Available at : https://ejournal.unib.ac.id/index.php/terrajournal ISSN 2621-0207
DOI : https://doi.org/10.31186 terra.2.1.9-17

TERRA
Journal of Land Restoration

The Simulation of Land Use Change On Soil Erosion and Sediment Transported Using SWAT Hidrological Models In The Upstream of Mrica Reservoir Catchment Area

Lukman Hidayat[1], Bambang Sulistyo[1]

[1]*Faculty of Agriculture, University of Bengkulu, Indonesia*
email: lukman_hidayat@unib.ac.id

ABSTRACT

The phenomenon of land conversion of natural forest into agricultural cultivation is an event in nature that must be understood to determine action in the future. The aim of this research was to know the influence of land use changes to soil erosion and sediment transported. Simulation on hydrological model was used as research method. Soil Water Assessment Tool (SWAT) Hydrological models that have been validated on a very good level based on the Nash-Sutcliffe Efficiency (NSE), is used to simulate in land use changes, based on Land Cover Index Changes (IPL) permanent and production scenarios, on soil erosion (SYLD) and sediment transported (Sed-out), in 101,027.250 hectares of the upstream of Mrica reservoir catchment area. SWAT model simulation results indicate that quantitatively, the increase IPL permanent followed by a decrease in IPL production has the potential to lower the value of soil erosion (ton/hectares/year) of approximately 5.77% to 82.37% and from 5.15% to 75.12% of sedimentary transported (mm/year). Qualitatively, positive Extreme scenario, can increase the value of soil erosion in some subcatchments and the upstream of Mrica reservoir catchment area, from worse quality on the existing condition become moderate, and even good. Watershed management efforts to reduce the rate of soil erosion and sediment transported on the river, with land use changes should be followed by soil and water conservation techniques such as bench terraces and contouring.

Keywords: land degradation; practical conservation concepts; agro-forestry models

INTRODUCTION

Degraded land due to soil erosion is a dilemmatic problem for most countries, especially for developing countries such as Indonesia. There are, from year to year, the occurrence of erosion caused by human activities is continuously accelerating as a result of population and economic growth (Sulistyo *et al*., 2009; Bohre & Chaubey., 2014; Sulistyo *et al*., 2017). More specifically, degradation of the watershed, especially in Java, continues to occur and is difficult to prevent, though, since the 1970s the Indonesian government has implemented several rehabilitation programs related to watershed management, such as reforestation, soil conservation measures, and others.

Problems of floods, drought, erosion and sedimentation, have always been a hot topic to talk about. Conversion of natural forest land into agricultural land is always associated with it. The growth of the population that impacts on the increase of food and water supply, triggers the occurrence of land conversion as a temporary solution to overcome it (Asdak, 2010; Alibuyog *et al*., 2009; Omani *et al*., 2007).

Upstream of Mrica Reservoir catchment area, with total area of 101,027.25 hectares, which should be conservation area has begun to be encroached into the area of farming activities. With a reservoir capacity of 140 million m^3, which began operations in 1989 and a sedimentation rate of 4.20 million m^3/year, then by 2021, it will be full of sediment (Soewarno & Syariman, 2008).

Debates are still going on among the general public, as to how far the role or effect of vegetation changes on the reduced or increased water yield. The debates even often occur between environmental management experts and hydrological experts (Asdak, 2010). The elementary hydrological model, composed of basic hydrological elements, such as rain, evaporation, recharge, storage, and flow, is seen as an extrapolation tool that can help to understand the phenomena.

The *Soil Water Assessment Tool* (SWAT), is a physically, deterministically, and continuously based basin-hydrology model developed by the USDA Agricultural Research Service (Arnold *et al*., 2012; Neitsch *et al*., 2004, 2005) . In its operations, SWAT can perform several simulations, including management practices on land and in rivers, including land use change, soil and water conservation practices, and the presence of *pound* - controlled sediment transport buildings (Neitsch *et al*., 2005; Suryani & Agus, 2005; Williams *et al*., 2008, Arnold & Allen, 1996; Alibuyog *et al*., 2009; Arnold *et al*., 2010; Gassman *et al*., 2007).

In the SWAT model, erosion caused by rainfall and runoff is calculated using the *Modified Universal Soil Loss Equation* (MUSLE). MUSLE is a modified form of *Universal Soil Loss Equation* (USLE) developed by Wischmeier and Smith in 1965 (Neitsch *et al*., 2005), and formulated as (Williams, 1995) :

$$sed = 11{,}8\ (Q_{surf}\ .q_{peak}\ .area_{hru})^{0.56}.\ K_{usle}\ .\ C_{usle}\ .\ P_{usle}\ .\ L_{usle}\ .\ CFRG \ldots\ldots (1)$$

sed = sediment yield/day (ton)
Q_{surf} = volume of surface flow (mm H_2O/hectares)
q_{peak} = peak rate of running water (m^3/sec)
$area_{hru}$= area of *hydrologic response units* (HRU) (hectares)
K_{usle} = soil erodibility factor of USLE (0.013 ton m^2 hour/(m^3-ton cm))
C_{usle} = USLE management and land cover factor
P_{usle} = the practical factor of supporting USLE
L_{usle} = USLE topography factor
$CFRG$ = quartz fragmentation factor

The aim of this research was to study the influence of some variations of land use on the yield of sediments-erosion on land and sediment transported in rivers, using the SWAT hydrological model.

The research location is in the upstream of Mrica reservoir catchment area covering 101,027.25 hectares, lies between 109.69°-109.84° E and 7.17°-7.37°S. Administratively, it covers two regencies in Central Java Province, namely Wonosobo and Banjarnegara (Figure 1.)

