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Economic Analysis of Agroforestry of Meranti (*Shorea leprosula* Miq) Planted Among Oil Palm Trees as a Model for Development of Environmentally Friendly Oil Palm Plantation in The Riau Province, Indonesia

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Abstract: ***The growth of oil palm plantations in Riau Province is a great opportunity to optimize the use of space and land by inserting meranti (S. leprosula) tree among the palm oil plants. The study was aimed to economic analyze the agroforestry of meranti planted among the oil palm trees as a model for development of oil palm plantations. This research was carried out in a mixed meranti-palm oil plantation privately owned by a farmer at the Village of Pasir Jaya, Sub-district of Rambah Hilir, Rokan Hulu Regency, Riau Province, Indonesia. The surveys and structured interviews were used to identify the management of oil palm plantations owned by the community. Economic valuation approach was used to determine the economic analysis of the management of oil palm plantations owned by the community. The results of study showed that agroforestry of meranti planted among the palm oil plants were able to provide additional benefits revealed from the economic value of meranti tree as Bank of Replanting of IDR. 56,017,737. The value of BCR of this agroforestry system was greater than the value of BCR on the monoculture system of about 3.1 compared to 2.7. The development model of this agroforestry system is economically feasible and beneficial and can also be implemented on a broader scale of oil palm plantations both in main estate and plasma estate.***

Keywords: Palm oil plantation, agroforestry, Shorea leprosula, environmentally friendly

1. Introduction

Riau Province currently has the largest oil palm plantations in the country. The area of oil palm plantation is approximately 2.4 million hectares with a yield or production of almost 40% of national scale. It is not surprising that oil palm plantation is the leading commodity in the economy of Riau Province as it provides a multiplier effects for the rural economy [16]. Of the 98 percent of forest loss in Indonesia, the deforestation mostly occurred in high density forest areas within Sumatra and Kalimantan Islands while Riau Province has the highest loss of forests [4]. The average conversion of forests In Riau Province happened between 2006 - 2010 reached of 40,857.75 ha yr^{-1} for four years [6].

Development of oil palm plantations in a monoculture system can lead to a habitat fragmentation, ecological and biodiversity degradation and further the decline of plant genetic resources conservation [10,14]. There are approximately 1,050,015 farmers from the total area of 2,405,245 ha of oil palm plantations all over the areas within Riau Province [13]. The growth rate of oil palm plantations tend to increase and this is a good opportunity to optimize the use of space by inserting and planting the species of Meranti among the oil palm trees stands.

According to the International Centre for Research and Agroforestry (ICRAF) agroforestry is a system of natural resource management which is ecologically dynamic by which planting trees in a farmland or grazing fields to obtain a wide range of sustainable products that increases social, economic and environment benefits [17]. In addition the integration patterns of some species within a piece of land in a agroforestry landscapes, in the long term, will have positive impacts in maintaining soil fertility from degradation, be an option for sustainable land use [1], as a carbon stock [9,15] and could play significant roles in reducing carbon dioxide in the air [3]. Insertion of Meranti tree species in the oil palm plantations is believed to be an alternative model for development of oil palm plantations that are environmentally friendly. Meranti trees will be ready to be harvested and cut down when it has reached a diameter of at least ± 30 cm. This kind of size of diameter could be further processed as sawnwood, wood panels, veneer and plywood [11]. The species of Meranti Tembaga can also be planted in an agroforestry system among oil palm trees in a plantation land as Meranti has rapid growth [11]. In addition, Meranti Tembaga is a tolerant tree species, which at the beginning of its growth requires the shade of other trees [5]. The difference of the cycle period is the reason to develop this model. The oil palm plantations will end its cycle at the age of about 25-30 years old. At the time, Meranti trees are predicted to be about 20 year old that it would be ready to be cut down. The study was aimed to analyze the financial impacts of agroforestry of meranti planted among the oil palm trees as a model for development of oil palm plantations.

2. Research Method

2.1. Research Site

The study was carried out at Pasir Jaya village, subdistrict of Rambah Hilir, Rokan Hulu Regency, Riau Province, Indonesia. The location was chosen because some of the farmers have planted this type of Meranti inserted among the oil palm trees within their own plantation lands.

