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Modeling of the Fresh Fruit Bunches Collection and Transportation System with Agent-Based Simulation in Optimizing the Mode of Transportation on Oil Palm Industry

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ABSTRACT

Uncertainty number of harvests per day causes the allocation of transportation modes are less optimal in collecting fruit from plantations to palm oil mills causing a shortage of trucks in some afdeling and some are unemployed in some afdeling causing large transportation costs. The use of Agent-Based Simulations can help to identify the factors that cause the number of trucks that are not optimal by looking at the behavior and interaction between the agent actors involved in the tbs collection and transportation process. The results showed the utilization rate of transportation modes increased from 27% to 40% by reducing the number of truck units rented from 177 trucks to 118 trucks and reducing transportation collection costs by 0.225% of the total cost value. With the reduced journey time, the quality of the oil palm is better with the reduction of free fatty acids (FFA) and the average weight loss of fruit.

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1. INTRODUCTION

The raw material collection system is an important part of the agricultural industry supply chain where attention needs to be paid. When considering the raw material collection system in the agricultural industry, the collection process appears to be the main activity in the system. Logistics costs are a very large part of the overall operational costs. Most of the logistics costs, both fixed costs, such as fixed costs of collection stations, and variable costs, such as transportation costs, depend on the operating model of the raw material collection system. In addition, the agricultural industry has special characteristics such as perishable products. Collection time and incentive system that affect the quantity of product collected, also need to be considered when setting up a raw material collection system. According to Pujawan (2005), competency pressures and high customer needs require companies to make various improvements in collection and transportation activities.

PT. XYZ is one of the state-owned companies engaged in agrarian and plantation natural resource processing, especially oil palm plantations. PT. XYZ itself has a wide coverage area of 156,404.3 hectares which is divided into 34 plantations and has 12 palm oil mills.

The company's transportation management is already quite good, because the company already has transportation management such as scheduling and determining shipping routes. The company has determined when a truck must depart and which route it must take to meet the target amount of fruit that must be sent from the plantation to the mill each day. However, the company wants to find out more about whether the number and types of trucks are working optimally and efficiently. What if the number of trucks is reduced or increased, and if the truck capacity is replaced, can it increase the productivity of the company.

The number of trucks ordered is determined by the area of the plantation. For example, the Dusun Hulu Plantation has an area of 2489.66 Ha which is divided into 8 afdeling. One afdeling consists of 8 complexes. In 1 day, the amount of harvest is 1 complex from each afdelling with the estimated amount of fruit harvested is 1.5 tons/ha. Therefore the amount of harvest per day is 11670 kg. Estimated data on the number of harvests for each afdeling each day can be seen in Table 1 below.

Table 1. Data on Estimated Total Fruit Harvest in Afdeling

Supplied Plantation	Large	Number Afdeling	Harvest wide per day (ha)	Number Harvesting per day (kg)
Dusun Hulu	2489.66	8	7.780	11670
Bangun	3378.83	4	21.118	31677
Sei Dadap	4.694,6 1	6	19.561	29341
Gunung Pamela	5589,05	8	17.466	26199
Gunung Monaco	2322,77	4	14.517	21776
Silau Dunia	4967,32	7	17.741	26611
Gunung Para	4030	6	16.792	25188
Sungai Putih	3040,05	3	25.334	38001
Sarang Ginting	3051,72	5	15.259	22888
Tanah Raja	3350,07	5	16.750	25126
Rambutan	6837,67	8	21.368	32052
Pulo Mandi	3766,4	5	18.832	28248

According to sources from the company, every day there is still an average weight loss of 4-5% of the total harvest per day due to rest. This causes the amount of processed fruit supplied to the palm oil mills to not reach the targeted number set by the company. The uncertainty of the number of harvests each day causes the allocation of transportation modes to be less than optimal in collecting fruit from the plantation to the palm oil mill which causes a shortage of trucks in several afdelings and some are idle in some afdeling causing large transportation costs. In addition to being available for restants in TPH, another factor that affects the quality of palm oil is the level of free fatty acids found in palm fruit which increases every hour by 0.4%. The length of the journey from the fruit is harvested until the fruit is processed affects this. According to company sources, trucks have wasted a long time because the trucks are waiting to be weighed (waiting time). Comparative data on targetted fruit processed and its realization can be seen in Table 2 below.