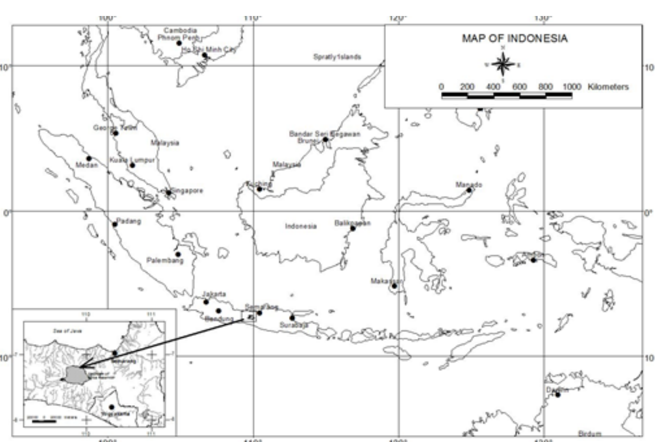


Figure 1. Upstream of Mrica Reservoir catchment area

MATERIAL AND METHOD

Simulations using the SWAT model on several land use change scenarios, are the basis of research methods, to assess watershed performance and determine their effect on sediment yields on land and sediment transported in rivers (Hidayat *et al*., 2014). Therefore, the SWAT model used for the simulated activity has been validated through calibration and verification.

Tools and research materials, including computers and other equipments, *ArcSWAT* 2005/2009 free license software, spatial data: DEM maps, land use, soil types and slopes; rain and climatic data within 2003-2013.

References used in validation activities (calibration and verification), ie: NSE value > 0.65 (*Very Good*), NSE 0.54 - 0.65 (*Adequate*), and NSE ≥ 0.50 (*Satisfactory*) (Moriasi *et al*., 2007). In addition to the NSE values, the values of R^2, PBIAS, and RSR can also be used in evaluating the performance or accuracy of watershed model simulation activities. If the NSE value is > 0.5; RSR ≤ 0.7 and PBIAS ± 25%, the model performs as *Satisfactory* on a monthly scale/monthly average scale (Moriasi *et al*., 2007).

The slopes serve as the basis for determining the scenarios. The land with a slope of ≥ 15% is defined as permanent vegetation land, and the land with slope < 15% is designated as production land. The maximum percentage of area is determined to be the limits of change or manipulation of regional land use. Land use under *existing conditions* comprises 79.6% of production IPL, 11.7% of permanent IPL, and the rest is 8.7%. Production IPL (irrigated rice field, rainfed rice field, garden and moor). Permanent IPL (forest land, shrubs/bushes, swamps and grasses), Other land (settlement, building and freshwater).

Negative *Extreme* Scenario: Manipulating permanent land which is potential for production land (agricultural cultivation), thus achieving a negative *Extreme* proportion with a permanent IPL margin of ≤ 2.0%.

Positive *Extreme* Scenario, Rational 1, 2, and 3: Manipulate production land having potential to be permanent land (forests), thus achieving a positive *Extreme* proportion with a production IPL margin of ≤ 2.0%; 70% (Rational 1); 60% (Rational 2); and 50% (Rational 3).

The scenarios used are based on regulations and guidelines related to watershed management and conservation of natural resources, especially those related to land cover manipulation/land use change, for example: Permen 32/Menhut-II/2009, SK Menhut 52/Kpts/2001; Directorate General of Water Resources - Ministry of Public Works, Balitbang Technology Watershed Management of Indonesia Region and Forestry Research and Development Agency - Forest Research and Nature Conservation.

RESULT AND DISCUSSION

The result of watershed model analysis shows that it has formed 1940 *Hydrological Response Units* (HRU's) and 113 Sub-catchment. Then, the soil type in the study area of Mrica Reservoir, are: latosol 88.5% of total area, grumusol (6.14%), regosol (3.33%), and alluvial 1.98%. Slope varies, <8% (20.10% of total area), 8-15% (29.50%); 15% - 25% (28.97%); 25-40% (15.30%), and the rest ≥ 40% (6.13%). Average air temperature 14 ^{o}C-26 ^{o}C, the altitude of +1.000 MSL; rainfall rate 2500-5000 mm/year. Inputs for the SWAT weather generator model use 6 rain stations and 2 climatological stations.

Validation

SWAT model validation results, statistically and graphically, show the degree of validity in the range of *satisfactory* to *very good*, and the value of $Q_{prediction}$ is close to $Q_{observation}$, so it is feasible for simulation activities. The calibration values are R^2 = 0.61; NSE = 0.61; PBIAS = -0.61%; RSR = 0.63 and MB = -0.25; Verify, ie :. R2 = 0.74; NSE = 0.73,; PBIAS = -4.06%; RSR = 0.52 and MB = -1.57. The T test for paired data indicates that $T_{calculated} < T_{table\ (23;\ 0.05)}$, $Q_{prediction}$ and $Q_{observation}$ values are not significantly different (Hidayat *et al.*, 2016).

Simulation

Simulation of validation results, to see land use change to erosion and sedimentation, run on *existing* conditions, and 5 land use scenarios, using data from 2003 to 2007. Land use distribution under *existing conditions* and land use maps under *simulation conditions* are presented in Table 1. and Figure 2.

