MANAGING SOIL EROSION CONTROL IN BABON CATCHMENT, CENTRAL JAVA, INDONESIA: TOWARD COMMUNITY-BASED SOIL CONSERVATION MEASURES

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Abstract
Soil erosion control is critical to sustain agricultural production and to overcome natural resource damage, yet implementation options are still debatable. We have tested three different land use systems include Rambutan (95% Rambutan and 5% shrub), Tegalan (Cassava, maize, some trees crop, and 60% area was planted with fodder grass) and Kalisidi (100% Rambutan, lower catchment encroached for annual crops), and also tested fodder grass planting in combination with cattle fattening aimed at developing community-based natural resource land management option for sustainable and profitable land use. Results from the first three years (2001-2003) shows that fodder grass planting in combination with cattle fattening reduces soil loss as much as 50% in the first year and 90% in the second year. Effectiveness may not be achievable if there is no involvement of farmers in implementation. To sustain the soil erosion control technology implementation, a management model involving fodder grass planting in combination with cattle fattening has been the best option.

Additional Keywords: hydrological response, grass-cattle fattening, Rambutan, Tegalan, Kalisidi

Introduction
In Indonesia, research on soil conservation measures has been initiated since 1911 during Dutch colonization and has been developed during last three decades. Many technologies have been created involving experiments in the plot scale. As far as design conservation measures are concerned, basic data of the soil loss due to erosion is needed. However, the basic data of soil loss by which the conservation technologies are created has involved an error explaining over estimation if it extrapolated at the catchment scale. In order to gain more realistic data to be used for designing erosion control measures, the study has been scaled up to micro catchment. Nevertheless, its implementation that involves varies approaches is still facing difficulties.

Profitable land management techniques need to be introduced to increase quality and quantity of crops yield and income of farmers as well as to sustain land resources. Innovative technologies under the correct approach to implement are being a focus to address acceptable agricultural management systems. In addition, research on the micro catchment scale (Craswell *et al*., 1998) is directed to develop such technologies, which are able to protect environmental damage and to be beneficial for farmers (Garrity and Agus, 1999).

Socio-culture as well as economic factors has played an important role in implementation of soil conservation measures. The first stage of research collaboration between Center for Soil and Agroclimate Research and Development (CSARD) and Managing of Soil Erosion Consortium (MSEC) under the International Water Management Institute (IWMI) has provided data of socio-economic aspect of soil conservation measures since the study has been focused on the integrated grass plating and cattle fattening (Watung *et al.*, 2003; Subagyono *et al.*, 2003). The study has involved a farm community who conduct conservation farming system under seasonal crops based cropping system. The objectives of the study are to (a) develop community-based land management options for sustainable soil conservation measures and (b) develop farmers' initiative to adopt soil conservation farming practices at catchment scale.

Methodology
This long-term (intended for 10 years) watershed scale research was started in late 1999 at upper Babon Catchment (having an area of about 285 ha; 07°20'S110°E), within Kali Garang Watershed (220 km^2), Central Java Province, Indonesia. Babon catchment is located about 3 km west of Ungaran, the capital of Semarang district, and about 20 km south of Semarang, the capital of the province. The study has been set up involving three micro catchments (MC) of Tegalan (1.1 ha), Kalisidi (13 ha), and Rambutan (0.9 ha). Characteristics of those MC are described in Table 1 (Agus *et al*., 2002). Since late 1999 each MC has been installed V-notch gauging weir with Automatic Water Level Recorder (AWLR) and staff gauge (manual water level recorder), and sediment trap. AWLR was set to record water level at one or five minute interval. The reading of the staff gauges was conducted three times daily at 08:00, 12:00 and 16:00.

It has been recorded in Tegalan MC that sediment yield was high reaching to 20t/ha/yr (Agus *et al*., 2001). Land management option was introduced by planting grass in combination with cattle fattening. This best bet option

Table 1. Characteristic of catchment used in the study

Catchment	Area (ha)	Runoff coefficient (%) [1]	Soils	Land use/Farming system	Dominant slope (%)
Tegalan	1.1	5	Andic Eutropepts	Cassava, maize, some trees in 2000 and 2001 and fodder grass covering about 60% area starting in December 2001	45 – 47(46)
Rambutan	0.9	1	Andic Dystropepts	95% Rambutan, 5% Shrub	22 – 55(40)
Kalisidi	13	14	Andic Dystropepts	100% Rambutan, lower catchment encroached for annual crops	22 – 55(37)
Babon	285		Typic Tropaquepts	All above + Rice field of about 17 ha	0 – 55(30)

[1] Based on March 2000 to February 2001measurement

strategy was based on lesson learnt from elsewhere in Indonesia that farmers' adoption of alternative technologies is determined by economic contribution of the measure to the household economy. Farmers are attracted to a practice only if the practice promises direct economic benefits and this consideration must be put forward in the participatory technology selection.

