Name	Counterpart	Title
Leti Sundawati, Fitta Setiajiati	B11	Comparison of Above-Ground Biomass and Economic Benefits of Oil Palm Plantation in Sumatra: Monoculture vs Agroforestry

Background and Methodology

The expansion of oil-palm cultivation is considered as one of the causes of decline in ecosystem function. As the highest producer of palm oil in the world, Indonesia needs to design a sustainable management system of oil palm cultivation, especially to overcome carbon emission issues without a significant reduction in cash income. Since oil-palm agroforestry is limitedly practiced and is still on trial in the field, research is needed to enrich data and show the characteristics of oil-palm plantation in both monoculture and agroforestry systems. The non-destructive method by allometric equation of Chave *et al.* (2014) and ICRAF (2009) was used to estimate the above-ground biomass (AGB), while financial analysis was determined based on the criteria of Net Present Value (NPV), Benefit-Cost Ratio (BCR), and Internal Rate of Return (IRR).

Objective

The objective of this study was to estimate and compare the AGB and economic benefits in monoculture and agroforestry structures of oil palm plantation, as a basis to find the best structure for oil palm cultivation.

Methodology

Data of each structure and species cultivation were collected by previous studies, field monitoring, in-depth interview, and literature review. The in-depth interview has been conducted on 11 farmers who live in the closest village to the plots (Bungku Village, Batanghari District) and extension staff. The method of Chave *et al.* (2014) was used for estimating AGB of trees, which is $AGB_{est} = 0.0673 \times (\rho D^2 H)^{0.976}$ where AGB is in kg, D is the diameter (cm), H is the height (m), and ρ is wood density (g/cm^{-3}). Meanwhile, estimation of oil palm biomass referred to ICRAF (2009) in Hairiah *et al.* (2011) with $AGB_{est} = 0.0976\ H + 0.0706$. In this research, the AGB did not consider necromass, understorey, litter, and invasive species, instead only focusing on oil palm stands and trees. The cultivation structure is feasible economically if the NPV is greater than zero and the BCR is greater than 1. The IRR is the discount rate in which the NPV of cost investment is equal to the NPV of benefits investment. The result of the comparison between AGB storage and economic benefits, as well as literature study and social acceptability was synthesized to find the best structure of oil-palm cultivation.

Results

AGB in agroforestry and monoculture plots were presented in Figure 1. In 2019, the age of the oil palms had reached 11–18 years, while the age of trees was 6 years. Because of the young age of trees, the high rate of trees mortality (49%), and slow-growing tree species (durian, julutung, meranti), the AGB of monoculture and agroforestry oil palm was not significantly different, but the graphic trend of agroforestry showed that the AGB would be higher compared to monoculture systems (see Figure 1).

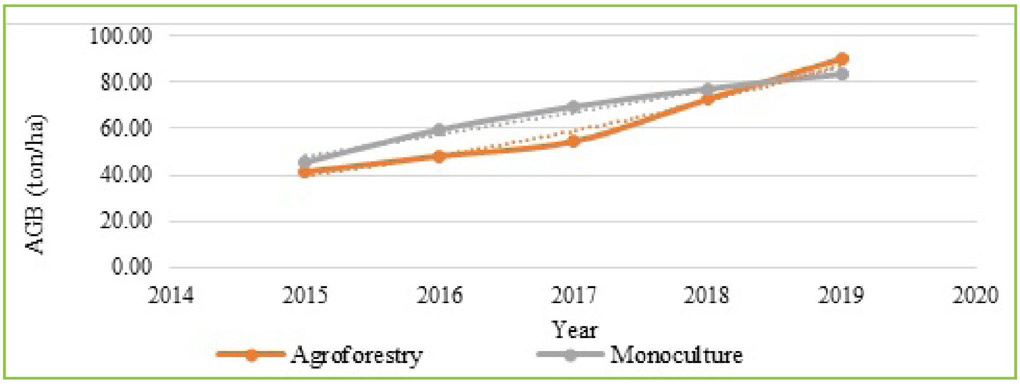

Figure 1. Dynamic of AGB in oil palm agroforestry vs monoculture

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Since jelutung, durian, and meranti species had a low percentage of survival (less than 50%), for the financial analysis, species with high percentages of survival rates (sungkai, jengkol, petai) were used. By a planting distance of about (2 x 2) m, there seemed to be a high competition rate for growing, thus the planting distance for the financial analysis was (6 x 6) m to reduce high competition, so the number of trees in 0.25 ha amount to 69. In the tree island plots, there were 2–3.25% of palm trees for each plot size.This means that in an area of 0.25 ha with a planting distance of (6 x 6) m, a maximum of two oil palm and 67 trees for the percentage of 3% are required. The financial analysis of each structure is presented in Table 1.

Table 1. Financial feasibility of each structure at discount factor 7%, period time 25 years, and 1 ha unit management

No	**Stand Structure and the number of plants**	Price of oil palm = IDR 1,000/kg			Price of oil palm = IDR 1,250/kg		
		NPV	BCR	IRR	NPV	BCR	IRR
1	Monoculture oil palm (143)	38,164,340	1,18	11.35	100,383,780	1.48	16.74
2	Oil palm (107) + oil palm in tree island (2) + sungkai (67)	25,874,084	1.14	9.51	73,656,003	1.41	13.52
3	Oil palm (107) + oil palm in tree island (2) + sungkai (33) + jengkol (34)	59,490,529	1.30	12.19	106,046,334	1.53	15.57
4	Oil palm (107) + oil palm in tree island (2) + sungkai + petai	117,011,585	1.55	14.11	163,567,390	1.76	16.72
5	Oil palm (107) + oil palm in tree island (2) + jengkol (67)	106,405,315	1.51	15.29	152,961,120	1.73	18.84
6	**Oil palm (107) + oil palm in tree island (2) + petai (67)**	**224,681,874**	**1.95**	**17.48**	**272,463,794**	**2.15**	**19.61**
7	**Oil palm (107) + oil palm in tree island (2) + petai (34) + jengkol (33)**	**193,117,551**	**1.97**	**18.58**	**240,899,471**	**2.21**	**21.08**

*Note: NPV: Net Present Value; BCR: Benefit-Cost Ratio; IRR: Internal Rate of Return

Based on AGB stocks and economic benefits, the agroforestry system appeared more profitable than the monoculture system. The agroforestry system of oil palm and sungkai produced the highest biomass, but the economic benefit was lowest due to uncertain price, long period of harvest time, and lack of social acceptability on sungkai. The agroforestry of oil palm and petai was the most favorable, followed by oil palm-petai-jengkol agroforestry (see Table 1). Therefore, the agroforestry of oil palm and fast-growing tree species for edible fruits is feasible to be practiced. Besides biomass stock and financial benefits, these systems were applicable in the village due to social acceptability and adoption ability.

References

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