Table 1. Land use distribution in the upstream of Mrica Reservoir catchment area

No	Land use	Area (hectares)	Area (%)
1	Shrub	9.582,12	9.48
2	Forest	1.414,85	1.40
3	Swamps	4,9013	0.005
4	Grasslands	587,344	0.58
5	Agricultural Cultivation1	31.204,39	30.89
6	Agricultural Cultivation 2	29.689,05	29.39
7	Irrigated Rice Fields	6.625,80	6.56
8	Rainfed Rice Fields	13.202,58	13.07
9	Building	40,8445	0.04
10	Settlements	7.449,22	7.37
11	Water Body	1.226,15	1.21
	Total	101.027,25	100

Source: Results of Watershed Modeling, HRU analysis (2014)

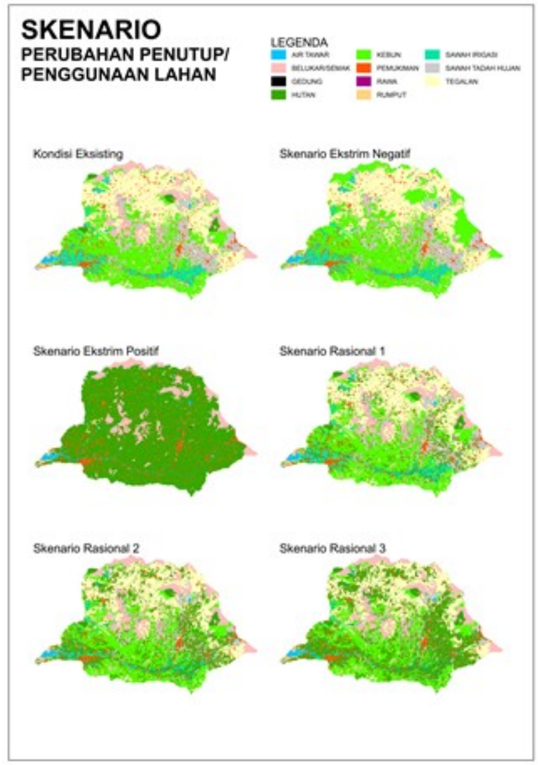


Figure 2. Land use maps under *simulation conditions*

Scenario Rational 1 (R1): 70% of IPL production and 21.30% of Permanent IPL.

In this R1 scenario, a percentage of the production IPL is decreased and a percentage of the permanent IPL is increased on the land use under *existing conditions*, resulting in 70% of the production IPL and 21.30% of the permanent IPL.

Sediment yield (ton/hectares) abbreviated as *SYLD* is one of the SWAT model output variables in the *subbasin output file*.SYLD, defined as sediments from sub-catchments transported into the channel (rivers) over a period of time (Neitsch *et al.*, 2005) . This definition can be understood that the sediment of the sub-catchment is the erosion process occurring in the land or sub-catchments due to the peeling of the soil, then transported into the channel (rivers), floating and deposited in it as sediment.

Soil erosion SYLD (ton/hectares) in some sub-basins which are presented in Figure 3. shows that scenario R1, gives effect in decreasing the value of soil erosion.

The value of soil erosion on sub-watersheds 72 and 88, ie 16.56 ton/hectares/month (198.75 ton/hectares/ year), and 24.30 ton/hectares/month (291.62 ton/hectares/ year), and 21.13 ton/hectares/month (253.52 ton/hectares/ year) in Mrica Reservoir catchment area. When it is compared to the value of soil erosion in the *existing condition* (269.04 ton/hectares/year), so it cause monthly decrease about 1.83 ton/hectares for sub-catchment 72 and 0.98 ton/hectares for sub-catchment 88, as well as 1.29 ton/hectares per month or 15.52 ton/hectares/ year (5.77%) in the upstream of Mrica Reservoir catchment area. In the rational scenario 1, the value of soil erosion occurring in several sub-catchments and upstream of Mrica Reservoir catchment area is qualitatively categorized as *heavy*, since the value is greater than 180 ton/hectares/year (Ministry of Public Works, 2010).

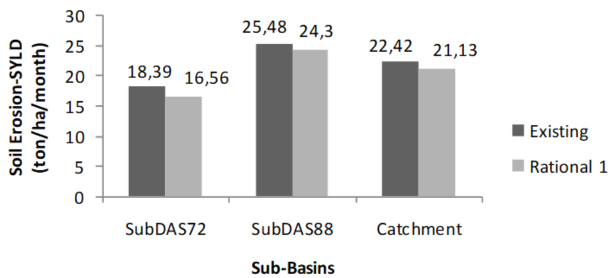


Figure 3. The monthly average of soil erosion SYLD (ton/hectares) of several sub-basins of Mrica Reservoir, under the *existing condition* and Scenario Rational 1

Figure 4. informs that land use change in rational scenario 1 decrease sediment values *Sed out* (ton/month) on some sub-catchments in the upstream of Mrica Reservoir catchment area.