Planting grass as an important soil conservation measures on upland had been known widely (Prawiradiputra and Talaohu, 1998) and almost in every farming systems technology package introduced in upland of Java has fodder grass in combination with livestock component (Hermawan and Prasetyo, 1991; Prawiradiputra *et al.*, 2000). The grasses act as filters of eroded soil and also reduce runoff while the cattle component serves as an income source. In this study the grass was planted at the end of 2001 covering about 60% of the land surface.

Results and Discussion

Hydrological response to different land use systems

Runoff was largely generated from Tegalan catchment and its much higher compared with that in Rambutan and Kalisidi catchments. As it has been shown in Figure 1 two peaks of discharge has been recorded during the storm event on January 1, 2003, a typical hydrological event for this catchment. Shape of the hydrograph at Tegalan catchment shows that flow sharply increased after storm started to reach the peak of the discharge indicating that quick flow was dominance. The flow also declined rapidly as showed by the falling limb of the hydrograph. In Kalisidi catchment, flow gradually increase but then decreased sharply during the falling limb means that the slow flow was dominance especially during on-set rain. As the falling limb sharply decreased its means that the flow rate increased showing that runoff may be dominated by the subsurface flow. This phenomenon suggests that the Rambutan, as the dominant vegetation in Kalisidi catchment, acts as a forest with respect to hydrological response in which the subsurface flow is dominance as mentioned by many authors (Peters *et al.*, 1995; Gibson *et al.*, 2000; Scanlon *et al.*, 2000). There was no clear trend has been initiatedfrom the shape of the hydrograph in the Rambutan catchment, but the magnitude of the flow was much lower compare to that in Tegalan catchment. Characteristic of the rainstorm and corresponding runoff is presented in Table 2.

During three consecutive year (2001, 2002 and 2003), the soil loss due to erosion was high under the seasonal cropping system. The soil loss decreased significantly since the conservation measure using Benggala grass (*Panicum maximum*) has been introduced at the end of the first year. Since December 2001 conservation measure has been set up by planting grass along countur line and some cultivated areas covering 60% of Tegalan catchment. Soil loss has been reduced up to 50% only during one year and it has been reduced as much as 90% after the second year (Figure 2). The reducing soil loss was mainly determined by bed load concentration. This differed with that occurred in Kalisidi catchment where suspended load was dominance. Although not as high as in Tegalan catchment, soil loss also tended to decrease in Rambutan catchment. Meanwhile, the soil loss in Kalisidi catchment varied from year to year. The amount of soil loss was also determined by the size of the catchment (see also Agus *et al.*, 2002). Since the Kalisidi and Rambutan catchments have the same land use but the size is different, comparison has been made with regard on the size of the catchment. Soil loss in Kalisidi was higher than in Rambutan catchment, which suggests that the larger the size of the catchment the higher total soil loss will be.

Integrated grass planting with cattle fattening

Many conservation technologies have been created, but the implementation is still unsuccessful. In most cases, technology adoption is being widespread under the control of the project implementation. Farmers will not able to sustain the adopted technologies if no incentive is provided by the project. Meanwhile planting grass as

