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Analysis of Runoff Curve Number Distribution into Surface Runoff of Lesti Watershed

Didit Priambodo[1*], Ery Suhartanto[2], Sumiadi[2]

[1]Perum Jasa Tirta I, State Owned Corporation, Malang, East Java, 65145, Indonesia
[2]Water Resources Engineering Department, Universitas Brawijaya, Malang, 65145, Indonesia

didit_priambodo@jasatirta1.net

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Abstract. Lesti watershed is a sub basin of Brantas River located in Malang Regency, which is the main source of inflow and sediment loads for the Sengguruh Dam. Human activities change the type of land cover by deforestation for the expansion of agricultural and residential areas. It makes a rapid increasing of runoff and discharges that were potentially carrying sediment into Lesti River. To measure surface runoff in a watershed can be held by modeling rather than directly in the field, it is cheaper and more effective with accurate results. This study is based on Soil Conservation Service (SCS) formula to illustrate surface runoff level by knowing curve number distribution. Using models based on land use changes in 2010, 2012 and 2017, generated by AV SWAT software, shows that increasing CN value each year affects the surface runoff, so there is a relationship between land use and runoff. The average CN value in 2010 is 63.644, 2012 is 63.942, 2017 is 65.49, while the average surface runoff in 2010 is 800.28, 2012 is 823.26, 2017 is 828.009. Conservation treatment on the area with a high CN value can reduce the surface runoff. It shows that watershed performance is getting better.

Keywords: curve number, Lesti watershed, runoff.

1. Introduction

Water flows naturally from a high to a lower area or its known as well as from upstream to downstream. In a hydrological system the water flow is divided into 4 sub-systems namely surface water, subregional groundwater, regional groundwater, and stream sub system. Rainfall is the most important component of the hydrological process. Rainfall depth is being transferred into stream, either through surface runoff, inter flow and sub surface flow or groundwater flow [1].

Erosion at upstream of watershed is a natural occurrence due to rainfall that reaches the ground surface where not full infiltrated into the soil [15]. In a good watershed, the erosion rate is small and can be held by an existing plant. And it is balanced with the rate of soil formation. But, since land use changes are not according to conservation principles, it is immediately increasing either the erosion rate and sedimentation in river and reservoir [2].

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In recent years, land use in Lesti watershed has already changed. There was an increase in agricultural land and residential area, while the forest was decreasing. This change has an impact on runoff and river discharge whose value are getting higher and potentially occurs the erosion and sedimentation in Sengguruh reservoir [3]. According to Perum Jasa Tirta I data, the storage capacity of Sengguruh reservoir in 2011 has been reduced to 76,8 % from its initial capacity [4].

Several recent studies [3, 5, 6, 7, 8] have used hydrological models that reflect the relationship between rainfall and surface runoff by considering the condition of land cover which is one of the erosion factors. Soil Conservation Service (SCS) is one of hydrological model to calculate the prediction of surface runoff and curve number (CN), which is a function of watershed characteristics such as land use, soil type, land cover, moisture, and land management methods.

This research conducted to analyze the relationship of surface runoff and discharge on Lesti watershed by creating the map of CN distribution value, and making an alternative model of improvement land use by conservation approach on Lesti watershed.

2. Materials and Methods

2.1. Study Location

This research uses the upstream Lesti River Basin as the area of study location. Lesti sub-catchment area is located in Malang Regency, East Java, Indonesia. Geographically, it is situated between 8°02'50" – 8°12'10" LS and 112°42'58" – 112°56'21" BT. The Lesti watershed area is 58,294 Ha, divided into sub-catchment areas, Upstream Lesti with 38,248 Ha and Downstream Lesti in 20,046 Ha.

Figure 1. Location of Study

2.2. Data and tools

The study conducted some analysis using spatial data from Arc View GIS 10.3 process, such as sensing of land use, soil type, and CN distribution maps. This program has an extension to analyze the model of watershed management and its impact to hydrology response unit, erosion, and sedimentation that relate with soil type, land use, and land cover periodically. It is called AV SWAT 2000. The data structure used to run this program consists of two spatial types, vector and grid-based data.

Several data are used in this study, i.e.:

1. Topography map in scale 1:25,000 of Lesti Watershed
2. River network map in scale 1:25,000
3. Land use map year 2010, 2012, and 2017.
4. Soil type map of Lesti watershed

5. Daily rainfall data in 20 years (2000 – 2019)
6. Tawangrejeni AWLR discharge data in 10 years (2010 -2019)

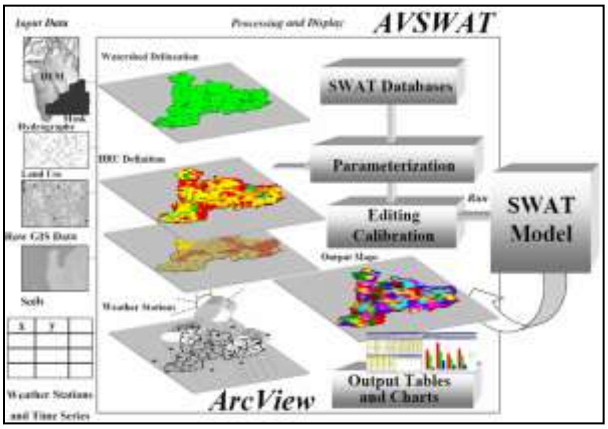

Figure 2. Data Structure Model in AV SWAT

To analyse the relationship of land use changes to runoff CN, this research uses three models simulation for 3 years of Lesti watershed land use, 2010, 2012, and 2017.

