Coffee agroforestry for sustainability of Upper Sekampung Watershed management

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Abstract

The main objective of watershed management is to ensure the optimal hydrological and natural resource use for ecological, social and economic importance. One important adaptive management step in dealing with the risk of damage to forest ecosystems is the practice of agroforestry coffee. This study aimed to (1) assess the farmer's response to ecological service responsibility and (2) analyze the Sekampung watersheds management by providing environmental services. The research location was Air Naningan sub-district, Tanggamus, Lampung Province, Indonesia. The research was conducted from July until November 2016. Stratification random sampling based on the pattern of ownership of land rights is used to determine the respondents. Data were analyzed using descriptive statistics and logistic regression analysis. Based on the analysis, it was concluded that coffee farmers' participation in the practice of coffee agroforestry in the form of 38% shade plants and multiple cropping (62%). The logistic regression analysis indicated that the variables of experience and status of land ownership, and incentive-size plans were able to explain variations in the willingness of coffee growers to follow the scheme of providing environmental services. The existence of farmer with partnership and CBFM scheme on different land tenure on upper Sekampung has a strategic position to minimize the deforestation and recovery watersheds destruction.

Keywords: coffee agroforestry, willingness, Sekampung watershed, Indonesia

1. Introduction

Way Sekampung is well known as the main watershed, troughs to seven districts in Lampung Province. Batu Tegi Dam at Upper Sekampung provides water irrigation for 66.573 ha wet paddy system (Public Work and Settlement Ministry, 2015). Most of Upper Sekampung watershed areas include protection forest Register 39 under Batutegi Forest Management Office (FMO) jurisdiction. Another part is private land. Several factors were being caused the damage to an ecosystem in WS

Seputih Sekampung. The carrying capacity of the environment has been declining due to the pressure on land use and lack of conservation efforts by the community. Significant changes in land use utilization, from the forest into the plantation, cultivated/farmland also turned into land residential, industrial, etc. Approximately 60% of forest lands converted into gardens and settlements in Batutegi watershed. The main water source of Batu Tegi Dam was supplied by Upper Sekampung watershed. The land degradation caused by erosion and deforestation in Seputih-Sekampung reach to138.026,38 ha (Mesuji-Sekampung River Basin Agency, 2010).

Erosion and sedimentation threaten the sustainability of the function of water resources as well. Erosion problems not only decreased land productivity in the on-site area but also increased sedimentation in the off-site area. The more severe watersheds need to be carried out in an effort to manage the watersheds more integrated. Upstream agricultural activities that do not heed the rules conservation, including illegal forest clearing for land agriculture have triggered the process of erosion and sedimentation (1). The quantification of land use affected dominant erosive processes (2). Ecological services will be threatening worst by those factors as the negative externalities. Watershed management is important to minimize negative externalities.

Watersheds management means to ensure the optimal hydrological and natural resource use for ecological, social and economic. One important adaptive watersheds management in dealing with damage ecosystems is the practice of agroforestry. Agroforestry is recognized as an integrated land-management to solve environmental problems in both developing and industrialized nations today. Agroforestry systems can be found specific differentially based on climatic conditions and socio-economic factors such as human-population pressure (3); (4); (5). Agroforestry systems retain much higher quantities of carbon in above and belowground biomass in comparison to crop and grazing land use systems (6). Agroforestry systems also have been shown in reducing erosion through their canopy cover and their contribution to the litter layer (7).

Most of the stakeholders at upper stream watersheds involved agricultural sector production, with the main cash crop such as coffee, cacao, banana, and other wood plantation. Upper watersheds mostly have specific topography elevation. For more than 5o elevation, the agricultural practise must consider conservation principals (1). Coffee and others cash crop could cultivate as well with the Good Agricultural Practices (GAP) with conservation.

Internalizing the negative externalities of ecological service reduction has been discussed broadly on Payments for Ecosystem Services (PES) domain (8); (9). It is commonly defined as a market-based environmental policy instrument to efficiently achieve ecosystem services provision. The conceptualization of PES cannot be easily generalized and implemented in practice. The gap between

PES theory and practice to increase sustainable ES provision and improve livelihoods may bridge the neither fairness nor efficiency (10).

