DEVELOPMENT OF AGROFORESTRY FOR LIVELIHOOD SECURITY: CASE STUDY OF PESAWARAN INDAH VILLAGE, PESAWARAN DISTRICT, INDONESIA

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Paper presented at the 14th Global Conference of the International Association for the Study of the Commons (IASC) in Kitafuji, Jepang (3—8 Juni 2013)

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ABSTRACT

The phenomenon of climate change and increasing the population density affect the cropping pattern developed. Agroforestry cropping pattern is one of the alternatives facing the conditions. The purpose of this study is to encourage the development of agroforestry through a review of the benefits of agroforestry, both economically and ecologically point of view. The study was conducted in Pesawaran Indah Village, District of Pesawaran bordering Great Forest Park of Wan Abdul Rahman in which some area were damaged by illegal logging. Focus group discussion (FGD), direct interviews and quantitative analysis were employed for data collective and data analysis. The study result show that the benefit obtained from agroforestry pattern is not only from crop and forestry plan but also from manure used as organic fertilizer and biogas reactor materials, also the use of discharge water as the driving force of Power micro Hydro (MHP). The average of total income of agroforestry farmers amounting to Rp 36,992,171/ha/year the contribution to total revenues of 91.44%. Agroforestry pattern with dominance cocoa is financially viable with a value of NPV is Rp 71,392,802.34, BCR is 7.39, and IRR is 96% by the age of feasibility are 20 years and interest rate of 12%. Potential uptake of carbon in agroforestry 209.64 mg/ha.

Key words: agroforestry, composition of plants, income, financial analysis

1. INTRODUCTION

The phenomenon of climate change and increasing the population density are serious threat to progress in developing countries. Climate change is already affecting some different types of rain variability, strong winds, heavy rain leading to flooding (in lowland areas), landslides and pests. Each of these occurs with different frequency and affects people's livelihoods to a different degree.

Indonesia as a developing country has the fourth largest population in the world after China, India, and the United States. The population of Indonesia is based on the results of population census calculations dated December 31, 2010 by Indonesian Ministry of Domestic Affairs reached 259,940,857 of people. Development of Indonesia's population increased more rapidly than the population of Indonesia in 2000 was 206.2 million, in ten years time, in 2010, has grown to over 50 million people who previously took approximately 40 years (www.anneahira.com). This increase affects the public welfare, environmental sustainability, and food security.

This concept combines the issues of availability and access to food, and people may adopt different strategies cropping patterns in response to food insecurity and environmental sustainability. These challenges include deciding how to combine food and non-food crops such as wood effectively.

In response, there is an increasing focus on the importance of integrating climate change adaptation into planning and programs to ensure that the planting pattern developed an effective and sustainable. This will reduce the risks posed by climate hazards to the success of planting patterns on a small scale and will help to ensure that development initiatives contribute to reducing vulnerability to climate change.

Agroforestry cropping pattern is one of the alternatives facing the conditions. Agroforestry according to Nair (1987) in Hairiah et al (2003) is an integrated system of land use, which have a social and ecological aspects, implemented through combining trees with crops and or livestock (animals), either together or take turns, so that from one land units achieved total vegetable or animal results are optimal. Agroforestry can be developed either in the forest or garden.

Agroforestry could be one solution to the problem of deforestation and forest degradation is no longer a new issue in the Province of Lampung. Community in Pesawaran Indah Village residing in one district in Lampung Province optimize the management of their land by agroforestry system.

Pesawaran Indah village is a village located on the slopes of Mount Pesawaran and directly adjacent to the protected forest areas. Statistical data in 2006 suggests that around 48.8 million people or 12% living in and around forest areas and of that number, 10.2 million people or 25% of them classified as poor (Ministry of Forestry, 2007). It is important to know the benefits of agroforestry both economically and ecologically in order to improve the welfare of the people and environment around the forest.

The purpose of this research is to encourage the development of agroforestry through a study of the benefits of agroforestry, both economically and ecologically for livelihood security.

2. METHODOLOGY

2.1 STUDY AREA

The study was conducted in Pesawaran Indah Village, District of Pesawaran in Lampung Province, Indonesia in March—April 2012.