Based on the above considerations, the company needs a simulation model to describe the transportation system from the plantation to a representative factory. Simulation is used when there is a problem that cannot be solved by simple mathematical calculations. Simulations are also used to solve or describe problems in real life which are full of uncertainty and fluctuate by not using or using certain models or methods and with more emphasis on using computers to find solutions. The company also hopes to find out the optimal number of trucks needed every day to transport fruit from the plantation to the factory according to the daily fluctuating number of harvests in order to determine the number of trucks that are rented to the transportation company every semester. It is hoped that in the future there will be no more average weight loss and increase in free fatty acid caused by too long restant fruit.

Table 2. Target and Realization in 2019

Month	Target (KG)	Realization (KG)	Percentage (%)
January	16,540,44	16,540,44	0.00
February	12,148,38	13,778,50	13.42
March	12,620,00	15,960,00	26.47
April	14,268,00	13,952,42	-2.21
May	16,112,00	18,805,58	16.72
June	14,384,00	14,702,68	2.22
July	18,138,600	17,652,17	-2.68
August	20,023,660	18,068,78	-9.76
September	19,322,692	19,715,76	2.03
October	18,861,034	19,641,54	4.14
November	18,283,722	18,856,24	3.13
December	18,193,176	19,254,38	5.83

Table 2. Target and Realization in 2019

Therefore, the researcher plans to focus on modeling the transportation system using a valid and representative agent-based predictive simulation. Agent-based simulation (C Troots, 2012) is a simulation model that describes individuals (agents) in a complex and dynamic system.

2. RESEARCH METHODS

2.1. Data Collection

The data used were obtained from several data collection techniques, namely initial data collection which was carried out through observation and field interviews starting from December 2019 in Serdang I and II region at PT. XYZ Districts with the status of land ownership being plantations belonging to PT. XYZ. The research was conducted at the Rambutan, Sei Mangke, and Hapesong Palm Oil Mill which received Fresh Fruit Bunches (FFB) from 12 plantation points. These data will be detailed on next subsections.

2.1.1. Behavior of Agents

Behavior of agents is data which is contained activities and characteristic of agents who are influencing the process of fresh fruit bunches collection and transportation. The agents are fleet company, plantation factory, and trucks. For example, behavior of fleet company agent can be seen in Table 3 below.

Tabel 3. Behavior of Fleet Company Agent

Karakteristik	Description
Activities	1. Receive information from the plantation regarding the number of fleets that must beoperated to each plantation unit, as well as their location every day. 2. Every day make notes on transportation problems, including the need and orders for spare parts, causes of delays, or deviations and so on. 3. Carry out maintenance scheduling for transportation equipment on a regular basis 4. Every morning, the transportation company checks transportation equipment such as fuel, radiator water, tires, etc
Position	Fleet Company
Decisions	1. Arrange and inspect all transportation equipment so that by 08.00 WIB the entire transport fleet is ready to operate.
Technical Spesification	1. Determine which trucks will operate to each of the agreed plantations. 2. Operates every day, 7 days a week.

Between the number and title of the table and figures should be given 1 space bar. If the title is too long, then the length should fit the table or figures. See Table 2.

2.1.2. Location of agents

Location of agents is coordinate point data obtained from *google maps*. For example, location of fleet company is in Perbaungan City, North Sumatera, Indonesia (3.5720973, 98.978557).

2.1.3. Distance, FFB Collection and Transportation Fees

The collection fee is the fee paid by the plantation company to the transport company when distributing FFB from the plantation to the mill. While the transportation costs are the driver's basic salary per month, which is Rp. 4,800,000 borne by the company.

