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EVALUATING OIL PALM SUPPLY SYSTEM EFFICIENCY

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ABSTRACT

In this study, simulation as a tool for decision making was used to evaluate the supply system in oil palm plantations. The simulation was done to determine the factors to be taken in the future to increase the efficiency of the oil palm plantation's supply system. The factors include the downtime due to the machines (mini tractors and trucks) breakdown or any mechanical problems were also evaluated. Models developed were found to adequately represent real system on every level, from individual work element, times through machine interaction dynamics to overall supply system operations. Results from the model experimentation showed the highest efficiency values of oil palm plantation's supply system came from scenario III, which is by using mini tractors. It was found that the used of the mini tractor will decrease the waiting time due to machine breakdown. As a result, it will increase the efficiency level of the supply system in the oil palm plantations operations.

Keywords: simulation, oil palm plantation, supply chain management, downtime

INTRODUCTION

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The Malaysian palm oil industry was at the forefront of technology and production in both plantations (upstream) and oleochemicals (downstream) products for the global markets. The main product from the plantation (upstream) is Fresh Fruit Bunches (FFB) which will be processed into palm oil derivatives products such as Crude Palm Oil (CPO), empty fruit bunch, kernel, fibre and shell (MPOB, 2012). Being one of the largest exporters, an efficient supply chain is needed in the plantations. According to Shamsudin (2008), the commercial value of the oil palm lies in the oil obtained from the mesocarp of the fruit and the kernel nut. Hence, a simulation model is used to evaluate the oil palm supply system to mills and the model addressed on the whole harvest operations such as cutting, gathering, the lead time taken for the fruits loading and unloading from the trucks to the mill.

There is a link between the lead time in the logistic system and the productivity. In order to improve the productivity, this study used to figure out how to improve the supply system. So, there is another better way to solve the problem through non-interruption of the real process flow of the logistic system which is using discrete event simulation modelling. With the use of discrete event simulation modelling, the modification process can be done without interrupting the real process flow for this study.

Problem Statement

With a planted area of 4.48 million hectares, it generated 17.73 million tons of palm oil annually through a combined processing capacity of 22.22 million tons by 438 mills and 69 refineries (MPOB 2009). Based on that, nowadays, Malaysia is currently the most highly organised sector of national agriculture in the world especially in the oil palm industry and has become the largest exporter of palm oil. In this context, the control of the time when the fruits are taken from the time of cutting to milling facilities in the mill is significant.

The time between the processes is known as a lead time which is referred to the period of waiting between the beginning and end of the operations of handling the raw materials (Cunha and Rangel, 2010). In this context, the lead time started from the moments of cutting the fruits-palm oil, to the process of gathering and loading into trucks, weighing, sampling and lastly the trucks going back to plant plots. The lead time is important because it has a direct relationship on the quality of the juice of sugarcane and based on this research, in turn, has an influence on the quality of oil produced by the mill (Cunha and Rangel, 2010). In this study, discrete event simulation can help in the theory-testing which is to simulate supply system operations in oil palm without disturbing the real system.

OBJECTIVE OF STUDY

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The purpose of this study is to evaluate the oil palm plantation supply system. The aim of the study is to develop the simulation model to represents supply system in oil palm plantations. The following objectives were identified and pursued in order to achieve the aim of this study:

1) To identify the process in palm oil plantation supply system.

2) To model the transportation process of fruits-palm oil to the mill.

3) To evaluate the performance in the transportation process.

4) To propose a better configuration of the process/system.

LITERATURE REVIEW

Supply Chain in Oil Palm Plantation

Malaysia is among the largest palm oil producers in the world thus making the palm oil production has a significant contribution to Malaysia's economy. But, to maintain the benefits yield from the palm oil industry, Malaysia faces challenges for years. As one of the challenges is low oil palm yield rate (MPOB, 2012). As analyzed by Yik (2011), low palm oil production rate and highland usage affects palm oil yield rate. Hence, low yield rate will decrease the average oil extraction rate (OER). Increasing land usage will increase the number of workers and raises production costs. As an alternative way to lower the production cost is by using mini tractor grabber (Yik, 2011).