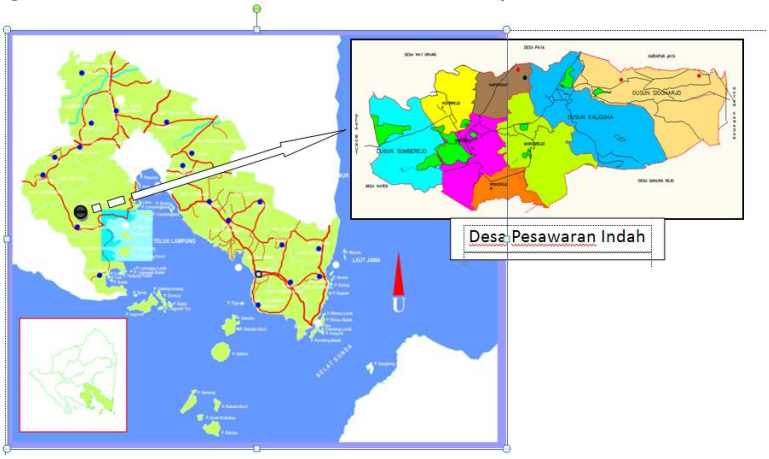

Figure 1. Map of Pesawaran Indah Village.

2.2 DATA COLLECTION

2.2.1 Primary data

a. Primary data was collected by means of focus group discussion (FGD), direct interviews, observation, and survey methods.
   Primary data include:
   1) Income: the identity of respondents, agroforestry income, household economic potential data, the composition of agroforestry, and production expenses. Primary data was collected by means of observation, interviews, and survey methods.
   2) Financial Analysis: Data regarding soil conditions, cropping pattern adopted agroforestry, agro results, revenues and costs of production on the application of agroforestry cropping pattern.
   3) Potential carbon: biomass data, such as names of tree species, height, diameter, and weight of wet litter. Vegetation data, such as number of each type found in the sample plots, diameter saplings, poles, and trees.

2.2.2 Secondary Data

Includes data obtained from the existing conditions in the study site such as socio-economic conditions of the study site. Secondary data collection conducted in this study using a study library/literature.

2.2.3. Potential Carbon

Based on Hairiah and Rahayu research (2007), for forest with an area that is not determined, but the condition of homogeneous vegetation, making a plot size of 5 m x 40 m to represent the condition of the land, based on mixed farms it made 10 field plots with an area of each plots of 20 m x 20 m and if totaled an area of 4,000 m2 while the coverage provisions Hairiah and Rahayu (2007) states that for agroforestry plots of 20 m x 100 m = 2000 m2 to represent the condition of the land. Making plots in the village of Great Pesawaran divided into 3 parts, namely physiographic bottom, middle and top.

Plots measuring 20 m x 20 m for the observation phase of the tree, plot 10 x 10 m for observation pole phase, plots 5 x 5 m for sapling phase observations, field plots 0.5 x 0.5 m for observation understorey/litter.

2.3 METHOD

2.3.1 Income

Equations used in data processing revenues that have been obtained are as follows (Hernanto, 1988):

1. Total household income can be calculated with the formula:

   Prt = Paf + Pnaf

   Description: Prt = household income (Rs / ha / yr)
   Paf = income from agroforestry management
   Pnaf = Revenue from non agroforestry

2. Income of each composition agroforestry crop:

$$\textbf{Pkt} = \sum \boldsymbol{Pi} - \sum \boldsymbol{Ci}$$

   Description: Pkt = Revenue composition of each plant agroforestry (Rp/ha/yr)
   $\sum Pi$= number of cash receipts from crop composition of agroforestry to-i
   $\sum Ci$ = sum of cash from the operation of the plant composition of agroforestry to-i.

3. Revenue earned from pengelolaaan agroforestry systems can be calculated with the formula:

   Paf = (Pkta Pktb + + + Pkt Pktc ...) - the cost of production

   Description: Paf = income from agroforestry management (Rp/ha/yr)
   Pkta, .. = the income of each composition agroforestry plants (Rp/ha/yr)

As for the composition of the data processing contribution of agroforestry products can be used the equation:

1. Revenue contribution from each product composition agroforestry:

   %Pkt = (Pkt / Paf) x 100 %

   Description: % Pkt = Percent revenue from any product composition agroforesry
   Acc = income of any product composition agroforestry/th
   Paf = income from agroforestry land management/th

2. The revenue contribution of agroforestry land management:

   %Paf = (Paf / Prt) x 100%

Description: Paf% = percentage of income from agroforestry management
Paf = income from agroforestry management per year
Prt = Household income per year.