The contribution of coffee farmers in the provision of ecosystem services is important to gain recognition, rewards and incentive rewards from stakeholders who enjoy the positive externalities of this agroforestry coffee. However, information on the willingness of coffee farmers and user communities to meet in the mechanism of rewards for environmental services is still very limited. The possibility of coffee farmer participation in environmental services needs to dig deeper. The certainty of agroforestry coffee practice in upstream of Sekampung River Basin will be providing water availability and other environmental services. Agroforestry coffee is a part of internalizing externalities of local land-use in upper Sekampung. The paper was aims to (1) assess the farmer's response to ecological service responsibility and (2) analyze the Sekampung watersheds management by providing environmental services.

2. Materials and Methods

2.1 Survey design

The research location was in Air Naningan sub-district, Tanggamus. Two villages were chosen as a representation of upper Sekampung territory in Air Naningan sub-district. There were Datar Lebuay and Sinar Jawa village. Both of the villages lay down between Sangarus and Sekampung river. Sangarus and Sekampung rivers was the main water sources for Batu Tegi DAM. Respondent represents the land tenure of coffee farming. There were private, CBFM, and non-CBFM land tenure. CBFM is standing for Community Based Forest Management. Upper Sekampung watershed was under the Batu Tegi Forest Management Office (FMO) territory.

Most of the upper Sekampung territory is protected forest under the jurisdiction of Batutegi FMO included all territory in Register 39 with area reached 58,162 ha. Air Naningan sub-district has population 30,185 people. There was 32 farmers group had been licensed as CBFM in Batutegi FMO jurisdiction. CBFM territory reached 14,609.15 ha and involved 16,169 farmers. Respondents of CBFM were HKm Mandiri Lestari and Wana Tani Lestari Utama. The management area of CBFM was located on upstream of Sekampung and Sangarus rivers. The total number of respondents is 400 coffee farmers. The field survey conducted from July until November 2016. The site location relevant to describe the upper Sekampung land-use related to Sekampung watersheds management. Site location can see at figure1 as follows:

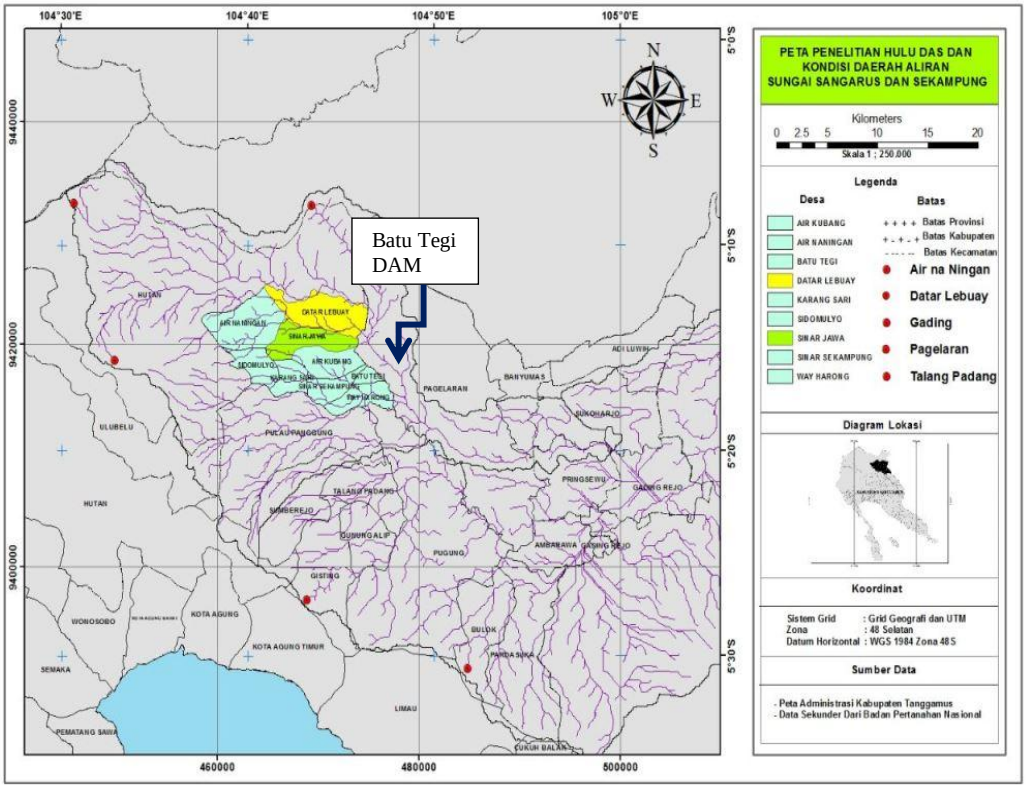

Figure 1. Site location of Datar Lebuay and Sinar Jawa village at Air Naningan Sub-district

