scenarios. The linear scaling method of bias correction was used to the grid-based climate model data for local observed stations to predict the future climate in a decadal time frame.Further, the future meteorological data so obtained are used as input data in SWAT model to simulate future streamflow and evapotranspiration. The analysis was carried out for two future time frames such as the period 2021–2045 and again, 2046–2070 and compared

Table 1: Average monthly and annual streamflow and evapotranspiration in Baitarani basin

Month	Base period	RCP 4.5		RCP 8.5	
	(1987–2010)	(2021–2045)	(2046–2070)	(2021–2045)	(2046–2070)
		Streamflow (mm)			
January	21.4	0.0	0.0	0.0	0.0
February	3.6	0.0	6.4	0.0	0.0
March	0.0	0.0	0.0	0.0	0.0
April	5.8	0.0	0.0	0.0	0.0
May	0.0	0.0	2.6	0.5	0.2
June	16.3	6.1	20.7	29.9	27.8
July	160.3	466.8	387.1	633.7	576.4
August	268.5	275.0	201.1	127.1	122.1
September	112.1	15.9	90.3	4.9	43.2
October	54.6	8.2	126.4	31.2	10.5
November	9.3	61.5	0.0	0.0	0.0
December	1.3	0.0	10.2	0.0	0.0
Annual avg.	653.3	833.6	845.0	827.4	780.3
		Evapotranspiration (mm)			
January	26.5	34.6	27.8	36.6	35.0
February	28.7	53.4	48.5	48.3	34.1
March	80.3	68.0	65.1	64.0	60.5
April	47.2	72.1	52.9	69.0	59.8
May	19.4	54.3	63.1	58.4	54.4
June	45.9	72.4	71.7	65.4	66.5
July	71.2	79.1	72.9	78.8	75.9
August	80.6	92.4	90.4	94.9	98.5
September	68.1	65.7	66.0	67.1	69.8
October	49.3	54.6	56.9	54.4	51.4
November	34.4	42.3	41.0	40.7	35.6
December	16.7	35.7	28.5	31.3	27.5
Annual avg.	568.3	724.6	684.9	708.9	669.2

with base period 1987–2010.

The SWAT model prediction reveals an increasing trend of discharge and evapotranspiration in both the scenarios as compared to the base period (Table 1). However, the increasing trend of average annual discharge was more conspicuous under RCP 4.5 than RCP 8.5. It is interesting to note that the highest discharge as recorded in the month of August for the base period 1987–2010 is gradually shifting towards July under RCP 4.5 (2021–2045, 2046–2070) and RCP 8.5 (2021–2045, 2046–2070). It may be due to the change in the precipitation pattern during the projected periods. The revelation portrays the fact that the present practice of transplanting rice during end part of July to middle of August in the study basin is likely to shift to July only in future and the reason for the same is attributed to the highest water availability during the month. Similarly, the projected average ET shows an increasing trend in both the scenarios as presented in Table 1. On the contrary, the highest value of ET as recorded in the month of August for the base period is unlikely to change in both the future

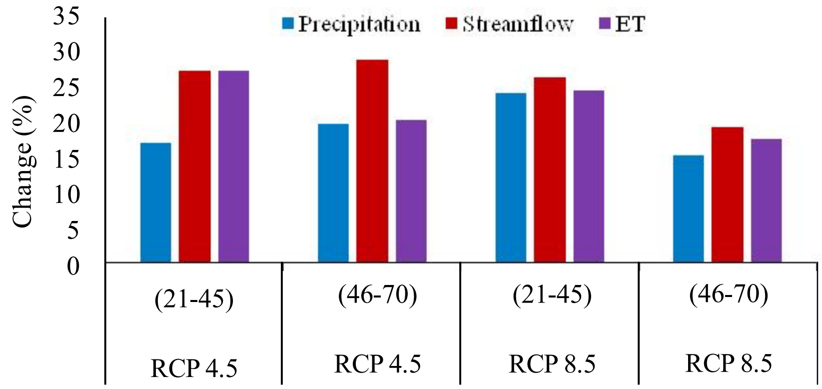

Fig. 1: Projections of average annual changes in precipitation, streamflow and ET with respect to base period under RCP 4.5 and 8.5

scenarios and thus, no shifting of the event has been suggested in the study.