2.1.4. FFB Yield Data

The data on the number of harvests used to design the optimization of transportation modes to collect FFB from the plantation and to the factory is predictive data on the average number of harvested FFB harvests in 2021 based on historical data in 2019 and 2020 by forecasting using the *smoothing method*. moving averages). The data on the average number of processed FFB yields can be seen in the Table 4 below.

Table 4. The Average Amount of Processed FFB Yields in 2021

No	Plantations	Average Amount of Processed FFB Harvested in 2021 (Kg)
1	Bangun	3,501,440
2	Gunung Pamela	2,923,546
3	Gunung Monaco	3,534,962
4	Silau Dunia	3,087,852
5	Gunung Para	1,235,650
6	Sei Putih	622,145
7	Sarang Ginting	957,061
8	Tanah Raja	1,469,431
9	Rambutan	5,229,328
10	Dusun Hulu	3,205,139
11	Pulau Mandi	2,987,997
12	Sei Dadap	4,645,623

2.1.5. Transportation Facilities

In the process of transporting FFB from the plantation to the factory in the Serdang Bedagai District area, land transportation is used in the form of trucks. Specifications of the mode of transportation used is Cold Diesel Truck with capacity 7000 kg.

2.1.6. Number of Modes of Transportation and Total Journey Time

Based on the collection time of the transportation mode capacity of the 6-wheel diesel colt truck used to provide services, the number of transportation modes used during the collection process according to the transportation mode collection schedule from the calculation results is described in Table 5 below

Table 5. Number of Modes of Transportation and Total Journey Time

No	Plantations	Number of Afdelling	Truck Number per afdeling (Unit)	*Journey Time* (Menit)
1	Bangun	4	3	795.83
2	Gunung Pamela	8	3	3162.77
3	Gunung Monaco	4	3	1677.72

Table 5. Number of Modes of Transportation and Total Journey Time

No	Plantations	Number of Afdelling	Truck Number per afdeling (Unit)	*Journey Time* (Menit)
4	Silau Dunia	6	3	1274.50
5	Gunung Para	1	3	197.52
6	Sei Putih	3	3	633.36
7	Sarang Ginting	5	3	1029.85
8	Tanah Raja	3	3	1340.80
9	Rambutan	6	3	1863.70
10	Dusun Hulu	8	3	1371.30
11	Pulau Mandi	5	3	1359.90
12	Sei Dadap	6	3	1542.60

2.1.7. Queue in Factory

The effectiveness of the oil palm FFB transportation system will not be separated from time. The time that needs to be taken into account is the queue time at the palm oil mill. This queuing time depends on the journey time cycle of collection and transportation from the plantation to the factory to the service system at the factory. The following will explain how queues can affect the effectiveness of FFB transportation which in the end is FFB quality. The type of queuing system that exists in Rambutan oil palm mill and Sei Mangke is Single Channel Single Phase, where this system only has a queue line that enters the service system (server).

The distribution of truck arrivals at PT. XYZ plantations is assumed to follow the Poisson distribution where in PT. XYZ plantations there are random arrivals of trucks. Meanwhile, for user service (server) in the weighing unit, it follows the exponential distribution, which is the distribution of units served by Poisson. So the notation of the queuing model is (M/M/1) or exponential service times, which means the queuing model states that the arrival of customers/trucks is Poisson distributed and the service time is exponentially distributed with the service being one person, the queue discipline used is First Come First Served (FCFS), the size of the system in the queue is infinite and the number of incoming customers is also infinite.

2.2. Research Methods

With the complete data available to build an agent-based model, the next step is data processing, which includes the development of the model design and implementation steps.

2.2.1. Model Algorithm

The model algorithm is a sequence of logical steps for solving problems that are arranged systematically. The algorithm becomes the basis for building the model in the simulation. The algorithm in the simulation of FFB transportation from the plantation to the factory is as follows.

