Analysis of Optimal Transport Route Determination of Oil Palm Fresh Fruit Bunches from Plantation to Processing Factory

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Abstract. Manufacturers engaged in the business, producing CPO and kernels whose raw materials are oil palm fresh fruit bunches taken from their own plantation, generally face problems of transporting from plantation to factory where there is often a change of distance traveled by the truck the carrier of FFB is due to non-specific transport instructions. The research was conducted to determine the optimal transportation route in terms of distance, time, and route number. The determination of this transportation route is solved using Nearest Neighbours and Clarke & Wright Savings methods. Based on the calculations performed then found in area I with method Nearest Neighbours has a distance of 200.78 Km while Clarke & Wright Savings as with a result of 214.09 Km. As for the harvest area, II obtained results with Nearest Neighbours method of 264.37 Km and Clarke & Wright Savings method with a total distance of 264.33 Km. Based on the calculation of the time to do all the activities of transporting FFB juxtaposed with the work time of the driver got the reduction of conveyance from 8 units to 5 units. There is also improvement of fuel efficiency by 0.8%.

1. Introduction
The manufacturing company as a whole will always be closely linked to the transportation and distribution process. Starting from the procurement of raw materials to the marketing of the final product are all very closely related to transportation. It is essential that a manufacturing plant minimize the costs sacrificed for transportation. One of the steps that can be done to make the transportation process better is to plan the travel route appropriately so that the product can reach the customer with timely and low cost. Similarly, in the transportation of raw materials. There are four things that are targeted for the smooth transportation of FFB that is maintaining free fatty acids (FFC) related to final product quality, capacity or smooth processing in a factory, FFB security in the field, and minimum transportation cost [1].
XYZ company is one of the companies that produce CPO and kernel produced by obtaining raw materials from the plantation owned by the factory concerned. Transport of raw materials by means of transportation provided by the manufacturer. Trucks used for branded Hino with a capacity of 10 tons of 8 units. The process of transporting FFB from plantation to factory still has not applied the standard system, causing some problems in the transportation process. The uncertainty of this transportation lane makes the cost increase and also increases the waiting time for FFB to be processed immediately.

Distribution route problems can be analyzed using transportation management approach. The Nearest Neighbours and Clarke & Wright Savings methods are a method used in determining the proper transportation path by trying to sequentially enter the place to be visited into the vehicle route by using the closest distance criteria so that it can solve the problem of vehicle scheduling route (vehicle routing and scheduling problem) [2,3] Clark and Wright (C-W) algorithm was developed by entering G. Clarke and J. W. Wright. The basis for the C-W algorithm is savings concept where these savings are realized by linking pairs of delivery points served by a single depot in the network, while Nearest Neighbours Procedure (NNP) builds a tour based on the cost or distance of traveling from the last-visited node to the closest node in the network.

2. Methodology and Experimental

- Data collection methods used in this study are:
  - Observation technique, which is to observe directly in the company to get data related to research.
  - Interview technique, which is conducting question and answer (interview) to the parties involved directly in about transportation of FFB
  - Creating a distance matrix is the intermediate distance matrix depot with node and distance between nodes.
  - Calculate the savings value \( S_{ij} \) in the form of distance travel from one node to another node.
  - Create an austerity matrix, then process it is repeatedly driven from the largest matrix to a matrix of small value to each, the austerity matrix was evaluated for further route repair

The steps in the Nearest Neighbours method are as the following:

- Determine the parameter K (the number of nearest neighbors).
- Calculate the quadratic distance of the Euclid (query instance) of each object against the given sample data
- Sort objects into groups that have the smallest Euclidean spacing.
- Collecting category Y (nearest neighbours classification)
- Using the nearest neighbor category of the majority, it can be predicted the value of the query instance that has been calculated [4,5,6].