2.3. Research procedure

The research method used is analytical research with stages as below:

1. Collect the data.
2. Analyse the hydrological aspects
3. Digitize the map
4. Running the hydrological, land use and soil type data using AV SWAT 2000 program, to result discharge model calculation.
5. Calibrate the model discharge with observation discharge from Tawangrejeni station AWLR.
6. Analyse CN value distribution map using output of calibrated model.
7. Analyse surface runoff of watershed for each model simulation.
8. Create alternatives of land use improvement simulation and analyse the CN and runoff value using the same process with the earlier model.
9. Analyse the comparison of each results simulation. Primary and secondary data collection

2.4. Watershed

A watershed has special characteristics related to land use, soil type, slope and its length and topography. Land use and slope are two factors that can be change by human, while the other factors are natural and uncontrol. Therefore, the land use change, slope, and land cover focus on watershed management [2]. Vegetation types are important in hydrological systems, and human intervention in this factor is enormous. Vegetation can affect soil physical and chemical characteristics to change soil surface condition and runoff value.

When rainfall intensity exceeds the infiltration capacity, water will fill the cavities on ground surface first. Then, the rest of water will flow over the ground or known as surface runoff. It will run into the trench or ditch, until it enters tributaries and collects as a river [1].

Volume and rate of surface runoff are depending on meteorology character of watershed. SCS are develop an index called runoff curve number that expresses the impact of soil condition, hydrology or water content simultaneously.

2.5. Hydrology analysis

The result of hydrological analysis is rainfall intensity in several period as input data for model development.

2.6. Soil Conservation Service (SCS)

The SCS method is develop from rainfall observation for years and involve many agricultural areas in US. This method is based on relationship between infiltration for every soil type with every rainfall that reaches the ground. Total rainfall in every rain (P) on the ground with maximum potential of soil retains water (S), will divide into 3 components; runoff water (Q), infiltration (F) and initial abstraction (Ia), with formulas [9]

$$Q = \frac{(P - I_a)^2}{(P - I_a + S)}$$

With:
Q = Volume of surface runoff (mm)
Ia = Initial abstraction
P = Daily rainfall (mm)
S = Volume of total retention parameter (mm)

To determine depth excess rainfall or surface runoff can be showed on formula above, where correlation Ia with S is [9]:

$$I_a = 0.2\,S$$

To simplify calculation of antecedent moisture condition, land use, and soil conservation, US SCS determine S value as below:

$$S = 25.4\left(\frac{1000}{CN} - 10\right)$$

CN: runoff curve number (0 – 100)

By plotting P and Q in SCS curve (graphic below), it finds the CN value. In SCS, soil type is classified into 4 type based on the type and land use (hydrological soil group). Usually, initial abstraction use approach 0.2 S. So, the formulas :

$$Q = \frac{(P - 0.2\,S)^2}{(P + 0.8\,S)}$$

Surface runoff will occurred when rain (P) is bigger than initial abstraction (Ia). For different CN value look this picture.

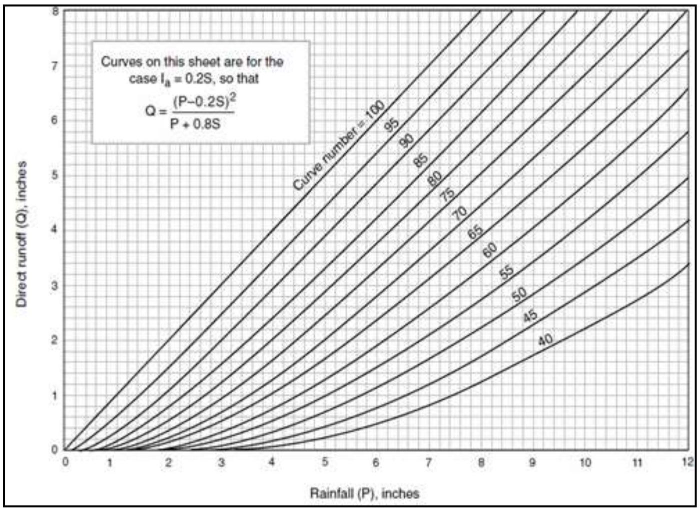

Figure 3. CN-SCS graphics

CN value is obtained from area study which has moderate climate. But this value can be used, when there is no value determined in area study.

Table 1. CN value by SCS classification

Land-use description		*A*	*B*	*C*	*D*
Cultivated land[1]:					
without conservation treatment		72	81	88	91
with conservation treatment		62	71	78	81
Pasture or range land:					
poor condition		68	79	86	89
good condition		39	61	74	80
Meadow: good condition		30	58	71	78
Wood or forest land:					
thin stand, poor cover, no mulch		45	66	77	83
good cover2		25	55	70	77
Open spaces, lawn, parks, golf courses, cemeteries, etc.					
good condition: grass cover on 75 percent or more of the area		39	61	74	80
fair condition: grass cover on SO to 75 percent of the area		49	69	79	84
Commercial and business areas (85 percent impervious)		89	92	94	95
Industrial districts (72 percent impervious)		81	88	91	93
Residential[3]:					
Average lot size	Average percent impervious[4]				
1/8 acre or less	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
Paved parking lots, roofs, driverways, etc.[5]		98	98	98	98
Street and roads:					
paved with curbs and storm sewers[5]		98	98	98	98
gravel		76	85	89	91
dirt		72	82	87	89

The Antecedent Moisture Conditions (AMC) have strong influence on assessing surface runoff volume. Therefore, SCS has compiled three level of AMC based on the amount of rain in 5 days earlier [12] :

1. AMC I. Soil in watershed is dry, lowest potential runoff, however it is not to the point of withering, have been planted with good results. AMC I analysis is used to analyse CN when dry season.
2. AMC II. Soil is in average condition.
3. AMC III. Heavy or light rain with low temperature, soil is in saturated condition, and highest potential runoff. AMC III is used to analyse CN when wet season.

