APPLICATION OF SMALL SCALE PROGRAM OF FARMER PARTICIPATION ON LAND AND WATER CONSERVATION MEASURES TO SIMULATE REALISTICS WATERSHED MANAGEMENT [1]

By:
Sahid Susanto, Chandra Setyawan, Sukirno[2]
e-mail: chandra.tep@ugm.ac.id

ABSTRACT

A small scale program of farmer participation on the fertile land and water conservation measures of mountainous area has been applied to simulate the realistics watershed management. The upper watershed area of Mrica dam, located at mountainous area of Dieng Wonosobo Central Java was used as the simulation. The area is intensively cultivated by the farmer for potatoes plant. Intensive cultivation gives the implication on land degradation in this area.

The small scale program was directed on cultivation land and river system. On the cultivation land, the program was focused on erosion control through application of plastic mulch and land contour cultivation. On the river system the program was directed to built, namely sediment control structures which has functioning for sedimentation storage and water harvesting on the river. The result shows that the small scale program is significantly affect the decreasing of erosion and at the same time it can increase productivity of potatoes cultivation.

The small scale program then was used to simulate with six realistic scenarios of watershed management in this area. The scheme of scenarios are directed to: 1) three realistic scenarios of land use pattern and 2) three realistic scenario of sediment control structures in term of number and position in the river system.

By using instrument of quantitative watershed management assessment the performance reflecting the scenario can be described the position of watershed condition. The range score of quantitative value is 1-4. Score in the existing condition is 1.9 (poor). Comparing with the existing condition, all the scenarios proved that score of watershed management increase for each scenario, ranging from 2.4-3.6. Application the scenarios in real condition have to be selected one of the scenario which reflects optimal watershed management. The selected scenario must consider social and economic aspect in related to land cultivation occupied.

Keyword: farmer participation, land and water conservation measures, waterhed management

[1] This paper to be presented in the International Conference On Sustainable Rural Development 2013 (ICSRD 2013), at Puwokerto Central Java 25-26 August 2013

[2] Staff member at The Department of Agricultural Engineering, Faculty of Agricultural Technology Gadjah Mada University

1. INTRODUCTION

A small scale program of farmer participation on fertile land and water conservation measures of mountainous area was applied to simulate the realistics watershed management. The small scale program was focused on the mountinous land cultivation and river system. On the land, farmers participation were involved on the program to control erosion by application of plastic mulch and land contour cultivation. On the river system, the farmers were invited in the program to build small sediment control structures and gully plug.

The upper watershed area of Mrica dam (1017.42 km^2), located at mountainous area of Dieng, Wonosobo Central Java was used as the simulation (**Fig.1**). The location is tipycally mountainous area with fertile soil. The farmers cultivate land intensively for pototoes without good land and water conservation principles. This intensive cultivation gives affect on land degradation in the form of increasing erosion on the land and sedimentation in the river. The aim of this study was directed to find realistics watershed management simplified by modified land use pattern on the land and constructing small sediment control on the river.