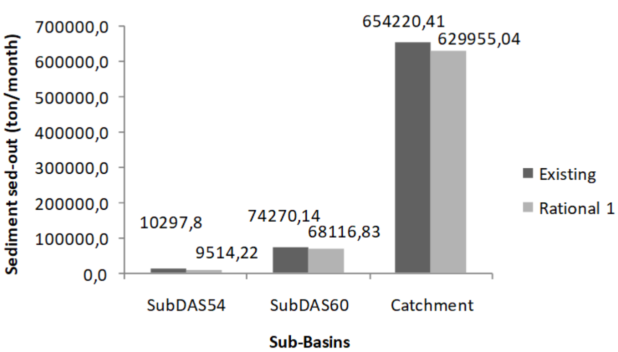


Figure 4. The monthly of *Sed_out* sediments (ton/month) of several Sub-basins and upstream of Mrica Reservoir catchment area, under the *existing conditions* and rational scenarios 1

The value of sediment *Sed out* in sub-watersheds 54 and 60, ie 9,514.22 ton/month, (equivalent to 116.77 tonnes/hectares/year, 4.41 mm/year) and 68,116.83 tonnes/month, (279, 29 ton/hectares/year, 10,54 mm/year) and 629,955,04 ton/month, (322,11 ton/ hectares/year, 12,15 mm/year) in Mrica basin area. Compared to the *existing condition* of 339.59 ton/ hectares/year, there was a decrease of about 9.64 ton/hectares (7.06%) for sub-watershed 54 and 23.13 ton/hectares (8.28%) for sub-watershed 60, and 17.48 ton/hectares (5.15%) in upstream of Mrica Reservoir catchment area. The value of river sediments in sub-watershed 60 and upstream of Mrica Reservoir catchment area is qualitatively categorized as *heavy* since the value is greater than 5 mm/year (Ministry of Public Works, 2010). However, land use change scenario R1, able to raise the value of river sediments in sub-watershed 54 qualitatively, to be *moderate*, from the *heavy* category in the *existing condition*.

Scenario Rational 2 (R2): 60% IPL production and 31.30% permanent

Land use change in rational scenario 2 affects soil erosion. Compared to the existing condition (269.04 ton/hectares/year), in the upstream of Mrica Reservoir catchment area, the value of soil erosion in Rational scenario 2 (232.76 ton/hectares/year) decreased 36.28 ton/ hectares/year or about 13.48%. The value of soil erosion, qualitatively included in the category of *heavy*, because the value is > 80 tons/hectares/year (Ministry of Public Works, 2010). However, land use change scenario R2, able to increase the value of soil erosion in sub-catchment 72 to14.59 ton/hectares/month (175.10 ton/ hectares/year), become *moderate* from the *heavy* category in existing condition.

Figure 5 shows that, compared to the Rational 1 scenario, in the Rational 2 scenario, the value of soil erosion occurring in the upstream of Mrica Reservoir catchment area decreased by 1.73 ton/hectares/month, equivalent to 20.762 ton/hectares/year (8.19%.).

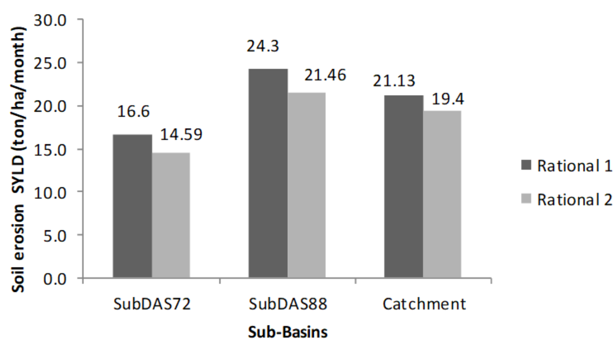


Figure 5. The monthly averages of erosion SYLD (ton/ hectares) of several Sub-basins and upstream of Mrica Reservoir catchment area, under rational scenario 1 and 2

Land use change in rational scenario 2 affects the decrease of sediment transported *Sed out* (ton) on some sub-catchments in upstream of Mrica Reservoir catchment area. In sub-watersheds 54 and 60, ie 7,650.77 tons/ month (93.90 tons/hectares/year, 3.54 mm/year) and 6,2297.22 tons/month, (234.30 tons/hectares/year; 8.84 mm/year) and 597,821.96 tons/month, (299.47 ton/hectares/year, 11.29 mm/year) in the upstream of Mrica Reservoir catchment area. Compared to the existing condition, there was a decrease of about 32.51 ton/hectares per year (25,72%) for sub-watershed 54 and 44.99 ton/hectares per year (16,11%) for sub-catchment 60, and 40.12 ton/hectares per year (11, 8%) in the upstream of Mrica Reservoir catchment area. The value of river sediment, qualitatively included in the *heavy* category because the value is > 5 mm/year, except in sub-watershed 54 included in the *medium* category. Therefore, scenario 2, both quantitatively and qualitatively has the potential to decrease the sediment values occurring in the sub-catchments.

Figure 6. shows that when compared to the Rational 1 scenario, in the Rational 2 scenario, the value of river sediments occurring in the upstream of Mrica Reservoir catchment area decreased by 32,133,08 ton/month, equivalent to 22.87 ton/hectares/per year or about 19.59%.

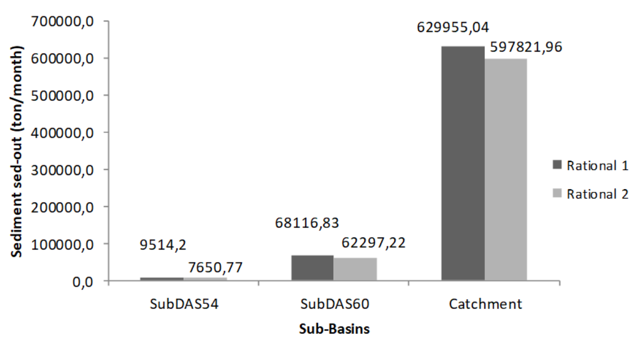


Figure 6. *Sed_out* sediment monthly average (ton) of several Sub-watersheds and upstream of Mrica Reservoir catchment area, under rational scenario 1 and 2 scenarios.

