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Regional Case Study

Sensitivity Analysis on Soil and Water Assesment Tool (SWAT) Model at Brantas Watershed, East Java Indonesia

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Abstract

Brantas Watershed and its tributaries (approximately 14,103 km^2) are essential in supplying water for About 30% of the East Java province population. Management of water resources in this watershed has become a challenging issue. The modelling processes' conformity and results to mimic the existing hydrological processes are still in question. This study aims to analyze sensitive parameters of the SWAT (Soil & Water Assessment Tool) model on the significant watershed. The input model is climate and spatial (DEM, soil layer, LULC) data. The observes the hydrological processes monthly and annually from the model result. Next, Sensitivity analysis using the SWAT-CUP tool and SUFI algorithm shows 18 sensitive parameters. The nine (9) parameters have a more than 50% sensitivity level. The four (4) correlated to the soil layer's runoff generation and water movement. Then, eight (8) parameters are related to baseflow calculation. Simulation results illustrate the strong effect of climate change (especially rainfall) on water yield and sedimentation.

Keywords: Sensitivity; analysis; SWAT-CUP; SUFI; brantas; east java

1. Introduction

Brantas watershed (Figure.1) covers an area of approximately 14,103 km^2, equivalent to 30% of the East Java Province area (approximately 47,075.35 km^2). The main river length of Brantas reaches 320 km (Kementrian PUPR, 2010). This watershed area comprises 19 Regencies (District) and Cities areas. The Brantas areas cover the administrative regency/city of Malang, Kediri, Blitar, Nganjuk, Batu, Blitar, Tulungangung, Trenggalek, Jombang, Mojokerto, Sidoardjo and Surabaya. The population in the Brantas watershed was around 16.2 million in 2010 (census) and approximately 16.9 million in 2015 (Projection) (BPS Jatim, 2014). About 30% of the East Java population has occupied the watershed land resources for residential, agricultural, urban, city facilities, road networks, tourism sites, plantation, industry, and other social-cultural and economic activities. The Brantas river network and its tributaries supply water for residential use, gearing the industry, electricity source, drainage, irrigating the agricultural field, and tourism activities (JICA, 2019). About 60% of the agricultural product of the province comes from the Brantas tributaries. Major reservoirs or Dam have been constructed on the Brantas tributaries, i.e., D1 (Sengguruh reservoir), D2 (Sutami), D3 (Lahor), D4 (Selorejo), D5 (Lodoyo), D6 (Wlingi), D7 (Wonrorejo), D8 (Waru Turi), D9 (Menturus), D10 (Gunungsari), D11 (Gubeng), and D12 (Jagir Dams) (Figure 1).

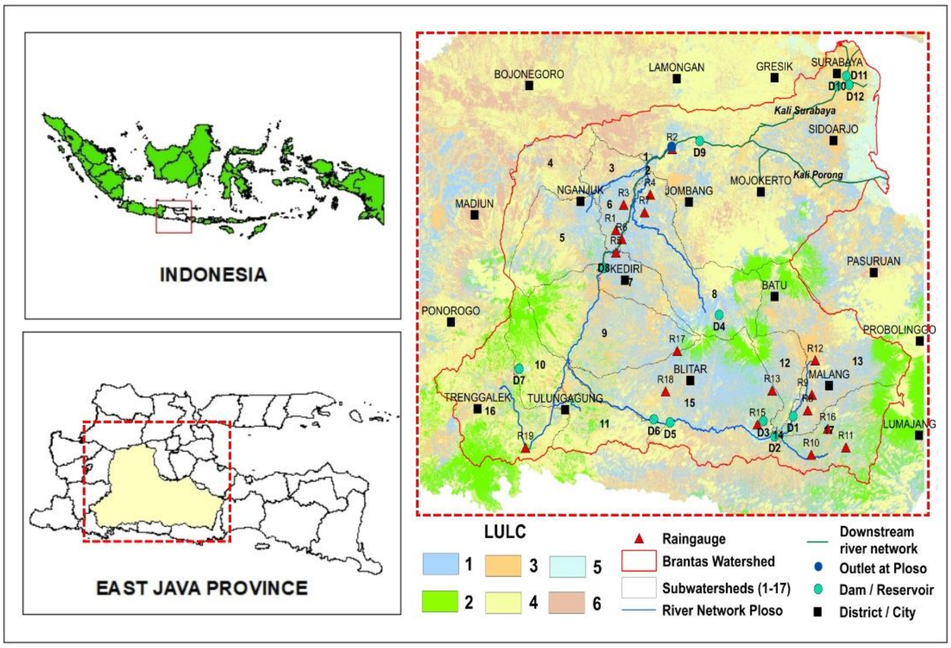

Figure 1. Study site

The complexity of the watershed ecosystem requires a model to simplify the explanation of the watershed system. SWAT (Soil & Water Assessment Tool) models provide reliable features in analyzing this complex watershed. Several studies using SWAT models by (Joseph et al., 2021; Liu et al., 2021; Rani and Sreekesh, 2021) have analyzed their watershed hydrological systems. Modelling this complex watershed system and using limited data available are challenging issues. How do we reduce the system's complexity to modulate the essential hydrological processes? How to adjust the parameter's value in the model with the limited data constraint. Thirdly, how to justify and explain that modelling processes and results can mimic the natural phenomenon questioned.