Curve Number value is equivalent on AMC I and III conditions can be counted by using this equation [10] :

$$CN_{(I)} = \frac{4.2\ CN_{(II)}}{10 - 0.058\ CN_{(II)}}$$

and,

$$CN_{(III)} = \frac{23\ CN_{(II)}}{10 - 0.13\ CN_{(II)}}$$

SCS has developed soil classification system based on soil characteristic and that are classified into four Hydrologic Soil Group (HSG), i.e :

Table 2. Hydrologic Soil Group Classification

HSG	Soil Texture	HSG definitions (USDA-NRCS, 1986)	The six types of soil textures in study area
A	Sand, loamy sand, or sandy loam	Low runoff potential and high infiltration rates; This soils have high rate of water transmission (greater than 7.62 mm/hr)	(1) Loamy Sand (LS) (2) Sandy Loam (SL)
B	Silt loam or loam	Moderate infiltration rates; The soils have moderate rate of eater transmission (3.81 mm/hr)	(3) Loam (LL)
C	Sandy clay loam	Low infiltration rates; The soils have a low rate of water transmission (1.27-3.81 mm/hr)	
D	Clay loam, silty clay loam, sandy clay, silty clay, or clay	High runoff potential; These soils have very low rate of water transmission (0-1.27 mm/hr)	(4) Clay Loam (CL) (5) Heavy Clay (HC) (6) Light Clay (LC)

2.7. Land use direction

To conduct a good land use, several criteria are determined for protecting forest and production forest according the watershed physical characteristic, such as land slope, soil type, sensitivity to erosion and response to daily rainfall. The criteria used in determining the area based on its function refer to Indonesian Government Regulation : PP No. 37/2012 and Minister of Forestry Regulation : P.60/Menhut-II/2014.

3. Results and Discussion

3.1. Digitalize the catchment Area

Initial process on AV SWAT program is to determine the watershed boundaries. By using topographic map and river network map, it can generate the digitized stream network with DEM format. Next step is to define the river and outlet location. This process needs data input for designated watershed outlet at the Tawangrejeni bridge and area threshold value of 500 ha. The result of this analysis are boundary of catchment area and river network of Lesti Watershed.

3.2. Irrigation Performance Index Calculation

- Analysis of Homogenous Rainfall
  Based on the analysis using Raps Method, with Q/√n calculation < Q/√n table and R/√n calculation < R/√n table, the rainfall data from Tangkil, Poncokusumo, and Dampit station is worth to use.
- Analysis of abnormality
  Based on the analysis of Inlier-Outlier all rainfall data is within range from Xh to Xl.
- Analysis of Consistency Rainfall
  This analysis using Double Mass Curve methode. The result of this analysis are R2 for each station. There are 0.989, 0.984, and 0.994. So, the rainfall data are consistent.

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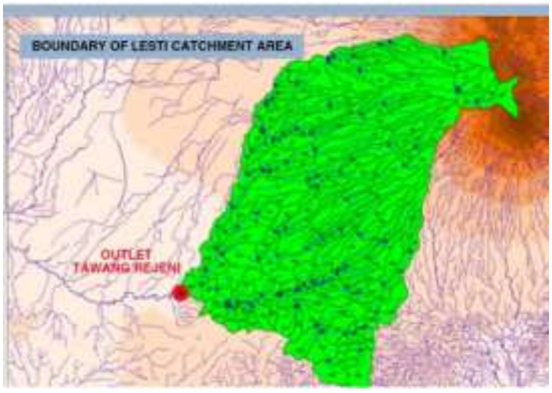
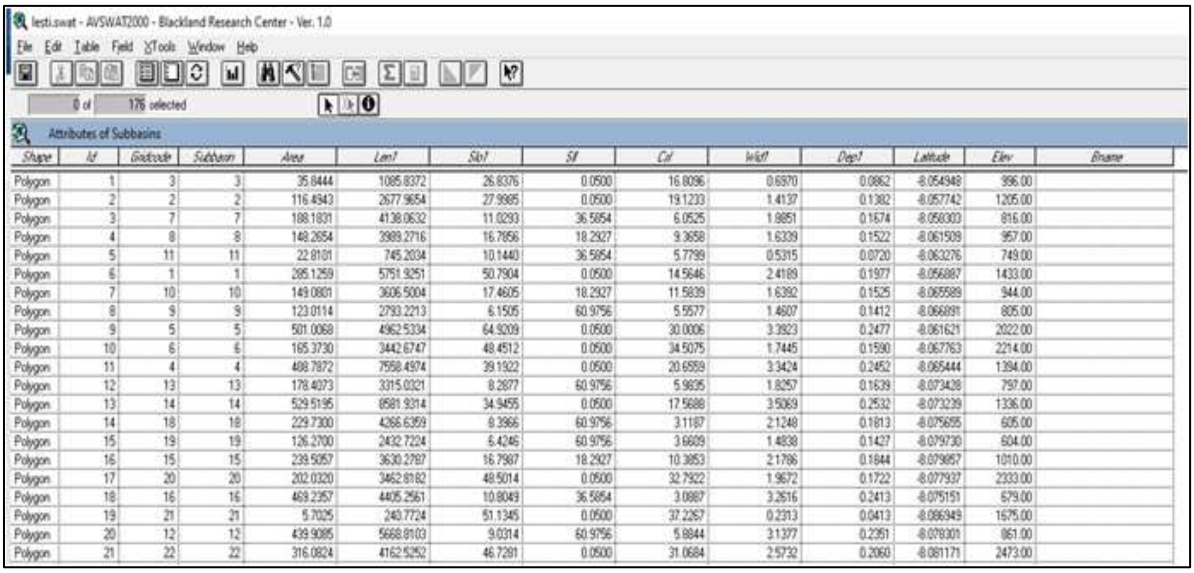