Scenario Rational 3 (R3): 50.00% IPL production and 41.30% permanent IPL

Scenario R3 gives effect to decrease the soil erosion. In the upstream of Mrica Reservoir catchment area, when compared to existing condition (269.04 ton/hectares/year), soil erosion on scenario Rational 3 (211.03 ton/hectares/year), decrease to 58,01 ton/hectares/year or about 21.56%. Those values, qualitatively included in the *heavy* category (Ministry of Public Works, 2010). However, qualitatively the R3 scenario, able to increase the value of soil erosion in sub-catchment 72 about 13.66 ton/hectares/month (163.96 ton/hectares/year), became *moderate* from the *heavy* category in the existing condition.

Figure 7. shows that in the R3 scenario, the soil erosion in the upstream of Mrica Reservoir catchment area, decreased by 1.81 ton/hectares/month, equivalent to 21.73 ton/hectares/year or about 9.33%.

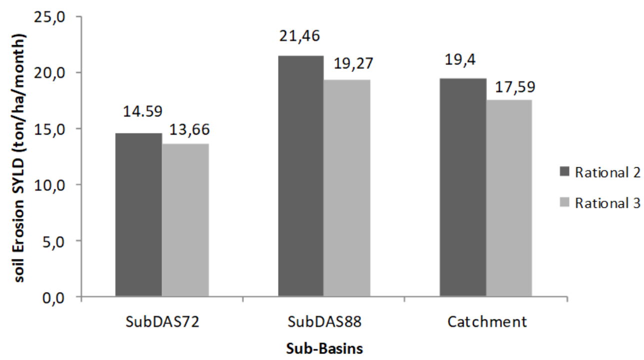


Figure 7. The monthly average of the soil erosion SYLD (ton/hectares) of several Sub-catchment and upstream of Mrica Reservoir catchment area, under the existing conditions and rational scenarios 3

The R3 scenario influences sedimentary *Sed out* in several sub-catchments in the upstream of Mrica Reservoir catchment area. In sub-watersheds 54 and 60, ie 7,029.91 tons/month (86.46 tons/hectares/year, 3.23 mm/year) and 58,445.85 tons/month, (219.76 tons/hectares/year; 8.29 mm/year) and 560,223.31 tons/month, (275.59 tons/hectares/year, 10.39 mm/year) in the upstream of Mrica Reservoir catchment area. Compared to the existing condition, there was a decrease of about 39.95 ton/hectares per year (31.60%) for sub-watershed 54 and 59.53 ton/hectares per year (21.31%) for sub-catchments 60, and 64.00 tons/hectares per year (18.85%) in upstream of Mrica Reservoir catchment area. The sediments in several sub-catchments and upstream of Mrica Reservoir catchment area is qualitatively categorized as *heavy* since the value is > 5 mm/year; except for 54 sub-watersheds including *medium* category. (Ministry of Public Works, 2010)

Figure 8 shows that in Rational 3 scenario, the sediments occurring in the upstream of Mrica Reservoir catchment area decreased by 37,598.65 ton/month, equivalent to 7.44 ton/hectares/per year or about 7.92%.

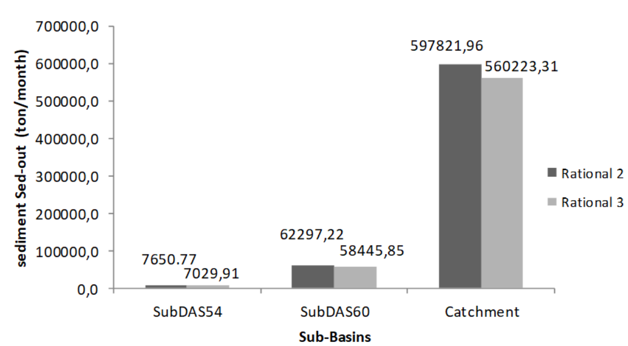


Figure 8. The monthly average of sediment *Sed_out* (ton) of several Sub-watersheds and upstream of Mrica Reservoir catchment area, under rational scenario 2 and 3.

***Extreme* Positive Scenario**: 1.9% IPL production and 89.6% permanent IPL

Qualitatively, the Positive Extreme scenario is able to increase the soil erosion in several sub-catchments and upstream areas of Mrica Reservoir catchment area, from *poor* in existing conditions to *moderate* or even *good*. In the upstream of Mrica Reservoir catchment area, when compared to existing condition (269.04 ton/hectares/year), in Positive Extreme land scenario (47.44 ton/hectares/year) there was a decrease of 221.60 ton/hectares/year (82.37%). The soil erosion occurring in sub-catchment 88 (64.68 ton/hectares/year) was classified as *moderate*; in sub-catchment 72 (47.39 ton/hectares/year), and the upstream of Mrica Reservoir catchment area (47.44 ton/hectares/year) was classified as *good*, because its value is < 60 ton/hectares/year (Ministry of Public Works 2010).

Figure 9. shows that when compared to the R3 scenario, in a positive Extreme scenario, the soil erosion occurring in the upstream of Mrica Reservoir catchment area decreased by 13.64 ton/hectares/month (163.58 ton/hectares/year) or about 77.52%.