2.2 Data Analysis

Data were analyzed by descriptive statistics and logistic regression analysis. Investigation of the logistic regression equation model is used to test the model of community willingness to participate in Sekampung ecological services (WTP). The model was developed for logistic regression function.
Logistic regression had well known as a good predictor to analyze the probability of willingness to participation (11)(12) (13). Describing the farmer's response to ecological service responsibility built as a logistic regression model, binner logistic regression. Formulation model predicted WTP as Y, dependent variable as binner, (1 = Yes, 0 = No) to participate in ecological services scheme. The logistic regression equation model is formulated as follows:

$$Pi = E\left(Y = \frac{1}{Xi}\right) = \frac{e\ ln(\frac{Px}{1-Px})}{1+e\ ln(\frac{Px}{1-Px})} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Furthermore logistic regression equations are modified in multiple regression equations (14)to be:

$$ln \frac{Px}{Pi/Px} = Y \text{ .... (2)}$$
$$Y = \beta 0 + \beta 1\, X1 + \beta 2 X2 + \beta 3\, X3 + \varepsilon \text{ ...(3)}$$

Information:
PX / P1-PX = Odd ratio, is a comparison of the opportunity of people who are willing to accept participate (WTP=Y) with the community (respondents) who are not willing to participate.
P (xi) = Community Opportunity in its willingness to participate or Y(1 = Yes, 0 = No)
P (xi) = Yp
β0 = Constant
X1 = Experiences
X2 = Land ownership
X3 = Compensation
β1..β3 = Regression coefficient,
E = Error in equation or interruption

3. Results and Discussions

3.1 Farmer's response on ecological service responsibility

Air Naningan sub-district has territory 116.5 km2 residence by 30,185,000 people. There were 10 villages under the Air Naningan sub-district jurisdiction. Datar Lebuay and Sinar Jawa were represented as a village which borders with protection forest Register 39 Batu Tegi. Most of the population cultivated annual plantation such as coffee, pepper, and cocoa as multiple cropping systems. There were also appeared the shade trees combination for the multipurpose benefit. Based on Table1 recognized that there no monoculture coffee cultivation. All of the respondents applied combined coffee plantation with another crop as shade trees and also multiple cropping for optimum benefit economically and ecologically.

Table 1. Coffee agroforestry form

Agroforestry form	Frequency	Valid Percent
Shade trees	168	43.6
Multiple cropping	217	56.4
Total	385	100.0

Coffee farmers have participated in agroforestry coffee practice with 43.6% shade trees form and multiple cropping (56.4%). Biologically coffee needs shade trees for their optimum productivity (15).

The combination of coffee and shade trees is a must to fulfill high vegetation requirement for the sustainability of protected forest and watersheds area, especially the land with elevation more than 5% (1). Coffee agroforestry system was well known as a management strategy to minimize ecological negative impact in Central America (16). Some of the major agroforestry systems in the tropics are grouped according to such a framework. The scheme appears a logical, simple, pragmatic and purpose-oriented approach to classification of agroforestry systems (5). Modifying agro forests according to their knowledge and tree preferences, and that the resulting agro-forest was very important. The higher proportion of pioneer trees relative to the forest is mostly explained by farmers' tree selection decisions (63%) rather than as a byproduct of management practices (37%) that disturb the soil and open the canopy, altering light penetration and microclimate conditions. Farmers gradually replace canopy trees of neutral and disliked species by preferred species, in particular, Inga spp. This indicates that farmers are receptive to incorporate outside knowledge into their knowledge systems and adapt their resource management practices accordingly (29), (30), (31).

The duration of agroforestry coffee practice showed in figure 2. Most of the respondents have been experienced in practicing agroforestry coffee for more than 5 years. The experience in agroforestry coffee is important to keep good agriculture practice on coffee cultivation.