Figure 4. The boundary of Lesti Catchment Area with Tawangrejeni station as the outlet.

3.3. Analysis of Land Slope

By calculating watershed proses on AV SWAT program, land slope distribution is recorded on a dbf watershed table.



Shape	Id	Gridcode	Subbasin	Area	Len1	Slo1	Sll	Csl	Wid1	Dep1	Latitude	Elev	Bname
Polygon	1	3	3	35.8444	1085.8372	26.8376	0.0500	16.8096	0.6970	0.0862	-8.054948	996.00	
Polygon	2	2	2	116.4943	2677.9654	27.9985	0.0500	19.1233	1.4137	0.1382	-8.057742	1205.00	
Polygon	3	7	7	188.1831	4138.0632	11.0293	36.5854	6.0525	1.9851	0.1674	-8.058303	816.00	
Polygon	4	8	8	148.2654	3989.2716	16.7856	18.2927	9.3658	1.6339	0.1522	-8.061509	957.00	
Polygon	5	11	11	22.8101	745.2034	10.1440	36.5854	5.7799	0.5315	0.0720	-8.063276	749.00	
Polygon	6	1	1	285.1259	5751.9251	50.7904	0.0500	14.5646	2.4189	0.1977	-8.056887	1433.00	
Polygon	7	10	10	149.0801	3606.5004	17.4605	18.2927	11.5839	1.6392	0.1525	-8.065589	944.00	
Polygon	8	9	9	123.0114	2793.2213	6.1505	60.9756	5.5577	1.4607	0.1412	-8.066891	805.00	
Polygon	9	5	5	501.0068	4962.5334	64.9209	0.0500	30.0006	3.3923	0.2477	-8.061621	2022.00	
Polygon	10	6	6	165.3730	3442.6747	48.4512	0.0500	34.5075	1.7445	0.1590	-8.067763	2214.00	
Polygon	11	4	4	498.7872	7558.4974	39.1922	0.0500	20.6559	3.3424	0.2452	-8.065444	1394.00	
Polygon	12	13	13	178.4073	3315.0321	8.2877	60.9756	5.9835	1.8257	0.1639	-8.073428	797.00	
Polygon	13	14	14	529.5195	8581.9314	34.9455	0.0500	17.5688	3.5069	0.2532	-8.073239	1336.00	
Polygon	14	18	18	229.7300	4266.6359	8.3966	60.9756	3.1187	2.1248	0.1813	-8.075695	605.00	
Polygon	15	19	19	126.2700	2432.7224	6.4246	60.9756	3.6609	1.4838	0.1427	-8.079730	604.00	
Polygon	16	15	15	239.5057	3630.2787	16.7987	18.2927	10.3853	2.1786	0.1844	-8.079857	1010.00	
Polygon	17	20	20	202.0320	3462.8182	48.5014	0.0500	32.7922	1.9672	0.1722	-8.077937	2333.00	
Polygon	18	16	16	469.2357	4405.2561	10.8049	36.5854	3.0887	3.2616	0.2413	-8.075151	679.00	
Polygon	19	21	21	5.7025	240.7724	51.1345	0.0500	37.2267	0.2313	0.0413	-8.086949	1675.00	
Polygon	20	12	12	439.9085	5668.8103	9.0314	60.9756	5.8844	3.1377	0.2351	-8.078301	861.00	
Polygon	21	22	22	316.0824	4162.5252	46.7281	0.0500	31.0684	2.5732	0.2060	-8.081171	2473.00	

Figure 5. Display of *.dbf* Watershed Table in AV SWAT program to shows the land slope

3.4. Analysis of Land Use Map

Distribution of land use in the sub-catchment area presented in table 3.

Table 3. Distribution of land use in 2010, 2012, 2017

Land Use	2010		2012		2017	
	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)
Shrubs	566.01	1.48	503.26	1.32	470.16	1.23
Forest	9,129.94	23.87	8,670.69	22.67	8,438.75	22.00
Plantation	3,199.18	8.36	1,044.12	2.73	1,014.31	2.65
Residence	1,642.94	4.30	2,578.52	6.74	6,242.09	16.32
Moor	17,598.49	46.01	14,044.64	36.72	12,182.62	31.85
Agriculture	6,069.12	15.87	11,376.17	29.74	9,873.70	25.82
Fallow	42.01	0.11	30.23	0.08	26.00	0.07
Total	38,247.63	100.00	38,247.63	100.00	38,247.63	100.0

The tables show that there are land use changes each years. Forest, shrubs, and plantation are decreasing from 25.35 % in 2010 to 23.99 % in 2012 and 23.29 % in 2017. While the agriculture area are increasing from 15.87 % in 2010 to 29.74 % in 2012, and 25.84 % in 2017. Residence are also increasing from 4.3 % in 2010 to 16.32 % in 2017. Distribution of land use can be shown in spatial mode by mapping it.

