The Effect of Land Use Change to Land Erosion and Sediment Transported on The Cacthment Area of Mrica Reservoir

Lukman Hidayat[1], Putu Sudira[2], Sahid Susanto[2], and Rachmad Jayadi[3]

[1]Agricultural Technology Dept., Agriculture Faculty, Bengkulu University
Jl. WR. Supratman Kandang Limun Bengkulu, 38371
[2]Agricultural Technology Faculty, Gadjah Mada University
Jl. Flora No. 1, Bulaksumur, Yogyakarta, 55281
[3]Engineering Faculty, Gadjah Mada University
Jl. Grafika No. 2, Kampus UGM, Yogyakarta 55281
E-mail: luqman@unib.ac.id

ABSTRACT

The problem of flooding, drought, erosion and sedimentation, has always been a topic of conversation that is always related with land conversion of natural forests into agricultural cultivation. The phenomenon of land conversion is an event in nature that must be understood to determine action in the future. 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 scenarious, on soil erosion SYLD and sediment transported Sed-out , in 101,027.250 ha the cacthment area of Mrica reservoir upstream zone. SWAT simulation model results indicate that quantitatively, the increase IPL permanent followed by a decrease in IPL production has the potential to lowering the value of land erosion (ton /ha/yr) of approximately 5.77 to 82.37% and from 5.15 to 75.12% of sedimentary transported (mm/yr). Qualitevely, extreme positive scenario, can increase the value of land erosion in some subbasin and the cacthment area of Mrica reservoir upstream zone, from heavy quality on the existing condition become moderate to light. Watershed management efforts to reduce the rate of soil-land erosion and sediment transported on the river, withland use changes should be followed by soil and water conservation techniques that others such as bench terraces,countering.

Key words: SWAT model, land use change, land erosion, sediment transported

INTRODUCTION

The problem of floods, droughts, erosion and sedimentation, has always been a hot topic discussed. Conversion or land conversion of natural forests into agricultural land has always been associated with it. Growth in the number of people who have an impact on the increase in the provision of food and water, be a trigger of land use as a momentary solution to overcome (Asdak 2010; Alibuyog et al., 2009).

Watershed (DAS) degradation , especially in Java, continued and hard to resist, even though. since the 1970s the Indonesian government has implemented several rehabilitation programs related to watershed management / water resources, such as reforestation-afforestation, soil conservation measures, and others.

Regions upstream catchment area (DTA) Mrica reservoirs, with a total area reaches 101,027.25 ha, which is supposed to be a conservation area has started encroached into the area of farming activity. Cover crop index (IPL) be dominated by production land as about 80% to total area. With a reservoir capacity of 140 million m^3, which began operation in 1989 and the sedimentation rate of 4.20 million m^3 per year, then the year 2021 will be full of sediment (Soewarno and Syariman, 2008 ***in*** Mulyana et al., 2011).Elementary hydrological model, which is composed of basic hydrological elements, such as rain, evaporation, infiltration, deposits, and streams, is seen as a means of extrapolation that can help understand the phenomenon.

Therefore, studies have been conducted to determine the effect of some variation land use to the sediment results in soil erosion and sediment transported in the river, using a hydrological model SWAT.

Soil Water Assessment Tool (SWAT), is a hydrological model scale watershed physically based, deterministic, and continuous, which was developed by the USDA Agricultural Research Service (Arnold et al., 1998; Neitsch et al., 2004, 2005 ***in*** Douglas-Mankin et al., 2010). In operation, SWAT can do some simulations, including management practices on land and in the channel of the river, including changes in land use, practice soil and water conservation, and the existence of pounds - building sediment control transported (Neitsch et al., 2005; Williams et al., 2008, Arnold and Allen, 1996 ***in*** Rossi et al., 2009; Alibuyog et al., 2009; Arnold et al., 2010; Gassman et al., 2007 ***in*** Douglas - Mankin et al., 2010).

In the model SWAT, erosion caused by rainfall and runoff-water runoff is calculated using the Modified Universal Soil Loss Equation (musle). MUSLE a modified form of the Universal Soil Loss Equation (USLE) developed by Wischmeier and Smith 1965, 1978 (Neitsch et al., 2005) MUSLE (Williams, 1995 ***in*** Neitsch et al., 2005), are:

$$Sed = 11.8\ (Q_{surf}\ .q_{peak}\ .area_{hru})\ 0{:}56.\ K_{usle}.\ C_{usle}.\ P_{usle}.\ L_{usle}.\ CFRG\ ....\ (1)$$