How can oil palm yield be increased? Yik (2011) mentioned that Claire et al. (2007) did raise two concerns on palm oil harvesting process. First palm oil industry is still in a labor-intensive system. Second, it is practically difficult to mechanize. According to National Biomass Vision 2020 (2010), harvesting operation today for FFBs are harvested and collected in the plantations and subsequently transported to the mills for the production of crude palm oil. As a result, EFBs, palm kernel shells and mesocarp fibre already accumulate at the mills and are thus readily available to be transported to aggregation hubs or downstream processing facilities. On the other hand, a new harvesting and collection system is needed to be established. Different collection methods could be adopted to collect the fronds ranging from the simple manual collection with a wheelbarrow to the collection with a buffalo cart or motorised cart, and finally to advanced mechanisation.

The plantation where the supply chain actually takes place is divided into sections which are made up of land plots aligned by furrows sown at appropriate distances so as to leave the necessary space for plants to grow and to facilitate fruit harvest. According to Wahid et al.

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(2004), the harvest is organized in groups of workers who load the wheelbarrows; these are pulled by animals force through rough and difficult-to-transit paths. Based on the research done by Garcia (2007), he claimed that the various groups of workers are responsible for harvesting fruit in a pre-established number of land plots; they must leave their daily load at internal stockpiling centers (hereinafter referred to as CAIs) located on the access roads. Besides, the harvest zone allotted to each group of workers must be previously determined per each production cycle. On the other hand, the road network is divided into zones which are passed through by truck-type vehicles in which the fruit are taken from CAIs to larger external stockpiling centers (hereinafter referred to as CAEs), located at various road intersections.

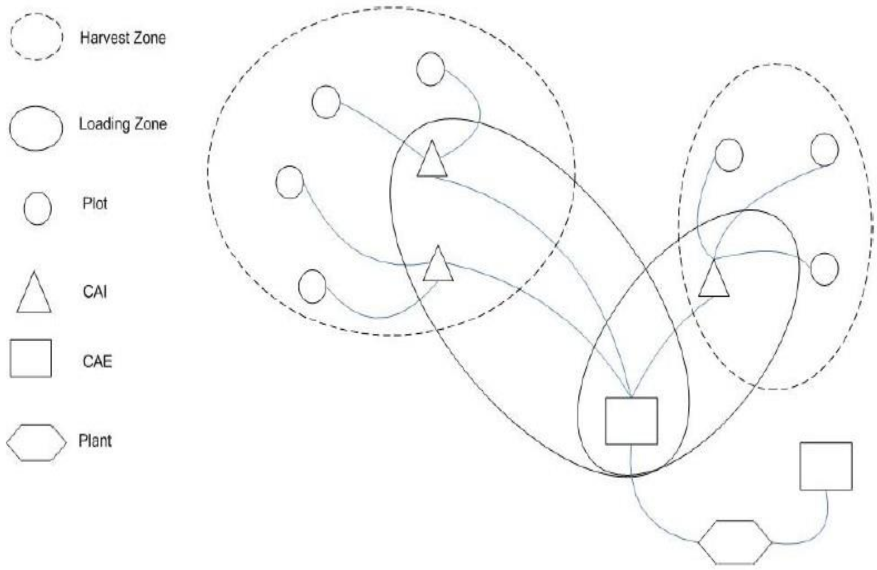

Figure 1: Supply Chain Scheme at Columbia Plantation
Source: (Garcia, 2007)

Besides, MPOC (2011) also explained that one important consideration for the vehicles used is that these guarantee the load security under difficult circumstances: road, weather, and geographical conditions. Further, plantations are connected to main roads for bulk transportation purposes from CAEs to processing plants, which represents a final transport echelon (Garcia, 2007). Vehicles running through this echelon must comply with certain technical requirements concerning capacity and speed. The whole process is supported by equipment used for lifting the fruit from the floor in stockpiling centers and loading it into vehicles; this task can be performed by attaching certain devices to the vehicles or independently by cranes or forklift trucks.

Garcia (2007) stated in his research that the reason for low efficiency is the almost total lack of sophisticated technology for decisions making techniques that would optimize raw material and product flow in the chain and minimize the costs involved in harvest, transport and production. In summary, the logistic and production operations in the palm oil industry are likely to be improved because of the system's complexity and the cost involved in making any improvements. Based on these events, a discrete-event simulation is an appropriate approach for the palm oil plantation industry to make an improvement in the palm oil plantation by developing a model that imitates the real process in the plantations and adjusts some problems related to those activities performed in the plantations.

