Advances in Economics, Business and Management Research, volume 199
Proceedings of 1st International Conference on Sustainable Agricultural Socio-economics, Agribusiness, and Rural Development (ICSASARD 2021)

Assessing the Appropriate Technology Options on Utilizing Oil Palm Biomass for Rural Development in Riau Province

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ABSTRACT
Oil palm cultivation by smallholders is an agriculture sub-sector that urgently requires transformative changes to support rural development in Indonesia. A transformation of this sub-sector requires the adoption of new and innovative approaches that support sustainable outcomes. This paper presents an analytic framework to assess appropriate technology options on utilizing oil palm biomass that are suitable for palm oil smallholders in rural areas. The technology options were empty fruit bunch charcoal briquettes, oil palm fronds pellet, oil palm leaf handicraft, empty fruit bunch mushroom, palm sugar, palm-based animal feed, oil palm board, and empty fruit bunch compost. The study was conducted in Siak District, Riau Province. BOCR - hierarchical analysis process (AHP) method was used to assess the most appropriate biomass utilization technology for smallholders according to the expert judgment through focus group discussions. The BOCR criteria used are benefits (B), opportunities (O), costs (C), and risks (R). The result showed that compared to the other technologies, empty fruit bunch charcoal briquettes were in the top list for the most appropriate technology for smallholders in Riau Province. This option was considered a potential alternative source of income for smallholders that will have a positive impact on rural development.

Keywords: *appropriate technology, smallholders, oil palm, income diversification*

1. INTRODUCTION

The palm oil industry is an important sector in supporting economic growth in Riau Province. Exports of palm oil and its derivatives are the largest contributor to the non-oil and gas sector in Riau Province. Throughout 2019, palm oil exports and its derivatives reached 829.593 tons or equivalent to Rp 5.5 trillion [1]. In addition, the oil palm sector in Riau has positive impacts, among others, it has opened up employment opportunities for rural communities, opened up remote areas due to plantation infrastructure development, development of transportation and transportation services and new economic growth centers in rural areas [2].

Riau Province is the largest oil palm plantation area in Indonesia with an area of 2.82 million hectares in 2019 or 19.34 percent of the total national oil palm plantation area. Riau Province also known as the largest smallholder oil palm plantation area in Indonesia, around 64.3 percent (1.8 million hectares) are smallholder plantations. Palm oil production in Riau in 2019 reached 9.86 million tons or 20.38 percent of the total national production [1]. Unfortunately, the rapid development of smallholder oil palm plantations in Riau has not been followed by strengthening the bargaining position of smallholders in the fresh fruit bunch (FFB) trade system because the smallholders' institutions are relatively weak. Dependence on income through the sale of FFB has a high risk of price fluctuations which will affect the level of welfare of oil palm smallholders.

Utilization of oil palm biomass can be an innovative approaches that support income opportunity for smallholders while supporting environmental sustainability and energy security for rural communities. Oil palm cultivation produce biomass during harvesting and replanting activities. During replanting activities in

Tabel 1. Oil palm biomass potential in plantation and mill

	Weight of the total source (%)	Quantity per hectare (ton/ha)
Plantation:		
Oil palm fronds (OPF)	20.50	16.00
Leaf	6.53	7.69
Oil palm trunk (OPT)	70.00	41.07
Mill:		
Empty fruit bunch (EFB)	22.00	4.42
Palm kernel shell (PKS)	5.50	1.10
Mesocarp fiber (MF)	13.50	2.71

Source: [4].

oil palm plantations, biomass is produced including oil palm fronds (OPF) and stems (OPT). During harvesting, fresh fruit bunches (FFB) and OPF are cut and returned to the field. In the mills, during the processing of fresh fruit bunches (FFB) into crude palm oil (CPO), several kinds of by-product including empty fruit bunch (EFB), mesocarp fiber (MF), palm kernel shell (PKS), palm kernel meal (PKM), and palm oil mills effluent (POME) are produced. The production of these by-product is abundant and can be found in 23 of provinces in Indonesia as oil palm plantation area [3]. The oil palm biomass potential in plantation and mill are listed in table 1 [4].

