Watershed Modeling with ArcSWAT and SUFI2 in Cisadane Catchment Area: Calibration and Validation to Prediction of River Flow

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Abstract - Increasing of natural resources utilization as a result of population growth and economic development has caused severe damage on the watershed. The impact of natural disasters such as floods, landslides and droughts become more frequent. Cisadane Catchment Area is one of 108 priority watersheds in Indonesia. SWAT is currently applied worldwide and considered as a versatile model that can be used to integrate multiple environmental processes, which support more effective watershed management and the development of better informed policy decision. The objective of this study is to examine the applicability of SWAT model for modeling mountainous catchments, focusing on Cisadane catchment area in West Java Province, Indonesia. The SWAT model simulation was done for the periods of 2005–2010 while it used landuse information in 2009. Methods of Sequential Uncertainty Fitting ver. 2 (SUFI2) and combine with manual calibration were used in this study to calibrate a rainfall-runoff. The Calibration is done on 2007 and the validation on 2009, the R² and Nash Sutcliffe Efficiency (NSE) of the calibration were 0.71 and 0.72 respectively and the validation are 0.708 and 0.7 respectively. The monthly average of surface runoff and total water yield from the simulation were 27.7 mm and 2718.4 mm respectively. This study showed SWAT model can be a potential monitoring tool especially for watersheds in Cisadane Catchment Area or in the tropical regions. The model can be used for another purpose, especially in watershed management.

Keyword - Model, SWAT, SUFI2, watershed, Hydrology, Cisadane.

INTRODUCTION

Water is a renewable resource, but availability is in conformity with the needs of the location, number, time and quality. Total demand for domestic water (household), industry and agriculture would increase along with the increase in population and standard of living due to development. Conversely, the potential water availability is relatively fixed and varies according to place and time. The situation resulted in insufficiency and demand problems for particular place and time, so it needs to be designed optimal management and utilization of water. Less effort of soil and water conservation and conversion of forests into agricultural land or agricultural land changes to urban area will reduce the ability of the watershed to infiltrate water into the soil and will increase the process of erosion and sedimentation. It gives impact on the environment such as floodsoh rainy season and drought in the dry season. Excessive erosion also resulted in sedimentation in reservoirs and river channels.

Indonesian land resources tend to have high soil erosion; it is influenced by three main factors: high rainfall intensity, steep slopes, and potentially eroded soil type. According to data from the Meteorology and Geophysics Agency in 1994, 23.1% of Indonesia has an annual rainfall greater than 3,500 mm, about 59.7% of them an annual rainfall between 2,000-3,500 mm, and only 17.2% of it has an annual rainfall of less than 2,000 mm. About 77% area in Indonesia has slope more than 3%. (Subagyo et al, 2000 in Adimiharja, 2008).

Increasing of natural resources utilization as a result of population growth and economic development, conflict of interest less of integration between sectors, upper-middle-downstream area, especially the era of regional autonomy has caused severe damage on the watershed.
The impact of natural disasters such as floods, landslides, and droughts become more frequent. Cisadane Catchment Area (CCA) is one of 108 priority watershed in Indonesia based on Decree of the Ministry of Forestry, SK.328/Menhut-II/2009.

This development shows the pressure expansion towards the west (Tangerang), East (Bekasi) and South (BOPUNCUR) form Jakarta area. Conversion of land in the region BOPUNCUR upper Ciliwung-Cisadane (BOPUNCUR) form encroachment into land cultivation. There will be a discharge extremities that would pose a threat of flooding in rainy season and the dry season will threaten the availability of water (Malazi and Sabar, 2010).

In last decades, hydrological models are more broadly applied by hydrologists and water resource managers as tools to analyses water resource management systems. The hydrologic modeling system is designed to simulate the precipitation and run-off process of dendritic watershed system. Hydrological process that represented by parameters can be declared conceptually by mathematical models after identified from field condition by hydrology system. In recent, many developed mathematical models it can simulate a lot of hydrology phenomena. Parsimony in parameter is a general orientation in developing a hydrology model, while model structure divided two classes of hydrology model which are conceptual model and physically base model (Pawitan, 2004). Whereas, (Singh 2002) stated that Hydrology model is an assemblage, a mathematical description of components of hydrology cycle. Singh also classified hydrology model based on; process description, time scale, space scale, technique of solution, land use, and model use.