METHODOLOGY

Case Study

This study focussed on oil palm plantations at a private company located in Pekan, Pahang. The name and profile of the company are confidential and only the data were provided for process analysis and evaluating their efficiency in supply system of oil palm plantations. The working hours of the plantations are 8 hours per day and 6 days per week. They are divided into their own lots. The data were collected from oil palm plantations as an input data. The daily records were calculated by dividing the difference of the current and actual data. Interview session with the expertise was also done to understand the process flow and operation in oil palm plantations.

System Description

Gathering fresh fruit bunches were the combining of harvesting and gathering system commodity entities used in the simulation model. In the model, the entity (fresh fruit bunches) that moves in the system has its arrival distribution, which is generated using the ARENA Create module.

In the process of developing the model, the most critical parts are at developing resources. Trucks and tractors were treated as resources in the model. The trucks section in the semi-mechanized system is strongly dependent on the mini tractors section, and vice versa in terms of variable assignments. In a semi-mechanized system's plantation, trucks entities were complete for the mini tractors at a higher priority than gathering fresh fruit bunches entities by using a wheelbarrow. If a mini tractor is not available, process gathering of FFB by harvester still occurred and if the mini tractor is present, the wheelbarrow will seize the FFB and delay it for the time period required to be loaded onto the mini tractor. The mini tractor moved around until the FFB is fully loaded in batches then transferred onto trucks. This process is similar to manual system plantation and the difference in the manual system is no mini tractors were used.

Trucks and mini tractors are recorded by RECORD module and then enter an ASSIGN module in which they influence variables such as the number of mini tractors and truck available and assigned such as their time of arrival. Following this assignment, it reaches DECIDE module, "which truck or mini tractors is available". If the value of this bunches does not reach the batch size, the mini tractors and trucks move to the PROCESS module, where it waits to be loaded either by mini tractor for the semi-mechanized system or wheelbarrow for a manual system. Once the number of fresh fruit bunches required for the mini tractors and trucks has been satisfied, they were released. The trucks and mini tractors will remain in the system until they reach the number size of their batch before being split and disposed.

The simulation model is used to represent an animated display of the supply chain system in plantations. This animation can be run concurrently during simulation. The modeler can also include animation in a real-time display of model statistic, such as dynamics plots, histograms, and time clock, during the simulation in order to illustrate or imagine system performance. Statistics such as cycle time, resource utilization, queue time, and throughput can also be computed from the simulation output.