Consequently, a calibration technique is needed to solve this problem. Calibration is adjusting model parameter components to local conditions to reduce uncertainty, while validation shows a feasible model based on function and time (Arnold et al., 2012). SWATCUP is a computer program used to calibrate and validate SWAT hydrological models. SWATCUP is easily accessible, thus shortening the calibration time and process (Abbaspour et al., 2008). SWAT-CUP has four program links: GLUE, ParaSol, MCMC, and SUFI2. The SUFI2 (sequential uncertainty fitting version 2) algorithm can optimize the model with many parameters (Abbaspour, 2015). SUFI-2 can analyze the uncertainty of input data with minimal estimation intervals. This study analyses of effect on the SWAT model's sensitive parameters using the SWAT-CUP Tool and SUFI (Sequential Uncertainty Fitting) algorithm (Abbaspour, 2015). Sensitivity analysis was conducted following the previous publication (Arnold et al., 2012; Moreira et al., 2018; Brighenti et al., 2019). The hydrological processes are modelled at the monthly level. The hydrological processes are modelled at the monthly level. The study was focused on Brantas Watershed in East Java Province, Indonesia.

The SWAT model (Krysanova and Arnold, 2008) has more comprehensive equations and features. SWAT can calculate the quality and quantity of soil and water-related hydrological processes. The SWAT model is based on HRU (Hydrological Response Unit) to calculate the spatially distributed hydrological processes (Arnold et al., 2012). The vertical components of water balance are computed for each HRU. Then the runoff, sediment, and nutrient are accumulated from HRUs to each sub-basin. The horizontal movement of water, nutrient and sediment from each sub-basin to the watershed outlet is calculated using the transfers function (Arnold et al., 2012).

2. Methods

2.1. Input Data

This study use flow measurement located at Ploso. Then, from Ploso as an Outlet, the boundary of the sub-watershed is delineated. The sub-watershed area covers an area of 8,844.26 km² (Figure 1). The inputs for SWAT are the digital elevation model (DEM), soil characteristics, land cover, climate variables (Temperature, Precipitation, humidity, solar radiation, relative wind speed), and land management practice. All of the input data is necessary to be formatted in raster.

Figure 2 visualizes the Digital elevation model (DEM), soil type layer, land cover in 2001, and land cover in 2015 of the Ploso sub-watershed. The DEM (Digital elevation model) is derived from DEMNAS (BIG, 2018). DEMNAS is the source of national-level digital elevation models provided by Indonesia's geospatial data agency or Badan Informasi Geospatial (BIG). The DEMNAS (BIG, 2018) has a spatial resolution of 8.3m x 8.3m and is sufficiently excellent for watershed delineation. In this case, the DEMNAS is used to determine the sub-watershed boundary and derive the river network. The altitude of the watershed varies from 17 to 3,653 m above sea level (Figure. 2a).

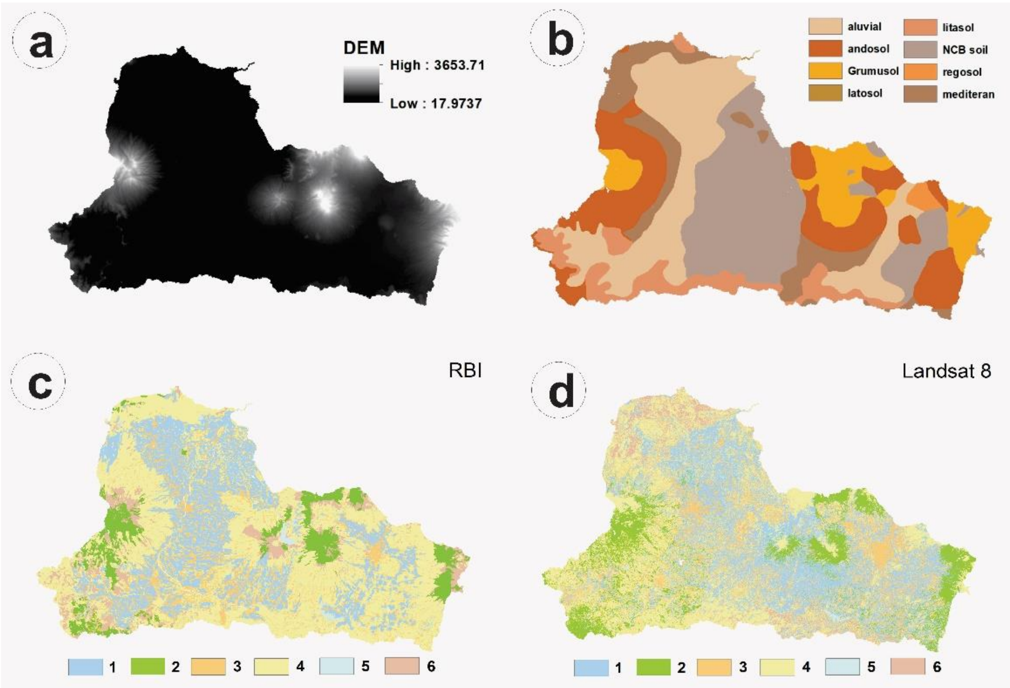

Figure 2. Input data: (a) Altitude (mm), (b) Soil Type, (c) Land cover 2001, (d) Land cover 2015, (1) Irrigated paddy, (2) Forest-Plantation, (3) Settlement or pavement area, (4) heterogeneous agriculture land, (5) Shrubs land