Nevertheless, the potential biomass produced in oil palm cultivation activities has not been fully utilized due to various technical, cost and institutional constraints [5]. Based on the problems, it is necessary to adopt new and innovative approaches on utilization of oil palm biomass that can support rural development. This study aimed to assess appropriate technology options on utilizing oil palm biomass that are suitable for palm oil smallholders in rural areas. The results of this study are expected to be useful for oil palm smallholders who want to implement new business opportunities through the use of palm oil biomass which is abundantly available around them.

2. METHOD

The study was conducted during July-September 2019 in Siak District, Riau Province. The determination of this province is based on the consideration that the province is the centre of smallholder oil palm plantations in Indonesia. The scope of technology for oil palm biomass utilization includes empty fruit bunch charcoal briquettes, palm-frond pellets, oil palm leaf handicraft, palm boards, palm-based animal feed, palm sugar, empty fruit bunch mushroom and empty fruit bunch compost.

The type of data used in this study is primary data that was obtained through Focus Group Discussions (FGD) with experts related to the utilization of oil palm biomass. The analytic hierarchy process (AHP) was used to assess the most appropriate technology on utilizing oil palm biomass. AHP steps in this study adopted from several previous studies [6], [7], [8]. The first step is to determine the AHP model developed based on FGD (Figure 1). The second step is the establishment of technological alternatives for AHP modeling (Table 1). This table is summarized according to the results of the FGD based on the criteria and sub-criteria. Table 2 can give consideration to respondents' decisions in determining the preferences for the most appropriate biomass utilization technology for oil palm smallholders. The contents of the questionnaire were then quantified by adopting Saaty's 1-9 scale of pairwise comparison [9].

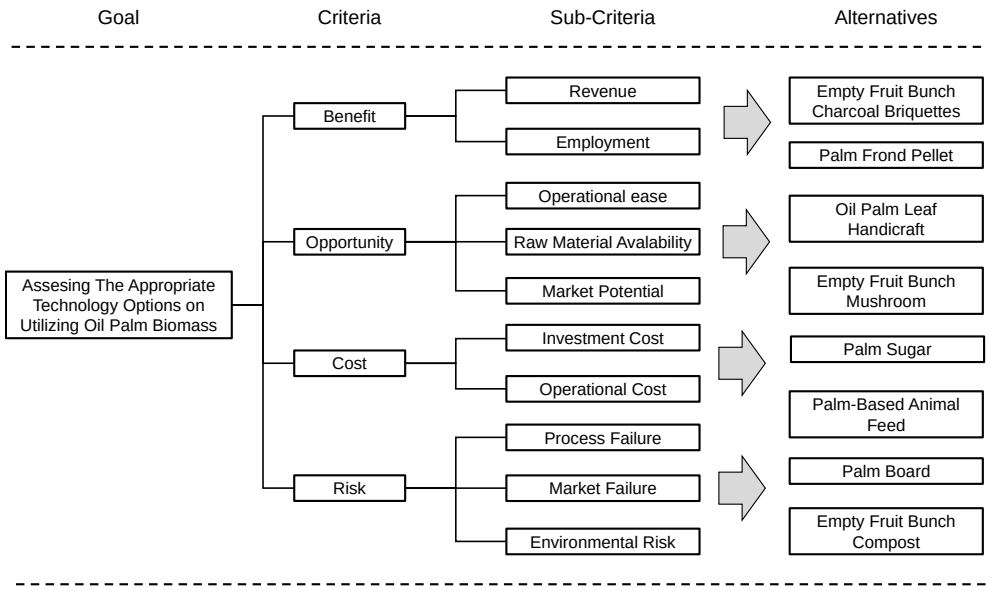

Figure 1. AHP model for assessing the appropriate technology on utilizing oil palm biomass

