

The application of SWAT (Soil and water assessment tool) model to predict the hydrology characteristics garang watershed in Central Java province

by Suharyanto Suharyanto

Submission date: 12-Dec-2019 09:25AM (UTC+0700)

Submission ID: 1232770445

File name: lication_of_SWAT_Soil_and_Water_Advance_Science_Letter_2017.pdf (351.13K)

Word count: 1649

Character count: 8348



The Application of SWAT (Soil and Water Assessment Tool) Model to Predict the Hydrology Characteristics Garang Watershed in Central Java Province

Imam Saifudin^{1,*}, Suripin², and Suharyanto²

1. INTRODUCTION

Land use planning is very important to do so does not cause a bad influence on the hydrological characteristics of the watershed. The dynamics hydrological characteristics demonstrate the performance a watershed in securing the availability of water.¹ Increasing capacity of infiltration and decrease runoff to be a priority in the preparation of land use. The influence of land use on watershed hydrology system is closely related to human activities in land use. The influence of population growth to the increase in land use resulting in changes in forest land use in the upstream Garang watershed. Changes in land use from one type to the other either permanently or temporarily become one focus in watershed management planning.² Land use forest changes in the watershed Garang from 1990 to 2000 amounted to 1957.69 ha to 1769.44 ha led to an increase in surface runoff coefficient (*c*) from 28% (1991) to 77% (2000).³

Study land use change on hydrologic characteristics can be done using a hydrological model.⁴ One of the hydrological model which is well used is a model SWAT developed for the USDA (United States Department of Agriculture) but it is also recommended to be developed by the association of soil and water conservation world (World Association for Soil and Water Conservation, WASWAC).

*Author to whom correspondence should be addressed.

The SWAT is Ecohydrologi Models⁵⁻⁷ has been tested for a wide range of watershed scales and environmental conditions worldwide⁸⁻¹¹ and has been used extensively to evaluate the impact of land use/land cover (LULC) changes on watershed hydrology, sediment results, nutrient dynamics (among other processes) and water quality.⁹⁻¹³ SWAT is a hydrological model that is widely used to evaluate the impacts of climate change, land use, and land management of the hydrological characteristics.¹⁴ This study aims to predict the hydrological characteristics of the Garang watershed using Model SWAT.

2. MATERIALS AND METHODS

2.1. Description Research Area

Garang watershed is located in Central Java Province, Indonesia. It has drainage area of 212.77 km², and situated between latitudes 06°45'18"–07°20'45" S and between longitudes 105°41'51"–109°33'33" E. The length of the main stream is 40.52 km.¹⁵ Garang watershed dominated soil types latosol, which comprised 63.03% of the entire watershed area Garang.

2.2. Data Input

Keys SWAT input data layer include a Digital Elevation Model (DEM), soil maps and soil characteristics, land use maps, and climate data. There are three climatology station (Mijen,

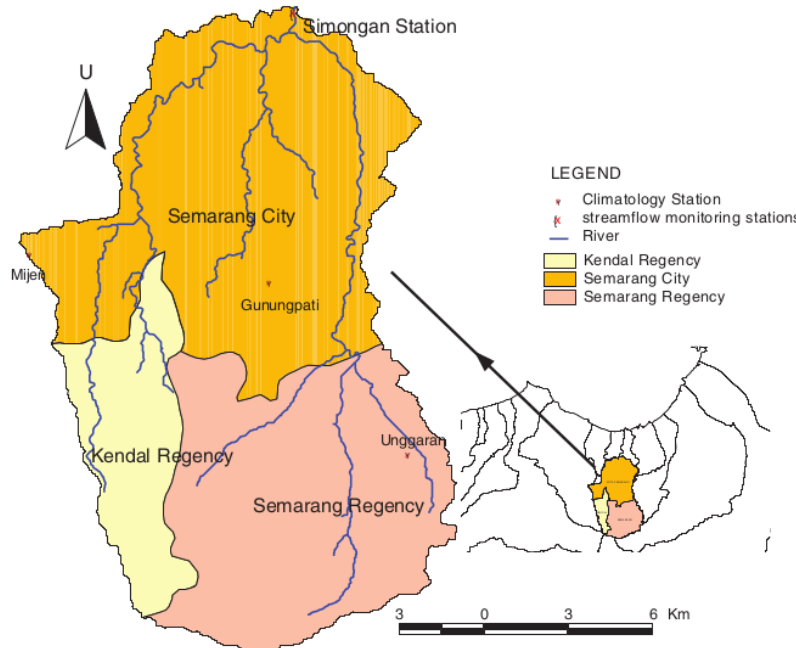


Fig. 1. Map of Garang Watershed showing relative location of meteorological, hydrologic station and stream network.

Gunungpati and Unggaran) that located in Garang Watershed (Fig. 1). In addition there is a streamflow monitoring station (Simongan), which is located at the outlet Garang Watershed.

Ten year of daily meteorological data (2001–2010) were analyzed and processed into mean monthly meteorological statistics to create data that was representative of the study area for SWAT weather generator. Daily minimum and maximum air temperature, wind speed, solar radiation and relative humidity obtained for the three climatology stations are shown in Figure 1 are used for simulation of SWAT.

