An Economic Analysis of The Effect of Soil Conservation on Food and Feed Provision in Dryland Agribusinesses on Timor Island, Indonesia

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ABSTRACT : The technical and economic benefits of food and feed crop integration are important facts needed in the devlopment of soil conservation on Timor Island. This study was conducted in South Timor Tengah (TTS) and North Timor Tengah (TTU) Regencies between March and May 2013 and was aimed to discover the amount of cash generated from food crops planted as hedgerows in vegetative conservation efforts compared to no conservation efforts, and the amount of cash generated by corn plants planted between hedgerows in five years of cultivation. The data were collected through interviews and field observations. The results of this study demonstrated that: (a) The production of feed biomass planted as hedgerows increase as time progressed and the production would stabilize after the fourth year at 25 tons ha-1year-1, (b) The relationship between biomass production and cultivation time formed a linear line with the equation y = 6,032.63x – 592.6. (c) The relationship between biomass income and cultivation time formed a linear line with the equation Y = 2,021,458.37x – 2,444,254.57, (d) Hedgerows could potentially supply the needs of 2-3 cattle per six months fattening or 4-6 cattle per year, (e) Vegetative conservation reduced the size of land effective for food crops by 10-20% and reduced food crop productivity; however, land productivity increased because the Land Equivalent Ratio (LER) was 6.74 times higher than that of unconserved soil, (f) The reduced corn plant productivity during the 5 years of maintenance formed the exponential line equation y = 4,559.18e-0.34x for soil which underwent vegetative conservation and the linear line equation Y = -634.4x + 3,930 for unconserved soil, (g) The total gross margin of vegetative conservation for five years cultivation was IDR 29,967,413 ha-1 and without conservation IDR 13,385,079 ha-1, (h) The relationship between the cultivation years and the income from land which had undergone soil conservation during the five years it was cultivated increased, creating a power regression line equation Y = 4E+06e0.146x, whereas on unconserved soil it decreased, creating the linear regression line equation Y = -1E+06x + 6E+06.

Keywords: economy, soil conservation, food, feed, West Timor

INTRODUCTION

The ever increasing population of Timor Island is leading to the increased needs for larger amounts of food with more variety and better quality. At the moment, the population of Timor Island is 1,382,771 people (NTT Central Bureau of Statistics, 2012; Kupang Regency Central Bureau of Statistics, 2012). If the population growth is 1.76% per year (Postel, 2009), in the mid 21st century the population will double and at the end of the 21st it will quadruple. The challenges in the future will be more difficult because the consequences of population growth is land conversion from agricultural uses to housing, industrial and other uses, while in fact at the moment East Nusa Tenggara Province still needs to import 4,043 tons of grain, especially rice, per year (Central Bureau of Statistics NTT, 2012).

The agricultural system in Timor Island is dominated by field cultivation. Farmers cultivate food crops and perennial crops in the mixed cropping pattern. The utilization of dryland by farmers is still within the subsistence level and has low productivity (Bobihoe *et al*., 1999) and does not give much attention to soil conservation, resulting in a high probability of soil erosion (Subandi *et al*, l997).

Besides planting crops, the farmers also raise livestock, which is an important component of the farmers' income. Wirdahayati (2007) stated that livestock raising in NTT, especially on Timor Island, is dominated by Balinese cattle, and in the past 30 years NTT has become the largest livestock producer. Livestock raising contributes quite a lot to the household income, approximately 15-50% of the farmers' income.

One form of soil conservation which integrates the crop component and the livestock component on one plot of land is the alley cropping pattern. The application of the alley cropping pattern is an alternative to support the development of a sustainable agricultural system. The utilization of technology in the implementation of development needs to cater to the creation of as many job opportunities as possible and increase productivity and exploit as many self-created tools as possible in order to help reach the aims of development (Mulyana, 2003 *in* Ritonga, 2003).

Various studies have recommended the vegetative method because not only could it curb erosion, it also guarantees increased land productivity (Sukmana and Suwardjo, 1991). The hedgerow conservation technology is technically live hedges formed from leguminous trees, terrace strengthening plants, and cover crops which are planted to follow certain contour lines. The kinds of grass often planted as terrace strengthening plants are elephant grass, cetaria, and benggala, whereas grass planted on terrace walls are usually climbing vines such as *Brachiaria sp*, *Cynodon dactylon*, *Paspalum conjugatum*, *Penicum repens*); and (c) cover crops such as *Mucuna sp* and *Centrosema sp* (Sudaryono,1995).