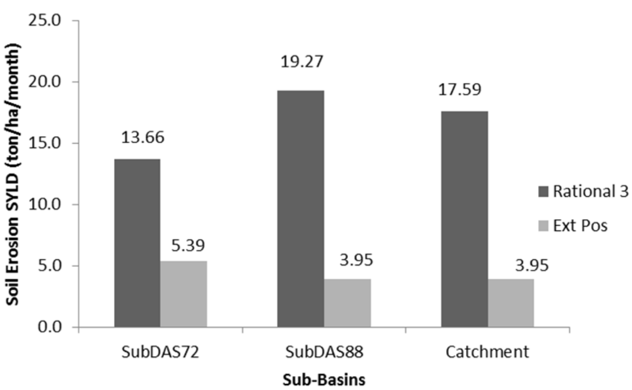
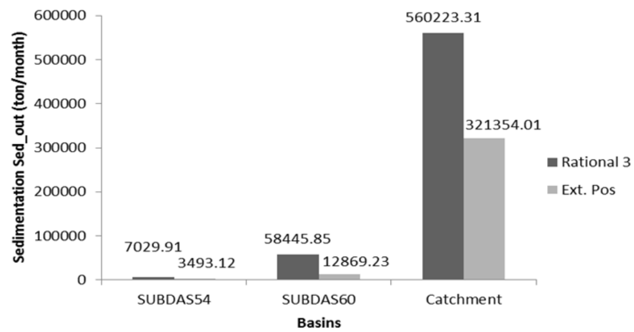


Figure 9. The monthly average of soil erosion SYLD (ton/hectares) of several Sub-catchment and upstream of Mrica Reservoir catchment area, under rational scenario 3 and positive Extreme

The positive Extreme scenario influences the decrease of sediment *Sed out* (ton) on several sub-catchments in the upstream of Mrica Reservoir catchment area. *Sed out* at sub-catchments 54 and 60, ie 3,493.17 tons/month, (42.87 tons/hectares/year, 1.61 mm/year) and 12,869.23 tons/month (48.40 tons/hectares/year, 1.82 mm/year) and 321,354 ton/month (99.46 ton/hectares/year, 3.75 mm/year) in the upstream of Mrica Reservoir catchment area. Compared to the existing condition, it decreased approximately 83.54 ton/hectares per year (66.09%) for sub-watershed 54, 230.89 ton/hectares per year (82.67%) for sub-catchments 60, and 240.13 tons/hectares per year (75.12%) in upstream of Mrica Reservoir catchment area. The sediments in some sub-watershed is qualitatively categorized as *good*, since the value is < 2 mm/year; while for the average upstream of Mrica Reservoir catchment area, qualitatively included in *medium* category, because its value is < 5 mm/year (Ministry of Public Works, 2010).

Figure 10., informs that when compared to the R3 scenario, in the positive Extreme scenario, the river sediments occurring in the upstream of Mrica Reservoir catchment area decreased by 238,869 tonnes/month



(176.13 ton/hectares/year) or about 63, 91%.

Figure 10. The monthly average of river sediment of *Sed_out* (ton) of several Sub-watersheds and upstream of Mrica Reservoir catchment area under rational scenario 3 and extreme positive

Negative Extreme Scenario: 89.4% IPL production and 1.9% permanent IPL

Negative Extreme Scenario gives influence to the increase of soil erosion. The value of soil erosion in sub-catchments 71 and 89, ie 18.10 ton/hectares/month (217.22 ton/hectares/year), and 17.05 ton/hectares/month (204.58 ton/hectares/year) and 26.19 ton/hectares/month (314.25 ton/hectares/year) in upstream of Mrica Reservoir catchment area. In upstream of Mrica Reservoir catchment area, when compared with existing condition (269.04 ton/hectares/year); in the Negative Extreme scenario, an increase of 45.21 tonnes/hectares/year (16.8%). In a quantitative Negative Extreme scenario, it has increased the soil erosion in several sub-catchments and upstream areas of the upstream of Mrica Reservoir catchment area. Qualitatively, the soil erosion occurring in several sub-watersheds and upstream of Mrica Reservoir catchment area is categorized as *heavy*, since the value is > 180 ton/hectares/year (Ministry of Public Works, 2010).

Figure 11. informs that when compared to the R3 scenario, in the Negative Extreme scenario, the value of soil erosion occurring in the upstream area of upstream of Mrica Reservoir catchment area increased by 8.60 ton/hectares/month (45.21 ton/hectares/year) or about 14.38%.

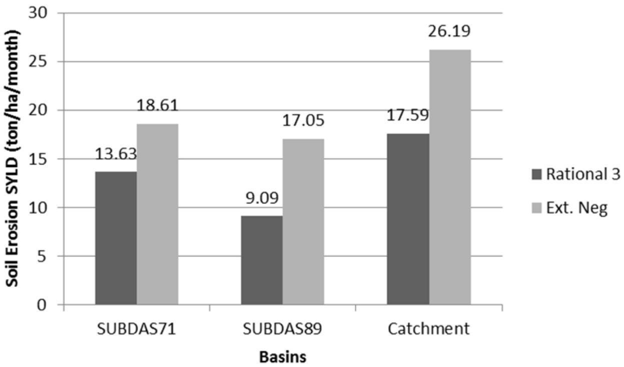


Figure 11. The monthly average of soil erosion SYLD (ton/hectares) of several sub-catchments and areas of upstream of Mrica Reservoir catchment area, under rational scenario 3 and negative Extreme scenarios

Changes in land use of the negative Extreme scenario have an effect on the sediment (ton) increase on several sub-catchments in the upstream of Mrica Reservoir catchment area. The sediment of *Sed out* in sub-watersheds 54 and 60, ie 10,301.36 ton/month, equivalent to 126.43 ton/hectares/year (7.66 mm/year) and 76,182.67 ton/month, equivalent to 286,47 ton/hectares/year (17.36 mm/year) and 719.024 ton/month, equivalent to 399.68 ton/hectares/year (24,22 mm/year) in upstream of Mrica Reservoir catchment area. Compared with sediment values of *Sed out* in existing condition there is an increase of about 0.02 ton/hectares per year for 54 sub-watersheds and 7.18 tonnes/hectares /year (2.57%) for sub-catchments 60 and 60.09 ton/hectares/year (17.70%) in upstream of Mrica Reservoir catchment area. The Negative Extreme Scenario has increased the value of river sediments in several sub-catchments and upstream of Mrica Reservoir catchment area quantitatively as well as qualitatively. Qualitatively, included in the *heavy* category, because the value > 5 mm/year (Ministry of Public Works, 2010).