2.3. Description of the Model

The SWAT models regarded as one of the most suitable model to predict the long-term impact of management actions land on water, sediment and results of agricultural chemicals (loss of nutrients) in the watershed large complex with ground varying, land use and conditions management.^{16, 17} The SWAT models is based on the physical, conceptual, continuous-time spatial parameter distributed watershed model operates on a daily time step. It is not designed to simulate a detailed, one event routing.¹⁸

2.4. Evaluation Model Method

The performance of the model was evaluated by the coefficient determination (R^2), and Nash-Sutcliffe efficiency (NSE) index.¹⁹ The R^2 is the square of the correlation coefficient and can range from 0 to 1. An R^2 value of 1 indicated a perfect alignment between predicted and observed values while an R^2 value of 0 indicates no alignment between predicted and observed values.

The R^2 can be calculated using the following formula:

$$R^2 = \frac{[\sum_{t=1}^n (O_t - \hat{O}) - (P_t - \hat{P})]^2}{[\sum_{t=1}^n (O_t - \hat{O})^2][\sum_{t=1}^n (P_t - \hat{P})^2]} \quad (1)$$

Where P_t is the magnitude of the predicted value (model), \hat{P} is the value of the average forecast, O_t is the value of observation (field) and is the value of the average observation (field). Value for NSE can range between $-\infty$ and 1. The NSE criteria²⁰ include: values between 0.5–0.65 are acceptable; values between 0.65–0.75 are good and values that exceed 0.75 are very good. The Nash-Sutcliffe coefficient is calculated as:

$$NSE = \frac{\sum_{t=1}^n (O_t - \hat{O})^2 - \sum (P_t - O_t)^2}{\sum_{t=1}^n (O_t - \hat{O})^2} \quad (2)$$

3. RESULTS AND DISCUSSION

3.1. Hydrological Response Unit (HRU)

Watershed delineation process of the networks formed the main river watersheds and 29 subbasins with a total area of 18,951.81 ha. Additionally formed 314 Hydrological Response Unit (HRU).

3.2. Parameter Calibration

Table I shows the parameters that affect surface runoff, among others CN2, SOL_AWC, SOL_K, SOL_BD, OV_N, GW_DELAY, GWQMN, CH_N2, CH_K2, ALPHA_BNK, ALPHA_BF, ESCO, and LATTIME. There are 13 parameters that are sensitive to the flow rate that will be carried out for

Table I. Parameters determined from sensitivity analysis.

| Parameters | Definition | Initial value | Final value | Range value |
|------------|---|--------------------------|-------------|-------------|
| CN2 | Curve numbers | Multiply original values | 1.085 | 35–98 |
| SOL_AWC | Available water capacity of the soil layer (mm H ₂ O/mm soil) | Multiply original values | 0.05 | 0–1 |
| SOL_K | Saturated hydraulic conductivity (mm/hr) | Multiply original values | 0.77 | 0–2000 |
| SOL_BD | Moist bulk density (g/cm ³) | Multiply original values | 0.71 | 0.9–2.5 |
| OV_N | Manning "n" value for overland flow | Multiply original values | 2.85 | 0.01–30 |
| GW_DELAY | Groundwater delay time (days) | 31 | 500 | 0–500 |
| GWQMN | Threshold depth of water in the shallow aquifer required for return flow to occur (mm H ₂ O) | 1000 | 225 | 0–5000 |
| CH_N2 | Coefficient manning the main channel | 0.014 | 0.0175 | 0.01–0.3 |
| CH_K2 | Hydraulic conductivity of river | 0 | 180 | 25–500 |
| ALPHA_BNK | Baseflow alpha factor for bank storage (days) | 0 | 0.083 | 0–1 |
| ALPHA_BF | Baseflow alpha factor for bank storage (days) | 0.048 | 0.842 | 0.01–1 |
| ESCO | Soil evaporation compensation factor | 0.95 | 1 | 0.01–1 |
| LAT_TTIME | Lateral flow travel time (days) | 0 | 175 | 50–180 |

calibration, the original parameters used to test the sensitivity analysis are 28 parameters.

3.3. SWAT Performance

Observation and simulation data series of river discharge period January 1 to December 31, 2009 (calibration) and January 1 to

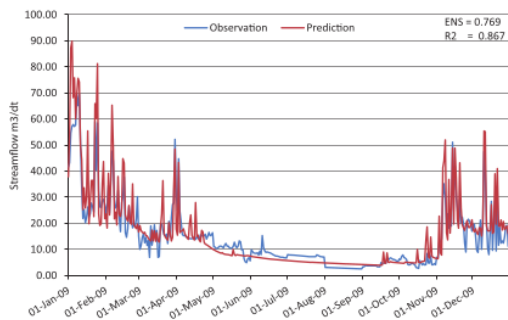


Fig. 2. Relationship streamflow SWAT model results and streamflow observations after being calibration.