According to Zamora (1995), sustainable agribusinesses must fulfill these five criteria: (a) economic viability; (b) ecologically sound and friendly; (c) socially just; (d) culturally appropriate; and (e) systems and holistic approach.

The application of vegetative conservation enables the dryland farmers to independently create a soil rehabilitation and conservation system on their land to support a sustainable agricultural production system. Plants that are planted as hedgerows do not merely control the flow of water on the surface and erosion, they also produce agricultural biomass which play a role in soil rehabilitation and fertilizers and produce nutrition-rich fodder for livestock. Reintjes *et al*. (1999 *in* Salikin, 2003) defined sustainable agriculture as the management of agricultural resources to fulfill human needs while maintaining or improving the quality of the environment and preserving natural resources. This concept emphasizes the importance of economic growth without sacrificing the quality of the environment (Mitchell *et al*., 2003).

This study aimed to discover (a) the additional cash generated by fodder crops planted as hedgerows in vegetative conservation compared to farms where no conservation efforts were applied, (b) the amount of cash generated by corn plants planted between hedgerows in vegetative conservation compared to farms where no conservation efforts were applied.

METHODOLOGY

Location and Time

This study is a survey research which compared the economic values of 2 kinds of land management, land where vegetative conservation efforts are applied and land where no such efforts were made during 5 years of land cultivation. The values compared were the feed biomass production and corn production. The surveys were conducted on 3 (three) villages in 2 (two regencies, Timor Tengah Selatan (TTS) and Timor Tengah Utara (TTU) Regencies, between March and May 2013.

Data Collection

Hedgerow Plant Biomass

The data collected consisted of:

a. The feed biomass production data collected through observations and on-site measurements.
b. The price of the biomass was determined based on the local farmers' willingness to pay
c. The cost of labor for the hedgerow, which consisted of the labor for planting and maintaining the hedgerow, was collected from semi-structured interviews of farm owners
d. Data of hedgerow harvesting costs, which consisted of labor cost for harvesting hedgerow in one year
e. The data of the materials needed for planting the hedgerow which consisted of the number of pols used in planting the hedgerow and the price of a pol were collected observations and semi-structured interviews

The economic value of the fodder crop biomass planted as hedgerow was calculated through the amount of feed biomass production that could be harvested in one year multiplied by the value of the biomass and subtracted by the cost of laor and materials.

Data Analysis

The relationship between the year of cultivation and the total income was analyzed using linear or non-linear regression.

The tool used for analyzing the relationship model was the SPSS program for Windows version 18. From the several alternative regression models, the one with the highest determiner coefficient (R2) was chosen. This was done because the higher the R2 value, the better the regression equation is acquired.

The economic value of the land was calculated from the direct profits, consisting of the revenue and cost. The value of unconserved land was calculated from the corn agribusiness subtracted by the costs of the corn agribusiness, whereas the benefits of the vegetative conservation technology was calculated from the productivity of the feed biomass which was planted as hedgerows + the productivity of the plants planted between the hedgerows subtracted by the costs needed for the agribusiness and the loss of soil nutrients caused by the feed biomass.

In order to compare the revenues and costs of the two types of land, conserved and unconserved, in one year, the Gross Margin analysis was conducted. According to Kennon (2010), the Gross Margin is the revenue subtracted by the variable cost which is calculated with the following equation:

Groos Margin = Revenue - Variable cost

This study's hypothesis is that vegetative conservation agribusinesses are more profitable than ones wihout conservation efforts. If the t-count > t-table, H0 is rejected at a certain level of error, meaning that the revenue from the land where vegetative conservation is conducted is higher than that of unconserved land. On the other hand, if t-count < t-table, H0 is accepted at a certain level of error, meaning that the revenue from land where vegetative conservation is conducted is similar or lower than that of unconserved land.