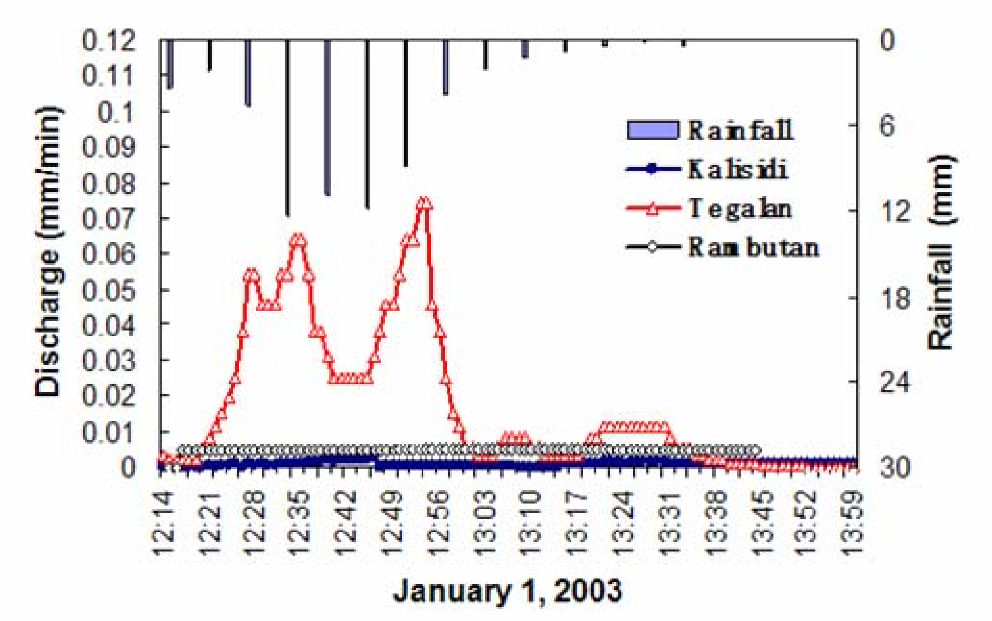

Figure 1. Hydrograph variation under different land use system

Table 2. Rainfall characteristics of the storm event on January1, 2003 with corresponding runoff

Rainstorm Characteristics	Value
Storm length (min)[a]	104
Total rainfall (mm)	62.8
Max intensity ($mm.min^{-1}$)	12.4
Total runoff ($mm.min^{-1}$)[b]	
• Tegalan	1.8
• Kalisidi	0.09
• Rambutan	0.44

a, b from 11:30 on August 21, 2001 (the storm started) to 15:30 on August 22, 2001 (the storm end) by excluding baseflow for the total runoff

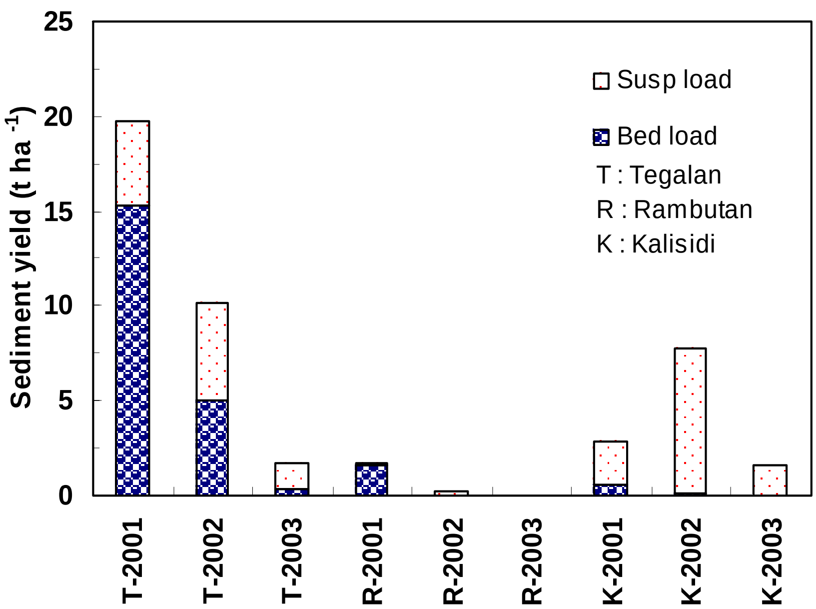

Figure 2. Temporal variation of soil loss due to erosion under different land use system

soil erosion measures are known widely in Indonesia and its affected significantly in reducing erosion (example Abujamin *et al*,1983). However, developing such techniques has often with low response of farmer because it reduces the cultivated area for their farm (Dariah *et al*., 1998) and may unsuccessful if less involvement of the farmers. Integrated grass planting with cattle fattening as it has been applied in Tegalan catchment will become a challenge to come up with the sustainable conservation measures (Figure 3).