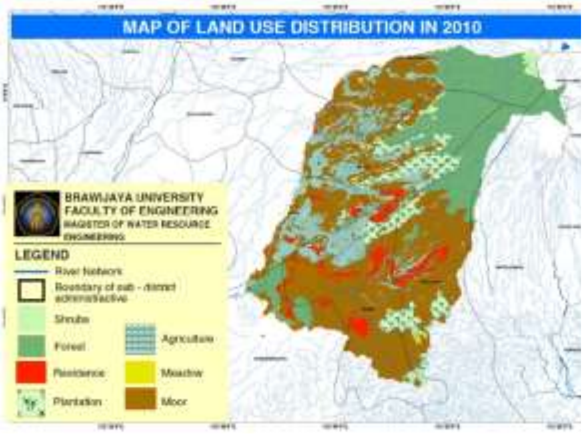


Figure 6. Map of Land Use Distribution in 2010

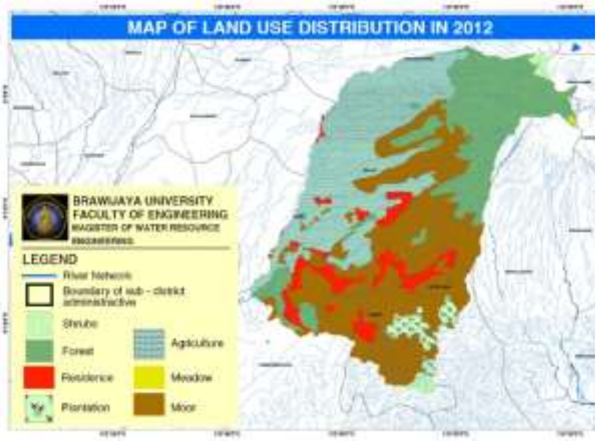


Figure 7. Map of Land Use Distribution in 2012

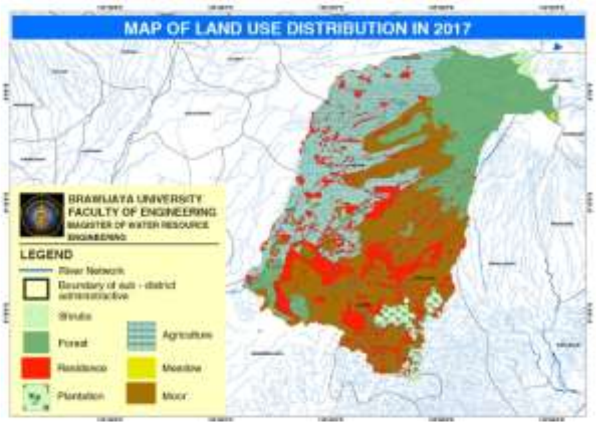


Figure 8. Map of Land Use Distribution in 2017

Table 4. CN II Value For Each Land Use

No.	Land Use	CN II Value			
		A	B	C	D
1	Water	49	69	79	84
2	Forest	36	60	73	79
3	Plantation	43	65	76	82
4	Residence	49	69	79	84
5	Meadow	39	61	74	80
6	Agriculture	58	69	77	80
7	Shrubs	35	56	70	77
8	Moor	43	65	76	82

3.5. Rehabilitation of Physical Infrastructure in Surak Irrigation Area

HRU distribution is used to determine the area of land use and soil type in the watershed model.

3.6. Rehabilitation of Physical Infrastructure in Surak Irrigation Area

This simulation aims to process all data to obtain discharge and surface runoff value in the area studies. In this research, hydrological spatial modeling's simulation process uses scenarios land use modeling in 2010, 2012 and 2017. There are 2 types of AV SWAT 2000 simulation results files: *Subbasin output file (*.sbs)* and *Main channel output file (*.rch)*

3.7. Rehabilitation of Physical Infrastructure in Surak Irrigation Area

To obtain applicable and acceptable model in accordance with field conditions, a calibration step is required for the SWAT model. The calibration process is needed to adjust the influencing parameters in the study area's watershed so that the modeling results are closer to the observation discharge, in this case AWLR Tawangrijeni. In this study, the calibrated parameters are limited to LAT_TIME, CN, ESCO, SOL_AWC, and ALPHA_BF parameters.

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Table.5 AV SWAT 2000 Parameters Calibrated

Parameter	Lower Limit	Upper Limit	Calibrated Value
CN2	35	98	15 % lower
SOL_AWC	0	1	0.05
ESCO	0	1	0.4 – 0.5
LAT_TIME	0	270	170 – 180 days
ALPHA_BF	0	1	0.55 – 0.75

The calibration process result is shown in the comparison graph for each modeling simulation in Figure. 10, 11 and 12. Calibrated model is tested statistically to compare the data population, both model discharge and AWLR data. In this study, statistic testing uses regression method, Nash Sutcliff Efficient Method, and Mean Square Error Method. The results of all tests prove that the model is suitable for use.