Sed = results of sediment per day (tons)
Q_{surf} = volume of runoff (mm H_2O / ha)
q_{peak} = peak rate of runoff water (m^3 / s)
$area_{hru}$ = area of hydrologic response unitsHRU (ha)
K_{usle} = USLE soil erodibility (0,013 ton m^2 h / (m^3- ton cm)
C_{usle} = factor management and land cover USLE
P_{usle} = factor supporting the practice of USLE
L_{usle} = topographic factor USLE
$CFRG$ = quartz fragmentation factor

MATERIALS AND METHODS

SWAT simulations using models of some land use change scenarios, is the cornerstone of research methods, to determine the influence of land use change to the results of sediment transported in the land and river. The location of research is the upstream catchment area (DTA) of Mrica reservoir (101,027.25 hectares); it is located on 7^0 LS and 110^0 BT. Administrtively covers several districts in Central Java, Wonosobo and Banjarnegara (Figure 1).

Tools and materials research, include computers and accessories, software Arc SWAT 2005/2009 (free license), spatial data: DEM maps, land use, soil type and slope; Rainfall and

Climatic data within the periode 2003-2013.

Land use in the actual conditions (existing condition) consisted of 79.6% of production IPL, IPL permanent 11.7%, and others 8.7%. IPL Production (irrigated land, rainfed, gardens and moor). IPL Permanent (forest, bush/shrub, marshes and grass. Other land (residential, building and water body).There are 5 scenarios: Rasional 1(R1, 70,00% IPL production; 21,30% IPL permanent), Rasional 2 (R2, 60,00% IPL production; 31,30% IPL permanent), Rasional 3 (R3, 50,00% IPL production; 41,30% IPL permanent), Extreme positive (1,90% IPL production; 89,4% IPL permanent) and Extreme negative (89,40% IPL production; 1,90% IPL permanent).

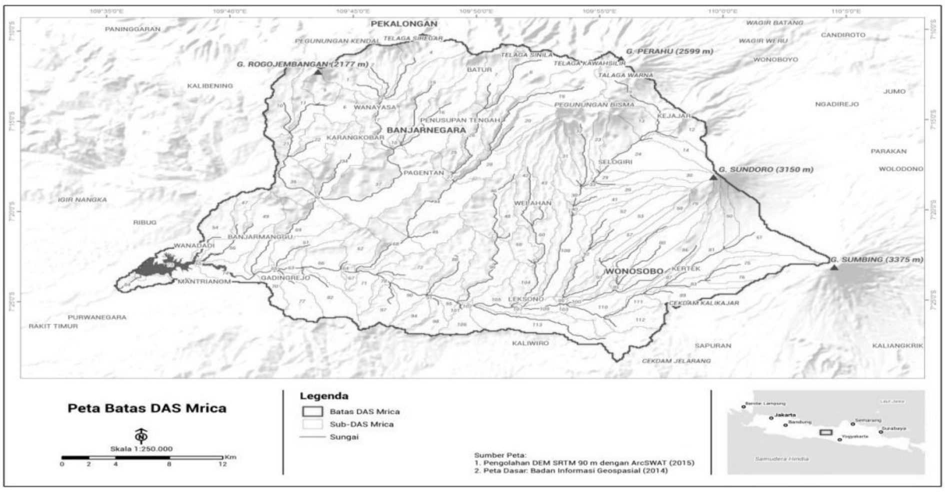

Figure 1. The upstream catchment area (DTA) of Mrica Reservoir

RESULTS AND DISCUSSION

The analysis of watershed modelling showed that there had been formed in 1940 HRU's (Hydrological Response Units) and 113 subbasin or SubDAS. Inputfor weather generatorin the hydrology model SWAT,using 6 rainfall and 2 climatology stations.

Validation

Model validation, statistically or graphically, indicates the level of applicability to the degree of satisfactory to very good: R2 = 0.61- 0.74; NSE = 0.61- 0.73 ((Moriasi et al., 2007 ***in***Rossi et al., 2009).. The value Qprediction have closeness with Qobservationvalue. T test, Tcal<Ttab (23;0.05), the Q value predictions and observations were not significantly different.

Table 1. Distribution of land use in The upstream catchment area (DTA) of Mrica Reservoir

No	Land Use	Area (Ha)	Persentage (%)
1	Bush/Shurb	9.582,1209	9.480
2	Forest	1.414,8537	1.400
3	Marshes/Swamp	4,9013	0.005
4	Grassland	587,3440	0.580
5	Garden	31.204,3851	30.890
6	Tegalan/Ladang/Moor	29.689,0540	29.390
7	Irrigated land	6.625,7956	6.560
8	Rainfed	13.202,5779	13.070
9	Building	40,8445	0.040
10	Settlements	7.449,2209	7.370
11	Water body	1.226,1520	1.210
Total		101.027,2500	100,00

Source:DAS Modeling, HRU analysis (2014)

Simulation

Simulation results of the validation, to see the changes in land use on erosion and sedimentation, run on the existing condition, and five land use scenarios, using data from 2003 to 2007. The distribution of land use in the existing condition and land use maps on the conditions of simulation scenarious are presented in Table 1.and Figure 2.