In recent years, SWAT model has gained international acceptance as a robust interdisciplinard watersheds modeling. SWAT is currently applied worldwide and considered as a versatile model that can be used to integrate multiple environmental processes, which support more effective watershed management and the development of better informed policy decision (Gassman et al., 2005). But little have been published on the applicability of SWAT model in the tropical catchments particularly in Indonesia. This study examines the applicability of SWAT model and combined with the Sequential Uncertainty Fitting version 2 (SUFI-2 in SWAT-CUP Application) to quantify the uncertainty of parameters and to provide a necessary reference for hydrological modeling in for modeling mountainous catchments, focusing on Cisadane catchment Area in west Java Province, Indonesia.

**METHODS**

The study covers the period of March to July 2009, but collection of data has been obtained since 2005. The study area is located in CCA. Located at 107° 42’ 21” E – 107° 58’ 32” E and 7° 7’ 4” S – 7° 24’ 45” S, which the area about 4,486 km². Administratively the study area belongs to Bogor Regency and Bogor City in upper area and Tangerang Regency in lower area. DASCisadaneis an inter-provincial river basin, which administratively located in the province of West Java and Banten, at a fraction downstream into theregionof Jakarta. Most of the watershed Cisadane in West Java Province with an area of 113,535.66ha (74.11%), the rest in Banten province covering 39,500ha (25.78%) and Jakarta 172.61ha (0.11%). The population in the basin is 4,163,799 with population growth rate is 2%.

The methodology of this study is limited to the condition of the data and used hydrology model application SWAT for ArcGIS (ArcSWAT). ArcSWAT is a graphical user interface, written in FORTRAN and ArcGIS as an “Programmable Geographic Information System” that supports manipulation, analysis, and viewing of geospatial data which associated attribute data in several standard GIS data formats.

SWAT was developed and enhanced from previous earlier models by Arnold for the United States.
Department of Agriculture in the early 1990s (Krysanova and Arnold, 2009). It was then extended to predict the impact of land management practices on water, sediment, agricultural and chemical yields in large river catchments with varying spatial and temporal aspects. The hydrologic cycle under consideration is based on the following water balance equation:

\[
SW_i^{day} = SW_i - Q_{surf} - E_a - W_i - Q
\]

Where \(SW_i\) is the final soil water content, \(SW_i^{day}\) represent the initial soil water content on day \(i\), \(t\) is the time (days), \(R\) is the amount of precipitation on day \(i\), \(Q_{surf}\) is the amount of surface runoff on day \(i\), \(E_a\) describe the amount of evapotranspiration on day \(i\), \(W_{seep}\) represent the amount of water entering the vadose zone from the soil profile on day \(i\), and \(Q_{ret}\) is the amount of return flow on day \(i\). For the estimation of surface runoff the SCS curve number (CN) is used in the model. This method uses two equations for runoff computation. The first relates runoff to rainfall and retention parameter as:

\[
Q = \frac{0.2S}{0.2S + 0.5S} \times R
\]

where, \(Q\) is daily surface runoff (in mm), \(R\) represents daily rainfall (in mm) and \(S\) is retention parameter, the maximum potential difference between rainfall and runoff (in mm) starting at the time the storm begins.

SWAT divides the watershed into sub-basins and these small hydrological parts are termed as hydrological response units (HRUs) as an unique landuse/management/soil attributes to help for improving the calculation accuracy (Neitsch et al., 2010). The SWAT model needs data from digital elevation model (DEM), soil map, and land use map. Meteorological data are also needed in daily or sub daily time steps. SWAT includes two methods for estimation of surface runoff - SCS CN and Green-Ampt infiltration method. In this research a first method is used for Hydrology model of CCA.

Landuse is one of the dynamic parameters caused by human activities. Landuse data have been classified from ALOS satellite image year 2009 by Hydro-informatics Laboratory in Research Centre for Limnology, Indonesia Institute of Science. The Landuse Class is classified based on Bakosurtanal Map. The classification has been compared with field data.