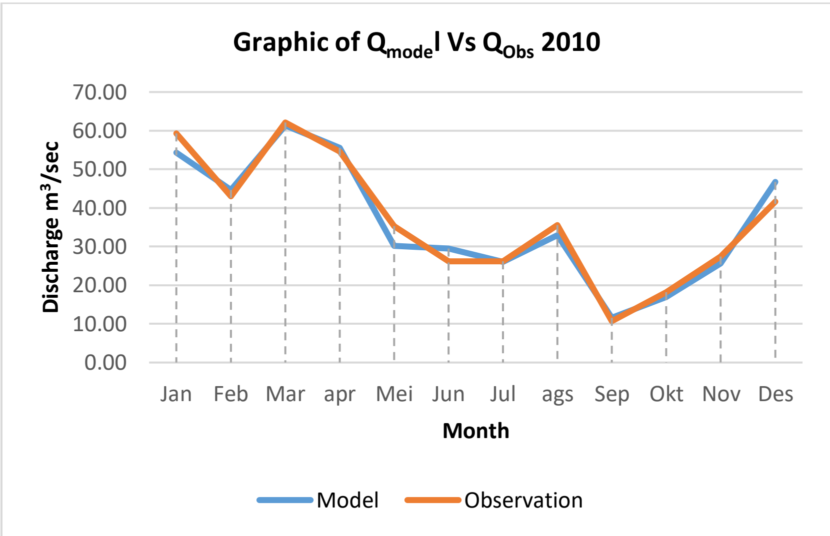

Figure 9. Comparation Graph of model discharge to AWLR discharge in 2010.

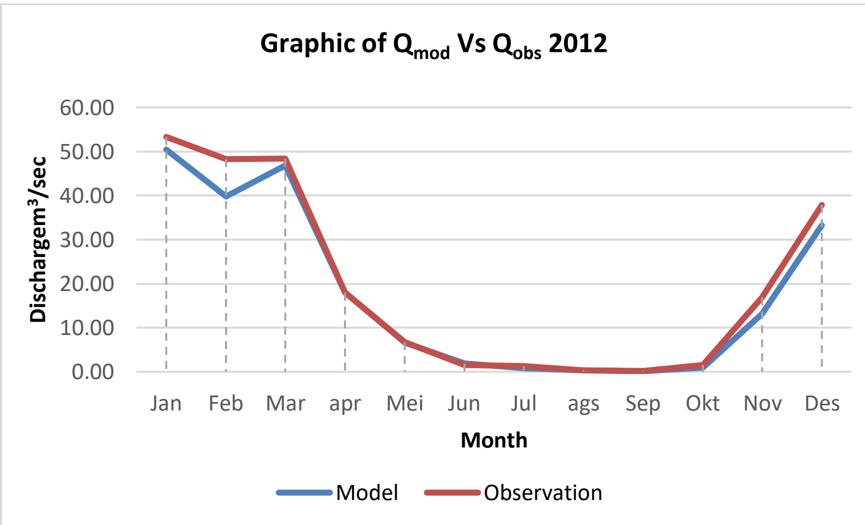

Figure 10. Comparation Graph of model discharge to AWLR discharge in 2012.

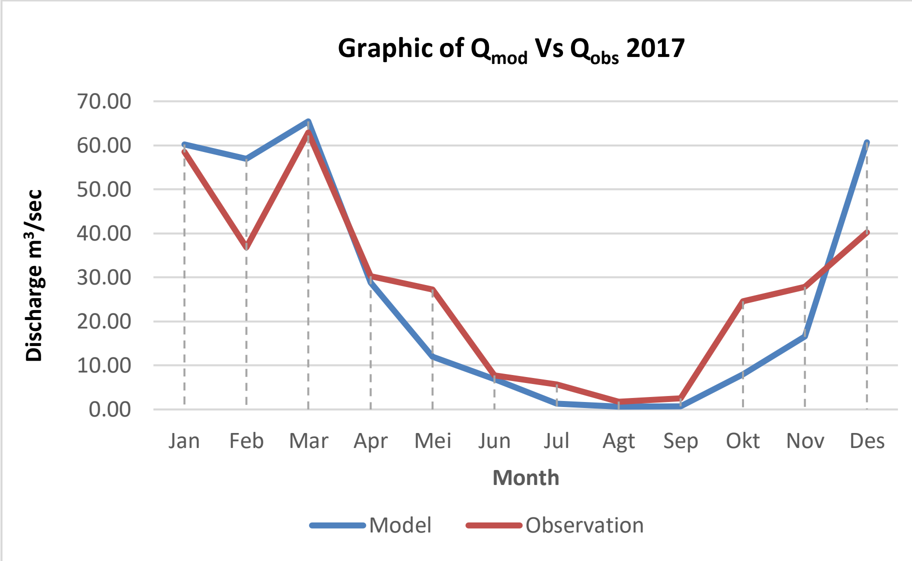

Figure 11. Comparation Graph of model discharge to AWLR discharge in 2017.

3.8. Rehabilitation of Physical Infrastructure in Surak Irrigation Area

One of the simulation outputs with calibrated parameter values is CN values for each sub basins and HRU. There are 176 sub basins in the model simulations divided by land use, soil type, and land management into each Hydrology Response Units. Each HRU has its own CN value obtained from running the AV SWAT program. By calculating each total HRU area's percentage factor, it can be obtained the average CN value for both sub-basin and watershed. The average CN value for each models are 63.44 in 2010, 63.94 in 2012, 65.49 in 2017.