3. Results and Discussion

3.1. Processing Clarke & Wright Savings Method

In harvest area I there are 26 Point of Result Collection (PRC), then total iteration did as many as 13 iterations with recapitulation as follows in Table 1 and while for harvest area II there are 24 Point of Result Collection (PRC).

| NO | PRC  | Amount of FFB/PRC (ton) | Total of FFB (ton) | Truck Capacity (ton) | Mileage (Km) |
|----|------|------------------------|--------------------|---------------------|--------------|
| 1  | PP25 | 4.0                    | 8.2                | 10.0                | 15.12        |
| 10 | PP18 | 5.5                    | 10.0               | 10.0                | 12.56        |
Minimum Total Mileage of with Clarke & Wright Savings Methods’ iteration in harvest I is 214.09 Km. The similar method did recapitulation as many as 12 interations in Harvest II and got the total 264,33 Km.

3.2. Processing with Nearest Neighbours Method
This method uses the simple principle of making the factory as the starting point of departure to the point of result collection (PRC) and to be addressed is the PRC which has the closest distance to the factory then to the nearest PRC with the last visited PRC, and so on until all the PRC has been visited. Recapitulation results can be seen in Table 2.

Minimum Total Mileage of with Nearest Neighbours Method iteration in harvest I is 200.78 Km. The similar method did recapitulation in Harvest II and got the total 264,37 Km.

| Table 2. Recapitulation of routes with the nearest neighbours area method of harvest I. |
|---------------------------------|---------------------------------|------------------|------------------|------------------|
| NO | PRC | Amount of FFB/PRC (ton) | Total of FFB (ton) | Truck Capacity (ton) | Mileage (Km) |
|----|-----|------------------------|-------------------|--------------------|--------------|
| 1  | PP12 PP8 | 7.7 2.2  | 10.0 10.0  | 10.06  |  |
| 2  | PP8  | 6.2 5.1  | 10.0 10.0  | 10.61  |  |
| 3  | PP13 PP15 | 3.2 6.8  | 10.2 10.0  | 9.98  |  |
| 4  | PP16 PP17 | 6.4 3.6  | 10.0 10.0  | 10.58  |  |
| 5  | PP17 PP14 PP11 | 3.4 5.1 1.6 | 10.0 10.0  | 11.53  |  |
| 6  | PP11 PP10 | 4.2 5.9  | 10.0 10.0  | 10.53  |  |
| 7  | PP10 PP9 PP7 | 6.7 3.3 3.3 | 10.0 10.0  | 10.49  |  |
| 8  | PP7 PP4 PP5 | 5.1 3.4 5.1 | 10.1 10.0  | 11.35  |  |

| NO | PRC | Amount of FFB/PRC (ton) | Total of FFB (ton) | Truck Capacity (ton) | Mileage (Km) |
|----|-----|------------------------|-------------------|--------------------|--------------|
| 9  | PP5 PP6 | 4.2 5.9  | 10.1 10.0  | 11.27  |  |
| 10 | PP45 PP46 | 0.8 7.6  | 10.0 10.0  | 18.06  |  |
| 11 | PP1 PP3 | 3.3 5.1  | 8.4 10.0  | 11.81  |  |
| 12 | PP20 PP21 | 7.6 2.4  | 10.0 10.0  | 12.17  |  |
| 13 | PP21 PP22 | 5.1 4.9  | 10.0 10.0  | 12.63  |  |
| 14 | PP22 PP23 PP26 | 2.8 6.0 1.2 | 10.0 10.0  | 14.64  |  |
| 15 | PP26  | 3.0  | 10.0 10.0  | 14.67  |  |
| 16 | PP24 PP18 | 4.1 5.5 9.6 | 10.0 10.0  | 13.77  |  |
| 17 | PP19  | 7.3 7.3 10.0  | 11.60  |  |

TOTAL 200.78
3.3. Calculation of Truck Amount

After calculating the route and the amount of mileage each truck will take in transporting FFB from the garden, calculating loading and unloading times, it can be calculated how many trucks it needs. With a working time of 8 hours per day, this becomes the limitation for consideration in determining the optimal number of trucks.