Within the process of setting up the model run/input files with ArcSWAT a series of operations are required. The first step in hydrologic data development for hydrology model SWAT is defining catchment area boundaries. These boundaries normally fall along the ridges in a watershed. On one side of the ridge, water flows into the watershed, while on the other side of the ridge, water flows into a separate watershed, after stream and sub-catchment delineated, the next step is creation of Hydrological Response Units (HRUs). An HRUs is an intersection of sub-catchment polygon with landuse, soil type and slope.

SWAT database used weather station and location and stored in SWAT2012 database. The Cisadane Catchment Area used two weather stations and eleven locations for rain gauges on 2005-2010 daily precipitation data. The weather stations belong to Climatology meteorology and Geophysics Agency (BMKG), and The Public Work Ministry (PU). After data file has been generated, SWAT model in Cisadane Catchment area is ready to simulate. The simulation has done on 2010 landuse data.

![Figure 2. Schematic framework of ArcSWAT (Revised from Diluzio and Arnold, 2004).](image)

**Calibration and Validation**

The simulation of the Cisadane catchment was completed using the ArcSWAT interface of SWAT model, whereas model calibration and validation were done by manual calibration and automatic calibration. The Automatic calibration and sensitivity analysis have been done using SWAT CUP tool. SWATCUPis a program that can be used as freeware application. The SWAT-CUP has four programs for calibration, namely SUFI2, GLUE, passalonrelatedMCMC. The model uncertainties have
been tested and analyzed using SUFI-2 (Sequential Uncertainty Fitting) uncertainty analysis procedures. SUFI-2 is convenient and easy. The modeler, however, should check a set of suggested posterior parameters to be prepared for next iterations (Bilondi, 2013) (Rouholahnejad and Abbaspour, 2010). Model SUFI-2 is a model which is rather low degree of difficulty compared by GLUE models, Parasoland MCMC (Abbaspour, 2011), despite MCMC more recommended because Bayesian inference has a statistical assumption underlying the likelihood function based on the autoregressive error model is testable and did not indicate significant violations of the assumptions (Yang et al., 2008). Based on availability and simplicity SUFI-2 is used in this study. SUFI-2 performs the parameter uncertainty analyses by determining all sources of uncertainties, namely uncertainty in driving variables, conceptual model, parameters and measured data.

SWAT model uses more than 500 parameters for simulation, but not all of them are used to develop a model for Upper Cimanuk Catchment Area, due to limited time and data support. The selection of those parameters is continued during calibration, especially in manual calibration process. Calibration is focused on surface, the procedure for calibration uses basic water balance and total flow calibration on SWAT user manual (Neitsch et al., 2012). The procedure started by adjust Curve Number (CN2 in .mgt file) until surface runoff is acceptable. If surface run off value is not acceptable the calibration is continued by adjusting soil available water capacity (SOL_AWC in .sol) and soil evaporation compensation (ESCO in .bsn or .hru). Once surface calibration is conducted it should be compared with the observed and simulation value of base flow resulting two condition; higher base flow or lower one. Figure 3 shows sensitive parameters to water discharge for calibration.

Simulation result from SWAT model can be compared to observed data to evaluate the capability of model prediction. The Nash-Sutcliffe model efficiency coefficient (NSE) (Nash and Sutcliffe, 1970) and the correlation coefficient ($R^2$) as a method to evaluate and analyze simulated Daily data and the $R^2$ value is a measure of the strength of the linear correlation between the predicted and observed values. The NSE value, which is a measure of the predictive power of the model, is defined by:

$$NSE = \frac{\sum (Q - Q')^2}{\sum Q'^2}$$

Where, NSE (Nash-Sutcliffe coefficient), $Q_o$ is present Observed discharge, $Q_m$ is Model discharge, $\bar{Q}_o$ point out mean observed discharge and $Q_i$ is Discharge at time $t$. $R^2$ describe of the proportion of variance in observed flows explained by the model and value of NSE and $R^2$ close to 1 indicates a complete harmony between observed and simulated stream flow.

Figure 3. Sensitive parameters to water discharge for Calibration (Heuvelmans et al., 2004).