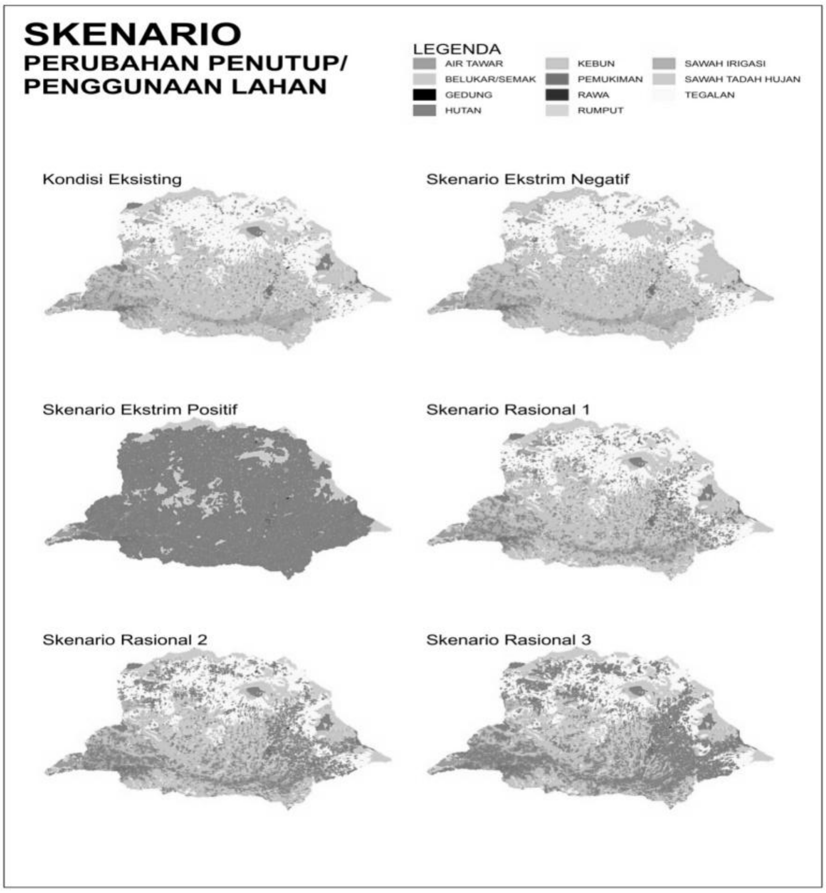

Figure 2. Land use maps on Simulationcondition

Exfoliation, transport and deposition is a process of erosion that takes place sequentially (Asdak, 2010). Sediment yield (tons / ha) abbreviated SYLD is one outcome variable in the model SWAT subbasin output file. SYLD, defined as sediment from catchment-subDAS transported into the channel (stream) within a certain time (Neitsch et al., 2005). This definition can be interpreted, that the sediments of catchment or subDAS is the process of erosion in land / subDAS as SYLD due to exfoliation of the soil, then transported into the channel (river), drift and deposited in it as sediment transported- Sed_out.

The land use change scenario giving effect to land erosion and sediment transported. When compared with the existing condition, except extreem negative scenario, 4 scenarios land use change giving effect to the impainment of SYLD and Sed-out. The effect of land use change to the land erosion (SYLD) and sediment transported (Sed_out), quntitatively and qualitatively, in the DTA Mrica reservoir are presented in Table 2. and 3.

Table 2. The effect of land use change to the land erosion (SYLD) , quntitatively and qualitatively, in the DTA Mrica reservoir

No.	Condition	SYLD (ton/ha/yr)	Quantitatively		Qualitatively
			+ (%)	- (%)	
1.	Existing	269.04			Heavy
	Simulation Scenario				
1.	Rational 1 (R1)	253.52	(5.77)		Heavy
2.	Rational 2 (R1)	232.76	(13.48)		Heavy
3.	Rational 3 (R1)	211.03	(21.56)		Heavy
4.	Extreem Postif	47.44	(82.73)		Light
5.	Extreem Negatif	314.25		(16.80)	Heavy

Source: Data analysis (2014)

Table 3. The effect of land use change to sediment transported (Sed_out), quntitatively and qualitatively, in the DTA Mrica reservoir