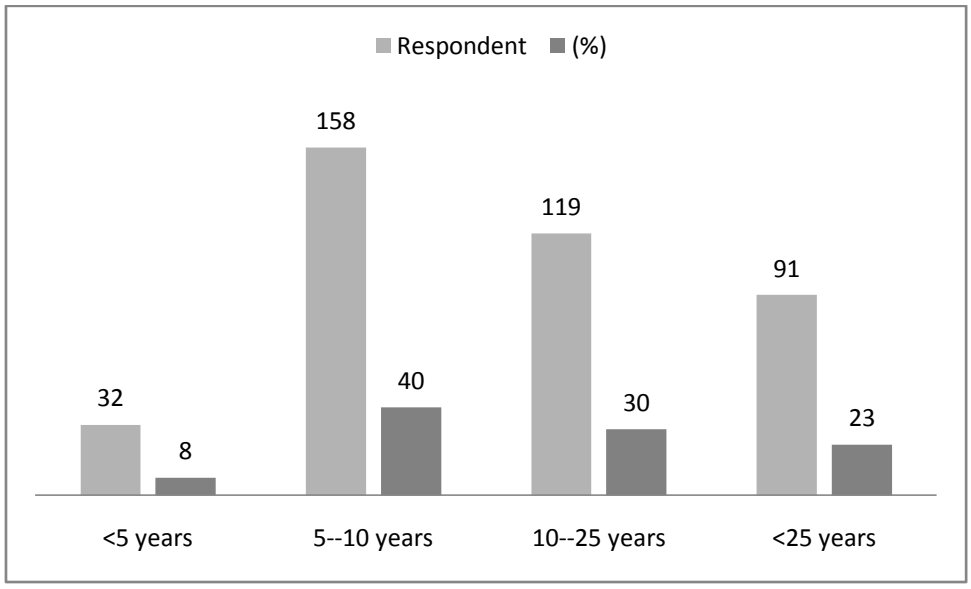

Figure 2. Duration of farmer's experiences in agroforestry coffee practiced

Based on the land ownership status, private/clan was the smallest. Private/clan lay on village jurisdiction land territory. The ownership of certification of private land still limited. Both of two villages follow the national program on land certification. Almost 500 land certificate has been

released for the community in 2016, the others still on issued process. There was CBFM dominantly (figure 3).

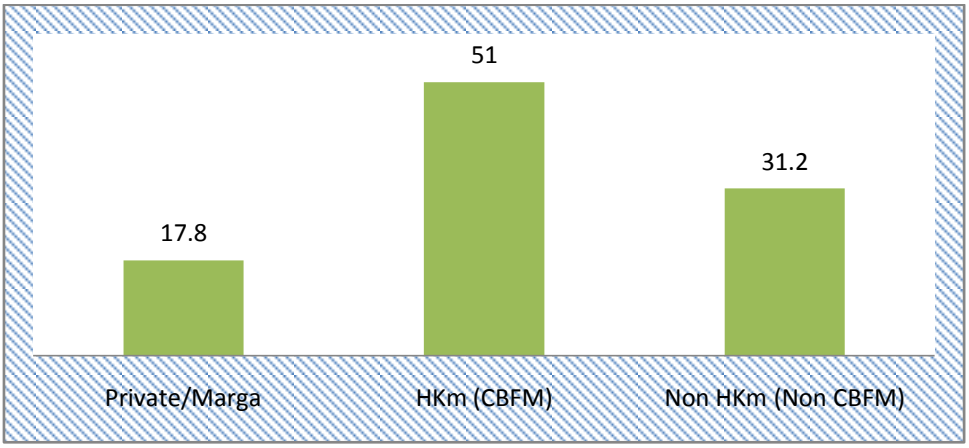

Figure 3. Respondent based on land ownership (%)

Table 2. Duration agro forestry adoption and land status cross tabulation

Duration years		Land status			
		Private/clan	CBFM	Non CBFM	Total
	<5	9	16	10	35
	5-10	35	76	47	158
	10-25	22	65	32	119
	<25	5	45	36	86
Total		71	202	127	400

The cultivation system of community on upper Sekampung watershed will be determining the sustainability Sekampung ecological services. Coffee farmers have been realized that agroforestry coffee gives them tobenefit more than monoculture. Coffee plantation must plant with other trees for biological needs.Agroforestry systems have been shown to reduce erosion through their canopy cover and their contribution to the litter layer. The agroforestry system examined, for the cultivation of coffee and mixed shade trees (Musa *spp* and Inga *spp*), an average of 10.4% of the area is affected by erosion. The soil was relatively little affected by erosion, around 13% of the cultivated area (7).

Describing the farmer's response to ecological service responsibility built as a binner logistic regression model. Based on Table 3 had revealed that most of the farmers (74.75%) prepared to participate inSekampung ecological services scheme, while the other was still considered about the

scheme. The analysis of coffee farmer willingness to participate onSekampung ecological services scheme presented at Table 4.