To test this hypothesis, an independent sample t-test with one way rejection criteria. To compare the effiency of land usage between monoculture (corn) and intercropping (corn + feed), the analysis of land equivalent ratio/LER was conducted. Nuryadi (1978) stated that the intercropping pattern was to be proclaimed efficient if the LER was greater than one (> 1), which was calculated using the following equation:

$$NSL = \sum_{i=1}^{n} \left(\frac{hi}{Hi}\right)$$

hi = the yield of the intercropping of the i-th plant species
Hi = the yield of the monoculture of the i-th plant species
i = 1, 2, 3,.... n the species of plants in the intercropping
The total economic value of vegetative conservation was calculated using the following equation:
NET = x1 + x2
NET: Total economic value
X1 : the economic value of the production feed biomass planted as hedgerows
X2 : the economic value of corn planted between the hedgerows
The costs calculated for land which had undergone soil conservation were the cost for the labor used to construct the hedgerows, the cost for maintaing the hedgerows, and the agribusiness costs for the corn plants planted between the hedgerows. The revenue for land which had not undergone soil conservation efforts was the revenue from the corn agribusiness. The costs calculated for land which had not undergone soil conservation were the costs for the corn agribusiness.

RESULTS AND DISCUSSION

The Effect of Conservation on the Hedgerow Biomass Production

There were some dissimilarities in the method of planting the hedgerows in the three locations observations. Conservation vegetation which was commonly planted by the farmers in North Mollo Sub-district, TTS Regency elephant grass (*Pennisetum purpureum*) together with corn in the first year, whereas the farmers in West Miomafo Sub-district, TTU Regency usually planted calliandra (*Calliandra calothyrsus*). Farmers in North Mollo Sub-district usually planted elephant grass at the same time as corn in the first year of cultivation using the graft method. In contrast, the farmers in West Miomafo Sub-district planted the calliandra seeds in the second year. The planting was commonly done in stages in different years.

The capital needed for planting was very little. The seeds or seedlings usually originated from the farmers' own fields or from their relatives' fields. They relied on family for the labor for planting. The farmers rarely patched their fields.

Results of the interviews demonstrated that 80% of the farmers owned cattle, ranging between 1 - 5 heads per head of household and the average was 1.97 heads per head of household. The results of the t-test of cattle ownership between land owners who conducted soil conservation and those who did not was insignificant. This means that there was no relationship between cattle ownership and vegetative conservation efforts. Not conducting vegetative conservation efforts did not automatically mean these farmers did not own any cattle, but they usually had more than one plot of land and one of them was planted with fodder crop, either planted as hedgerows or around the perimeter of their field, lawn, or on the part of their land which had steep slopes. Some formers who did not have livestock conducted vegetative conservation by planting elephant grass as hedgerows because elephant grass was easy to market and they were sold as bulk.

Elephant grass can be harvested 2-3 months after planting, whereas calliandra, which is a leguminous tree, can only be harvested after the second year.

Farmers usually harvested the feed biomass in stages, 2-3 times a day at around 15-20 kg per harvest, and the biomass can only be harvested 4-6 times per year. Roughage collection is usually done by family members and not a single farmer paid for labor from outside the family. The harvested biomass was fed to the cattle; however, the manure was not returned to the field but used on separate vegetable plots, sold, or not utilized at all.

The results of the observation of wet biomass weight per meter in rows was that it increased as the age of the plants progressed. The production stabilized after the fouth year of cultivation when the production reached 25 tons $ha^{-1}year^{-1}$.

If the biomass was valued in cash, the revenue was IDR 500 per kg wet biomass. If the need for elephant grass seed was calculated from the distance between rows, 7.21 meters, and the distance between plants, 15 cm, 9242 stek were needed per hectare and the price of the seedlings was IDR 100 per graft then the cost of elephant grass seedlings was IDR 924,200. On the other hand, for calliandra, the need for seed was 7 kg per hectare at a price of IDR 50,000 per kg. The cost for planting and harvesting labor was valued at IDR 20,000 per man day. The cost of the loss of soil nutrients contained in the biomass was measured by converting dry biomass to 2% N, 0,25% P_2O_5, and 4% K_2O (Manglayang Farm Online, 2005); therefore, the farmers' total income from vegetative conservation was IDR 18,100,000 ha^{-1} (Tables 1, 2 and 3).