RESULT AND DISCUSSION

SWAT Model Setup

The first step in hydrology model SWAT development is defining catchment area boundaries. These boundaries normally fall along the ridges in a watershed. On one side of the ridge, water flows into the watershed, while on the other side of the ridge, water flows into a separate watershed. Elevation data for this process is derived from Bakosurtanal topographic map (RBI Map, scale 1:25,000). The result of this process was divided Cisadane Catchment Area on 49 subcatchment. The next step is creation of Hydrological Response Units (HRUs). An HRU is an intersection of subcatchment polygon with landuse, soil type and slope. The landuse class of Cisadane Catchment Area is dominated by paddy plantation (27%) and plantation area (21.85) especially on flat areas, whereas on steep area is covered by forest. Soil type is dominated by Association TypicHumitropepts-TypicEntropepts (25.8%) and TypicHumitropic (19%). The Slope of Cisadane Catchment area mostly flat area, about 43% of area is located on slope less than 8% slope. composition of landuse class, soil type and slope are represented on Table 1 and the distribution of the area on figure 4.

After input file have been generated, SWAT is ready to do simulation, the simulation period is from 1 January 2005 to 31 December 2010. The calibration is done on 2007 and the validation on 2009. The options are to get comparison between river discharge simulation and observed data. Several options must be considered: time step for rainfall and routing (daily), method for calculating runoff-Curve Number Method, rainfall distribution-skewed normal and method for evapotranspiration used Penman-Monteith method.
Figure 4. Model input landuse, soil type and slope of Cisadane Catchment Area

Table 1. Characteristic of Landuse and Soil type in Cisadane Catchment Area

| Landuse Class          | SWAT ID | Area (ha) | %   |
|------------------------|---------|-----------|-----|
| Pasture and open Area  | PAST    | 12419.1   | 9.9 |
| Residential            | URMD    | 19065.79  | 15.2|
| Tea Plantation         | TEA     | 27275.46  | 21.8|
| Rice                   | RICE    | 34239.91  | 27.4|
| Agricultural           | AGRR    | 9331.001  | 7.5 |
| Forest                 | FRSD    | 22751.98  | 18.2|
| Water                  | WATH    | 2.1271    | 0.0 |
|                        |         | 125085.4  | 100 |

| Soil Category          | SWAT Code | Area (ha) | %   |
|------------------------|-----------|-----------|-----|
| Aerictropaquept        | CSD 1     | 4102.7    | 3.28|
| Aeric tropic fluvaquent| CSD 2     | 1454.4    | 1.16|
| Association TypicDystropepts-TypicPaleudults | CSD 4 | 2044.0 | 1.63|
| AssociationTypicHapludands-TypicTropopsamment | CSD 5 | 14184.8 | 11.34|
| AssociationTypicHapludults-AquicHapludults | CSD 6 | 3076.9 | 2.46|
| AssociationTypicHumitropepts-TypicEutropepts | CSD 7 | 32361.4 | 25.87|
| AssociationTypicTropopsamments-AndicHumitropepts | CSD 8 | 7579.1 | 6.06|
| OrthoxicTropudults     | CSD11     | 15754.0   | 12.60|
| KompleksTypicHumitropepts-LithicTroporthen | CSD10 | 66.2 | 0.05|
| TypicDystropepts       | CSD14     | 9728.0    | 7.78|
| TypicEutropepts        | CSD15     | 44438.2   | 2.53|
| TypicHumitropepts      | CSD16     | 7810.9    | 19.54|
| TypicTroporthents-TypicFluvaquents | CSD18 | 7125.7 | 5.70|

| Slope Class           | Area (ha) | %   |
|-----------------------|-----------|-----|
| <8%                   | 53859.7   | 43.2|
| 8% – 25%              | 27998.9   | 22.4|
| 25% - 30%             | 24174.5   | 19.4|
| 30% - 45%             | 10.383.3  | 8.3 |
| >45%                  | 8286.5    | 6.7 |

**Sensitivity Analysis, Calibration and Validation**

Parameters and sensitivity analysis using SUFI-2

The analysis of relative sensitivity of the parameters during model calibration and twelve parameters were found to be more sensitive according to the relative...
sensitivity values. Table 3 is showed the minimum and maximum ranges of parameters in the SUFI-2 uncertainty techniques. The parameters have given ranks for their sensitivity to the model calibration for both procedures. Parameter specification and estimation were important to identify sensitive parameters ensuring correct representations of hydrologic processes (Binhanu, 2009). The most sensitive parameters recorded after sensitivity analysis for daily calibration in SUFI-2 procedures is presented in Table 4, it has been showed that these sensitive parameters were mostly responsible for the model calibration and parameter changes during iteration processes.