2.3.2 Financial Analysis

For criteria in financial analysis, using the Net Present Value (NPV), Benefit Cost Ratio (BCR), Internal Rate of Return (IRR).
The formula used (Suharjito, et al (2003):

1. Net Present Value (NPV)

Net Present Value of the difference between revenue and cost. Profitable venture if NPV > 0, otherwise if NPV < 0 means that the business is not profitable.

$$NPV = \text{PV revenue} - \text{PV cost}$$

$$= \sum_{t=1}^{t=n} \frac{Bt}{(1+i)^t} - \sum_{t=1}^{t=n} \frac{Ct}{(1+i)^t}$$

$$= \sum_{t=1}^{t=n} \frac{Bt-Ct}{(1+i)^t}$$

Description: NPV = net present value (Rp)
PV = present value (Rp)
Bt = benefits per year (Rp)
Ct = costs incurred each year (Rp)
i = interest rate (%)
t = time period (years)

2. Benefit Cost Ratio (BCR)

Management of agroforestry cropping pattern is said to be beneficial (profitable) if the value of Net B / C> 1 and vice versa if the B / C <1 means that the pattern is not profitable management.

$$\textbf{BCR} = \frac{\sum_{t=1}^{t=n} \frac{Bt-Ct}{(1+i)^t}}{\sum_{t=1}^{t=n} \frac{Bt-Ct}{(1+i)^t}}$$

$\longrightarrow$ Bt – Ct > 1

$\longrightarrow$ Bt – Ct < 1

Keterangan: BCR = perbandingan antara pendapatan dan pengeluaran
Bt = manfaat yang diperoleh setiap tahun (Rp)
Ct = biaya yang dikeluarkan setiap tahun (Rp)
i = suku bunga (%)
t = periode waktu (tahun).

3. ***Internal Rate of Return*** **(IRR)**

Criteria shows that agroforestry management would benefit if the value of said IRR greater than the rate current interest.

$$\textbf{IRR} = i_1 + \frac{NPV_1}{NPV_2 - NPV_1} \times i_2 - i_1$$

Description: IRR = maximum interest rate that can be paid by the project (%)
NPV = NPV is positive at a certain interest rate (Rp)
NPV2 = a negative NPV at a certain interest rate (Rp)

i1 = first interest rate where the NPV Positive (%)
i2 = second rate where NPV negative (%).

1.3.2 Potential Carbon Sequestration

a. Tree Biomass

The measurement results were analyzed by allometric equations.

Table 1. Allometric equation models were used.

No.	Tree Species	Allometric Equetions (Source)
1.	Mahogany *	$BK = 0{,}902(D^2H)^{0{,}08}$ (Purwanto, 2009)
2	Sonokeling*	$BK\ 0{,}745(D^2H)^{0{,}64}$ (Purwanto, 2009)
3.	Teak *	$BK = 0{,}015(D^2H)^{1{,}08}$ (Purwanto, 2009)
4.	Sengon*	$BK = 0{,}020(D^2H)^{0{,}93}$ (Purwanto, 2009)
5.	Acacia*	$BK = 0{,}077(D^2H)^{0{,}90}$ (Purwanto, 2009)
6.	Branched trees **	$BK = 0{,}11\rho(D)^{2{,}62}$ (Ketterings, 2001)
7.	Unbranched trees **	$BK = \pi\ \rho\ D^2\ H / 40$ (Hairiah, 2002)
8.	Coffee**	$BK = 0{,}281(D)^{2{,}0}$ (Arifin 2001)
9.	Banana**	$BK = 0{,}030(D)^{2{,}13}$ (Arifin 2001, Van Noordwijk, 2002)
10.	Bamboo**	$BK = 0{,}131(D)^{2{,}28}$ (Priyadarsini, 2000)

Sources: * = Hall Forest Area Consolidation XI, 2009
** = Hairiah and Rahayu, 2007

Description: BK = Dry Weight (kg / tree)
H = Total Plant Height (cm)
D = diameter (cm) at breast height (1.3 m)
BA = Basal Area (cm2)
ρ = Density Wood (0.7 g).