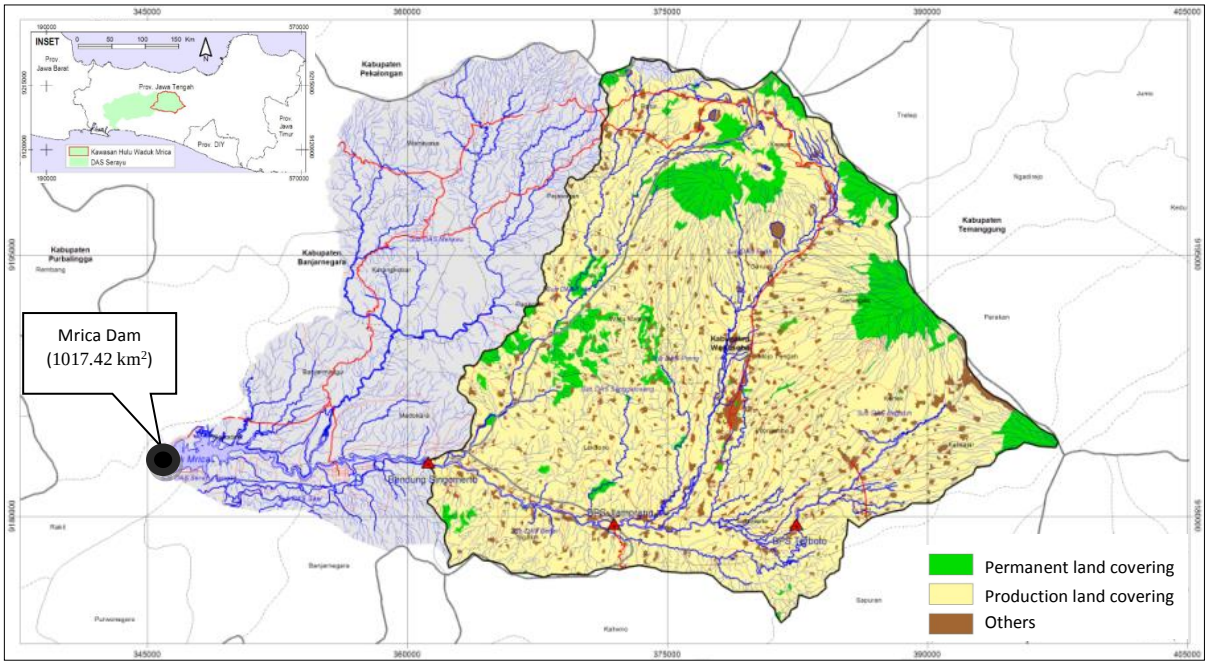

Fig.1. Upper Watershed of Mrica Dam

2. METHOD

The small scale program which contain soil and water conservation measures was inisiated through dissemination of the program to the farmers and the selected villages. PRA (Participatory Rural Appraisal) and RRA (Rapid Rural Appraisal) were used to indentify social and economic aspect of the farmers.

In one side, the farmers were placed as the implementator of the program and beneficiaries as well. The other side, the government sq. the Serayu Opak River Basin Office (BBWS-SO) were placed as financial and material support. The role of Gadjah Mada University team involved in planning, designing, coaching and supervision of the program.

The small scale program then was extended to simulate watershed management simplified by optimal land use pattern on the cultivated land and sedimentation control on the river system. Six scenarios was developed to execute the watershed management. The six design of scenarios were: 1) three realistic scenarios of land use pattern and 2) three realistic scenario of sediment control structures in term of number and position in the river system.

On the land, three scenarios of land use pattern were directed to change cultivated land to forest area on high slope land as permanent land cover. On the river system, three scenarios were carried out by constructing small-scale sediment control on tributaries and gully plug in term of number and position in the river system.

To asses watershed management scenarios were used a quantitative model. The model contains three indicators: (i) basic performance indicators as the output reflecting the integrated effects, (ii) proxy indicator as the input reflecting the intervention of watershed through water resource conservation measures, and (iii) impact indicators reflecting the social and environment effects. As the watershed outlet can reflect the integrated effect of watershed management, the basic parameter can be used as indication of effectiveness of watershed management scenario. Parameter of the basic indicator contains hydrology, erosi and sedimentation and water availability. Calculation of hydrologic parameters are used simple hydrologic model of Mock, erosion and sedimentation calculated by USLE and meyer peters muller equation and water balance approach is applied to predict water availability

Total indicators are performed by scoring with applying weighting factors in each indicator. Range of the total score is 1-4. As the outlet of watershed.

3. RESULT AND DISCUSSION

3.1. Results

Small scale program

The small scale program was implemented at Patak Banteng village where most of people there work as farmer. About 3 km2 cultivated area in this village was used in the program. Farmer participation was applied in the program which was directed in two places, ie. on land and on river. Program that focused on the cultivated land were regreening, applying mulch and terracing (**Fig.2**).