The soil layer is obtained from the national soil layer map (Balitbang Pertanian, 2014). The major soil type class on the watershed include: aluvial (24.5%), andosol (19.5%), grumosol (9.8%), latosol (0.02%), litosol (8.4%), regosol (10.4%) , MCB soil (0.9%), mediteran (26.5%). The slope is derived from DEM. Slope classification follows the provisions of the Indonesian Ministry of Forestry, namely 0 - 8% (10.6%), 8 - 15% (26.1%), 15 - 25% (36.3%), 25 - 40% (15.7%), and > 40% (11.3%).

This study covers the period from 1996 to 2015. This study uses two editions of Land use (LU) and land Cover (LC) maps. The first map is a clip from the digital maps of RBI (Rupa Bumi Indonesia) (BIG, 2018). The RBI map was produced during the year 2000-2001. The second map clip from the classified Landsat-8 Image. The available time series data were divided into periods 1 (1996-2005) and 2 (2006-2015). The model is run according to the period. The RBI represented the LULC for the first period. In comparison, Landsat represents the LULC for the second period (Figures. 2c and 2d). LULC in Brantas, from 2001 to 2015, experienced significant changes. The change is marked by increasing irrigated paddy fields (+ 21,24%) and forests-plantation areas (+42.44%). The land occupied for urban or pavement areas is also increased by +26.36% from the beginning. Contrary, the increase in LULC class above is compensated by the decrease in agricultural land (non-irrigated area) by -30.87% from the beginning (Table 1).

Table 1. LULC change in Ploso sub-watershed

LULC	Area (km²)				Change
	RBI	(%)	Landsat-8	(%)	(%)
Paddy filed	2,134.72	24.73	2,588.28	29.98	21.25
Heteregeneous agriculture land	3,746.27	43.40	2,589.9	30.00	-30.87
Settlement or Pavement	1,415.25	16.40	1,788.35	20.72	26.36
Forest-plantation	707.93	8.20	1,008.4	11.68	42.44
Shrubland	581.21	6.73	606.93	7.03	4.42
Water bodies	46.78	0.54	50.30	0.58	7.52

Rainfall data were obtained from 19 measurement sites (Table 2). The location of the rainfall measurement site is presented in Figure.1 (R1 to R19). The recording period for all the climate variables ranges from 1996 to 2015 (20 years). Discharge data is taken from an existing AWLR (Automated Water Level Recorder) at the outlet of this basin.

Table 2. Rainfall stations

No	Station	Latitude	Longitude	Elevation
1	Dingin	-7.6697	112.059	54
2	Kedungrejo	-7.4665	112.226	34
3	Kertosono	-7.6059	112.082	44
4	Ktr Cab. Perak	-7.5806	112.161	45
5	Minggiran	-7.7256	112.059	59
6	Papar	-7.6918	112.077	55
7	Wonomarto	-7.6251	112.145	73
8	Blambangan	-8.118	112.633	444
9	Bululawang	-8.0786	112.646	402
10	Clumprit	-8.2292	112.645	329
11	Dampit	-8.21	112.748	414
12	Kedung Kandang	-7.9929	112.656	438
13	Ngajum	-8.069	112.527	449
14	Sumber Pucung	-8.3895	112.676	308
15	Sitiarjo	-8.1538	112.483	20
16	Turen	-8.1639	112.694	391
17	Kalibadak	-7.9708	112.243	562
18	Pojok_Dadapan	-8.0721	112.208	243
19	Besuki	-8.2141	111.79	89

First, the discharge and rainfall data are requested from the public offices of the water management and watershed authorities. The climate data (i.e., Precipitation, wind speed, humidity, temperature, and solar radiation) were obtained from the nearby climatological stations. This study, ArcSWAT 2012, is used as the primary tool for hydrological analysis, while GIS software visualises the maps.

Table 3. Description of model input

Data Type	Source	Description
DEM (Digital elevation model)	Geospatial Information Agency of Indonesia http://tides.big.go.id/DEMNAS/Jawa.php	Resolution 8,3 m
Digital soil layer	Soil Research Institute, 1998 Bogor, Indonesia	Scale 1:250.000
Land use - land cover layer	Rupa Bumi Indonesia https://tanahair.indonesia.go.id/) Intepretation of landsat 8	Scale 1:250.000 (satellite image)
Climate /meteorological data series	Meteorology and Climatology Geophysical Agency of Banyuwangi	1996-2015 (20 years)
Daily rainfall data	Dingin, KedungRejo, Kertosono, Ktr Cab.Perak, Minggiran, Papar, Wonomarto, Blambangan, bululawang, clumprit, dampit, Kedung kandang, ngajum, sumber pucung, sitiarjo, turen, kalibadak, Pojok_dadapan, and Besuki Stations.	1996-2015 (20 years)

2.2. Procedure

The general procedure of the modeling task consists of (1) Watershed delineation and HRU determination, (2) Writing table and climate data input, (3) creation of model output, and (4) Calibration and validation. This step consists of sensitivity analysis and model performance evaluation for calibration and validation periods. The final step (5) is conducting the model simulation, water balance, and sediment yield analysis. Figure 3 presents the flowchart of the research procedure.