Annual changes in streamflow and evapotranspiration for RCP 4.5 and RCP 8.5 scenarios from the base periods are illustrated in Fig. 1.As compared to the annual discharge during the base period, the event may rise up to the extent of 27.6 per cent for RCP 4.5 and 26.7 per cent for RCP 8.5 during the period 2021–2045, respectively and again, 29.3 per cent for RCP 4.5 and 19.4 per cent for RCP 8.5 during the period 2046-2070. This may be due to the increase in the projected precipitation during coming 50 years (Fig. 1). Further, it is observed that the percentage increase in streamflow is at a higher rate than the corresponding increase in precipitation under both the scenarios. This indicates that the rainfall will be more intense in coming 50 years. Under no change in land use scenario, the higher intensity of rainfall will be the driving force for boosting the streamflow in coming years. Considering the current trend of decrease in forest cover and increase in concrete cover due to urbanization, the trend of increase in steamflow may exacerbate further resulting in lesser recharge of groundwater leading to further decline in water table.

Similarly, percentage increase of average annual evapotranspiration as compared to the base period may rise up to 27.5 per cent under RCP 4.5 and 24.7 per cent under RCP 8.5 during the period 2021–2045 and again, 20.5 per cent for RCP 4.5 and 17.7 per cent for RCP 8.5 during the period 2046-2070, respectively. Evapotranspiration being a climate driven variable, its increase is mostly caused due to increase in ambient temperature. Thus, it is assumed that the trend of atmospheric temperature is likely to follow an upward trajectory in coming 50 years. The prediction analysis depicts an increasing trend in agricultural water demand across Baitarani river basin during coming 50 years.

Overall, the decreasing trend of water availability for crops is likely to intensify further due to more runoff losses in the form of streamflow. On one hand, the crop is expected to suffer from moisture stress owing to frequent dry spells and on other hand, unexpected inundation due to frequent flash floods vis-à-vis intensive rainfall across the basin during monsoon season. Therefore, for achieving sustainable crop production in order to meet the food grain demand of growing population, the following suggestions may be underlined.

- Climate resilient cropping pattern to utilize the monsoon rain effectively
- More storage structures across the basin to restrict the streamflow and harvest the excess for irrigation during dry spells
- Heavy duty crops grown at present across the basin may be substituted by light duty ones or low duration varieties to mitigate the higher irrigation demand of the crops accentuated under the increasing trend of evapotranspiration.
- Emphasis on more afforestation, and soil and water conservation measureswould help reducing the runoff losses across the basin and thereby, increasing the *in situ*soil moisture storage and groundwater recharge.

REFERENCES

Dar, Mehraj D., Aggarwal, R. and Kaur, S. (2017). Effect of climate change scenario on yield and water balance components in rice-wheat cropping system in central Punjab. *J. Agrometeorol.,* 19(3); 226-229.

Ficklin, D.L., Stewart, I.T. and Maurer, E.P. (2012). Effects of projected climate change on the hydrology in the Mono

Lake Basin, California. *Climate Change*, 116: 111-131.

Frederick, K.D. and Major, D.C. (1997). Climatic change and the water resources. *Climate Change*, 37 (1): 7-23.

Gosain, A. K., Rao, S. and Basuray, D. (2006). Climate change impact assessment on hydrology of Indian river basins. *Current Sci.,* 90(3): 346-353.

Praskievicz, S. and Chang, H. (2009). A review of hydrological modelling of basin-scale climate change and urban development impacts. *Prog. Phys. Geog*. 33 (5): 650–671.

Saharia, A.M. and Sarma, A. K. (2018). Future climate change impact evaluation on hydrologic processes in the Bharalu and Basistha basins using SWAT model. *Nat. Hazards*, 92: 1463-1488.

Received : November 2018; Accepted: November 2018