The final result of the sensitivity analysis are parameters arranged in the ranks, where the parameter with a maximum effect obtains rank one, and parameter with a minimum effect obtains rank which corresponds to the number of all analyzed parameters. After sensitivity analysis, 12 parameters that significantly influenced the rainfall-runoff model for Cisadane Catchment Area were established.

| No | Parameter_Name      | Fitted_Value | Min_value | Max_value |
|----|---------------------|--------------|-----------|-----------|
| 1  | R__CN2.mgt          | -0.14        | -0.2      | 0.2       |
| 2  | V__ALPHA_BF.gw      | 0.35         | 0         | 1         |
| 3  | V__GW_DELAY.gw      | 32.5         | 10        | 60        |
| 4  | V__GWQMN.gw         | 0.7          | 0         | 2         |
| 5  | V__GW_REVAP.gw      | 0.01         | 0         | 0.2       |
| 6  | V__ESCO.hru         | 0.89         | 0.8       | 1         |
| 7  | V__CH_N2.rte        | 0.135        | 0         | 0.3       |
| 8  | V__CH_K2.rte        | 111.25       | 5         | 130       |
| 9  | V__ALPHA_BNK.rte    | 0.45         | 0         | 1         |
| 10 | R__SOL_AWC(..).sol  | 0.17         | 0.2       | 0.4       |
| 11 | R__SOL_K(..).sol    | 0.24         | 0.1       | 0.8       |
| 12 | R__SOL_BD(..).sol   | 0.5          | 0.1       | 0.6       |

The most sensitive parameters to changes in discharge, the calibration process shows the CN parameter is the most sensitive parameter, this shows Cisadane Catchment Area will be severely affected due to changes inland representative of CN and infiltration in the watershed, the value of CN calibration results vary between added 20 or minus 20 of its original value depending on the type of land use. Other parameters after CN is a parameter related to groundwater, among which ALFA_BF parameter is an index value that describes the underground flow response to changes in inflow. Value of about 0.1 to 0.3 found on land with a slow response to changes in inflow. Value of 0.9 to 1 are on land with a rapid response to changes in groundwater. At Cisadane Catchment Area, value obtained was a response to changes in groundwater flow.

GW_DELAY is parameter of time between the water flow from the soil profile to the saturated zone (aquifer) in a watershed. An area that has geomorphic (Landform) which has a value equal to the same GW_DELAY (Sangrey et al. 1984 in Neitsch et al., 2010). Based on the simulation results obtained for the Cisadane Catchment Area, 0.35 which shows the value obtained was a response to changes in groundwater flow.

| Parameter Name | rank | t-Stat     | P-Value |
|----------------|------|------------|---------|
| R__CN2.mgt     | 1    | 1.324272387 | 0.227013 |
| V__ALPHA_BF.gw | 2    | 0.232031793 | 0.823151 |
| V__GW_DELAY.gw | 3    | 2.051756529 | 0.079324 |
| V__GWQMN.gw    | 4    | 0.585847879 | 0.576371 |
| V__GW_REVAP.gw | 5    | 1.236567016 | 0.256124 |
| V__ESCO.hru    | 6    | 1.049884034 | 0.328661 |
| V__CH_N2.rte   | 7    | 1.565833881 | 0.161369 |
| V__CH_K2.rte   | 8    | -6.67780619  | 0.000283 |
| V__ALPHA_BNK.rte | 9  | 2.618492264 | 0.034485 |
| R__SOL_AWC(..).sol | 10 | -0.955975391 | 0.370926 |
| R__SOL_K(..).sol | 11 | 3.552908082 | 0.009307 |
| R__SOL_BD(..).sol | 12 | 1.84147118  | 0.108111 |
Area $GW\_DELAY$ values by 32.5 days. $GW\_QMN$ a threshold depth of water in the shallow aquifer to allow for water flow. The flow of underground water (groundwater) into the river can occur if the water depth in the shallow aquifer is equal or greater than the value $GW\_QMN$. $GW\_QMN$ values obtained from the simulation results is 0.7 mm.