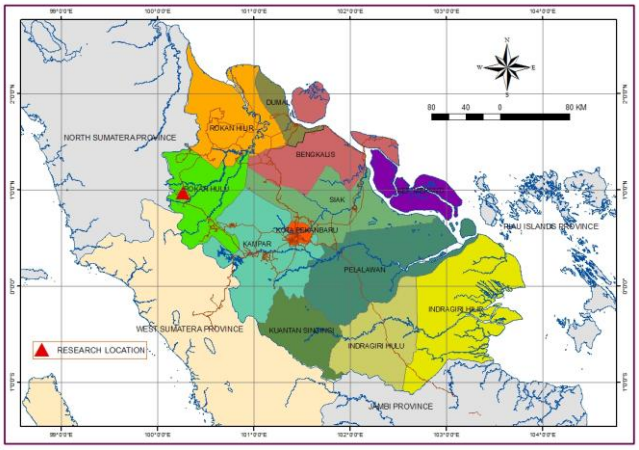

Figure 1: Map of Research Location

2.2. Collection Data

Collection of data and informations related to the monoculture management of oil palm plantations and agroforestry system of meranti planted among palm oil trees was conducted by surveys and structured interviews. The surveys and structured interviews were carried out to the farmers owning and managing the palm oil plantations that were mixed with meranti trees. The survey was undertaken using list of questions that had previously been prepared. The questions cover all the aspects related to the cost required to pay the palm oil plantations management as well as the revenue taken from the plantations. The economic analysis of the collected data is carried out using the economic valuation approach. The components that were analysed included age of recycling of Meranti and Palm oil trees (years), planting distance among Meranti and oil Palm trees as well as planting patterns (meter), the cost of production of fruit fresh bunches (FFB), the amount of FFB production (meter square), the amount of meranti wood production (meter square), the price of FFB at farmer level (IDR), the selling price of meranti (IDR) and the interest rate or discount rate assumed to be 10% year^{-1}.

2.3. Data Analysis

The valuation of economic analysis carried out through calculating all the components associated with the cost-benefit analysis. Based on the value of each of these components will be calculated:

1) CBR or *Net* B/C, using the formula:

$$Net \quad B/C \quad = \quad \frac{\sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+i)^t}}$$

Explanation :

B_t = Gross revenue at the year t;

C_t = Gross Cost at the year t;

n = Economic age of agroforestry model of Meranti-Palm Oil Plams; and

i = *discount rate*

Measurement criteria applied are if Net B/C > 1 then the development of agroforestry of Meranti mixed with oil palm plants considered as profitable. On the other hand if the Net B / C < 1, then the development of agroforestry of Meranti mixed with palm oil plants is considered as not profitable and suggested not to be continued.

2) *Net Present Value (NPV)* is calculated using this formula:

$$NPV \quad = \quad \sum \frac{(B_t - C_t)}{(1+i)^t}$$

Explanation:

B_t = Revenue of agroforestri meranti – oil palm plants at the time t;

C_t = Cost of management of agroforestri meranti- oil palm plants at time t

t = Economic age of Meranti inserted into palm oil plantation area, and

i = *Discount rate*

Measurement criteria applied are if value of NPV > 0 then the development of agroforestry of Meranti mixed with oil plam plants is considered as profitable. On the other hand if the value of NPV < 0, then the development of agroforestry of Meranti mixed with oil plam plants is considered as not profitable and suggested not be continued. While if the value of NPV = 0, it means that cost and revenue on developing the agroforestry of Meranti with the oil palm plants is just equal.

To calculate the value of the Meranti trees then tree volume calculation was carried out according to [8]. The formula used to calculate the volume of a tree is as follows:

$$V = ¼ \pi D^2 Hf$$

Explanation:

V = Volume of the log (m³)

D = Diameter at breast height (cm)

H = High of the trees (m)

f = Constanta (0,7)

The comparison method was used to estimate the number of production factors and the amount of production of FFB per year on monoculture pattern of oil palm plantations and agroforestry Meranti mixed with oil palm plantation in the last (early of planting) and in the future time (the end of the plantation cycle).

3. Result and Discussion

3.1. Economic Value of Meranti Tree

The economic value obtained from agroforestry of meranti planted among oil palm trees was not only from the value of oil production in the form of FFB but also derived from the economic value of meranti trees cut down when the oil palm plants to be replanted. The projections of diameter growth and height of the Meranti tree was predicted by using a non-linier regression equation. The projected growth both meranti tree diameter, height and volume of standing tree as well as the price is presented in Table 1.