Table 1. Revenue from Hedgerow Biomass in Vegetative Conservation

Cultivation Year	Wet biomass production per m (kg)	Distance between rows (m)	Harvest frequency per year (times)	Wet biomass production (kg/ha/year)	Revenue from biomass (IDR)*)
1	1.67	10.65	4	8,774	4,387,000
2	2.17	10.65	5	14,117	7,058,500
3	1.67	6.97	6	17,353	8,676,500
4	6.33	6.77	4.33	28,391	14,195,500
5	5.83	8.13	4.67	26,522	13,261,000

Note: *) The price of biomass was calculated at IDR 500/kg

Table 2. The Cost of Seed/Seedlings for Hedgerow Plants in Vegetative conservation

Cultivation Year	Seed/seedling cost		Planting cost (man days)		Harvesting cost (man days)		Total cost Seed+labor
	Material	Value (IDR)	Material	Value (IDR)	Material	Value (IDR)	
1	6,161 graft*)	616,143	7	133,333	122	2,433,333	3,182,810
2	2.33 kg**)	116,667	3.33	66,667	122	2,433,333	2,616,667
3	0	0	0	0	183	3,650,000	3,650,000
4	0	0	0	0	183	3,650,000	3,650,000
5	0	0	0	0	183	3,650,000	3,650,000

*) Commodity: elephant grass. The distance between rows was 7.21 m, planted in rows at a distance of 15 cm, the price per pols IDR100

**) Commodity: calliandra. Seven kg of seed was needed per ha at IDR 50,000/kg

Table 3. The Cost of Soil Nutrients Lost through Feed Biomass in Vegetative Conservation

Cultivation year	Production of dry biomass (Conversion: 25% of wet biomass) (kg/ha/yr)	N content of dry biomass (2%)*) (kg/ha)	P2O5 content of dry biomass (0.25%)*) (kg/ha)	K2O content of dry biomass (4%)*) (kg/ha)	Loss of urea at IDR2400/ kg (IDR)	Loss of SP36 at IDR3000/ kg (IDR)	Loss of KCl at IDR3600/ kg (IDR)	Cost of nutrient loss (IDR/ha/ year)
1	2,193	29	4	58	155,975	30,464	457,752	644,191
2	3,529	47	6	94	250,971	49,018	736,546	1,036,535
3	4,338	87	11	174	462,741	90,379	1,358,044	1,911,165
4	7,098	142	18	284	757,092	147,869	2,221,899	3,126,861
5	6,631	133	17	265	707,261	138,137	2,075,656	2,921,054

*) Source: Manglayang Farm Online (2005)

The hedgerow production and economic value increased as time progressed. The relationship between biomass production and cultivation time formed a linear relationship (Figure 3) with the following equation:

Y= 6,032.63x – 592.63

Where: Y = Hedgerow wet biomass production (kg ha-1year-1)

x = Cultivation year

Whereas the relationship between the revenue from biomass and time formed a linear relationship with the follwoing equation:

Y = *2,021,458.37x – 2,444,254.57*

Where: Y = revenue from hedgerow plant biomass (IDR ha-1tahun-1)

x = Cultivation year

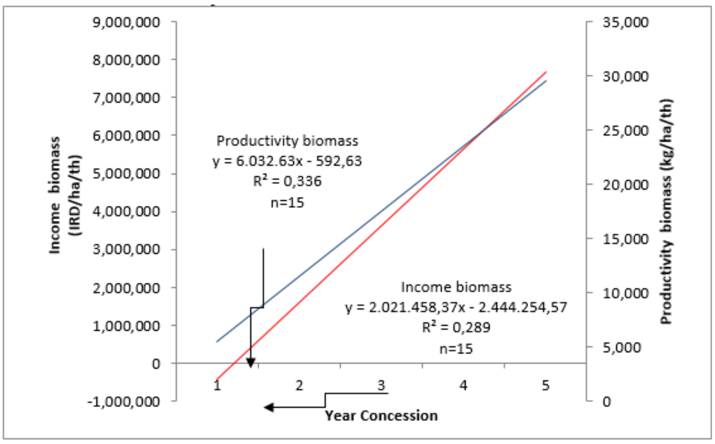

Figure 3. The Regressive Equation for Hegde Row Biomass Production and Revenue on Land Where Soil Conservation Efforts were Conducted for Five Years

Hedgerow biomass is an organic matter supplier. The production of wet biomass in the fourth and fifth year was 25 tons or equivalent to 6 tons dry biomass. If it is assumed that the contents of elephant grass biomass is 2%N, 0.25% P_2O_5 and 4% K_2O (Manglayang Farm Online, 2005), the biomass produced would contain 120 kg N, 15 P_2O_5 and 240 kg K_2O.