Table 1. Technology options on utilizing oil palm biomass on AHP modelling

Criteria	Sub-Criteria	Empty Fruit Bunch Charcoal Briquettes	Palm Frond Pellet	Oil Palm Leaf Handicraft	Empty Fruit Bunch Mushroom
Benefit	Revenue	Briquettes price IDR 6.000/kg; production capacity 1.5 ton/day, revenue IDR 18 million/month	Pellet price IDR 4.000/kg; production capacity 1 ton/day; revenue IDR 25 million/month	Handicraft price IDR 8.000/pcs; production capacity 50 pcs/day; revenue IDR 5 million/month	Mushroom price IDR 18.000/kg; production capacity Rp 50 kg/day; revenue Rp 9 million/month
	Employment	3 workers	3 workers	10 workers	2 workers
Opportunity	Operational ease	easy	easy	easy	easy
	Raw material availability	4.42 ton/ha/year	16 ton/ha/year	350 kg/ha/year	4.42 ton/ha/year
	Market potential	renewable alternative fuel for domestic and export	renewable alternative fuel for domestic and export	creative product	food
Cost	Investment cost	IDR 70 - 100 million	> IDR 250 million	IDR 5 million	IDR 30 million
	Operational cost	IDR 7-8 million/month	IDR 10 million/month	IDR 2 million/month	IDR 4,5 million/month
Risk	Process failure	low	low	low	low
	Market failure	high	high	low	low
	Environmental risk	low	low	low	low

Table 1. Technology options on utilizing oil palm biomass on AHP modelling (Continued)

Criteria	Sub-Criteria	Palm Sugar	Palm-Based Animal Feed	Palm Board	Empty Fruit Bunch Compost
Benefit	Revenue	Palm sugar price IDR 13.000/kg; production capacity 4 ton/35 days; revenue IDR 23.5 million/35 days	Feed price IDR 6.500/kg; production capacity 500 kg/day; revenue IDR 30 million/month	Palm board price IDR 8 million/m^2; production capacity 220 m^2/batch; revenue IDR 850 million/month	Compost price IDR 4.000/kg; production capacity 10 ton/day; revenue Rp 800 million/month
	Employment	6 workers	4 workers	> 10 workers	> 10 workers
Opportunity	Operational ease	difficult	easy	difficult	easy
	Raw material availability	7-9 liters of sap per palm tree	16 ton/ha/year	220 m^2/ha	4.42 ton/ha/year
	Market potential	food	animal feed	laminated board for domestic and export	compost
Cost	Investment cost	IDR 7.5 million	IDR 10 - 20 million	> IDR 10 billion	IDR 10 billion
	Operational cost	IDR 4,5 million/35 days	IDR 10 million/month	IDR 100 million/month	IDR 80 million/month
Risk	Process failure	low	low	high	middle
	Market failure	low	high	high	high
	Environmental risk	low	low	low	low

Table 2. Saaty's 1-9 scale of pairwise comparison [8]

Intensity of importance	Definition	Explanation
1	Equal importance	Two criteria contribute equally to the objective
3	Moderate importance	Experience and judgement slightly favour one activity over another
5	Strong importance	Experience and judgement strongly favour one activity over another
7	Very strong importance	A criteria is favoured very strongly over another; its dominance demonstrated in practice
9	Absolute importance	The importance of one over another is recognized as unassailable
2,4,6,8	Intermediate values	Used to represent a compromise between priorities listed above

3. RESULT

3.1. Focus Group Discussion

The FGD in Riau was conducted on November 11, 2019 and was attended by 21 expert respondents with backgrounds as academics, researchers, private company staff and farmers who are members of oil palm associations (Figure 2). At the end of the FGD, the expert respondents then filled out research questionnaires to determine the appropriate technology for the use of biomass for rural development.