For trucks, if the amount of FFB harvested in one estate is greater than the truck's capacity of 7 tons, then the truck must return to the garden until there are no more harvesting points left. For plantations, to find out if there is still FFB left in the garden TPH, then the resulting output is +1 or 0. If +1, then there are still fruit in the TPH, and if 0 then there is no fruit left after the FFB distribution process from gardens to factories. For factory, to clarify the problems that occur, it is necessary to know the flow or description that occurs in the factory queue. This explanation can be explained through the creation of a conceptual model, in the form of an activity cycle diagram. Flowcharts of algorithm can be seen in fig. 1, 2, and 3 below.

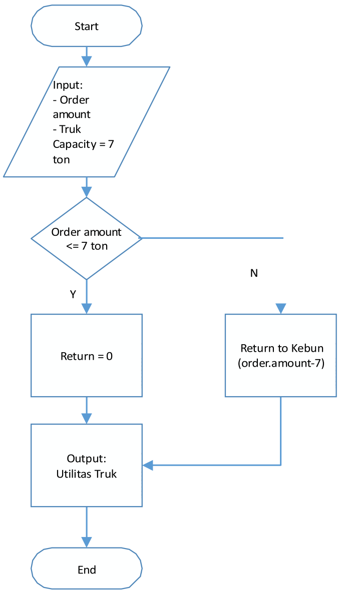

Figure 1. Algorithm of Truck

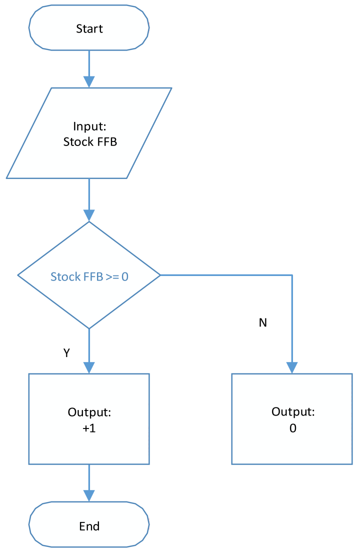

Figure 2. Algorithm of Plantantion

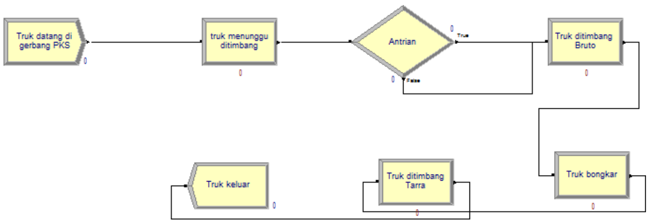

Figure 3. Algorithm of Factory

2.2.2. Simulation Model

The next stage is the model is filled with the agent movement process. This process requires the placement of defining points in the model environment, sequentially linked process logic units, and separate model agent management units. In the final stage, the model is enriched by both adjusting the settings in the process logic, such as setting agent input and coloring as well as agent specifications. This stage is the stage that will lead to the implementation of model simulation and model analysis. With the completion of this stage, the model is very ready to be analyzed and run the simulation.

The following is a description of Process Modeling and State Chart of the FFB transportation simulation model which can be seen in Figure 5.

1. Process Modeling of TBS Transportation

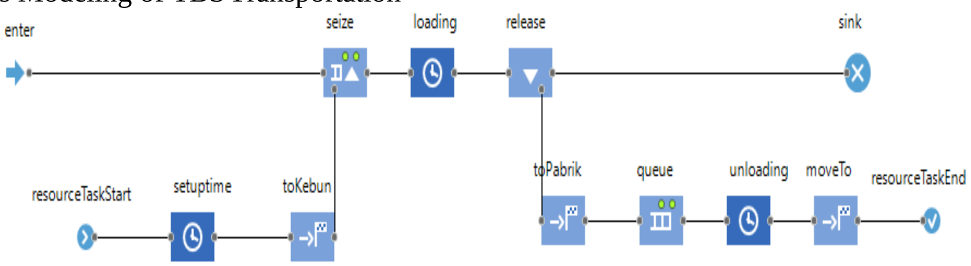

Figure 4. Process Modeling of TBS Transportation

From above, the process modeling diagram as follows:

a. The transportation company will receive an order from the plantation to send its transportation fleet according to the needs. The need for the number of transportation fleets is determined based on the number of daily harvests in kilograms.
b. Then after arriving at the plantation, the FFB that has been collected at the TPH will be loaded into trucks. Once completed, immediately taken to the factory that has been scheduled.
c. The factory assistant receives the arrival of the truck, the truck is immediately weighed if there is no queue and is unloaded. If there is FFB remaining in the plantation, the truck will return to the plantation. If not, then the truck has finished and returned to the haulage company location.

2. Statechart of Agents
The State Chart below has been filled with process logic and actions in each state that describes how the agent behaves as we can see in figure 6,7, and 8.

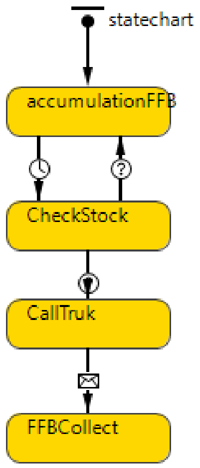

Figure 5. Plantation

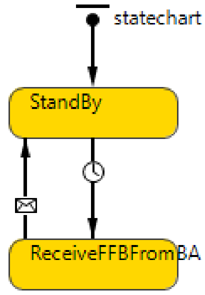

Figure 6. Factory

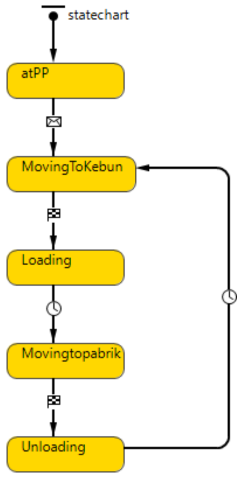

Figure 7. Truck

2.2.3. Model Verification and Validation

It is necessary to verify and validate the previously built model. Verification is carried out to ensure that the simulation model that has been built has run with the logic of the running of the model. While validation is a step to ensure that the model built has the same behavior as the actual system.

1. Verification
At the verification stage, there are 2 stages. The first step is to ensure that there are no errors when the model is run. The second stage is to ensure that the logic of the running of the model is in accordance with the evidence from the correct mathematical calculations.

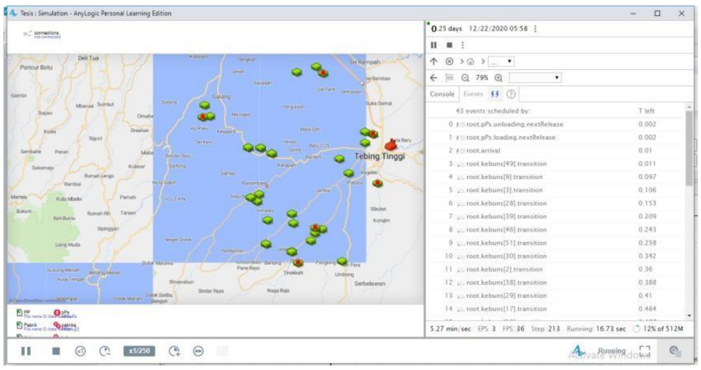

Figure 9. Simulation Model Events When Running

From Figure 9 above, it can be seen that the results of the utility of transportation modes are in accordance with the manual calculation formula for utilities. The utility value is the average number of trucks used compared to the number of trucks provided by the transportation company during the entire simulation time. The examples of calculations in actual conditions are as follows:

$$\text{Utility value} = \frac{N - \chi}{N} x100\% = 27\%$$

$$\text{Utility value} = \frac{177 - 130}{177} x100\% = 27\%$$

2. Validation

Model validation was carried out by comparing the simulation results of FFB collection and transportation time. Hypothesis testing using the z-test distribution was used to check whether the simulation results were significantly different from the data in the field. If the results are not significantly different, then the simulation model can be said to be valid and can be used for further research. Z-test is used because the data provided by PT. XYZ so that the sample used is > 30 samples. To perform the validation, a comparison of the z value between the calculated z and the z table is carried out. From Figure 10 below, it can be seen that the value of the cycle time for collecting real conditions with simulation is in the range of ± z critical two tails. The calculated Z value is smaller than Z table, which is 1.004 < 1.96. Therefore, Ho is accepted that the existing collection and transportation cycle time (real field conditions) is not much different from the simulation collection and transportation cycle time. Thus, the utility value of the actual mode of transportation is also not much different from the simulation results, which is 27%.

Proportions

Independent-Samples Proportions Group Statistics

	Condition	Successes	Trials	Proportion	Asymptotic Standard Error
Hasil = 212.33	= Simulasi	0	59	.000	.000
	= Riil	1	59	.017	.017

Independent-Samples Proportions Confidence Intervals

	Interval Type	Difference in Proportions	Asymptotic Standard Error	95% Confidence Interval of the Difference Lower	Upper
Hasil = 212.33	Agresti-Caffo	-.017	.017	-.071	.038
	Newcombe	-.017	.017	-.090	.046

Independent-Samples Proportions Tests

	Test Type	Difference in Proportions	Asymptotic Standard Error	Z	Significance One-Sided p	Two-Sided p
Hasil = 212.33	Wald H0	-.017	.017	-1.004	.158	.315

Figure 10. Test Results Validation of FFB Collection and Transportation Time with Z test with SPSS

2.2.4. Experiment Simulation

The simulation of optimizing the number of trucks for FFB transportation in the palm oil industry is run using Anylogic Software 8.4.0 PLE with a model time of 6 months, starting from January 30, 2021-June 31, 2021. The simulation is run by specifying the scenario of the number of trucks. The scenario for optimizing the number of trucks for rent is carried out by conducting several experiments on the model, namely reducing or increasing the number of trucks that collect TPH in the plantation and by generating random numbers for the amount of FFB transported per day in kilograms.

a. Scenario 1
The selected condition for scenario 1 is to perform a simulation with the actual conditions, namely the number of trucks being rented 3 units per afdeling. Harvest data obtained from the results of random number generation. The simulation is run in days.

b. Scenario 2
The selected condition for scenario 2 is to do a simulation with the number of trucks being rented 2 units per division. Harvest data obtained from the results of random number generation. The simulation is run in days.

c. Scenario 3
The chosen condition for scenario 3 is to do a simulation with the number of trucks being rented 4 units per division. Harvest data obtained from the results of random number generation. The simulation is run in days.

3. RESULT AND DISCUSSION

3.1. Highest Utility

From Figure 11 below it can be seen that the level of utility of transportation modes to changes in the location of the transportation company is up to 42% compared to the actual condition. That is the highest utility value for 2 another scenarios.