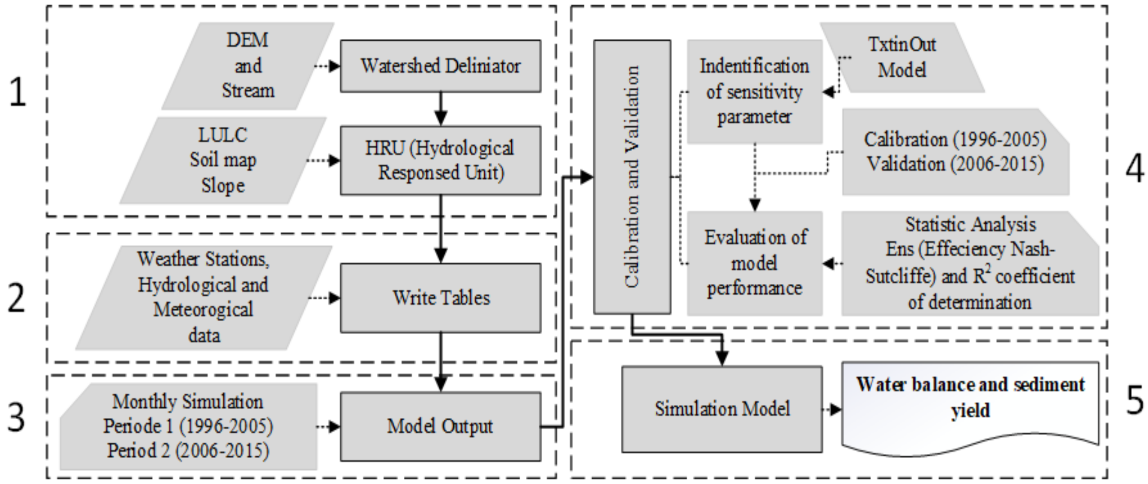

Figure 3. Research procedure

The SWAT simulation model has 2 stages, namely preprocessing and processing. Stage 1. SWAT Preprocessing

1. Watershed delineation and HRU processing.

In this case, the ArcSWAT module fills the sink to determine the flow direction and accumulation from the input DEM (DEMNAS). Then, the result uses to create the stream network, outlet, and sub-basin. The arcSWAT will delineate the boundary of the watershed. Furthermore, the ARcSWAT produce HRUs (hydrological response unit). HRU was constructed from 3 layers, overlaid among land use (land cover), soil type, and slope classes. Finally, the HRU was determined using a 10% threshold.

2. Climate input (Writing tables).

The SWAT-weather database (Weather Generator) calculates 14 necessary parameters. Seven (7) parameters depend on rainfall data, and the other seven (7) parameters are adjusted for climate data

(Table 4). Each parameter is then used for updating the SWAT database. The model will automatically calculate according to available data.

Table 4a. Parameter dependent on rainfall data

No	Parameter	Description
1	PCPMM	Average monthly rainfall (mm / day),
2	PCPSTD	Standard deviation of daily precipitation per month (mm / day),
3	PCPSKW	Skew coefficient of daily precipitation for one month,
4	PR_W1	Probability of a rainy day after a dry day every month,
5	PR_W2	Probability of a rainy day after a monthly rainy day,
6	PCPD	Average number of rainy days (days) per month,
7	RAINHHMX	Up to 0.5 hours of precipitation over the entire recording period (mm) of the month.

Source: Arnold et al. (2012)

Table 4b. Parameter determined from climate data

No	Parameter	Description
1	TMPMX	Average monthly maximum temperature (° C)
2	TMPMN	Average minimum temperature (° C) for the month,
3	TMPSTDMX	Standard deviation of maximum temperature (° C) per month,
4	TMPSTDMN	Standard deviation of minimum temperature (° C) per month,
5	SOLARAV	Monthly average solar radiation (MJ / day / m^2),
6	DEWPT	monthly average dew point temperature (° C)
7	WNDAV	month alyverage wind speed (m / s)

Source: Arnold et al. (2012)

Stage 2 SWAT Preprocessing

3. SWAT Output.

Simulation results are read through the SWAT output menu. The model provides three types of output, i.e. (output.Rch: Flow_out) for calculated flow (in m3/s) and The "TxtInOut folder (output.std)" to visualise the computed water balance result. Calibration is set for periods 1996 to 2005, and validation starts from 2006 to 2018 using flow data from the model. The SWAT GUI (graphical user interface) tests the model on the two periods.

The SWAT CUP module uses to evaluate model performance. In this case, the SUFI-2 (Sequential Uncertainty Fitting) is explored to fit the parameter value during calibration and validation. Calibration and validation follow the procedure as published by Abbaspour (2015).

