Model of Mechanization Implementation on the Handling of Oil Palm Fronds (OPF) Waste into Compost and Mulch in Aceh Province, Indonesia

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Abstract. The application of mechanization for waste handling in oil palm plantations should be done due to abundant waste of oil palm fronds (OPF). This study aims to examine the feasibility of applying mechanization in the handling of oil palm fronds with a dynamic model approach in the province of Aceh, Indonesia. The mechanization implementation model is designed with the placement scenario of its centralized and decentralized processing equipment. The results show that the mechanization system approach can be implemented in handle oil palm fronds waste. The management of the equipment with the current centralization shows the best scenario model. The results are expected to be a reference for oil palm planters to be able to apply their waste treatment with a mechanized approach of centralization.

1. Introduction
Extensification of oil palm plantations aims to create employment opportunities, improving the welfare of Indonesian societies and can be a source of foreign exchange. Selection of palm oil commodity to become the mainstay of plantation commodities in Indonesia is due to consideration of the magnitude of benefits expected to be obtained from this commodity. On the other hand, extensification of oil palm plantations produces several environmental problems [1, 2]. One of them is waste in the area of oil palm plantations. This waste is in the form of oil palm fronds that is only stacked among the oil palm crops. This makes the stacking in a harvest lane of transportation [3-5].

This research on the utilization of oil palm fronds has been done by several researchers [6-8]. One result is oil palm fronds which is an organic material can be processed into compost [9, 10]. The management of oil palm fronds waste into compost requires the application of mechanization technology. Therefore, the purpose of this study is to assess the feasibility of waste management of oil palm fronds waste through agriculture mechanization approach system. This study will focus on assessing the viability of the palm oil waste management system, which implements a centralized and decentralized system in placing its waste treatment equipment.
2. Materials and Methods
The research was conducted at PT Agro Sinergi Nusantara plantation in West Aceh district of Aceh Province, Indonesia. The area of land used as the object of study is an area of 576 ha. The study was conducted in 2015 with the rupiah exchange rate against the dollar is 13,000 IDR/USD. The application used to analyze is Powersim constructor 2.5d.

Stages of model-making analysis are presented as shown in Figure 1. The component formulations affecting the management of oil palm rest continue to be identified and poured into the cause-effect model diagram (Figure 2). The causal-loop diagram is then entered in the Powersim Constructor 2.5d application as shown in Figure 3. The cause-effect diagram model was simulated to see the feasibility of oil palm fronds waste management under 20 years according to the age of the oil palm crop.

![Figure 1. Procedure of research](image1)

![Figure 2. Cause-effect diagram of oil palm fronds processing model](image2)
3. Results and Discussion

3.1. Simulation of Oil Palm Fronds Production and Total Compost

The number of oil palm fronds generated annually from the plantation of PT Agro Sinergi Nusantara of West Aceh Regency of Aceh Province is shown in Fig. 4. The amount of oil palm fronds increased with the age of the plant [11-13]. The maximum of oil palm fronds was obtained when the plants are aged 10th year to 17th year. After that, the amount of oil palm fronds decreased as the production of fresh fruit bunches decreases. The amount of compost to be produced also increased in the year 10th to the 17th. The amount of compost produced was the multiplication between the number of oil palm fronds and the weight of the leaves in one oil palm fronds. The results used to determine the amount of livestock manure that was required i.e. 25% of the total weight of the leaf to be composted. During the composting fermentation occurred shrinkage of weight of 34.07%.

![Figure 4. The number of OPF and compost produced from PT Agro Sinergi Nusantara plantation](image.png)
3.2. First Scenario of the Dynamic Model  
The first dynamic scenario model assumes that the oil palm fronds processing site was at the center point of plantations. The potency of oil palm fronds from all blocks was brought to the center of processing palm fronds. The maximum oil palm fronds potential occurred on the first and second day of the week, which was 781 oil palm fronds. The income derived from the processing of palm oil in the first scenario was to assume the selling price of compost of 1,000 IDR/kg. Revenue and expenditure using the first dynamic scenario model can be seen in Figure 5.

The simulation results showed that from year 0 to year 5, the management of oil palm fronds into compost and mulch still not profitable. The management of processing would benefit from the 6th year to the end of the oil palm fronds management. Revenue from palm fronds management continued to increase from year 6 to 17. In the 18th year to the end of management, revenue from oil palm fronds management continued to decline. This revenue decline continued until the end of the 20th year. At the end of the 20th year, the management unit should be dismissed as the plantation also begin to enter the replanting phase. Fluctuations in the simulation results were also caused by the productivity of the types of varieties used in the plantation of PT Agro Sinergi Nusantara of West Aceh Regency of Aceh Province. The decrease in the number of fresh fruit bunches production caused a decrease in the number of palm fronds that can be managed by palm stem-managing units. This first scenario was feasible to apply based on a dynamic model analysis.

![Figure 5. Simulation of income and spending on the first scenario](image)

3.3. The Second Scenario of the Dynamic Model  
The second dynamic model concept was to build two oil palm fronds processing units in one plantation. The potential of oil palm fronds from all blocks was divided into plant "A" and plant "B". The amount of potency that was processed at plant "A" every week was 1,562 oil palm fronds. The amount of potency of palm fronds to be processed at plant "B" each week was 2,343 oil palm fronds. On the first and second day of each week, the plant "B" did not operate for chopping and forging the palm fronds as there was no palm fronds. Plant “B” operated on the third day until the sixth day where factory A did not operate. Revenues earned from palm fronds processing in the second scenario was to assume the composting price of 1,000 IDR/kg. Revenue and expenditure using the first dynamic scenario model can be seen in Figure 6.

Simulation results showed that from year 0 to year 9, processing of oil palm fronds into compost and mulch still not profitable. Processing of oil palm fronds would be profitable in the 10th to the 17th year. Income from oil palm fronds management continued to be the same from year 10 to 17, but in the 18th to 20th years income would continue to decline and was not profitable. The second scenario was not feasible to be applied to PT Agro Sinergi Nusantara plantation of West Aceh Regency of Aceh Province based on dynamic model analysis. This was caused by the production of oil palm fronds that had not reached the standard of tenera varieties. However, if PT Agro Sinergi Nusantara
plantation of West Aceh Regency of Aceh Province increased the production of oil palm fronds to reach the standard of tenera, then the second scenario was better applied to the plantation. It considered that the use of the second scenario was able to absorb more manpower than the first scenario.

![Figure 6. Simulation of income and spending on the second scenario](image)

4. Conclusions
The dynamic system approach to mechanical oil palm fronds (OPF) management has been successfully modeled and simulated. Scenarios applied to the designed model are able to simulate in accordance with data obtained from PT Agro Sinergi Nusantara plantation of Aceh Barat District, Aceh Province. The first scenario is feasible to be applied in PT Agro Sinergi Nusantara plantation of Aceh Barat district of Aceh Province because of the shorter payback period and lower total investment cost while the second scenario is not yet feasible because the production level of PT Agro Sinergi Nusantara plantation has not met the target production (tenera varieties) annually so as to affect the profits derived from the management of oil palm fronds into compost and mulch. This is not possible for PT Agro Sinergi Nusantara plantation to adopt the second scenario if the production level has started normally. The palm oil palm-based management model indicates that the management of oil palm fronds into compost and mulch can be prepared from the period of the plantation crop starting to produce fresh fruit bunches and will end five years before the replanting period.

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