Calculation time can be calculated by using the largest distance from the calculation route selected above that is by Clarke & Wright Saving method on harvest area II as many as 15 routes with a total distance of 264.33 Km.

\[ T = \frac{S}{V} \]
\[ T = \frac{264.33}{25} \]
\[ T = 10.57 \text{ hours} \]
\[ T = 634.2 \text{ minutes} \]
\[ T = 10.57 \text{ hours} \]

Where = Travel time (hours)

\[ S = \text{Mileage (km)} \]
\[ V = \text{Speed (km/hour)} \]

Activity data carried out in transporting FFB from plantation to factory for the 15 selected routes can be seen in Table 3.

| Activity     | Amounts (route) | Times (minutes) |
|--------------|-----------------|-----------------|
| Traveling    | 15              | 634.20          |
| Loading      | 15              | 553.95          |
| Unloading    | 15              | 27.49           |
| Weighting    | 15              | 30.0            |
| **Total**    | **1245.64**     |                 |

From Table 3, we get the amount of time required, but for the calculation of the number of trucks is also affected with the system that is applied to the factory that is completed every 1 trip transporting FFB then the driver and helper are given 1 hour rest period. So for the calculation of the number of trucks performed calculations with assumption, as follows: [7,8,9]

1. With 4 truck units, the following results are obtained:

\[ \text{Working hours} = \frac{\text{Total of Time (hours)}}{\text{Amount of Trucks}} + \left[ \frac{\text{Amount of routes}}{\text{Amount of Trucks}} \right] [\text{resting time (hour)}] \] .... (2)

\[ = \frac{1245.64}{4} + \left[ \frac{15}{4} \right] [1] = 8.94 \text{ hours} \]

Due to the time result obtained > working hours, then 4 trucks is not possible.
2. With the number of 5 units of trucks obtained the following results:

$$\text{Working hours} = \frac{\text{Total of Time (hours)}}{\text{Amount of Trucks}} + \left( \frac{\text{Amount of routes}}{\text{Amount of Trucks}} \right) [\text{resting time (hour)}] \ldots (3)$$

$$= \frac{1245.64/60}{5} + \left[ \frac{15}{5} \right] [1] = 7.15 \text{ hours}$$

Due to the time obtained < working hours, 5 trucks can be transported.

3.4. Allocation of Trucks

For the allocation of trucks, the carrier is within the authority of the transportation foreman, by following the harvest data obtained from the plantation division. The gardens are divided into 2 harvest areas where the goal is to arrange the harvesting schedule once every 2 weeks. Then, the harvested area will be harvested for the next 2 weeks. In the previous chapter has been calculated the number of trucks required by the time of transportation that is a number of 5 units. As for the number of tours that will be done has been set in the area of harvest I as much as 17 tours and for the harvest area II as many as 15 tours. So for the allocation of trucks can be seen in Table 4.

| TOUR | TRUCK NO | ROUTE       | TOUR | TRUCK NO | ROUTE       |
|------|----------|-------------|------|----------|-------------|
| 1    | DT 1     | PP0-PP12-PP8-PP0 | 9    | DT 3     | PP0-PP5-PP6-PP0 |
| 2    | DT 2     | PP0-PP8-PP13-PP0 | 10   | DT 5     | PP0-PP2-PP1-PP0 |
| 3    | DT 3     | PP0-PP13-PP15-PP0 | 11   | DT 4     | PP0-PP1-PP3-PP0 |
| 4    | DT 4     | PP0-PP16-PP17-PP0 | 12   | DT 5     | PP0-PP20-PP21-PP0 |
| 5    | DT 5     | PP0-PP17-PP14-PP11-PP0 | 13   | DT 2     | PP0-PP21-PP22-PP0 |
| 6    | DT 2     | PP0-PP11-PP10-PP0 | 14   | DT 3     | PP0-PP22-PP23-PP26-PP0 |
| 7    | DT 1     | PP0-PP10-PP9-PP7-PP0 | 15   | DT 1     | PP0-PP26-PP25-PP24-PP0 |
| 8    | DT 4     | PP0-PP7-PP4-PP5-PP0 |      |          |              |

Table 4. Allocation of truck area of harvest I.