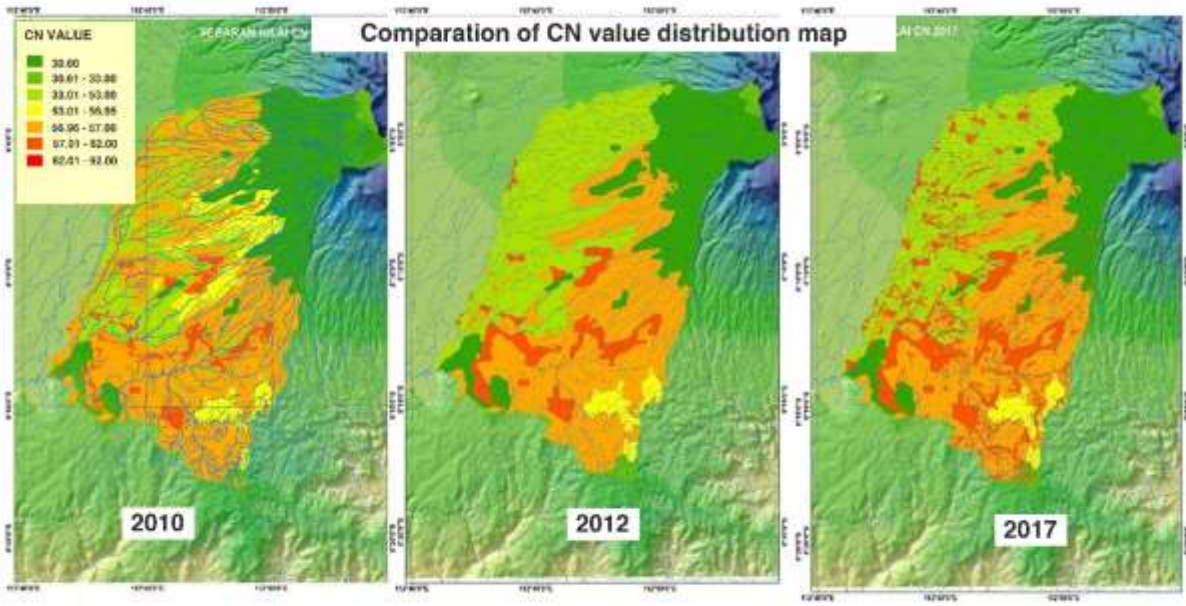

Figure.12 Comparation of CN value distribution map in 2010, 2012, and 2017 models.

From that spatial models (figure 12) are known, there are changes of CN values distribution that simultaneously with surface runoff rate changes. The increasing of agriculture area from 2010 to 2012 is more than 5,000 ha. Furthermore increasing of residence area from 2010 to 2017 are quite significant, is more than 4,500 ha. Otherwise, the area of forest and plantations continued to decline to nearly 3,000 ha in 7 years. It affects higher CN value in the following year.

3.9. Rehabilitation of Physical Infrastructure in Surak Irrigation Area

The results of model simulation using calibrated parameter values obtained the watershed rate of surface runoff distribution value. Mapping of the surface runoff distributions in each models are shown in Figure. 14, 15 and 16.

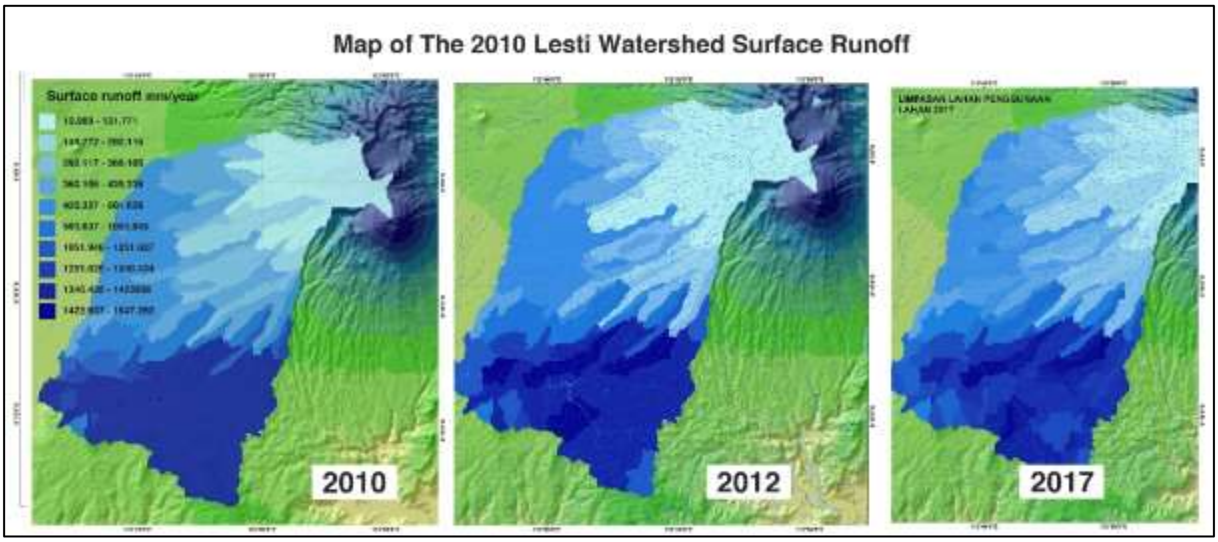

Figure 13. Map of The 2010 Lesti Watershed Surface Runoff

According to the figures above, there is an increasing of surface runoff values from 2010 to 2017. The average surface runoff in 2010 is 800.28 mm/year, 2012 is 823.26 mm/year, and 2017 is 828.009 mm/year. Surface runoff rates and watershed outlet river discharge also be measured as an evaluation of the CN Value.