Water balance is calculated at monthly and annual intervals. About 33 parameters are selected for sensitivity analysis by 500 iterations. Table 5 shows the 18 selected parameters. In this case, the r (multiples) and v (replace) procedures, as published by Abbaspour (2015), were used to find optimal parameter values.

Table 5. The estimated parameter value for calculating flow

No.	Parameter Input	Parameter Description	Range Parameter
1	SMFMX.bsn	Maximum annual snow melting rate (occurs in summer)	0-20
2	CH_N1.sub	Manning's "n" value for the tributary channels	0.01-30
3	CH_L1.sub	The most extended channel length in the subbasin.	0.05-20
4	SL_SUBBSN.hru	Average slope length (m)	10-150
5	SMFMN.bsn	Minimum annual snow melting rate (occurs on winter solstice)	0-20

No.	Parameter Input	Parameter Description	Range Parameter
6	GW_SPYLD.gw	Specific yield of shallow aquifer (m^3/m^3)	0 – 0.4
7	ESCO.bsn	Compensation factor for plant uptake	0 – 1
8	CH_W1.sub	The average width of tributary channels (m)	1 to 1000
9	LAT_TTIME.hru	Lateral flow travel time	0-180
10	GW_REVAP.gw	Groundwater revap coefficient	0.02-0.2
11	GW_DELAY.gw	Groundwater delay (days)	0 – 500
12	GW_QMN.gw	Threshold of shallow aquifer depth required for backflow (mm)	0 – 5000
13	REVAP_MN.gw	Threshold of shallow aquifer depth required for for revap to occur (mm)	0 -500
14	RCHARG_DP.gw	Deep aquifer percolation fraction	0-1
15	SOL_AWC.sol	Available water capacity of the soil layer (mm H2O /mm soil)	0 – 1
16	SOL_BD.sol	Moist bulk density (g/cm3 @ Mg/m^3)	0.9 to 2.5
17	CANMX.hru	Maximum canopy storage.	0 to 100
18	SOL_K.sol	Saturated hydraulic conductivity(mm/hour)	0 to 2000

Source: Arnold et al. (2012)

The model performance was evaluated by two statistical tests, i.e., Nash-Sutcliffe Efficiency (NSE) and determination coefficient (R2). Moriasi et al. (2007) stated that NSE values range from $-\infty$ to 1; NSE = 1 is the optimal value. NSE values between 0.0 and 1.0 are generally acceptable model performance, while NSE ≤ 0.0 indicates that model performance is unacceptable. The value of R2 describes the correlation between observed and calculated (estimated) values. The higher value indicates a low error variant. R2 = 0 shows no correlation between the experimental and calculated values, whereas R2 = 1 shows a strong correlation between observed and calculated values (Table 6).

Table 6. Classification of statistical indices

NSE	R^2	Classification
0.75 < NSE ≤ 1.00	$0.75 < R^2 \leq 1.00$	Very good
0.60 < NSE ≤ 0.75	$0.60 < R^2 \leq 0.75$	Good
0.36 < NSE ≤ 0.60	$0.50 < R^2 \leq 0.60$	Satisfactory
0.00 < NSE ≤ 0.36	$0.25 < R^2 \leq 0.50$	Bad
NSE ≤ 0.00	$R^2 \leq 0.25$	Inappropriate

Source: Moriasi et al. (2007)

Water balance and sediment yield are calculated during the simulation periods. The optimal parameter values are obtained from calibration, and validation is then used to run SWAT to calculate water balance and sediment yield at the location of interest.

3. Result and Discussion

3.1. Initial Calibration

Figure 4 shows the initial calibration result of SWAT to calculate flow at Ploso Outlet (Subbasin 1 in Model). The NSE and R2 obtained are 0.05 and 0.01, respectively. Figure 4 indicates that seasonal variation of a rainfall event is followed by seasonal variation in flow (discharge). It is shown (in Figure 4) that the dot-line (calculated flow) starts from zero and increases linearly by a slope, which is not correlated to the observed flow or rainfall series. Therefore, it is necessary to search which parameters may be adjusted to mimic the experimental flow and respond to the rainfall variation.