No.	Condition	Sed-out ton/ha/yr	mm/yr	Quantitatively + (%)	- (%)	Qualitati-vely
1.	Existing	339.59	12.83			Heavy
	Simulation Scenario					
1.	Rational 1 (R1)	322.11	12.17	(5.15)		Heavy
2.	Rational 2 (R1)	299.47	11.31	(11.80)		Heavy
3.	Rational 3 (R1)	275.59	10.41	(18.85)		Heavy
4.	Extreme Postive	99.44	3.76	(75.12)		Moderae
5.	Extreme Negative	399.68	15.09		(17.70)	Heavy

Source: Data analysis (2014)

Compared with existing condition, Table 2 and 3 shown the increasing IPL Permanent followed by the decreasing of IPL production (R1 to extreme positive) potentially capable of decline the value of land erosion (ton /ha/yr) and sediment transported (mm/yr) quanitatively.

Impairment ranged between 5,77- 82.37% for SYLD and approximately 5.15 to 75.12% for Sed_out. The increasing of IPL production that followed by the decreasing of IPL permanent (negative extreme scenario) has the potential to be able to rise up the value of land erosion (ton /ha/yr) and river sediments (mm / yr) quantitatively. The value increase of about 16.8% for the erosion of land and approximately 17.70% sediment transported.

Qualitatively, the extreme positive scenario potential to increase the value land erosion and sediment transported in the DTA Mrica reservoir, from heavy in existing condition to become moderate to light (The Ministry of Public Works, 2010).

Graphically, the average annual value of land use associated with land erosion and sediment transported, in the existing condition and various land use scenarios in the DTA Mrica reservoir, is presented in Figure 4. and 5

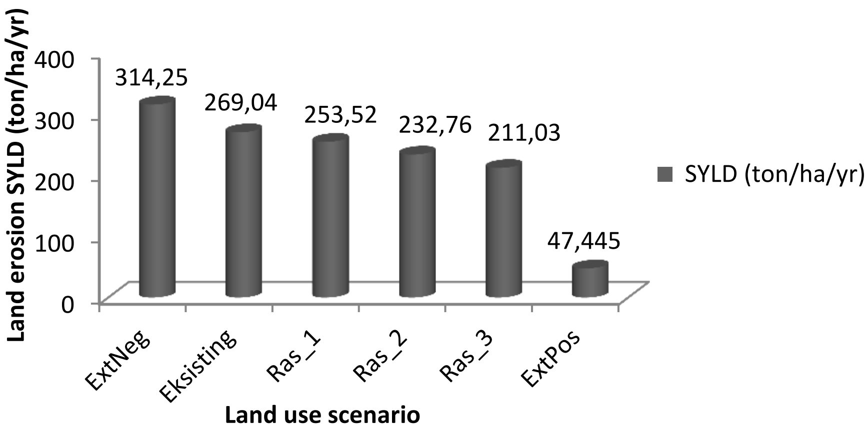

Figure 4. Average annual land erosion SYLD (ton/ha/yr) in the DTA Mrica Reservoir on the existing condition and land use scenario

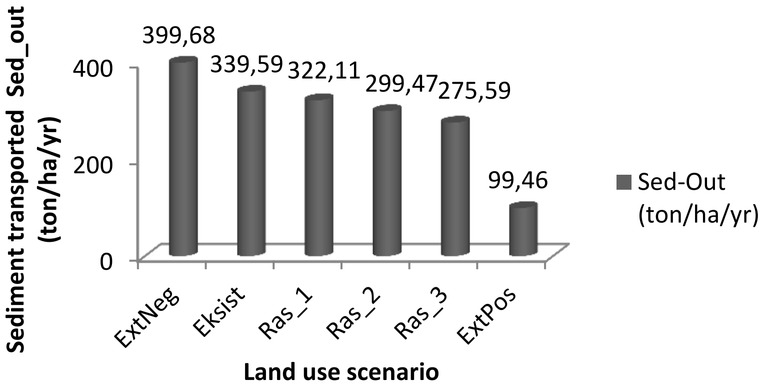

Figure 5. Average annual sediment transported Sed_out (ton/ha/yr) in the DTA Mrica Reservoir on the existing condition and land use scenario.

CONCLUSION

1. In quantitative and qualitative terms, the increase in IPL Permanent followed by a decrease in IPL production IPL (R1 to extreme positive) potentially capable of lowering the value of land erosion (ton /ha /yr) and sediment transported (mm/yr).
2. The use of conservation techniques, as increasing IPL permanent and decreasing IPL production as, to reduce land erosion rate and sediment transported, to be followed by soil and water conservation techniques such as bench terraces, contouring and others.

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