Table 1: Projection of Diameter Growth, Height and Volume of Meranti (*S. leprosula*) and Price of Sawnwood of Meranti

Age of Meranti (year)	Projection of Growth			Volume of Standing Tree (m^3)[b]	Volume of Tree (m^3ha^{-1})[c]	Price per Log (IDR/m^3)[d]	Total Price ha^{-1} (IDR/ha)[e]
	Diameter (cm)	Height (m)	BTH (m)[a]				
10	19.62	13.58	7.06	0.15	13.44	882,000	11,857,858
15	26.00	17.82	9.27	0.34	30.98	1,125,680	34,872,495
20	27.92	19.45	10.11	0.43	38.99	1,436,685	56,017,737
25	28.58	20.01	10.41	0.47	42.03	1,833,615	77,071,384

Explanation:
a= Branchless Tree Height (0.52 of total height)
b= Volume of Standing Tree
c= 82 % of total tree volume in per hectar
d= Price of standing tree and it is assumed that the increase of price is 5 % a year.
e= Total price without counting the price of wood over the BTH

Table 1 shows that when Meranti reach the age of 20 year old, log diameter will be about 27.92 cm, while the total tree height is 19.45 m. If the branchless tree height (BTH) is assumed by a ratio of 0.52 of the total height then the branchless tree height average is 10.11 m, so that the average volume of a tree is 0.43 m^3. There were about 110 Meranti trees in every hectar area of palm oil plantation while there will be about 82% of them can be harvested in the age of 20 year old. Therefore there would be about 90 trees of Meranti to be harvested in a hectar of area so that would produce volume of processed wood about 38.99 m^3. This is out of the above part of the trees (above the branchless height tree) which can also still be used for other various purposes.

Assuming that the market price of meranti timber is IDR. 2,000,000/m^3 and price of standing timber is 40%, then the price of standing timber is IDR. 800,000/m^3. Assuming that the price is increasing of 5% per year, then in 2025 the price of standing meranti timber will be IDR. 1,436,685/m^3. This means that additional revenue from the sales of meranti timber at the end of the cycle of oil palm plantations (25 year old) is IDR. 56,017,737 excluding in the above part of the branchless height tree that could also be sold. Agroforestry of Meranti planted into the oil palm plantations will be so beneficial for the community. This is because the growth of *S. leprosula* is relatively faster than other species of meranti trees [12,11,7]. Therefore this could be a significant consideration for the farmer to choose *S. leprosula* as a Bank of Replanting (BoR) at the end of cycle of their oil palm plantations. The BoR could be economically beneficial in supporting the replanting activities for their plantations.

3.2. Economic Value of Oil Palm Plantation

To calculate the production of oil palm plantation harvested, the comparative data taken from the Indonesian Oil Palm Research Institute (IOPRI) are needed. Furthermore, the data will be compared with data of FFB oil palm plantation of the study location. The expected result is to obtain ratio between the two kinds of data that will be required when determining the projection of production in the future. The FFB production data taken from IOPRI for land suitability S-3 and the oil palm plantation owned by the communities in research location and the ratio are presented in Table 2.

Table 2: Production Ratio of IOPRI compared with Production of Monoculture Oil Palm Plantations at the age of 9 to 13 year old.

Age of Palm Oil Tree (year)	Production of FFB (Kg ha^{-1} $year^{-1}$)				
	IOPRI*	Monoculture System**		Agroforestry System**	
		Average	Ratio	Average	Ratio
9	25,938	17,250	0.66	16,950	0.65
10	27,593	18,600	0.67	18,300	0.66
11	27,600	20,250	0.73	19,800	0.72
12	27,614	20,260	0.73	19,660	0.71
13	27,572	20,230	0.73	19,480	0.71
Average	27,264	19,318	0.71	18,838	0.69

Explanation:
*Source: IOPRI
**The data taken from research location

At the age of 25 year old, production of FFB of monoculture system of oil palm plantations is 11,287 kg, while production of FFB taken from agroforestry system is 10,233 kg. In total FFB production of monoculture oil palm plantations was 336,356 kg and the production of research site (agroforestry of oil palm plantation mixed with meranti)

is 329,978 kg. The production of both systems is still below the production IOPRI that is reaching 475,229 kg. After the estimation of price and projections of production of FFB obtained, the revenue from oil palm plantations that are managed either in monoculture or in agroforestry patterns mixed with meranti among the oil palm plantations can be known. Net revenue from the monoculture system of oil palm plantation in one cycle (25 years) were IDR. 367,826,527 whereas the net income gained from the agroforestry system of meranti planted among the oil palm plantations were IDR. 357,138,999 (the difference were of IDR. 10,687,528). If the selling price of meranti timber at the end of cycle is taken into account, the net income of meranti agroforestry patterns among oil palm plants amounted to IDR. 413,156,736 as shown in Figure 2.