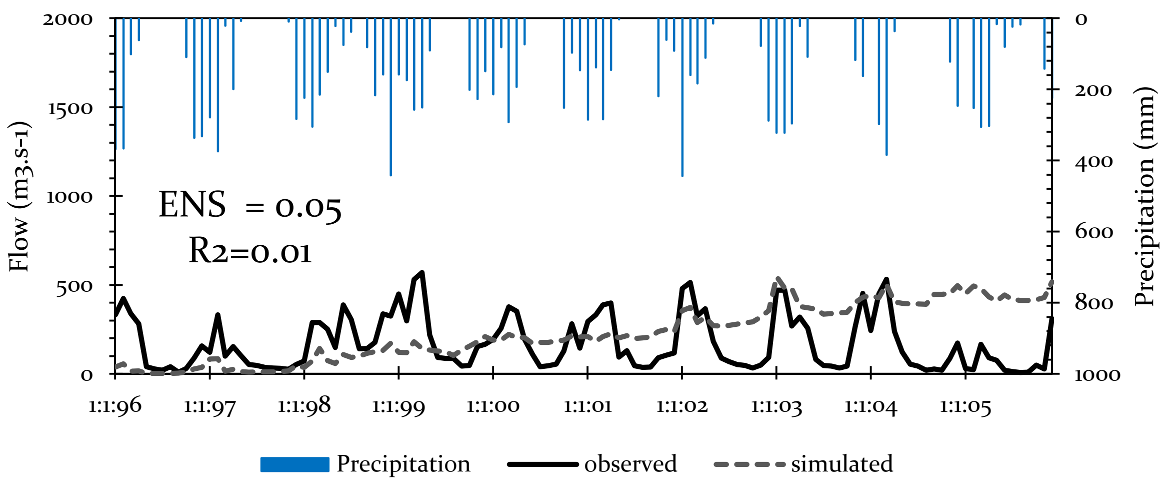

Figure 4. Initial calibration result for a period (Monthly 1996-2005) (Source: Own analysis)

3.2. Sensitivity Analysis

As listed in table 5, parameter values are evaluated through iteration processes on the SWAT CUP module. Figure 5 shows the best-fitted result of parameter values. The "t-Stat" value (in Figure 5) indicates the sensitivity of the parameter. The zero (0) of the "t-Stat" value shows the most sensitive parameter. Furthermore, the "P-Value" visualize how the strength of such parameter contributes to the flow calculation. The "P-Value" close to one (1) signifier is the most determinant parameter. Therefore, the change in calculated flow is more significant by changing or manipulating this parameter's value (Abbaspour, 2015).

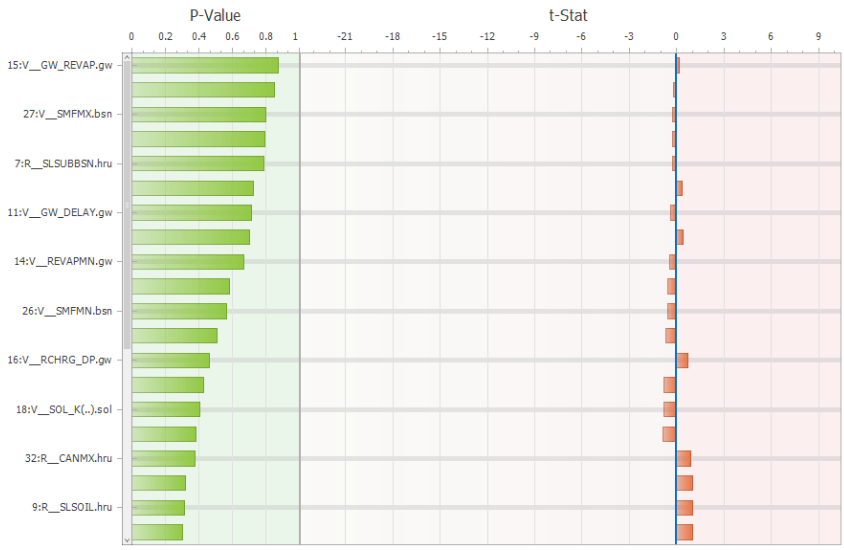

Figure 5. Sensitive parameters (Source: own analysis using SWAT CUP)

As presented in Figure 5, the sensitivity result is obtained after 10x simulation processes and is treated with 500 iterations for each simulation. Finally, Table 7 shows the fitted 18 parameters that perform more sensitive to produce runoff for the Ploso sub-watershed. It is noted that 9 parameters are more sensitive (>50% sensitivity) than other parameters. These include (GW_REVAP, ESCO, SMFMX, SOL_AWC, SLSUBBSN, CH_N1, GW_DELAY, CH_L1, dan REVAPMN). The four (4) parameters (ESCO, SOL-AWC, SOL_BD, and SOL_K) correlated to the soil layer's runoff generation and water movement.

Then, eight (8) parameters (i.e., GW_REVAP, SMFMX, GW_DELAY, REVAPMN, SMFMN, GW_SPYLD, RCHRG_DP, and GWQMN) correlated to baseflow calculation (Brighenti et al., 2019).

Table 7. The fitted value of each parameter

No	Parameter Name	t-Stat	P-Value	Fitted
1	V__GW_REVAP.gw	0.16	0.87	0.06
2	V__ESCO.hru	-0.19	0.85	0.13
3	V__SMFMX.bsn	-0.26	0.80	15.09
4	R__SOL_AWC.sol	-0.26	0.79	1.03
5	R__SLSUBBSN.hru	-0.27	0.79	22.25
6	R__CH_N1.sub	0.35	0.73	1.31
7	V__GW_DELAY.gw	-0.37	0.72	0.57
8	R__CH_L1.sub	0.38	0.70	87.93
9	V__REVAPMN.gw	-0.43	0.67	66.90
10	R__SOL_BD.sol	-0.55	0.59	1.62
11	V__SMFMN.bsn	-0.58	0.56	4.10
12	V__GW_SPYLD.gw	-0.66	0.51	0.17
13	V__RCHRG_DP.gw	0.73	0.46	0.51
14	R__CH_W1.sub	-0.79	0.43	219.02
15	V__SOL_K.sol	-0.83	0.41	1120.90
16	R__LAT_TTIME.hru	-0.87	0.38	47.24
17	R__CANMX.hru	0.88	0.38	78.4
18	V__GWQMN.gw	0.99	0.32	3863.88