Table 3. Coffee farmerwillingness to participate inSekampung eco services scheme

	Alternative answer	N	(%)
Coffee farmer willingness to participate Sekampung eco services scheme	Yes	299	74.75
	No	101	24.25
	Total	400	100

Table 4. Logistic regression of coffee farmerswillingnessfor Sekampung Ecoservices scheme

	Estimate	Std. Error	Wald	Odd
[EcoServices = 1.00][Y]	16.46	0.48	1,174.10	
Experiences [X1]	0.05	0.01	19.28***	1.04
Land ownership [X2]	0.40	0.18	5.20***	1.5
[Compensation] [X3]	13.55	0.29	2,132.37***	
Link function: Logit.				
Chi-Square 34.09 Sig 6.46E-06				
Nagelkerke value 0.12068				

At the Table 4 was showed that Chi-Square value 34.09 with Sig. value 6.46E-06 (p-value <0.05), significant with α 5%. It means that the variation of the coffee farmer to participate in the ecological services scheme significant influenced by variable experiences, land ownership, and compensation.

$$Y = a + b_1 X_1 + b_2 X_2 + b_3 X_3 + e$$

$$Y = 16.46 + 0.05X_1^{***} + 0.40X_2^{***} + 13.55X_3^{***}$$

From the logistic regression analysis, indicates that the variables of experience (X1), the status of land ownership (X2), and compensation (incentive-size plans) (X3) were significantly able to explain variations in the willingness of coffee growers to follow the scheme of providing environmental services. Odd ratio of experience variable (X1) was 1.04. It means that long duration of practicing coffee agroforestry will influence the probability to participate in ecological services scheme. The odd value of land status variables was 1.5. It means that if every each changing in land tenure status, odds of private/clan ownership status 1.5 times greater to participate on environmental services scheme than CBFM and non CBFM land tenure, assuming all variables in the model were constant. The variable amount of the compensation plan was significant in determining the willingness of the coffee farmers participates in the scheme.

3.2 Sekampung watersheds management

Batutegi Forest Management Office (FMO) was established in 2011 with an area of 58,162 hectares (based on Forest Ministry Policy No: SK.650/ Menhut-II/2010). Based on Landsat imagery in 2010, the vegetation cover is dominated by non-forest vegetation (76%) and dominated by farmers' fields with the staple crop of coffee. The existence of these tenant farmers is one of the important considerations for Batutegi FMO in formulating its management plan. Thus, the vision of Batutegi's FMO is "Achieving the Function of Protected Forests Providing Community Welfare".

BFM group in Tanggamus regency in 2015 was 32 groups. According to the Head of Batutegi FMO, currently, there is many farmer groups and farmer groups association that are in the process of applying for partnership permit to manage the land in Reg. 39. Strong public support is needed to create private incentives for exploring economic and environmental win-win innovations (17).

Mr Yayan Ruchyansah as Batutegi FMO head officer mentioned that they have been developed an excellent partnership farmers program. The program has been pioneered since 2012. It is directed to embrace the illegal farmers to become farmers established by providing the legality of cultivation in the form of partnership cooperation. Until the year 2016 has been successfully built 11 farmer groups with an area of 2,582 hectares and the number of members of more than 1,546 peasants. They have maintained seedlings planted more than 500,000 stems with various types of plants such as nutmeg, cloves, areca nut, aren (Arenga pinnata), jengkol (Archidendron pauciflorum) and gaharu (Aquilaria malaccensis). Eleven groups have planted, only 3 groups have been verified and agreed on the number of crops to be imaged, the rest is the stage of verification. This is done to clarify the responsibility of each farmer in the calculation of profit sharing. Figure 4 described one sample design of agroforestry plot by Batu Tegi FMO-farmers partnership coverage 1,200 ha.