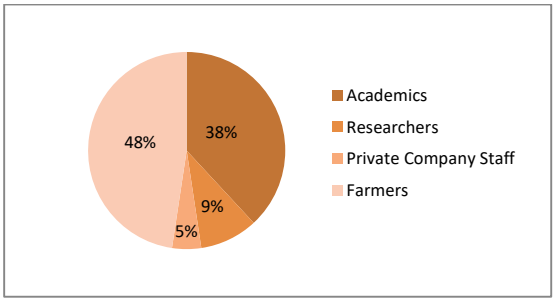

Figure 2. Proportion of expert respondents

3.2. Assessing The Appropriate Technology Options on Utilizing Oil Palm Biomass

The weights that measure the relative importance of each criterion (as calculated using Expert Choice for all pairwise comparisons) are shown in Table 3. This table shows the weights of the criteria for each level and the overall weight of the AHP modeling. The results of the AHP analysis showed that in Riau, the most important criteria according to experts opinion are: opportunity (0.362), followed by benefits (0.336), then costs (0.155) and lastly risk (0.146). For the sub-criteria, the highest influence related to determining the most appropriate biomass utilization technology for oil palm smallholders in Riau Province is revenue (0.191), followed by raw material availability (0.152) and employment (0.145).

Table 3. Weighting criteria and sub-criteria

Criteria	Weight[1]	Sub-Criteria	Weight[2]	Total Weight[1x2]
Benefit	0.336	Revenue	0.567	**0.191**
		Employment	0.433	**0.145**
Opportunity	0.362	Operational ease	0.298	0.108
		Raw material availability	0.421	**0.152**
		Market potential	0.281	0.102
Cost	0.155	Investment cost	0.539	0.084
		Operational cost	0.461	0.071
Risk	0.146	Operation failure	0.320	0.047
		Market failure	0.412	0.060
		Environmental	0.269	0.039

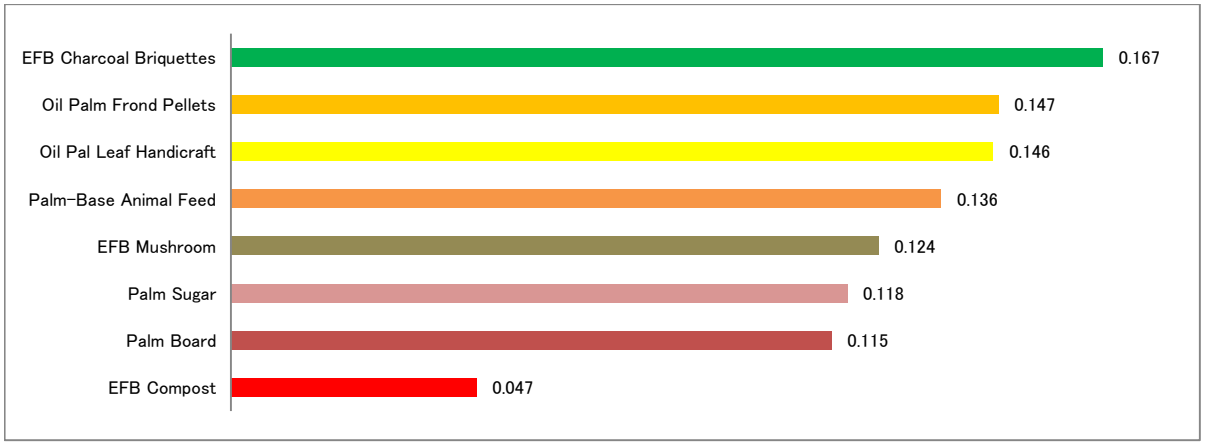

Figure 3. Weighting the oil palm biomass utilization technology alternatives

Based on the priority scale, the experts opinion are the utilization of oil palm biomass in Riau has high opportunities and potential for income, although the risks and benefits are no less large. Therefore, the development of oil palm biomass needs to properly consider all aspects so that can grow and develop optimally and sustainably. The results of the weighting according to expert judgment in assessing the most appropriate technology for using oil palm biomass in Riau indicate that empty bunch charcoal briquettes are the main priority with the largest weight (0.167) compared to other technologies. Charcoal briquettes are preferred because it can replace the need for LPG for cooking which is increasingly expensive in rural areas. Meanwhile, palm oil boards (0.115) and empty fruit bunch compost (0.047) are the last priority (Figure 3). Palm oil board is less preferred because the investment cost is higher. Moreover, empty fruit bunch compost is deemed not that important since usually the farmers applied it directly to the individual palm's circle path than the processed one.