Other parameters such as CH_N1, CH_L1, CH_W1, and LAT_TIME influence the properties and velocity of flow at the main river channel. Specific parameters related to the groundwater (gw) significantly influence the streamflow calculation. For example, the parameter "GW_REVAP.gw" is gradually modified from 0.02 to 0.06 to increase the baseflow level until the vegetation root zone is reached. The increasing value of "GW_REVAP.gw" normalized the calculation of potential evapotranspiration. And then, less or no water will infiltrate the soil, and increased runoff production will saturate the root zone. Therefore, the REVAPMN parameter value should be reduced from 750 to 66.9 to increase water until the root zone. The parameter "GW_REVAP.gw" has 87% sensitivity, and the REVAPMN parameter got 67% sensitivity.

Moreover, reducing the value of "GW_DELAY.gw" from 31 to 0.57 will accelerate the filling time of the aquifer zone. Furthermore, increasing the value of "GW_SPYLD.gw" from 0.003 to 0.27 did the balanced ratio between water volume and rock material in the unsaturated zone. The

"GWQMN.gw" value increased from 1000 to 3863.88 to compensate for other groundwater parameters and reversely permit water flow in the unsaturated zone. The "RCHRG_DP" is adjusted from 0.05 to 0.51 to recharge the deep aquifer from the root zone through percolation.

Moreover, parameters describing soil properties are adjusted to maintain water content at a certain level in the soil layer (for example, SOL_AWC from 0.11 to 1.03, SOL_BD from 1.1 to 1.62 SOL_K from 5.4 to 1120.90). Also, related parameters for describing HRU, Basin, and Sub-basin are optimized; for example, the ESCO value is set up from 0.95 to 0.13 to reduce evaporation. SL-SUBBSN is adjusted from 91.46 to 22.25; LAT_TTIME is increased from 0 to 47.24 (Table 8). All adjustments of these parameter values, therefore, improve the model performance in calculating flow.

3.3. Hydrograph Results

Figure. 6 shows the observed and calculated hydrograph of monthly flow for calibration periods from 1996 to 2005. The calibration produce NSE = 0.66 and R^2 = 0,67. The calculated flow pattern is more adjusted and follows the fluctuation of observed flow and rainfall events.

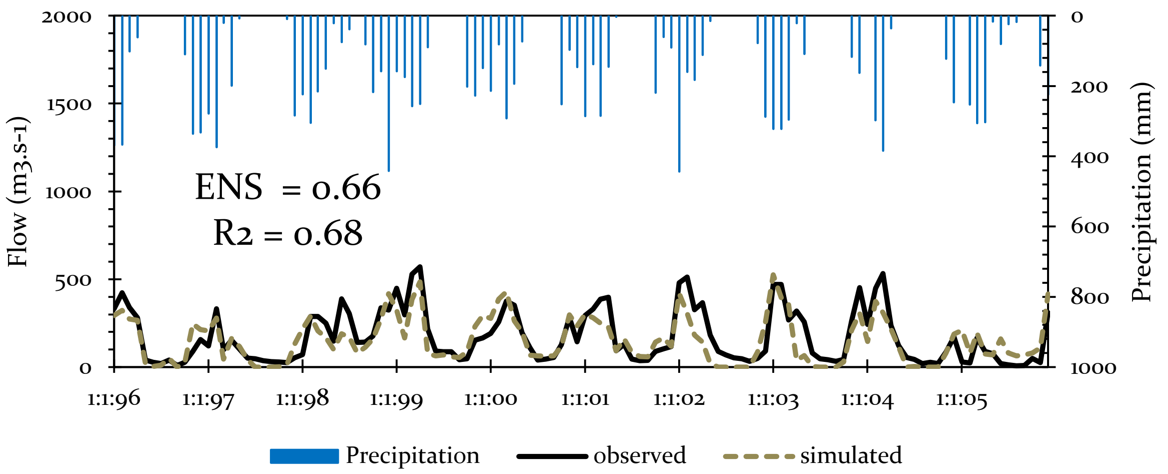

Figure 6. Hydrograph of monthly flow (for calibration periods 1996-2005)

Figure 7 visualizes the simulated and observed hydrograph of monthly flow during the validation periods from 2006 to 2015. The validation processes produce NSE and R2 = 0.55 and 0.56, respectively.