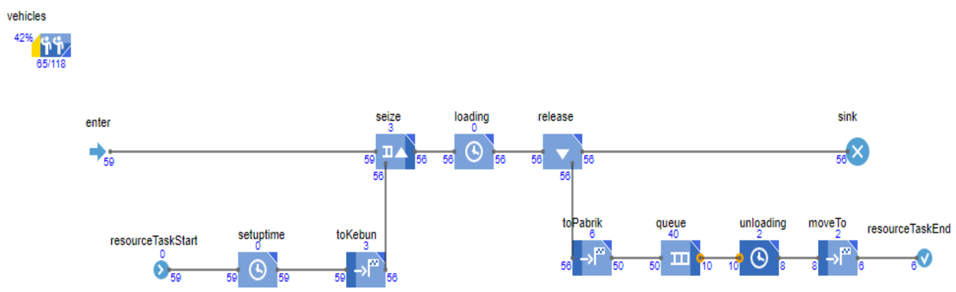

Figure 11. The Second Simulation Result

3.2. Long Queue Time and FFB Quality

From the results of the queue data, it can be seen that there is a waste of time caused by the length of time the trucks wait to be weighed (waiting in process) at Rambutan and Sei Mangke factory, which peaks at 12.00 WIB - 14.00 WIB This causes the Free Fatty Acid of the palm fruit to increase and the weight loss of the stalks, which in turn causes the total weight of processed FFB not to reach the target amount.

According to Mamet (2007), the increase in free fatty acid every hour after the fruit fell to the ground was around 0.4%. Meanwhile, the hourly weight loss is influenced by the evaporation of the water content in the palm fruit, which is around 0.05%. The following is data on the analysis of the length of the queue time on the quality of palm oil which is presented in Table 6 below.

Table 6. Analysis of Queue Time on Palm Oil Quality

No	Plantation	Queue Time/Day (Minutes)	Queue Time/Month (Minutes)	Increase in FFA/Day (%)	Weight Loss /Month (%)
1	Bangun	74	2220	0,50	1,85
2	Gunung Pamela	251	7530	1,67	6,00
3	Gunung Monaco	39	1170	0,26	0,90
4	Silau Dunia	121	3630	0,80	3,00
5	Gunung Para	42	1260	0,28	1,20
6	Sungai Putih	21	630	0,14	0,60
7	Sarang Ginting	100	3000	0,67	2,5
8	Tanah Raja	98	2940	0,65	2,45
9	Rambutan	76	2280	0,50	1,90
10	Dusun Hulu	244	7320	1,63	6,10
11	Pulau Mandi	108	3240	0,72	2,70
12	Sei Dadap	164	4920	1,09	4,10

3.3. Number of Modes of Transportation and Total Collection Time

Comparison of the realization of the total collection time in each district area and the number of transportation modes used based on the number of FFB collected against the capacity of the transportation mode with the proposed experimental simulation described in Table 7. Below

Table 7. Comparison of Realized Number of FFB Transportation Modes with Proposed

No	Plantation	Requirement	Realization		Usulan	
		Transportasi/ afdeling (Unit)	Transportasi/ afdeling (Unit)	*Journey Time* (Minutes)	Transportasi/ afdeling (Unit)	*Journey Time* (Minutes)
1	Bangun	2	3	795.83	2	721,83
2	Gunung Pamela	4	3	3162.77	2	2911,77
3	Gunung Monaco	3	3	1677.72	2	1638,72
4	Silau Dunia	2	3	1274.50	2	1153,5
5	Gunung Para	1	3	197.52	2	155,52
6	Sei Putih	1	3	633.36	2	612,36
7	Sarang Ginting	1	3	1029.85	2	929,85
8	Tanah Raja	3	3	1340.80	2	1242,8
9	Rambutan	4	3	1863.70	2	1787,7
10	Dusun Hulu	3	3	1371.30	2	1127,3
11	Pulau Mandi	3	3	1359.90	2	1251,9
12	Sei Dadap	5	3	1542.60	2	1378,6
	Total	**176**	**177**	16249.85	**118**	14911.85

From Table 7 above, it can be seen that the number of transportation modes used to collect FFB from the plantation to the factory has decreased to 118. This is because according to the experimental simulation results that several trucks are idle because the capacity of the transportation mode far exceeds the number of harvests in 2019 so that the allocation of the number of trucks in these units garden units are not optimal. The total idle trucks are 50 trucks. Meanwhile, the total shortage of trucks is 19 trucks. There are still 31 trucks left idle after being allocated to the afdeling unit, which is experiencing a shortage of trucks and this is a waste of money from a cost perspective.