Since the introducing cattle provided an additional income for farmer through fattening program, grass planting was initially accepted. The ease in finding grass and reduction of food crops area if grass is planted are the reasons for the low response of planting grass. To eliminate the problem alternative to plant grasses are on the terrace lips or on the alternate terraces. Before the introducing this technology, farmers' income was US$ 372.55, which almost equals to their expenditure. The expected additional net income from the cattle weight gain varies from US$ 8 to 14 per month (Table 3).

Fodder given to the cattle was mostly natural grass and daily approximate fodder required as 300-450 kg for 13 cattle raised by 12 farmers. The grass was collected from their upland and paddy field as well as from the estate land or common land. The introduced grass was only 570 kg and this amount was only for 2 days. Other fodder source was rice straw. The rice straw as fodder given to the cattle was vary around 15 % (100 kg), 5 % of introduced grass and the rest was from common grass or other green.

To increase farmers' income in raising cattle based on the earlier study at least 4 cattle for each farmer was needed but this alternative might not be suitable due to shortage of fodder or farmers capital. Daily projected fodder required was approximately 10% of the cattle weight. While, based on their average of 0.03 ha upland approximately fulfilled about 570 kg grass monthly. Given a scenario of 0.4 – 0.5 kg increased of cattle weight the projected fodder required is given on Figure 4. Assumption has been made in which the initial weight of cattle of 200 kg, with additional weight of 0.4 kg day^{-1} and the daily fodder required was 10% of the cattle weight or 20 kg fresh grass or rice straw. The amount of fodder required by cattle was fulfilled by natural grass, introduced grass and rice straw. Introduced grass was assumed as an average of 570 kg $month^{-1}$ based on introduced grass production in 2003 harvested twice a month planted on 1000 m^2 upland. The rice straw was assumed as high as 240 kg collected twice a year in March and August after paddy field harvest. The daily optimum weight of 30 kg of natural grass collected by farmers, usually woman, in surround area i.e. common land, estate crops land, and paddy field ricers.

The Figure shows that raising one cattle causes no problems for the farmers they may fulfill the required fodder even from collecting grass only from natural grass up to11 months of raising cattle. At that time the weight of his cattle has been added 132 kg and the total weight of 332 kg. After 11 months of raising cattle he required more inputs i.e. workers or spend more time in collecting grass. At that time he will earn gross profit of approximate US$ 232/11 months (1 US$=Rp 8400, carcass weight 45 % of total weight and carcass price US$1.55/kg) or additional monthly income of US$21. This Figure agrees with the earlier report of US$ 15.44 – 21.13 additional expected income based in 4 cattle raising weight in 2002 (Subagyono *et al*., 2003). They have also reported that based on the projected required fodder of two cattle raised, the farmers require slightly effort to find grass after five months and after seven months the efforts increase over time. Since that time they have to find more grass or collecting rice straw from his village or to search out of the village. After five months the expected gross income will be US$362.70, but since then the efforts increase such as more time to collect grass and the profit will decreased as well.

Conclusions

Benggala grass (*Panicum maximum*) has been proven to have an effective soil erosion control. During the period of 2 years, soil loss has been reduced up to 90% under seasonal-based cropping system (Tegalan). However, such effectiveness control will be achieved only through involvement of farmers in the implementation phase. Integrated grass planting and cattle fattening is believed to be a valuable approach in sustainable technology implementation. Additional income achieved by farmers after introducing cattle facilitates farmer community adoption of conservation technology of grass planting.