The hedgerow plant biomass is potential cattle feed. If it is assumed that 50% of the biomass could be consumed by livestock, the vegetative conservation could potentially produce 25 tons of fodder per year. Wirdahayati *et al*. (1999) stated that Balinese cattle consume between 10% and 15% of their body weight. If it is assumed that a 200 kg cow needs 20 - 30 kg per day, for cattle fattening that lasts six months (for a single fattening period), the need for one cow would be 3,600 – 5,400 kg per per 6 months. The fodder supply potential is 25 tons per year; therefore, the potential for six months would be 12.5 tons. This pattern would supply the needs of 2-3 heads of cattle per 6 months fattening or 4-6 heads of cattle per year.

The introduction of grass as hedge plants was a vegetative conservation technique that was readily accepted by the farmers because not only could it control erosion, it could also solve the problem of fodder shortages for the ruminants they raised (Soelaeman, 1999). Haryati *et al*. (1991) stated that the terrace strengthening plants on bench terraces could support between 21-59 heads of sheep ha-1year-1. This included the waste products of food crops planted on arable land that could be given to livestock. The terrace stregthening plants' contribution to fodder supply was between 51% and 60%.

Better soil conservation efforts are hoped to increase land productivity and the revenue from food crop. However, pertaining to the relationship with terrace strengthening plants in the form of livestock feed (especially grass), not all of the farmers could accept them due to a variety of reasons, for example, the presence of grass would reduce the size of arable land available for food crops, their grass was harvested by other farmers, the farmers do not own ruminant livestock, grass could become a nesting site for rats and other pests, and the grass would compete with the cassava plants the farmers wereaccustomed to planting (Dariah *et al*., 1998).

Soelaeman (1999) stated taht the presence of grass as terrace strengthening plants had a positive impact on cattle and goat raising, at 6% and 8% respectively.

According to the study conducted by Sudharto *et al*. (1994) in South Sulawesi, vetiver (*Vetiveria zizanioides*) and Guatemala grass (*Tripsacum laxum*) hedgerows could contribute 7.2 – 13.3 t ha-1 fodder and control erosion between 15.6 and 85% better compared to land where no conservation efforts were made in shifting agriculture locations.

Land Use Efficiency

The presence of hedgerows which incorporate the fodder crop component into field cultivation is a form of multiple cropping because there are more than two kinds of crops on one tract of land in one year. It has been explained in the previous sections that the presence of hedgerows had a better impact on the resource conservation compared to single cropping. In the ecomonic point of view, the hedgerows have additional economic value from the fodder crop produced; however, the value of the corn production is reduced until the fourth year due to reduced plot size.

In Table 4 it is shown that the income (revenue - cost) from land where conservation efforts were done (intercropping of corn + fodder hedgerow) was higher than that of unconserved land (corn monoculture) from year one to year five. The results of the analysis of land equivalent ratio/ LER was > 1 and the value continued to increase as cultivation time progressed. In the first year of cultivation the LER was 1.63 which meant that the income from conserved land was 1.63 times higher than that of unconserved land, whereas in the fourth year the income was 6.74 times higher; moreover, in the fifth year, the income from unconserved land was minus. Therefore, conserved land was much more efficient than unconserved land.