Figure 12. shows that in the Negative Extreme scenario, the value of river sediments occurring in the upstream of Mrica Reservoir catchment area increased by 158,800.69 tons/month or equivalent to 124.09 tons/hectares/year or about 45.03%.

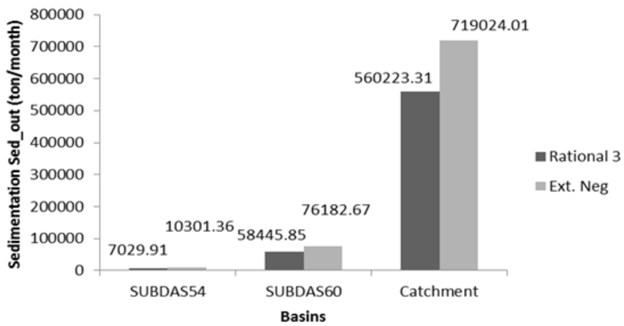


Figure 12. The monthly average sediment *Sed_out* (tonnes) of several sub-catchments and upstream of Mrica Reservoir catchment area, under rational scenario 3 and negative Extreme scenarios

Graphically illustrated, the average annual land use associated with the value of soil erosion and river sediments, on existing conditions and various land use scenarios in the upstream of Mrica Reservoir catchment area, is presented in Figures 13 and 14.

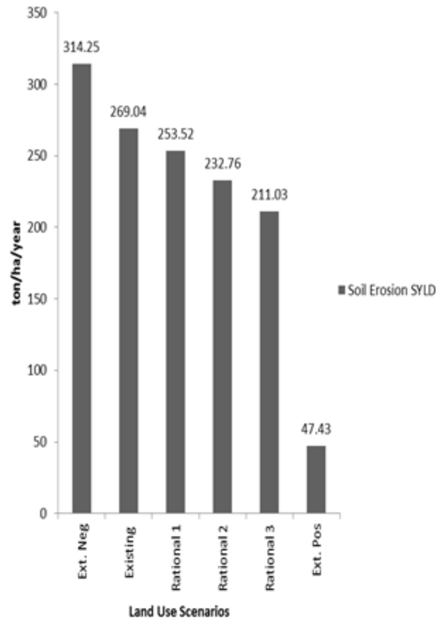


Figure 13. The annual average of soil erosion SYLD (ton/hectares) in the upstream of Mrica Reservoir catchment area on existing condition and various land use scenarios

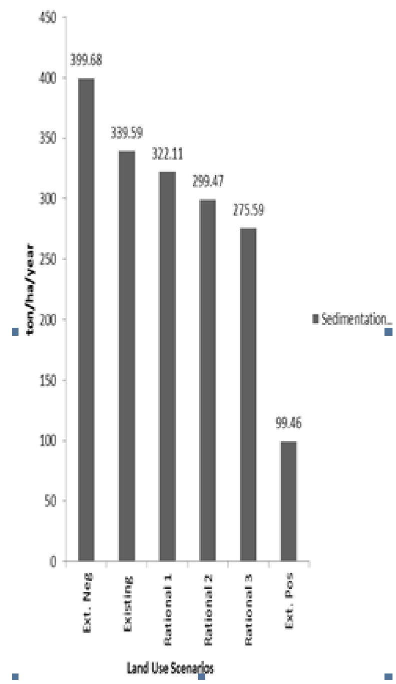


Figure 14. The annual average of Sediment of *Sed_out* (ton/hectares) in the upstream of Mrica Reservoir catchment area on existing condition and various land use scenarios

CONCLUSION

In relation to the influence of land use scenarios on the value of soil erosion and river sediments in Mrica Reservoir catchment area, when compared with the existing conditions, it was found that:

Quantitatively, an increase in Permanent IPL followed by a decrease in production IPL (R1 to positive Extreme) has the potential to decrease the value of soil erosion (ton/hectares/year) and river sediment (mm/year) quantitatively, between 5.77 - 82.37% for soil erosion and about 5.15 - 75.12% for river sediments. Increased IPL Production followed by a decrease in permanent IPL (negative Extreme) has the potential to increase the value of soil erosion (ton/hectares/year) and river sediment (mm/year) quantitatively. The increase in value is about 16.8% for soil erosion and about 17.70% for river sediments.

Qualitatively, scenario R2, R3 and Extreme positive scenario potentially increase the value of soil erosion and sediment transported in several sub-watersheds and upstream of Mrica Reservoir catchment area, from *poor* on the existing condition to *moderate* or even *good*.

The use of conservation techniques to increase or decrease the production or permanent IPL to reduce the rate of soil erosion and sediment transported in the river should be followed by other soil and water conservation techniques such as bench terraces and contouring.

References

Alibuyog N.R., Ella, V.B., Reyes, M.R., Srinivasan, R., Heatwole, C. & Dillaha, T. (2009). Predicting the effects of land use change on runoff and sediment yield in Manupali River Subwatersheds using the SWAT model. *International Agricultural Engineering Journal, AAAE* ,18(1-2), 15-25.