Total tree biomass (kg) = BK1 BK2 + + ... + RB
Biomass per unit area (tons / ha) = Total Biomass (Kg)
Wide area (m2)

b. Understorey Biomass

Wet and dry weight of plants under / litter used to estimate biomass with Biomass Expansion Factor formula (Brown, 1997):
Total BK (kg) = $\frac{\text{BK sub-sample (g)}}{\text{BB sub-sample (g)}}$ x Total weight (g)
Description: BK = Dry Weight (g) BB = Wet Weight (g)

c. Carbon sequestration potential

Carbon content estimated biomass values obtained from allometric equations or value of BEF (Biomass Expansion Factor) which is almost 50% (Brown, 1997) of biomass is carbon stored. Absorption of Carbon Stored = Biomass (LB) x50%.

3. RESULTS AND DISCUSSIONS

Pesawaran Indah Village is one of the villages adjacent to protected forest areas (Register 19). Unlike the general public residing in the forest, the people in this village do not do economic interaction of the protected forest. Forest benefits for society generally only for water conservation and the environment. Availability of abundant ground water used by the public as a primary source of water for domestic use, water rice paddies and fish ponds. Irrigating rice fields in several villages are close to the water source is not affected by the drought that occurred. Farmers still unable to cultivate their fields 2 times a year, although this condition has not been evenly distributed in all villages, especially some of the other villages that are relatively far from water sources.

High water discharge is continuously required as turbine propulsion on Micro Hydro Power (MHP). Rural electricity needs can be fulfilled if both Pesawaran Indah turbine can work well. To meet the water needs of the community, both for household, fields, ponds and turbines, required plant canopy height as timber plants and plant Multy Purpose Trees Species (MPTS), which has the function of water conservation, not only on land but also in the forest community land outside the forest area. Economic life of the village of Great Pesawaran supported by revenue from the garden that is in his land. Community gardens managed by agroforestry systems.

Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components (Lundgren and Raintree, 1982). This definition implies that:

- agroforestry normally involves two or more species of plants (or plants and animals), at least one of which is a woody perennial;
- an agroforestry system always has two or more outputs;
- the cycle of an agroforestry system is always more than one year; and
- even the simplest agroforestry system is more complex, ecologically (structurally and functionally) and economically, than a monocropping System (Nair, P.K.R., 1993).

Agroforestry systems implemented in Pesawaran Indah Village generally a simple agroforestry consisting of a combination of woody plants (trees) with non-timber plants (agricultural and forestry) and livestock or better known as Agrosilvopastoral. Sardjono, MA, et al (2003) defines Agrosilvopastura (Agrosilvopastural systems) by combining woody component (forestry) and agriculture (seasonal) and at the same farm/animals on the same land management unit.

As in the pattern of agroforestry in general, the pattern developed here does not produce basic foodstuffs. Basic foodstuffs such as rice is grown in monoculture in lowlands. Providing agroforestry land plants as a source of supplementary food, building materials and supplies spare cash income such as tree species with high economic value (coconut, rubber, cloves, coffee, cocoa, jackfruit, melinjo, banana, teak, mahogany) or value low economic (dadap, hibiscus, etc.), and grass or other

plant species. Overall managed agroforestry in Pesawaran Indah Village is community owned land.

Table 2. Agricultural crops and forestry in Pesawaran Indah Village.

NO	LOCAL NAMES	SCIENTIFIC NAME
I.	**AGRICULTURE**	
1	Kakao/Cocoa	*Theobroma cacao*
2	Kopi/ Coffee	Coffea robusta
3	Pala/ Nutmeg	*Myristica fragrans*
4	Kelapa/ Coconut	*Cocos nucifera*
5	Pisang/ Banana	*Musa paradisiaca*
6	Durian/ Durian	*Durio zibethinus*
7	Cengkeh/ Clove	*Syzygium aromaticum*
8	Nangka/ Jackfruit	*Artocarpus heterophylla*
9	Alpukat/ Avocados	*Persea americana*
10	Kedondong/ Kedondong	*Spondias dulcis*
11	Jolang Jaling/ Jolang Jaling	*Archidendron microcarpum*
12	Mangga/ Mango	*Mangifera Indica*
13	Jengkol/ Jengkol	*Pithecellobium lobatum*
14	Petai/ Petai	*Parkia speciosa*
15	Duku/ Duku	*Lansium domesticum*
16	Jeruk/ Oranges	*Citrus sinensis*
17	Manggis/ Mangosteen	*Gabcinia mangostana*
18	Rambutan/ Rambutan	*Niphelium lappaceum*
19	Sawo/ Sapodilla	*Manilkara zapota*
20	Salak/ Salak	*Salacca edulis*
II.	FOREST (WOOD)	
1	Bayur	*Pterospermum javanicum*
2	Medang	*Litsea Spp*
3	Mindi	*Melia azedarach*
4	Waru	*Hibiscus tiliaceus*
5	Jati/Teak	*Tectona grandis*
6	Cempaka	*Michelia champaca*
7	Medang	*Litsea Spp*
8	Mahoni/ Mahogany	*Swietenia mahagoni*
9	Sengon	*Paraseriantes falcataria*
10	Akasia/ Acacia	*Acacia auriculiformis*
11	Dadap	*Erythrina lithosperma*
12	Pulai	*Alstonia scholaris*
13	Karet/ Rubber	*Hevea brasiliensis*