Table 4. The Land Equivalent Ratio for Conserved and Unconserved Land

Cultivation Year	Income from unconserved land	Income from conserved land	LER
1	4,604,444	4,600,843	1.63
2	4,382,222	4,594,165	1.71
3	2,931,111	5,416,754	2.79
4	1,613,333	8,185,899	6.74
5	-146,032	7,169,751	∞
Total	13,385,079	29,967,413	3.27

The Total Economic Value

The total income from land where vegetative conservation was conducted during the five years of cultivation was IDR 62,510,048 ha^{-1}, whereas from land without conservation was IDR 20,265,079 ha^{-1}. The total cost for vegetative conservation for five years was IDR 32,542,635 ha^{-1}, while for land without conservation was IDR 6,880,000 ha^{-1}. Therefore, the total gross margin vegetative conservation during the five years of cultivation was IDR 29,967,413 ha^{-1} and without conservation was IDR 13,385,079 ha^{-1} (Table 5).

The relationship between cultivation and income from conserved land during the five years of cultivation showed an increasing trend and formed a power regression line with the equation y = $4E{+}06e^{0.146x}$, while on unconserved land it showed a decreasing trend and formed a linear regression line with the equation y = -1E+06x + 6E+06 (Figure 6).

Table 5. The Gross Margin Analysis of Conserved and Unconserved Land

Cultivation Year	Conserved						
	Revenue (Rp)			Cost (Rp)			Gross margin
	Biomass	Food crops	TRK	Biomass	Food crops	TCK	
1	2,924,528	6,333,333	9,257,862	3,217,019	1,440,000	4,657,019	4,600,843
2	4,705,708	4,864,994	9,570,702	3,536,537	1,440,000	4,976,537	4,594,165
3	8,676,395	3,681,524	12,357,919	5,561,165	1,380,000	6,941,165	5,416,754
4	14,195,469	2,107,291	16,302,760	6,776,861	1,340,000	8,116,861	8,185,899
5	13,261,137	1,759,668	15,020,805	6,571,054	1,280,000	7,851,054	7,169,751
Total	43,763,237	18,746,811	62,510,048	25,662,635	6,880,000	32,542,635	29,967,413
			Unconserved				
1		6,044,444	6,044,444		1,440,000	1,440,000	4,604,444
2		5,822,222	5,822,222		1,440,000	1,440,000	4,382,222
3		4,311,111	4,311,111		1,380,000	1,380,000	2,931,111
4		2,953,333	2,953,333		1,340,000	1,340,000	1,613,333
5		1,133,968	1,133,968		1,280,000	1,280,000	-146,032
Total		20,265,079	20,265,079		6,880,000	6,880,000	13,385,079

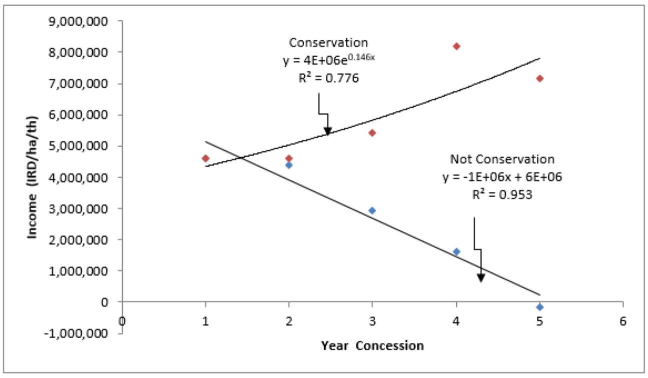

Figure 6. The Regression Equation for the Effect of Cultivation Time on Revenue from Land where Vegetative Conservation Efforts Have and Have not been done

CONCLUSION

Conclusion

a) Vegetative conservation generated IDR 18,100,602 extra cash from the fodder crop planted as hedgerows during the five years of cultivation, whereas unconserved land did not generate any extra cash.

b) The amount of cash generated by the food crop planted between the hedgerows on land where vegetative conservation was conducted for five years was IDR 11,866,811, whereas on unconserved land it was IDR 13,385,079.

c) The total gross margin land with vegetative conservation during the five years of cultivation was IDR 29,967,413 ha^{-1} and that of unconserved land IDR 13,385,079 ha^{-1}.

Suggestions

Vegetative conservation could be optimized by: (a) utilizing hedgerow biomass as a source of organic matter by periodically trimming and spreading the biomass onto the land, (b) integrating crops and livestock, (c) altering the habit of not fertilizing the land to fertilizing with manure, and (d) not burning the biomass from food crops when preparing the land.

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