Arnold J.G., Allen, P.M.,Volk, M., Williams, J.R. & Bosch, D.D. (2010). Assessment of different representations of spatial variability on SWAT Model Performance. The ASABE SWAT 2010 Special Collection. *Transaction of The ASABE,* 53(5), 1433-1443.

Arnold, J. G., Moriasi, D. N., Gassman, P. W., Abbaspour, K. C., White, M. J., Srinivasan, R. C., Santhi, Harmel, R. D. van Griensven, A., Van Liew, M. W., Kannan, N. & Jha, M. K. (2012), SWAT: Model use, Calibration, and Validation, *Transactions of the ASABE, American Society of Agricultural and Biological Engineers*, 55(4), 1491-1508.

Arnold, J.G. & Allen, P.M. (1996), Estimating hydrologic budgets for three Illinois Watersheds. *Journal of Hydrology*, 176, 57-77.

Asdak C. (2010). Hidrologi dan Pengelolaan Daerah Aliran Sungai. Gadjah Mada University Press, Yogyakarta.

Badan Penelitian dan Pengembangan Kehutanan. (2003). Balai Penelitian dan Pengembangan Teknologi Pengelolaan DAS Wilayah Indonesia Bagian Barat. Departemen Kehutanan RI.

Badan Penelitian dan Pengembangan Kehutanan. (2003). Pusat Penelitian dan Pengembangan Hutan dan Konservasi Alam. Info DAS No. 15/ 2003 ISSN 1410-1114. Departemen Kehutanan RI.

Bohre P & Chaubey OP. (2014). Restoration of degraded lands through plantation forests. *Global Journal of Science Frontier Research*, 14, 18-27.

Departemen Kehutanan RI. (2001). Keputusan Menteri Kehutanan No. 52/Kpts-II/2001 tentang Penyelenggaraan Pengelolaan DAS. Departemen Kehutanan RI.

Gassman, Philip W.. Reyes, Manuel, R. Green, Colleen H. Arnold, & Jeffrey G. (2007). The Soil and Water Assessment Tool: Historical Development, Applications, and Future Research Directions. *Economics Publications*. 28.

Hidayat, L., Putu, S., Sahid, S., Racmad, J. (2016). Validation of the SWAT hydrological model on the catchment of Mrica reservoir. *AGRITECH*, 36(34), 337-346.

Hidayat, L., Sahid, S., Putu, S., Racmad, J. (2014). Performance assesment of watershed management based on elementry hydrological models. case: The Catchment of Mrica Reservoir. *AGRITECH*, 34(3), 337-346.

Kementerian Kehutanan RI. (2009). Peraturan Menteri Kehutanan No. P.32/Menhut-II/2009 Tentang Cara Penyusunan Rencana Teknik Rehabilitasi Hutan dan Lahan Daerah Aliran Sungai (RTkRHL-DAS). Kementerian Kehutanan RI.

Kementerian Pekerjaan Umum., (2010). Panduan Monitoring dan Evaluasi Prasarana Sumberdaya Air. Kementerian Pekerjaan Umum-Dirjen Sumberdaya Air, Satuan Kerja Balai Besar Wilayah Sungai Serayu Opak.

Moriasi, D. N., Arnold, J. G., Van Liew, M. W., Bingner, R. L., Harmel, R. D. & Veith, T. L. (2007). Model Evaluation Guidelines For Systematic Quantification Of Accuracy In Watershed Simulations, Transactions of the ASABE, *American Society of Agricultural and Biological Engineers*, 50(3), 885−900.

Neitsch SL, Arnold JG, Kiniry JR, &Williams J.R. (2005). Soil and water assessment tool theoretical documentation. Version 2005. Temple, Tex.: USDA-ARS Grassland Soil and Water Research Laboratory.

Neitsch SL, Arnold JG, Kiniry JR, Srinivasan R. & Williams, J.R. (2004. Soil and water assessment tool input output, file documentation. Version 2005. Temple, Tex.: USDA-ARS Grassland Soil and Water Research Laboratory

Neitsch, S.L., Arnold, J.G., Kiniry, J.R. & Williams, J.R. (2005). Soil and Water Assessment Tool Theoritical and Documentation, Version 2005. Grassland, Soil and Water Research Laboratory-Agricultural Research Service 808 East Blackland Road-Temple, Texas 76502. Blackland Research Center-Texas Agricultural Experiment Station 720 East Blackland Road-Temple, Texas 76502.

Soewarno and Syariman, P. (2008). Sedimentation Control : Part II, Intensive Measures the Inside of The Mrica Reservoir, Central Java, *Journal of Applied Sciences in Environmental Sanitation*, 3(1).

Sulistyo, B., Gunawan, T., Hartono, Danoedoro, P., (2009). Toward a fully and absolutely raster-based erosion modeling by using RS and GIS, Indonesian *Journal of Geography*, 41, 149-170.

Sulistyo, B., Gunawan, T., Hartono, Danoedoro, P., Listyaningrum, N. (2017), Absolute Accuracy of the Erosion Model of DEM-NDVI and it's Modification, *International Journal of Geoinformatics*, 13: 23-34.

Suryani, E. & Agus, F. (2005). Perubahan penggunaan lahan dan dampaknya terhadap karakteristik hidrologi: Suatu studi di DAS Cijalupang, Bandung, Jawa Barat. *Prosiding Multifungsi Pertanian*: 87-104. ISBN: 979-9474-42-6.