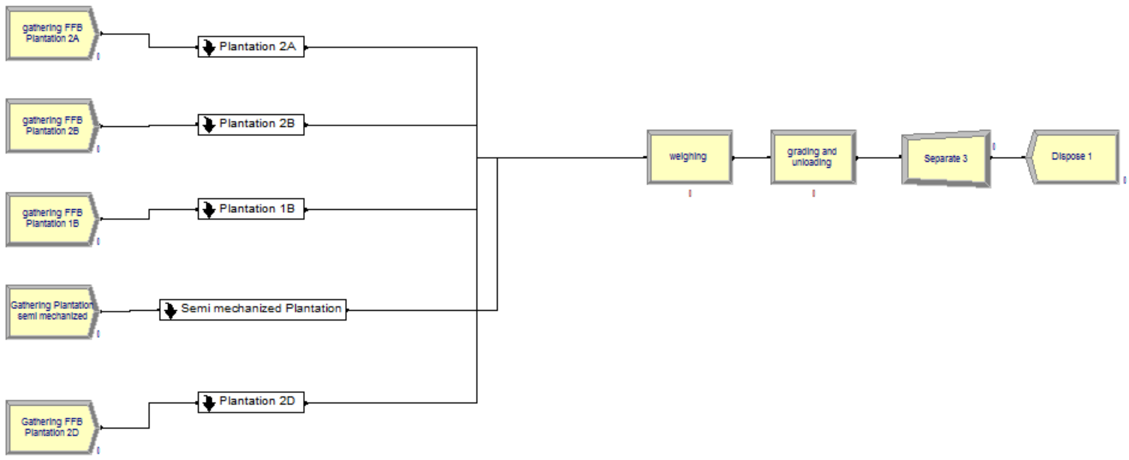

Figure 2: Constructed model simulation by Arena 9

RESULT AND DISCUSSION

Simulation allows managers of oil palm plantations to understand the real world structure. Unfortunately, the model built was as not complex as the real world. For experimentations, an average lead time is decreased by 16.67%. The lead time is the throughput or transferring time of entity to the station. Scenario I is tested by assuming that downtime occurs for every plantation while Scenario II is tested by adding a number of workers at each manually and semi-mechanized plantations and Scenario III is tested by adding mini tractors for each

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manual system of plantations. All results are shown in Table 1. The scenario was chosen based on management considering the higher number of waiting time and lead times when applying traditional technology in plantations. As a result, it also lengthens the number of downtime in operations. Similarly, for each of the scenarios, the model was run for 12 times number of replications.

For Scenario I, by assuming downtime occurs for every plantation was affecting the plantation throughput. It decreased from 69,440 bunches in the base case to 55,720 bunches of FFB and both resource utilization for truck and mini tractors also decreased to 97.95% for trucks and 98.95% mini tractors. Average lead time for FFB to be transferred to the mill is increased to 9.8 hours when the average of waiting time (the time where the harvesting, loading and unloading of FFB into trucks) is increased.

In Scenario II, when a number of workers were added at each manually and semi-mechanized plantations, the plantation throughput increased to 75,040 bunches as targeted by the company. The resource utilization raised for both trucks is about 98.35% and mini tractors are about 99.35%. However, average waiting time also increased for both plantations and affected the average lead time for transferring FFB to the mill.

For Scenario III, Table 1 clearly depicts that by adding mini tractors for both plantations, the plantation throughput is only about 56,240 bunches. The utilization for both trucks and mini tractors is about 97.95% and 98.95%. Yet, there is no waiting time in this process and the average of lead time is decreased. Therefore, it is vital for the management of plantations to find the most suitable current practices in their operations to make sure that their supply system is efficient. Hence, they also can meet the demands in future by considering the production costs.

Table 1: Simulation Results

	Base Case	**Scenario I**	**Scenario II**	**Scenario III**
Plantation throughput	69,440 bunches	55,720 bunches	75,040 bunches	56,240 bunches
Resource Utilization	Trucks (98%) Mini Tractors (99%)	Trucks (97.95%) Mini Tractors (98.95%)	Trucks (98.35%) Mini Tractors (99.35%)	Trucks (97.95%) Mini Tractors (98.95%)

Waiting Time (Average)	Trucks (6.4 hours) Mini tractors (5.2 and 5.4 minutes per bunch)	Trucks (6.54 hours) Mini tractors (5.3 and 5.5 minutes per bunch)	Trucks (7 hours) Mini tractors (6 and 6.3 minutes per bunch)	No waiting time
Lead Time (Average)	8.9 hours	9.8 hours	10 hours	5.9 hours

CONCLUSION

Recently, palm oil industry in Malaysia grows very rapidly compared to previous decades. This industry has become one of the contributors to the gross domestic product (GDP). Malaysia has also become one of the largest exporters of palm oil industry in the world. The palm oil plantations experienced few problems because of the few scenarios such as machines break down that create downtime, low cooperation from harvesters and manual system that takes a longer time to finish the process. This is due to several factors which include the machines (mini tractors and trucks) breakdown which led to downtime. As a result, the number of fresh fruit bunches (FFB) supplied to the mill were decreased.

In this study, the simulation model has been developed with the purpose of improving the efficiency of supply system in the plantation under study. The research and the simulation model developed have improved understanding of the inter-relationship of the several physical components of the plant. The process of constructing the simulation models and reviewing the connection of these components has given an insight into the different operational characteristic at the plant. The approach of the system analysis is not only beneficial to the modeler, but it is useful to the planner since it gives a thorough understanding of how the supply system in plantation occurs and not how one thinks it occurs. Simulation provides a mechanism for robust validation under realistic conditions and can substantially reduce the risk of deploying a new process.

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