Fig. 2. Soil and Water Conservation Measures on Land

a). farmer participation meeting b). hand over of forest plant to the farmer c.) plastic land mulch d.) land terracing

The program on the river includes reforestation along the river, making gully plug, and build sediment control structures (**Fig.3.)**

Fig. 3. Soil and water conservation measures on the river:
a) gully plug, b). Regreening on river bank, c). and d). Sediment control structures

The result shows that the program can improve degraded cultivated land in this area.

Land use pattern simulation

Application of the program then was extended to a watershed scale. Using instrument of quantitative assessment of watershed management, total score of the existing condition of the watershed is 1.9 (poor condition).

The basic parameters of the instrument show that erosion is 234.8 ton/ha/year) and reservoir sedimentation is 6.2 mm/year, or about 4 million m3/year. Assessment results of watershed in the existing condition is presented in **Table 1**.

Table 1. Assessment Results of Watershed Condition

No	Indicators	Unit	Value	Category
1	Erosion	ton/ha/year	234.8	bad
2	Sedimentation	mm/year	6.2	bad
3	Specific maximum discharge	m^3/sec/ km^2	0.25	good
4	Specific minimum discharge	m^3/sec/ km^2	0.0098	moderate
5	Coefficient of river regime	-	42.61	good
6	Water storage	million m^3/year	0.76	moderate

In order to reduce erosion and sedimentation in this watershed, modification of land use pattern was used three scenarios (**Fig.4.**). In this scenarios, land use pattern was simplified in two types of index, namely and permanent land cover index (LcPi) and production land cover index (LcDi) Permanent land cover consists of forest, scrub/shrub, and grass, meanwhile the production land cover consists of upland crop and rice field (**Table 2** and **Figure 4**).

Table 2. Scenarios of modification of land use pattern

Land Use pattern	Modification of land use pattern
Existing condition	6% of LcDi & 80% of LcPi
Scenario I	70% LcDi & 20% LcPi
Scenario II	60% LcDi & 30% LcPi
Scenario III	50% LcDi & 40% LcPi

Notes:
LcDi= Land Cover Production Index
LcPi= Land Cover Permanent Index

The result shows that three scenarios of modification of land use pattern are able to reduce sedimentation significantly. The value of basic indicators is presents in **Table 3.**