Table 6. Comparation of hydrological value in Lesti Watershed

Parameter	Units	2010	2012	2017
Q_{min}	m^3/s	11.59	0.12	0.64
Q_{max}	m^3/s	61.35	50.44	60.71
Runoff Rate	mm/year	800.28	823.26	828.01
Avrg CN Value	-	63.44	63.94	65.49

3.10. Rehabilitation of Physical Infrastructure in Surak Irrigation Area

Conservation efforts aim to improve the watershed ability to store the rainfall to reduce the surface runoff. The land improvement proposed through rearrangement the watershed existing land use (2017). The treatment priority are on sub basin or HRUs which have high CN values.

This study proposes two alternative conservation scenarios. First alternative is changing the land use of moor area with plantation with dense plants. The type of vegetation is also important. Sengon, Jabon, and fruit tree like Durian, Lamtoro, Kemiri, Avocado, and Jackfruit tree are highly recommended for use. Other treatment is adding 0.5 Ha infiltration pond in the residence area by putting some infiltration wells in each house, making a wetland designed as a town park, and building some pond. Treatment of alternative I conservation scenario as seen on Figure 14.

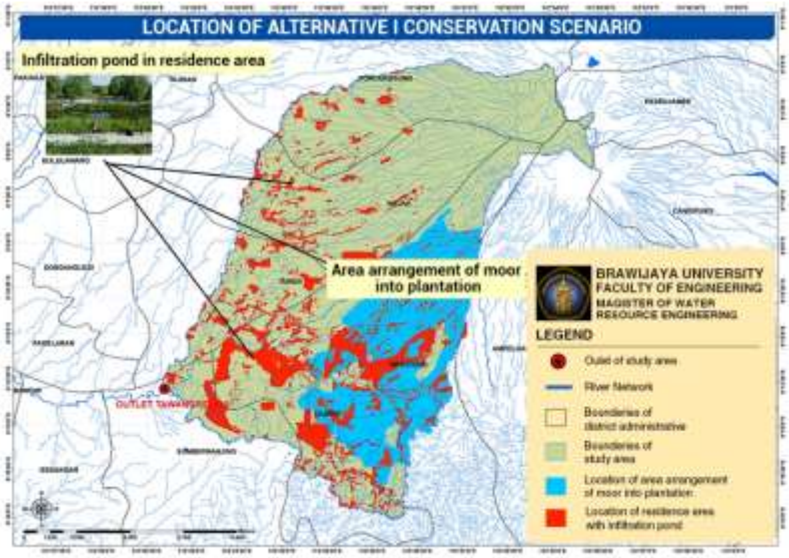

Figure 14. Location of Alternative I Conservation Scenario.

Second alternative is designed by keep the existing land use. Conservation effort are carried out through land treatment by changing the straight row crops into contoured fields or terraces (figure 15). The hydrologic effect of contouring results from the surface storage provided by the furrows because the storage prolongs the time during which infiltration can take place. The magnitude of storage depends not only on the dimensions of the furrows but also on the land slope, crop, planting and cultivation manner.

Figure 15. Location of Alternative II Conservation Scenario

Both conservation model simulations are run by changing the CN value of 2017's model, especially on the areas selected for conservation. The changes of CN Value are refer to the table of SCS CN classification.

3.11. Rehabilitation of Physical Infrastructure in Surak Irrigation Area

Both of conservation models are obtain similar simulation results (Table 7).

Table 7. Comparison Of Watershed Hydrology Parameter

Parameter	2010	2012	2017	Conservation Alt I	Conservation Alt II
Q_{min} (m^3/sec)	11.59	0.12	0.64	0.85	1.64
Q_{max} (m^3/sec)	61.35	50.44	60.71	39.55	39.88
Runoff Rate	800.28	823.26	828.01	796.89	797.87
Averg CN Value	63.44	63.94	65.49	64.27	62.75

Both of conservation models are proven can reduce CN value, runoff rate, and outlet discharge in Lesti watershed. It means that the conservation models are successful and can be used to improve the watershed performance.

4. Conclusion

To predict the CN value of Lesti watershed, AV SWAT software analysis is used based on SCS formulas. There are three model scenarios with different years of land use, 2010, 2012, and 2017. Each models are calibrated with watershed outlet discharge obtained from Tawangrejeni AWLR data. The results of calibration is tested by Nash Sutcliff Efficient Method, and Mean Square Error Method. From all tests are proof that the model is suitable for use. Average CN values for each model are 63.44 in 2010, 63.94 in 2012, and 65.49 in 2017, with a 0.264/year growth rate. Spatially, the increasing of CN values mostly occurred in the southern and western part of the watershed. It happened because of land use changes such as forest reduction, expansion of agricultural area, and rise of residence area.

The increasing of CN value each years affects on increase of surface runoff rate. The average surface runoff in 2010 is 800.28 mm/year, 2012 is 823.26 mm/year, and 2017 is 828.009 mm/year. It proves that changes in land cover and land management affects the watershed ability to storage the rainfall. When rainfall intensity exceeds the infiltration capacity, water will fill the cavities on a ground surface first. Iit can change runoff value

Conservation treatment is needed to improve watershed ability to store the rainfall, reducing the surface runoff. In this study, there are two alternative scenarios. Alternative one is designed by change some land use of sub basin and adding ponds of infiltration on residence area. Alternative two is designed by keep the land use, and change the land cover and land management with lower CN value. The conservation simulation results are CN value is 64.27 for an alternative I and 62.75 for an alternative II. While the rate of surface runoff for alternative I is 796.89 mm/year and for alternative II is 797.873 mm/year. It means that the conservation models are successful and can be used to improve the watershed performance.

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