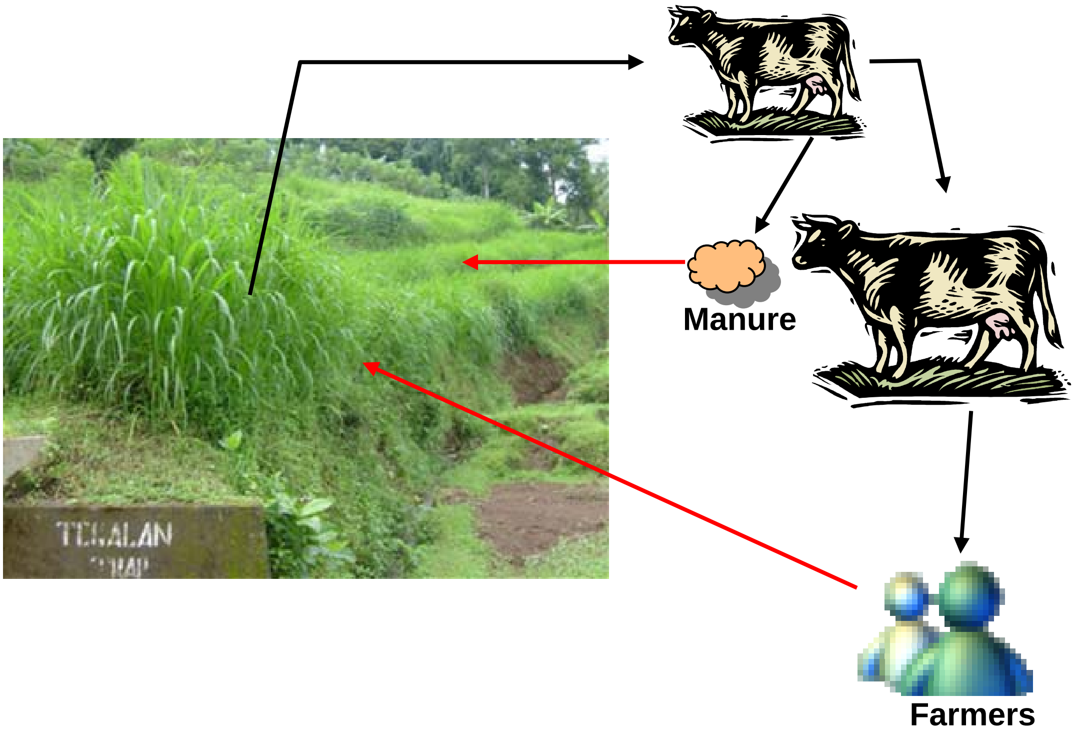

Figure 3. Integrated grass plating and cattle fattening for sustainable erosion control in Babon subcatchment, Central Java

Table 3. Expected additional farmers' income based on cattle weight gain

Farmer	Cattle weight (kg)			45% Carcass weight (kg)	Additional Income range (USD month^{-1})	
	Initial 14/2/02	Current 17/10/02	Additional weight		Gross income	Net income
Kasnin	240	370	130	58.50	21.13	14.13
Warsono	210	341	131	58.95	21.29	14.29
Muhyaeni	215	320	105	47.25	17.06	10.06
Supar	248	343	95	42.75	15.44	8.44

Source: Watung *et al.* (2003)

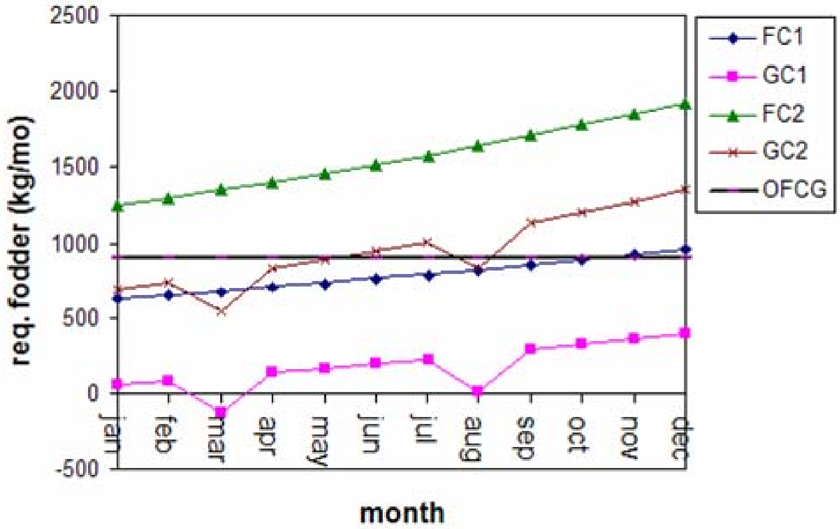

Figure 4. Fodder and grass required for raising one and four cattle (Subagyono *et al.*, 2003)
FC1= monthly weight of fodder required for one cattle; GC1=monthly weight of field grass required for raising one cattle; FC2=monthly weight of fodder required for two cattle; GC2=monthly weight of field grass required for raising two cattle; OFCG=optimal monthly weight of field grass collecting by farmers

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