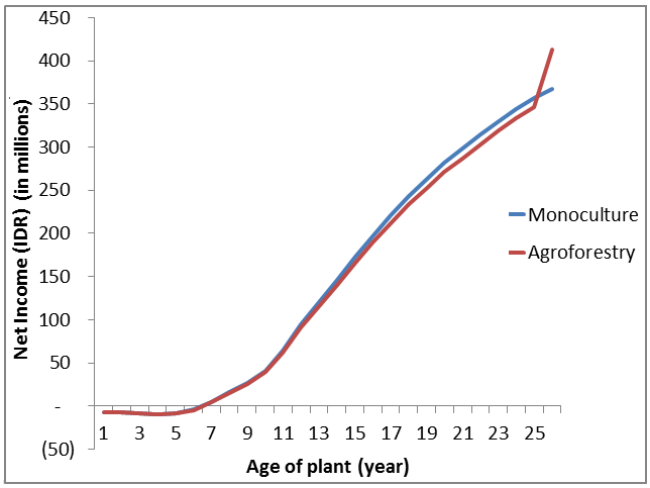

Figure 2: Projection of Net Total Income of Monoculture oil palm plantations and the Agroforestry of Meranti mixed with oil Palm Plants in one cycle (25 year).

Figure 2 shows that the management of oil palm plantations will be able to provide net income after the plant is 5 year old. Net revenue of monoculture oil palm plantations and agroforestry of meranti planted among oil palm plants is directly proportional to the amount of production, the higher the number of production the higher the net income earned by the farmers. The significant difference between the net revenue of the two patterns of oil palm planting is due to the existence of meranti planted among palm oil plants that in which its timber could be sold at the end cycle to get extra income. The additional income of IDR. 200,690,528 gained by the farmers from Meranti as a product of high economic value planted among the main crop (oil palm plants). This additional revenue would be able to be utilised by the farmers as a Bank of Replanting (BoR) to rebuild and manage their oil palm plantations.

3.3. Cost Analysis

The cost component that has been taken into account in this study is cost of investment and working capital. The working capital is devided into two namely fixed costs and variable costs. Total costs required to manage the two models of oil palm plantations is presented in Figure 3.

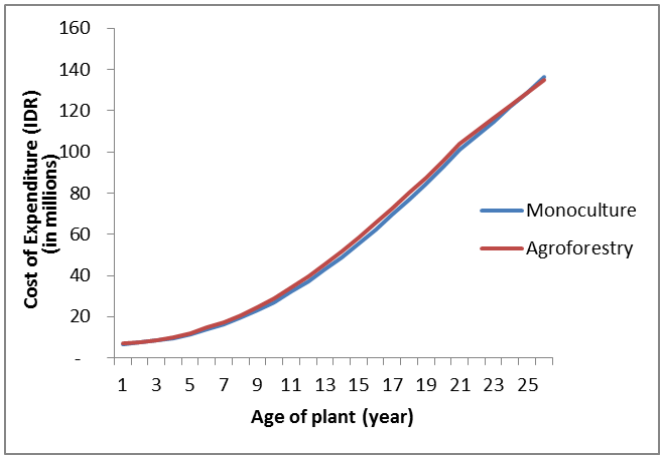

Figure 3: Projection of working cost of Monoculture dan Agroforestry Patterns for a cycle (25 year)

Figure 3 shows that the total cost of production between monoculture oil palm plantations and agroforestry mixed with meranti showed the same pattern. The total cost required to manage the monoculture oil palm plantation were IDR. 135,889,221 whereas for the cost required for agroforestry mixed with meranti planted among the palm oil plants were about IDR. 134,717,802.

3.4. Cost-Benefit Analysis

The benefit cost ratio as well as the net present value between the monoculture and agroforestry system is shown in Table 3.

Table 3: Calculation of total cost and revenue, benefit cost ratio as well as net present value in both monoculture and agroforestry system of oil palm plantations

Silviculture models	Result of Calculation			
	Total Cost (IDR)	Total Net Revenue (IDR)	BCR	NPV
Monoculture System	135,889,221	367,826,527	2.7	91,056,318
Agroforestry System	134,717,802	413,156,736	3.1	92,771,093

Results of the cost-benefits analysis of monoculture oil palm plantations and agroforestry mixed with meranti planted among the oil palm trees show that the value of BCR of both system were 2.7 and 3.1 respectively. Both of these BCR values were greater than 1.0. This indicates that revenue earned is greater than cost to be paid. It also indicates that both of management system are highly beneficial. However based on the BCR analysis, agroforestry system is much more beneficial compared to the monoculture one. The value of NPV of monoculture oil palm plantations for the discount factor of 10% is IDR. 91,056,318. This figure represents sum of all the present value of net income in each year over the analysis period. A positive value of NPV indicates that oil palm plantations managed by the community financially feasible to develop. Similarly, The NPV value of agroforestry meranti among oil palm found were IDR. 92,771,093. These facts support the conclusion that the model of agroforestry mixed with meranti among the oil palm trees is feasible to develop. Development model of oil palm plantations through agroforestry mixed with meranti

among oil palm plants is not merely financially profitable, but also ecologically very positive impacts in terms of carbon sequestration and reducing carbon emissions in the air.