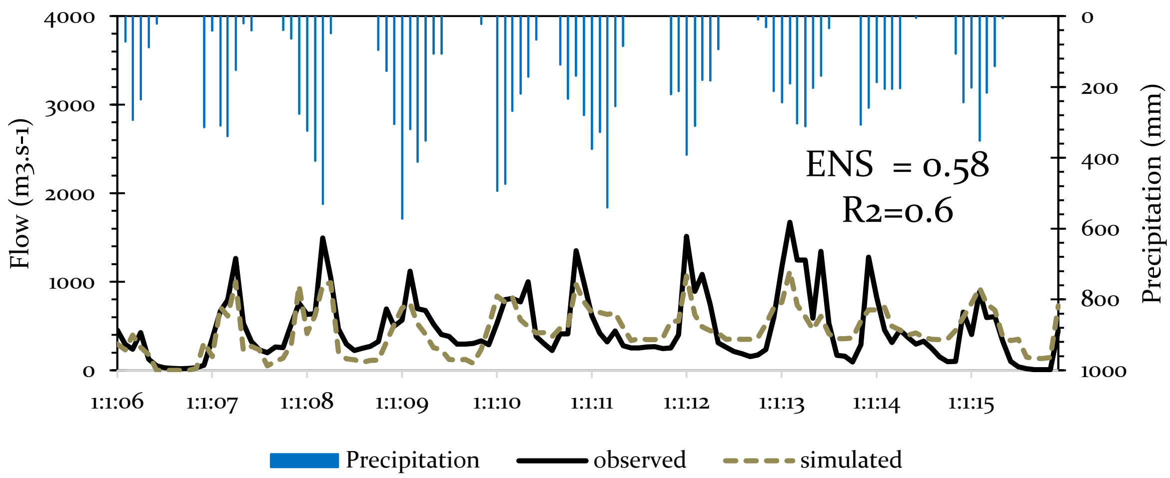

Figure 7. Hydrograph of monthly flow for the validation period (from 2006-2015)

3.4. Hydrological Simulation of The SWAT Model

Figure 8 illustrates an overview of the annual SWAT simulation. We can divide the result into three periods. The average annual rainfall series divided into 3 segment (1^{st} red line = 3,009.9 mm/yr, 2nd red line = 1,860.1 mm/yr, and 3rd red line = 3,946.3 mm/yr). Similarly, we can divide the average annual sediment yield into 3 segment (1st black-line = 1,547.7 ton/ha/yr, 2nd = 890.4 ton/ha/yr, and 3rd = 3,600.0 ton/ha/yr). Finally, the average annual water yield was divided into three segments (first greenline =2,481.8 mm/yr, second = 1,413.7 mm/yr, third = 3,522.0 mm/yr). It is noted that the distribution of water yield and sediment follows rainfall fluctuation.

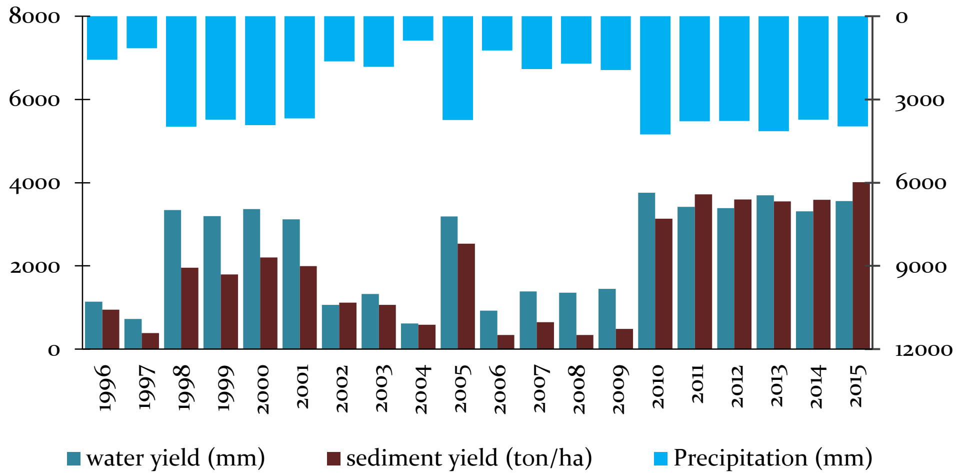

Figure 8. Resume of the SWAT Model Simulation (source: own analysis)

Previous studies have reported that the abundance of rainfall in segment 3 (from 2014 to 2015) caused flood events in four districts of the Brantas watershed (Erlina, 2018) and increased sediment concentration by 60.50%. The sediments deposit propagated by a flood event, reducing the capacity in 6 large reservoirs (2005-2006) in the Brantas (Kementrian PUPR, 2010).

4. Conclusions

Brantas Watershed conducted a sensitivity analysis of the SWAT model using the SWAT-CUP tool. The results show that 18 parameters are sensitives. The nine (9) parameters have a sensitivity level of 50% (GW_REVAP, ESCO, SMFMX, SOL_AWC, SLSUBBSN, CH_N1, GW_DELAY, CH_L1, and REVAPMN). The four (4) parameters (ESCO, SOL-AWC, SOL_BD, and SOL_K) correlated to the soil layer's runoff generation and water movement. Then, eight (8) parameters (GW_REVAP, SMFMX, GW_DELAY, REVAPMN, SMFMN, GW_SPYLD, RCHRG_DP, and GWQMN) correlated to baseflow calculation. The model simulation illustrates that rainfall and land cover changes drive the hydrological processes, producing more water yield and sediment in the Brantas watershed.

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