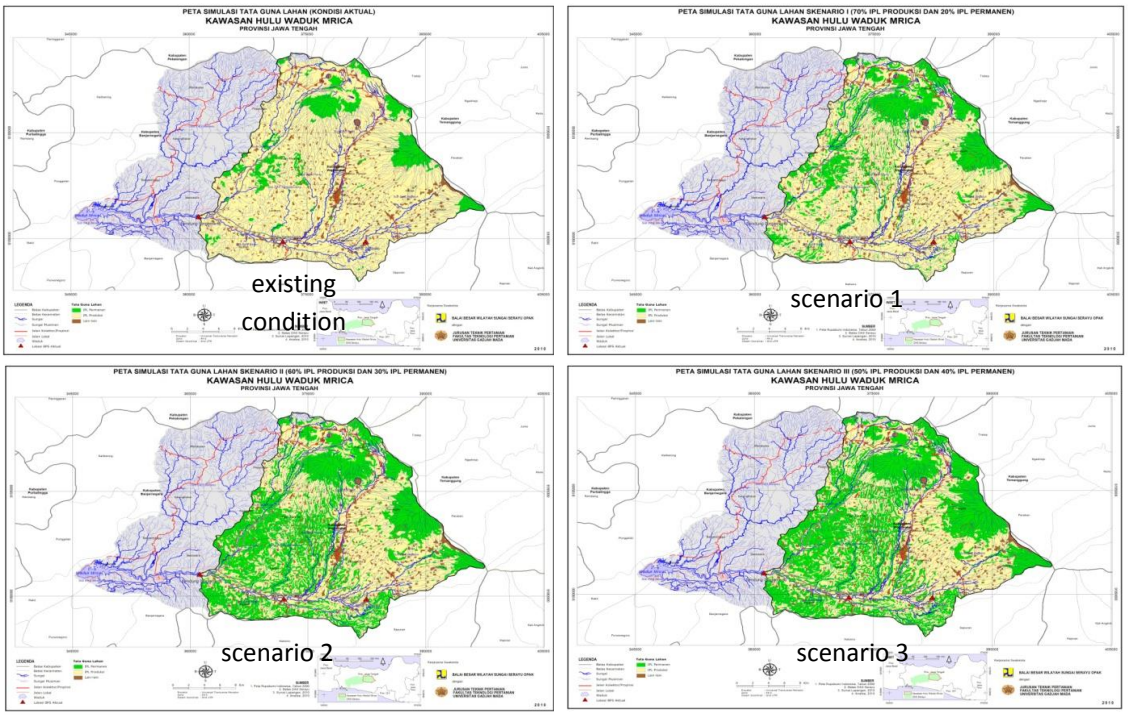

Fig.4. Scenario of Land Use Management

Tabel 3. Basic indicator of watershed management

Land Use Simulation	Hydrology, (runn off coef.)	Erosion (mm/thn)	Sedimentation (mm/thn)	Water Storage
Existing condition	0.32	19.53 (high)	5.46	Surplus
Scenario I 70% LcDi & 20% LcPi	0.24	9.85 (moderate)	2.85	Surplus
Scenario II 60% LcDi & 30% LcPi	0.18	7.34 (moderate)	1.86	Surplus
Scenario III 50% LcDi & 40% LcPi	0.13	4.77 (mild)	0.94	Surplus

Notes:
Lcdi= Land Covering Production Index
Lcpi= Land Covering Permanent Index

Sediment control structures simulation

Applying watershed management in the form of sediment control structures, simulation was directed to find how many total structures needed to control sedimentation on the river. The simulation was use with applying the sediment control structures which was built in several points on river network of order 2. The location and distribution of the structures can be seen in **Fig. 5.** The control structures capacity determined based on the analysis of sediment yield

in the catchment area. There scenarios was use to simulate constructing number of the sediment control structures of 10, 20 and 30. The results shows that the simulation with three scenarios proved that sedimentation can be reduced 47.85% for scenario 1, 65.84% for scenario 2 and 82.69% for scenario 3, respectively.

Discussion

The real condition of degraded watershed is significantly due to socio-economic pressures. Open land for cultivation for potatoes plant covers until 80% of total watershed area is closely related with densely populated area in this watershed with average people per square kilometer is 796.98. Natural carrying capacity of this area to support food for the people who live here is already exceeded. The potatoes land cultivation is the main livelihood for the farmers. Therefore, the selection of the scenarios to be applied in the field depends on the socio-economic condition of the farmers. In the real condition, selected choosing one of the scenarios should be considered in order to get optimal watershed management.