Empty fruit bunch charcoal briquettes is the most appropriate technology for using oil palm biomass in Riau with the largest weight (0.167). Experts argue that the development of the empty bunches charcoal briquette business has a high opportunity in Riau considering the large potential availability of raw materials and operational ease as well as environmentally friendly alternative fuel briquettes. This is in line with [10] stating that biomass supplies a clean and renewable energy source that can greatly improve our environment, economy and energy security by reducing fossil fuel

combustion, greenhouse gas (GHG) emissions and environmental pollution. So far, the charcoal briquette business in Indonesia is still limited to the use of wood and coconut shells. This explains that business opportunities by utilizing empty bunches are still very wide open in Indonesia.

4. CONCLUSION

Considering the benefits, opportunities, costs and risks, the result explained that oil palm empty bunches charcoal briquettes were the most appropriate technology to be developed by oil palm smallholders in Riau province. The development of this business can be an alternative source of income for oil palm smallholders in rural areas in addition to selling FFB.

ACKNOWLEDGMENTS

The author would like to thank The Ministry of Research and Technology for facilitating this research through funding for the National Research Incentive Program (INSINAS) 2019.

REFERENCES

[1] BPS-Statistic Indonesia, Indonesian Oil Palm Statistic 2019. Jakarta, 2019.

[2] Syahza, Almasdi. Percepatan Ekonomi Pedesaan Melalui Pembangunan Perkebunan Kelapa Sawit. Jurnal Ekonomi Pembangunan Universitas Muhammadiyah Surakarta, 2011, Volume 12 no. 2: 297-310.

[3] Hambali, E., and M. Rivai. The potential of palm oil waste biomass in Indonesia in 2020 and 2030. In IOP Conference Series: Earth and Environmental Science, vol. 65, no. 1, p. 012050. IOP Publishing, 2017. DOI:10.1088/1755-1315/65/1/012050.

[4] Abnisa, Faisal, Arash Arami-Niya, WMA Wan Daud, J. N. Sahu, and I. M. Noor. Utilization of oil palm tree residues to produce bio-oil and bio-char via pyrolysis. Energy conversion and management 76,2013. pp. 1073-1082. https://doi.org/10.1016/j.enconman.2013.08.038

[5] Oktarina, S.D., Nurkhoiry R., Amalia R., Nasution Z P. S. "Stakeholder Perception and Empirical Evidence: Oil Palm Biomass Utilization as Climate-Smart Smallholder Practice" In Interlocal Adaptations to Climate Change in East and Southeast Asia, SpringerBriefs in Climate Studies, edited by T. Ito et al. Springer, 2022. https://doi.org/10.1007/978-3-030-81207-2_16

[6] Khawkomol, Sasiwimol, Ryozo Noguchi, Tofael Ahamed, Takuma Genkawa, and Tomohiro Takigawa. ANP modeling to select biomass energy plant in rural areas of Thailand. Agricultural Information Research 22, no. 2,2013. pp. 117-131.

[7] Nasution, Muhammad Ansori, Dhani S. Wibawa, Tofael Ahamed, and Ryozo Noguchi. "Selection of palm oil mill effluent treatment for biogas generation or compost production using an analytic hierarchy process." Journal of Material Cycles and Waste Management 20, no. 2 (2018): 787-799.

[8] Nasution, Zulfi Prima Sani, R. Amalia, R. Nurkhory dan M.A. Nasution. Penentuan Teknologi Tepat Guna Pemanfaatan Biomassa Kelapa Sawit untuk Pekebun Rakyat Skala UMKM di Sumatera Utara Menggunakan Pendekatan BOCR-AHP. *Inovasi* 17, no. 1,2020. pp. 85-98.

[9] T.L. Saaty. The Analytic Hierarchy Process, New York:McGraw-Hill, 1980.

[10] Gaetano C, D'Amicoa M, Rizzo M, Pecorino B. Analysis of biomass availability for energy use in Sicily. Renewable and Sustainable Energy Reviews. 2015;52:1025-1030. DOI: 10.1016/j.rser.2015.07.174