For the second harvest area, PRC PP27-PP50 gets the next harvest turn after harvest area I, with the allocation to the 5 planned trucks which can be seen in Table 5.

**Figure 1.** The Line of Harvesting Area I.  
**Figure 2.** The Line of Harvesting Area II.
Table 5. Allocation of truck area of harvest II.

| TOU | TRUCK NO | ROUTE          |
|-----|----------|----------------|
| 1   | DT 5     | PP0-PP41-PP43-PP0 |
| 2   | DT 3     | PP0-PP50-PP49-PP0 |
| 3   | DT 2     | PP0-PP49-PP40-PP42-PP0 |
| 4   | DT 4     | PP0-PP42-PP45-PP46-PP0 |
| 5   | DT 1     | PP0-PP46-PP39-PP0 |
| 6   | DT 2     | PP0-PP39-PP27-PP0 |
| 7   | DT 1     | PP0-PP38-PP44-PP0 |
| 8   | DT 4     | PP0-PP28-PP29-PP0 |

| TOU | TRUCK NO | ROUTE          |
|-----|----------|----------------|
| 9   | DT 3     | PP0-PP29-PP30-PP37-PP0 |
| 10  | DT 5     | PP0-PP37-PP47-PP0 |
| 11  | DT 4     | PP0-PP47-PP48-PP0 |
| 12  | DT 3     | PP0-PP36-PP35-PP0 |
| 13  | DT 1     | PP0-PP35-PP32-PP0 |
| 14  | DT 2     | PP0-PP32-PP31-PP34-PP0 |
| 15  | DT 5     | PP0-PP34-PP33-PP0 |

3.5 Calculation of Total Fuel Usage

In the calculation of the previous FFB transport route, it is known that the chosen route is based on the smallest mileage number which can be seen in Table 6 [10,11].

Table 6. Selected distance data.

| Harvesting Area  | Choose Route | Mileage (Km) |
|------------------|--------------|--------------|
| Harvesting Area I| Nearest Neighbour Clarke & Wright Saving | 200.78 |
| Harvesting Area II|             | 264.33 |
| Total            |              | 465.11 |

Based on the clearing result done by the factory, it is found that the carrying capacity to the fuel usage in the ratio of 1:2,50 with 1 Liter definition can travel 2,50 Km. So for the calculation of total fuel is calculated as follows: [12, 13]

\[
\text{Total Fuel} = \text{Total Distance} \times \text{Trucking Capacity} \tag{4}
\]

\[
= 465.11 \times \frac{1}{2.50}
\]

\[
= 186.05 \text{Liters}
\]

So when compared to actual fuel use with a ratio of 1:2.48, then obtained efficiency improvements for:

\[
\frac{2.50-2.48}{2.48} \times 100\% = 0.8\% \tag{5}
\]
4. Conclusion
The conclusions obtained based on the results of data processing and analysis that has been done is in the area of harvest I Nearest Neighbours method has less mileage compared to Clarke & Wright Savings method. The total distance of Nearest Neighbours method and Clarke & Wright Savings method are 200.78 Km and 214.09 Km respectively. As for the area of harvest II obtained different results, with Nearest Neighbours method obtained more mileage compared with Clarke & Wright Savings method. The total distance of Nearest Neighbor method and Clarke & Wright Savings method are 264.37 Km and 264.33 Km respectively.

The number of FFB transport tours that formed both methods in the first harvest area with Clarke & Wright Savings and Nearest Neighbours method were 18 tours and 17 tours respectively, while in the harvest area II were 15 tours in both methods. In accordance with the time calculation carried out all the activities of transporting FFB, recommend the number of trucks used is reduced from 8 units to 5 units. The average fuel usage ratio of 1: 2.5 makes an increase of 1: 2.48. Thus, the improvement of fuel consumption refers to the achievement of the standard sets by the company, with an efficiency improvement of 0.8%.

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