Cocoa is the main crop in Pesawaran Indah Village. Completing cocoa, most households grow various crops such as bananas, coffee, coconut, nutmeg, cloves, durian, petai and wood. Cocoa and coffee as a cash crop grown by most households, but not a significant strategy for poor households, who do not have the land needed for the scale.

Total income of farmers is calculated within a period of one year cash money earned from all sources, both agroforestry and non agroforestry. Agroforestry income includes income from agriculture, forestry (timber), and livestock. Income from outside agroforestry includes proceeds from trade, labor, services, entrepreneurs, and others.

Table 3. Agroforestry Farmers Income in the Pesawaran Indah Village in 2012.

Revenue	Total Income (Rp/year)	Average Revenue/year (Rp/year)	(%)
Agroforestry			91.43
➢ Agriculture	652,204,118	15,528,670	74.98
➢ Wood	66,060,054	1,572,858	7.59
➢ Livestock	77,067,500	5,137,833	8.86
Non Agroforestry			8.57
➢ Trade	44,580,000	7,430,000	5.13
➢ Labor	21,400,000	3,057,143	2.46
➢ Service	8,520,000	4,260,000	0.98
Total	**869,831,672**	**32,701,140**	**100**

Based on Table 3, agroforestry provide a greater contribution (91.44%) of the total income of farmers per year. This contribution is obtained from agricultural crops, forestry (timber) and livestock. Agricultural crops such as cocoa, coffee, cloves, rice and fruits derive most of their income that is equal to 74.98% due to crop harvest to include plants that do not require a long time and has economic value so that farmers get a continuous income to meet daily needed.

Cocoa is the most widely grown crop. On the sidelines of cocoa, banana and coconut cultivation and other species as shade cocoa but it results can be sold for added income of farmers.

Timber species are widely grown in agroforestry is chrysolite, bayur, teak, sengon, medang and hibiscus. Timber grown mostly for long-term savings, if households need large amounts of cash then the wood is cut down. Timber prices vary widely depending on the type, age, size, and quality of the wood.

Commercialize livestock farmers as savings for the future. Many households keep cattle that are regularly sold or redeemed for cash and food as part of their normal activities yearly. Cows and goats are the animals that most commonly cultivated by farmers. In addition to the use of manure as a fertilizer for crops as well as the fuel of biogas.

Greatest revenue from non agroforestry obtained from a job as a trader is equal to 5.13%. Traders in Pesawaran Indah Village is small scale traders that sell daily needed and fruits traders who sell fruit from the garden such as cocoa and coconut. Income from labor only 2.46%. While waiting for the plants in his garden harvest, many farmers work as laborers on other people's gardens to increase revenue and to spend leisure time.

Cost of production in agroforestry management covers the cost of fertilizer, pesticide, labor, and seed. Land management is not carried out intensively. Maintenance is generally performed on the cocoa with branch cutting, land clearing, fertilizer and pesticide. Most farmers do not fertilizing and pesticide to minimize costs to be incurred farmers.

Employment is one of the costs to be incurred by the farmers. Labor is usually worn during the cocoa harvest and wetland loose. The cost of labor of men or women ranged from Rp 25,000-Rp 30.000/day. Female labor is usually used for jobs that require skill and precision such as cacao fruit pulp and separation of grains, while the labor of men used to work that requires considerable energy as cocoa and palm fruit harvesting.