$GW\_REVAP$s a significant parameter in a watershed that are saturated, not far from the surface of the soil or vegetation near the root zone is limited. $GW\_REVAP$ value close to 1 indicates that the movement of water from the shallow aquifer to the root zone is limited. $GW\_REVAP$ value of 0.01 indicates the limited movement of water from the aquifer to the root.

Plant uptake factor (EPCO) takes into account the amount of water released on a day is a function of the amount of water needed for transpiration and the amount of water available in the soil. If top layer of the soil does not have enough water content to meet potential water use (water uptake), the soil layer below can replace the role of the topsoil layer. EPCO values ranged between 0.1 to 1. The results of the calibrations showed that the value 0.89 is the optimal value. In addition to the parameters associated with movement of groundwater, there are extraneous parameters related to both routing in the main channel (CH_N2) or its tributaries (CH_K2). The 95PPU as represented a combined model prediction uncertainty including parameter uncertainty resulting from the non-uniqueness of effective model parameters, conceptual model uncertainties, and input uncertainties (Schoul and Abbaspour, 2006). The SUFI-2 combined effect of all uncertainties is described by the results of parameter uncertainty. The 95PPU derived by SUFI-2 on Batubelah river gauge is presented on figure 5.

![Figure 5.95PPUs derived by SUFI2 (dark gray area) during the calibration and validation period on Batubelah river gauge.](image)

**Calibration and Validation**

SWAT is a distributed hydrology model and consequently many potential parameters are involved. With the result that it would be impossible to calibrate all parameters, until reduction of the number of parameters to be estimated is done. Due to spatial variability, measurement error, incompleteness in description of both element and process present in the system, the value of all parameters will not be exactly known. To achieve a good fit between simulated and observed data, models need to be calibrated to match simulated and observed data by optimizing the same parameter. In most model applications, a calibration is necessary to estimate model parameter values. Model calibration helps reduce the parameter uncertainty, which in turn reduces the uncertainty in the simulated results (Cibinet al, 2010). The calibration procedure can be done manually or automatically.

Calibration on Cisadane Catchment Area hydrology model was done during 2007, and then validation is done for 2009 period. The calibration used combination of automatic and manual calibration. Manual optimized is done by trial and error by comparison of observed and simulation data, where the parameters of the results of automatic guided on calibration process. The quality of each parameter for which the SWAT model was run and tested according of the following two criteria: Daily simulated stream flow data and annual water balance component. The annual simulation result of each component can showed by SWATCHECK application, after the result of annual water balance components sense then be calibrated on daily simulation is conducted.

Hydrology model of Cisadane Catchment Area was calibrated by comparison of observed data from an in stream Public Works Department flow gauging station to model and to adjust the key of hydrologic parameter. Based on the fact of hydrograph comparison the calibration focused on several solutions which are adjusted to infiltration, interflow and base flow recession parameter. The calibration is done on groundwater.
parameter (gw). Routing parameter (.rte) and management parameter (.mgt). Manual calibration is conducted by SWATEditorApplication, details of adjustment for calibration is showed in Table 2.

Manual calibration of several parameters resulted in correlation error (R²) of 0.708 where Q_{obs} = 0.6663Q_{Sim}+35.052 and NSE is 0.71, and then the validation is conducted in 2009 by the simulation results using the same parameters as the parameters calibrated. The validation R² value are 0.709 where Q_{obs} = 1.63565Q_{Sim}+9.7087 and NSE is 0.72, respectively, for validation model. The value of R² and NSE is good criteria base on general performance ratings for recommended statistics (Moriasi et al, 2007) and the model can use for other purposes. Other studies yield different values but validated on monthly discharge, the value of R² and NSE obtained was 0.79 and 0.63, respectively (Junaedi, 2009). This values better than SWAT hydrologic modeling obtained in Cimanuk with R² and NSE is 0.64 and 0.5, respectively (Ridwansyah, 2010). SWAT Model had better result on Upper Cilimung Catchment Area with R² and NSE are 0.7 and 0.74, respectively (Yustika, 2013), but the process is done only on two months (February-March). SWAT models are also applied in Ciganum Catchment Area where the ratio of monthly discharge and simulated yield R² values were 0.88 and 0.72 for NSE (Suryani and Fakhmuddin, 2009).