The researcher proposes that 118 trucks are maximized to 2 units per afdeling with a maximum of 2 trips per day. The average journey time has also decreased, because the queue time has been reduced by optimizing the number of servers at the weighing station, which is 1388 minutes.

3.4. Collection/Transportation Fee Mode of Transportation

The total cost of FFB transportation modes from the transportation company to the plantation and then to the mill in each proposed district area through experimental simulations with the realization of collected demand is described in Table 8 below.

Table 8. Comparison of Realized Number of FFB Transportation Modes with Proposed

No	Plantation	Realization		Proposed	
		Qty (Kg)	**Fee (Rp)**	**Qty (Kg)**	**Fee (Rp)**
1	Bangun	3,501,440	2,951,758,016	3,566,217	2,946,958,016
2	Gunung Pamela	2,923,546	1,880,236,293	3,098,959	1,875,436,293
3	Gunung Monaco	3,534,962	1,183,023,088	3,566,777	1,178,223,088
4	Silau Dunia	3,087,852	1,438,826,128	3,180,488	1,434,026,128
5	Gunung Para	1,235,650	765,440,427	1,250,478	760,640,427
6	Sei Putih	622,145	695,449,689	625,878	690,649,689
7	Sarang Ginting	957,061	495,897,389	980,988	491,097,389
8	Tanah Raja	1,469,431	547,156,903	1,505,432	542,356,903
9	Rambutan	5,229,328	9,717,627,277	5,328,685	9,712,827,277
10	Dusun Hulu	3,205,139	3,349,731,746	3,400,652	3,344,931,746
11	Pulau Mandi	2,987,997	2,233,137,172	3,068,673	2,228,337,172
12	Sei Dadap	4,645,623	467,115,961	4,836,094	462,315,961
	Total	**33,400,174**		**34,409,319**	

From the results and discussion above, it can be determined that the optimal number of trucks that must be provided by the transportation company is 118 trucks in 1 semester with a utility rate of 42% with an allocation of 2 trucks per division and the addition of 1 server at the weighing station to maintain the quality of palm oil. at a predetermined standard.

4. CONCLUSION

Based on the research that has been done, the following conclusions can be drawn:

a. The FFB transportation system model from the plantation to the factory is described by the Agent Based Modeling method which is described in the action chart diagram in the main main as Top- Level-Agent which will regulate how the model simulation process works using Anylogic Software
8.4.0 PLE.

b. The research locations are 12 plantation points and 2 palm oil mills in Serdang Bedagai District I and II, and Asahan District.

c. The experimental model simulation is carried out with a model time of 6 months starting on January 30, 2021 until June 30, 2021 with 3 scenarios of the number of trucks to be rented, namely the scenario of the number of trucks being 2 units, 3 units, and 4 units per affeling. Data on the number of harvests in the scenario of the number of trucks obtained from the results of random number generation. The simulation is run in days.

d. The scenario of the number of trucks given in the simulation model shows that the number of trucks greatly affects the optimal allocation of transportation modes that transport FFB from the factory plantations. From the scenario carried out, we can see the utility of the number of trucks and it can be seen that the number of trucks that must be provided by the transportation company within 1 semester is 118 trucks with a utility rate of 42% with an allocation of 2 trucks per division.

e. There is a decrease in the total cost of collection/transportation due to changes in the allocation of transportation units by 0.225%, namely Rp. 57,600,000.

f. There is a decrease in total journey time due to the addition of server units to 2 at the FFB weighing station, which is 1388 minutes.

g. There was an increase in the quantity of processed FFB entering the factory by 2.93%, namely 1,009,145 kg due to improvements in waiting time reduction.
h. There is a decrease in the ALB value and the average weight loss that determines the quality of palm oil after the queuing system at the weighing station has been improved.

Future Work

The suggestions given to this research are as follows:

a. This research can be used as a tool to determine the number of trucks rented from the transportation company.
b. It is necessary to conduct further research on other variables that can affect the optimization of transportation modes.

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