4. Conclusion

Agroforestry system mixed with meranti planted among oil palm trees as a model for the development of oil palm plantations in Riau Province, Indonesia is environmentally feasible to develop. It is also able to provide additional benefits in terms of economic value gained from meranti tree as a BoR of IDR. 56,017,737. The value of BCR of agroforestry system is greater than the value of BCR of monoculture oil palm plantations in the amount of 3.1 versus 2.7. Development model of agroforestry meranti among oil palm can be implemented on a large scale of oil palm plantation industry both in the main and the plasma estate as well as in the private oil palm plantations owned by the individual farmer.

References

[1] Alam M., Furukawa Y., Harada K., 2010, Agroforestri as Sustainable Landuse Option in Degraded Tropical Forest: A Study from Bangladesh, *Journal Environ. Dev. Sustain*. 12:147-158.
[2] Germer J., Sauerborn J., 2007, Estimation of the Impact of Oil Palm Plantation Establishment on Greenhouse Gas Balance, *Journal Environ. Dev. Sustain.,* 10:697-716.
[3] Hairiah K., Ekadinata A., Sari RR dan Rahayu S., 2011, The Measurement of Carbon Stocks: from field to landscape, practical guidance, 2-nd edition. Bogor, World Agroforestry Centre, ICRAF SEA Regional Offce, University of Brawijaya (UB), Malang.
[4] Hansen M., Potapov P., Margono B., Stehman S., Turubanova S., Tyukavina A., 2013, High-Resolution Global Maps of 21st-Century Forest Cover Change, *Science,* Vol. 342.
[5] Indriyanto., 2008, Introduction to Forest Silviculture. PT. Bumi Aksara. Jakarta.
[6] Indonesian Ministry of Forestry., 2011, Indonesian Forestry Statistics in 2010.
[7] Istomo, Wibowo C., dan Hidayati N., 1999, Evaluation of Growth Plant of Meranti (Shorea spp) at Haurbentes Research Forest Jasinga Bogor, Perum Perhutani Unit III West Java, Journal Manajemen Hutan Tropika, Vol. V (2).
[8] Jaya I.N.S., Samsuri, Lastini T., Purnama E.S., 2010. Guidance of Ramin Inventory in the Peat Swamp Forest, ITTO, Indonesian Ministry of Forestry, Bogor.
[9] Kongsager R., Napier J., Mertz O., 2012, The Carbon Sequestration Potential of Tree Crop Plantations. Journal Mitig. Adapt. Strateg. Glob. Change, DOI 10.1007/s11027-012-9417-z.
[10] Obidzinski K dan Dermawan A., 2013, Pulp Industry and Environment in Indonesia: is there Sustainable Future?, *Journal Reg. Environ. Change*, Vol. 12:961-966.
[11] Omon M., 2008. Criteria Techniques and Indicators of the Quality of Seed of Dipterocarpaceae, Puslitbang, Bogor.
[12] Pamoengkas P dan Prayogi J., 2011, The Growth of Red Meranti (*Shorea leprosula* Mig*)* with Selective Cutting and Line Planting of Silvicultural System at the Forest Concessionaire PT. Sari Bumi Kusuma Central Kalimantan, *Journal of Silvikultur Tropika,* Vol. 02 (01):9-13.
[13] Plantation Department of Riau Province, 2014. The Pocket Book of Plantation Department in Riau Province in 2013.
[14] Purnomo DW., 2012, Vegetation Corridor Design to Enhance Conservation Values at Oil Palm Plantation , *Journal of Bumi Lestari*, Vol. 12 (2):268-282.
[15] Roshetko JM., Lasco RD., Angeles MSD., 2007, Smallholder Agroforestry Systems for Carbon Storage, *Journal Mitigation and Adaptation Strategies for Global Change*, 12:219-242.
[16] Syahza A., 2011, Acceleration of the Rural Economy Through the Development of Oil Palm Plantation, *Journal of Ekonomi Pembangunan*, Vol. 12 (2):297-310.
[17] Widianto, Hairiah K., Suharjito D., Mustofa A.S., 2003, The Role and Function of Agroforestry, World Agroforestry Centre (ICRAF), Bogor.