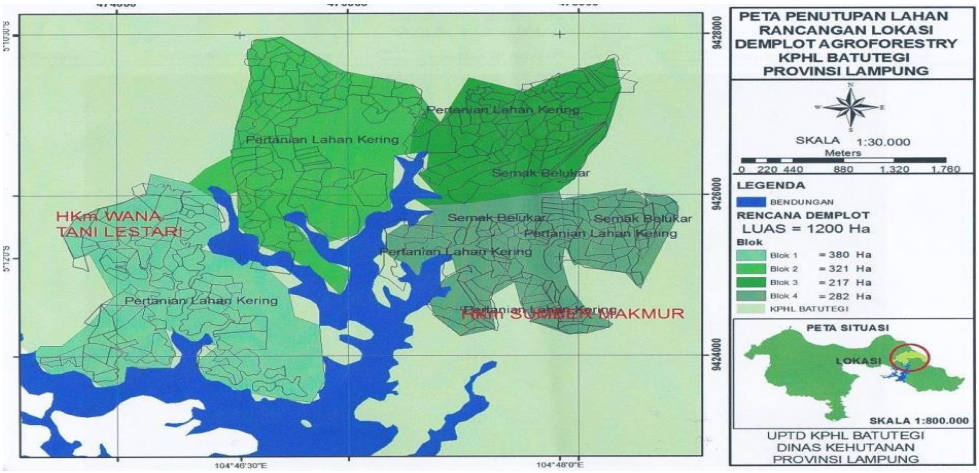

Figure 4. Design of agro forestry plot by Batu Tegi FMO
Sources: Batu Tegi FMO, 2015

The program emphasized not just on planting, but the program for harvest. It means that the plant must be maintained in order to grow properly and harvest optimally. Cooperation arrangement was carried out by involving farmer actively through intensive discussion in the field. It set agreement on yield distribution between farmers and FMO was 20-25% for FMO and 75-80% for farmers. The difference is based on the amount of cost sharing in each location. The first goal is sustainability on financial benefit for the farmer and Batutegi FMO. The last but the most important is environment benefit for ecological services sustainability.

The existence of farmer with partnership and CBFM scheme on different land tenure on upper Sekampung has a strategic position to minimize the deforestation and recovery watersheds destruction. Previous research also found the fact that the scenario of land management of CBFM with the pattern of agroforestry cultivation is the best scenario on rehabilitating the forest area and changing the management of monoculture coffee land into a mixed coffee planting pattern (18). In the watershed management circuit, there is a management activity involving mutual relationships between natural resources and the community. In the execution of the impact of reciprocal relationships between humans and the environment specifically identified with externalities (19).

These results indicate that it is important to improve forest area monitoring during the early establishment of a participatory forest management association to maximize the effect of CBFM formation (20). Awareness among group members of CBFM is higher than those who have not received permission. CBFM member and household groups believe that participation in the forestry program will substantially increase their security of land ownership, land value, land investment, and income. CBFM existence has a positive impact on non-coffee tree planting and contributes to increasing their income (21).

Well, watersheds management is primary action due to protecting the hydrological cycles. The worst management will effects on dominant erosive processes and contribute to more targeted efforts and relevant incentives to reduce (or live with) sediment load of the rivers (2). Damage to watersheds in Indonesia increasing every year so had caused very harmful excesses. Every year there is always a flood, landslides, droughts and disasters. Watershed management activities have been a long time practised, but the results achieved not optimal yet. One source of caused failure is emphasizing patterns command and control with approach top-down policy, operational level, and implementation. Watershed management in new paradigm is the deep community empowerment watershed management efforts at the level operational and implementation with using a bottom-up approach(22).

Based on information on Table3 revealed that land ownership between CBFM and non CBFM status was significant in determining the willingness of the coffee farmers participate in the scheme. This fact had relief that coffee farmer responsible with their obligation to take good care the Upper Sekampung watersheds environment. Based on Indonesian Law No. 7, 2004, the water resources management pattern is the basis for planning, implementing, monitoring and evaluation of conservation activities, utilization and control of natural resources damages. The management pattern

becomes the foundation of coordination among related parties based on the principle of sustainability, the balance of social-economic-environmental function and the general benefit principle and involves the role of society at large.

4. Conclusions

Based on the analysis, it was concluded that coffee farmers' participation in the practice of coffee agroforestry in the form of 38% shade plants and multiple cropping (62%). The logistic regression indicated that the variables of experience, the status of land ownership, and incentive-size plans were able to explain variations in the willingness of participation coffee growers to follow the scheme of providing environmental services. The odd value of land status variables means that if every each changed in land tenure status, odds of private/property ownership status 1.5 times greater following the environmental service reward scheme than others land tenure, assuming all variables in the model were constant. The variable amount of the compensation plan was also significant in determining the willingness of the coffee farmer's participation. The existence of farmer with partnership and CBFM scheme on different land tenure on upper Sekampung has a strategic position to minimize the deforestation and recovery watersheds destruction.

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