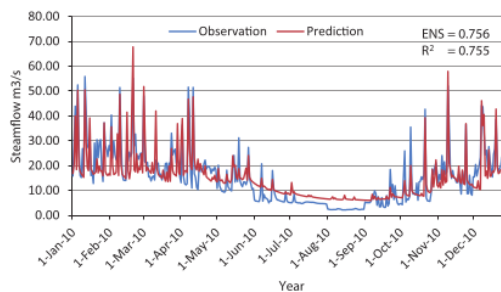


Fig. 3. Relationship streamflow SWAT model results and streamflow observations after being validated.

December 31, 2010 (validation) at the measuring daily basis stations Simongan. The results are as shown in the Figure 2 that some excessive time and some time is reduced, but overall performed well during the simulation. Seen during the calibration period, the value of NSE and R² respectively 0.769 and 0.867. Relations streamflow SWAT model results and streamflow observations after being validated is shown in Figure 3. The results of the validation is decreasing the value of NSE and R² both have value almost the same, namely 0.755. These results indicate that the predicted streamflow during periods of extremely accurate calibration, but slightly reduced streamflow measured during the validation period. Calibration and validation results show that the model SWAT including criteria very good.

3.4. Hydrology Characteristics

SWAT modeling in Garang Watershed resulted hydrological characteristics. Those were surface runoff was 1645.09 mm, maximum streamflow was 67.71 m³/s, minimum streamflow was 5.96 m³/s, interflow was 44.86 mm and base flow was 915.96 mm. The coefficient of river regim was 11.36, it compared maximum and minimum streamflow and was in good category. Coefficient runoff was 0.53, that means 53% of the rainfall went to watershed Garang.

4. CONCLUSION

In conclusion, this study shows that SWAT model was applied to Garang watershed, Central Java Province, (18,951.81 ha) for the modeling of the hydrological. So the hydrological characteristics of watersheds Garang results for 2010 year was surface runoff was 1,645.09 mm; maximum streamflow 67.71 m³/s; minimum streamflow was 5.96 m³/s; coefficient of river regime was 11.36; the value of c (coefficient runoff) was 0.53; lateral flow was 44.86 and baseflow 915.96 mm.

Acknowledgments: This research supported by the Ministry of Environment and Forestry of Republic Indonesia through the Center for Education and Training of human resources. We wish to thank the Center for Watershed Management Pemali Jratun, Semarang and Masters Program in Environmental Science of Diponegoro University for supporting the success of this study.

The application of SWAT (Soil and water assessment tool) model to predict the hydrology characteristics garang watershed in Central Java province

ORIGINALITY REPORT

23%

SIMILARITY INDEX

18%

INTERNET SOURCES

14%

PUBLICATIONS

13%

STUDENT PAPERS

PRIMARY SOURCES

1

www.abepublishing.org

Internet Source

13%

2

Submitted to Kwame Nkrumah University of Science and Technology

Student Paper

2%

3

Santra, Priyabrata, and Bhabani Sankar Das. "Modeling runoff from an agricultural watershed of western catchment of Chilika lake through ArcSWAT", Journal of Hydro-environment Research, 2013.

Publication

1%

4

www.tandfonline.com

Internet Source

1%

5

link.springer.com

Internet Source

1%

6

Boini Narsimlu, Ashvin K. Gosain, Baghu R. Chahar. "Assessment of Future Climate Change Impacts on Water Resources of Upper Sind

1%

River Basin, India Using SWAT Model", Water Resources Management, 2013

Publication

-
- | | | |
|----|---|-----|
| 7 | ir.library.oregonstate.edu Internet Source | 1% |
| 8 | Neupane, Ram P., and Sandeep Kumar. "Estimating the effects of potential climate and land use changes on hydrologic processes of a large agriculture dominated watershed", Journal of Hydrology, 2015. Publication | 1% |
| 9 | Angela Candela. "Receiving water body quality assessment: an integrated mathematical approach applied to an Italian case study", Journal of Hydroinformatics, 01/2012 Publication | <1% |
| 10 | www.mdpi.com Internet Source | <1% |
| 11 | Zhi Li, WenZhao Liu, XunChang Zhang, FenLi Zheng. "Assessing and regulating the impacts of climate change on water resources in the Heihe watershed on the Loess Plateau of China", Science China Earth Sciences, 2010 Publication | <1% |
| 12 | "Groundwater Recharge and Contribution to the Tana Sub-basin, Upper Blue Nile Basin, Ethiopia", Springer Geography, 2016. | <1% |

13

Submitted to Asian Institute of Technology

Student Paper

<1%

14

Jing Yin, Fan He, YuJiu Xiong, GuoYu Qiu.

"Effect of land use/land cover and climate changes on surface runoff in a semi-humid and semi-arid transition zone in Northwest China",
Copernicus GmbH, 2016

Publication

<1%

Exclude quotes Off

Exclude matches Off

Exclude bibliography Off

The application of SWAT (Soil and water assessment tool) model to predict the hydrology characteristics garang watershed in Central Java province

GRADEMARK REPORT

FINAL GRADE

/0

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4