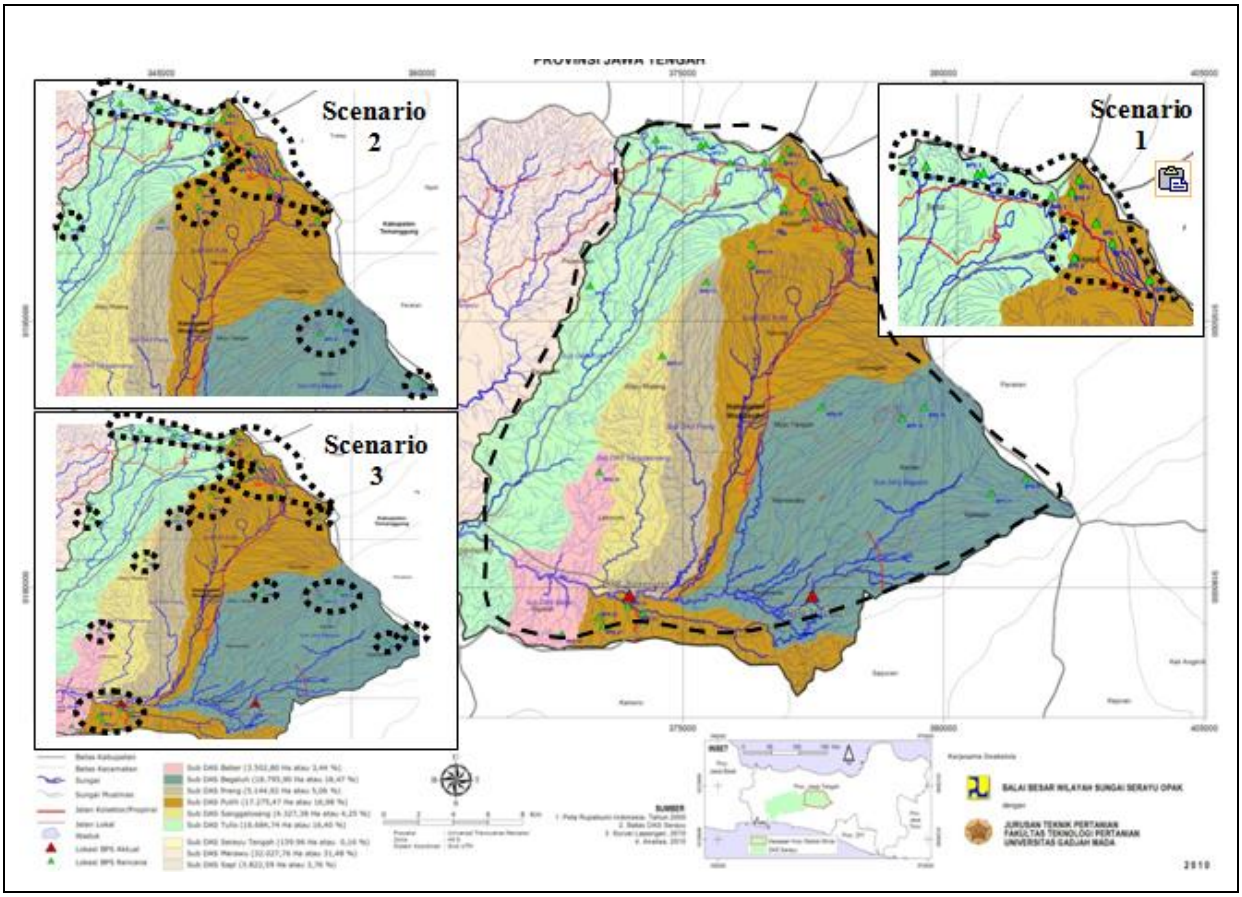

Fig.5. The Location and Distribution of The Sediment Control Structures

CONCLUSION

Implementation of small scale program in the form of soil and water conservation measures with involving farmer participation can be placed as an intervention of degraded watershed management. The program which is directed in two areas, on the land and on the river proved that erosion on the land and sedimentation on the river can be reduced. Scaling up the program to watershed area using some scenarios oriented on the cultivated land through modifying land use pattern and on the river through constructing sedimentation control structures show that erosion and sedimentation can be reduced significantly. Using instrument of quantitative assessment of watershed management can increase score of the existing condition of watershed from 1.9 (poor) to 2.4-3.6 (good).

Simulation results of land use or sediment control structures only can't improve the condition of watersheds in both categories. Watershed conditions in good category can be achieved using a combination of sediment control structures and land use arrangement.

Application the scenarios in real condition must be selected one of the scenario which reflects optimal watershed management. The selected scenario must consider social and economic aspect in related to land cultivation occupied.

REFERENCE

Brooks, K.N. 2003. *Hydrology and The Management of Watershed*. Iowa State University Press.

Soemarto, C.D. 1999. *Engineering Hydrology*. Erlangga. Jakarta, Indonesia

Debarry, Paul A. 2004. *Watershed Processes, Assesment and Management*. John Wiley and Sons, New Jersey,USA.

Fangmeier, Delmar D. Etc. 2005. *Soil and Water Conservation Engineering*. Thomson Delmar Learning.New York.USA.

Frederick R. Troeth. 2004. *Soil and Water Conservation for Productivity and Enviromental Protection*. Pearson. New Jersey. USA.

ACKNOWLEDMENT

This paper could not be realized without financial support from the Office of Serayu-Opak River Basin Development, Yogyakarta. For that reason, sincerely thank is addressed.