Details of the sale price in the last 1 year farmers for cocoa and coffee is ranging from Rp 10,000 to Rp 15,000 per kg, the price of Rp 50.000/kg cloves, coconut price of Rp 1.000, nutmeg with prices ranging from Rp 40,000 to Rp 50,000 per kg, banana price Rp 500-Rp 1.000, for durian price range of Rp 1,000 to Rp 5,000, while for woody follow price of each type of wood.

Cultivation of agroforestry in the study assumed a 20-year economic life adapted to Cocoa (Theobroma cacao) as the main crop of the most dominant (Siregar et al, 2007). The main crop is the dominant plant in a pattern while the charger is not the dominant crop (fewer in number than the main crop). The main crop accounts for approximately 50% - 70% in the cropping pattern of farmers cultivated. The main crop is the main component of each pattern. Seen from the main plant species, there are nine (9) farmers' cropping patterns are applied as shown in Table 4. Financially, the project is feasible/profitable when NPV> 0, BCR> 1 and IRR> i. In accordance with these criteria then the agroforestry pattern is applied in Pesawaran Indah Village financially feasible at NPV of Rp 71,392,802.34, -, BCR value of 7.39 and an IRR of 96% by the age of feasibility are 20 years and interest rate of 12%.

Carbon uptake value indicates the amount of carbon/greenhouse gases in the air that can be absorbed by plants through photosynthesis vegetation (Rahayu et al 2004). Carbon uptake calculations performed with no harvest, meaning that the resulting value is alleged potential. According Intergovermental Panel on Climate Change (IPCC, 2007), the recommended number of carbon stocks on forest land categories of primary, secondary and agroforestry (forest land) is 138 Mg/ha quite good. Ability of carbon uptake in agroforestry systems in the beautiful village of Pesawaran 209.64 Mg/ha and quite good. Carbon uptake value in Pesawaran Indah Villages can be potential income in the future if the system of carbon trading, REDD and carbon trade policy in Indonesia has been executed.

Besides the economic benefits in the form of cash money, farmers have the potential revenue from biogas. At this time the Pesawaran Indah Village lot that raising cattle, by combining the location of residence of the cattle business with residence. The number of cattle which are maintained by the public will lead to the high amount of waste generated in the form of cow dung. The results in 8 households involved in the construction of biogas reactor showed that the adult cow capable of producing an average of 5 kg of dung per day. The average population of cows owned by a

breeder was 5 tails. Thus, each farmer producing 25 kg manure. When added up, the breeder of 8 people involved in development activities biogas reactor will produce as much as 200 kg of cow dung per day. This amount is more than enough raw material for biogas reactor unit 4 was built.

Income earned from each biogas reactor (when converted to LPG prices) amounted to Rp105,000 per month or Rp1,260,000 per year per household or Rp10,080,000 to 8 households involved or for 4 units biogas reactor is successfully built. This revenue does not include byproduct of biogas reactors in the form of organic fertilizer.

Each unit is capable of producing biogas reactor by 7 bags of organic fertilizer per month or 84 bags per year. If the price of organic fertilizer in Pesawaran Indah Village of Rp 10,000 per bag, then the construction of biogas reactor is able to increase the income of farming households is Rp 840,000 per unit per year or USD 3,360,000 for the four reactor units were successfully constructed biogas . Based on the existing cattle population, then in Pesawaran Indah Village approximately 50 units could be built biogas reactor. Of this amount, the construction of biogas reactor is expected to be able to increase the incomes of Rp 105,000,000 per year. This number comes from the biogas of Rp 63,000,000 per year and from the sale of organic fertilizer as a byproduct of the biogas reactor of Rp 42,000,000 per year.

4. CONCLUSION

The benefit obtained from agroforestry pattern is not only from crop and forestry plan but also from manure used as organic fertilizer and biogas reactor materials, also the use of discharge water as the driving force of Power micro Hydro (MHP). The average of total income of agroforestry farmers amounting to Rp 36,992,171/ha/year the contribution to total revenues of 91.44%. Nine composition of plants are developed with the highest dominance in the cocoa plant is financially viable with a value of NPV is Rp 71,392,802.34, BCR is 7.39, and IRR is 96% by the age of feasibility are 20 years and interest rate of 12%. Potential uptake of carbon in agroforestry 209.64 mg/ha.

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