### Table 2: Initial and final value of SWAT Calibration parameters for stream flow

| SWAT variable name | Parameter                                      | Range       | Final value |
|--------------------|------------------------------------------------|-------------|-------------|
| Alpha_BF           | Base flow alpha factor (days)                  | 0 - 1       | 0.35        |
| REVAP_MN           | Percolation to the deep aquifer to occur       | 0 - 500     | 0.01        |
| GWQMN              | Threshold depth of water in the shallow aquifer required for return flow to occur (mmH₂O) | 0 - 5000    | 0.7         |
| GW-Delay           | Groundwater delay (days)                       | 0 - 500     | 32.5        |
| CH_N2              | Manning’s value for main stream                | 0 - 3.5     | 0.25        |
| CH_K1              | Effective hydraulic conductivity in tributary stream | 0-300      | 0.5         |
| CH_K2              | Effective hydraulic conductivity in main stream |             | 0.5         |
| CN2                | Curve Number                                  | 0 - 100     | ±20%        |
| Sol_BD             | Soil Bulk Density (g/cm³)                      | 0.9 – 2.5   | 0.1         |
| Sol_K              | Saturated hydraulic conductivity of first layer (mm/hr) | 0-2000     | 0.24        |
| Alpha_Bnk          | Bank flow recession constant or constant of proportionality | 0-1        | 0.45        |

The hydrologic parameters are dominant in controlling water quality predictions. There are also clearly different results between the catchments that are obviously due to climate, but the results also reflect differences in soil and land properties. Thus, each new basin model requires its own sensitivity analysis to select a subset of parameters to be used for model calibration uncertainty analysis (Griensven et al, 2006). Necessary to study the sensitivity of the parameters on the other as in Indonesia that have diverse characteristics. The result of calibration in Cisadane Catchment Area is showed in figure 6 and the validation is showed in figure 7. The correlation error of calibration and validation is showed in figure 8.

![Figure 6. Comparison between observed and simulated daily stream flow at Batubelah river gauge after calibration.](image-url)
SWAT interface of SWAT model has been used successfully for analyzed hydrological characteristics of the Cisadane catchment Area. The calibration and validation by combination automatic and manual methods have good result and The SWAT-CUP advance calibration and uncertainty analysis tool has been used for automatic calibration of stream-flow measurements on period 2005–2010 using SUFI-2 procedures. The sensitivity analysis adopted for the stream-flow calibration is showed variations between the parameter ranges which had been initialized for the model calibration. SUFI-2 procedures gave good results in minimizing the differences between observed and measurement data, by using SUFI-2, we could perform uncertainly analysis and calibrate the model for more number of parameters (Omani et al, 2007).

This study shows that SWAT model can be potential monitoring tool especially for watersheds in Cisadane Catchment Area or in the tropical regions. This whole model uncertainty and calibration analysis can be used for futuristic prediction and assessment of water balance, impact of landuse change and other management scenarios for streamflow measurements especially for the Cisadane catchment Area.

CONCLUSIONS
The ArcSWAT interface of SWAT model has been used successfully for analyzed hydrological characteristics of the Cisadane catchment Area. The calibration and validation by combination automatic and manual methods have good result and The SWAT-CUP advance calibration and uncertainty analysis tool has been used for automatic calibration of stream-flow measurements on period 2005–2010 using SUFI-2 procedures. The sensitivity analysis adopted for the stream-flow calibration is showed variations between the parameter ranges which had been initialized for the model calibration. SUFI-2 procedures gave good results in minimizing the differences between observed and measurement data, by using SUFI-2, we could perform uncertainly analysis and calibrate the model for more number of parameters (Omani et al, 2007).

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