Determining Distribution Center Locations to Optimize Food Supply Chain Integration (A Case Study of an Agribusiness Company in Indonesia)

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ABSTRACT

PT Asagri Selaras Asia is an agribusiness company in Jakarta, Indonesia that provides food supply for entrepreneurs in the tourism sector, such as hotels and restaurants. In running their business, the company has a supply chain network that effectively integrates suppliers, manufacturers, warehouses, and stores. Supply chain management optimization is deemed necessary to maximize efficiency in every process carried out at PT Asagri Selaras Asia. One of the processes that can be optimized is the determination of facility location. The right facility location can minimize distance, delivery time, and operational costs and optimize the company's profit. Currently, the contract period for the distribution center (DC) used by PT Asagri Selaras Asia is about to expire therefore a decision is needed regarding the determination of the DC location for the next period, either extending the current DC contract or moving to a new location. This study aims to maximize the company's profit by comparing the profit obtained under existing and alternative DC, and the proposed DC from the experimental results using the Green Field Analysis (GFA) method. This study also aims to determine the feasibility of the three DC locations using the Network Optimization (NO) method with Anylogistix software. Based on the data analysis, the new DC is recommended to be located in the West Pejaten area, South Jakarta with latitude -6.2729150574 and longitude 106.8230798418 which will give an increase in profit of 80.53% compared to the existing DC.

1. INTRODUCTION

PT. Asagri Selaras Asia is a company engaged in agribusiness in Indonesia that aims to provide the best food ingredients for household and business needs that are sold through e-commerce for end customers and tourism businesses, such as hotels and restaurants. PT Asagri Selaras Asia provides various kinds of premium quality rice, such as Serta Ramos rice and Pandan Wangi rice from Cianjur City, special fried rice from Subang City in Indonesia, besides Japonica or Japanese rice. In addition, PT Asagri Selaras Asia also provides organic rice from Karanganyar, Central Java, Indonesia (Asagri, 2020).

Supply chain management has an important role in running a business. Supply chain management activities integrate suppliers, manufacturers, warehouses, and retail stores effectively. Optimal supply chain management can maximize the level of efficiency in every process carried out (Johnson & Pyke, 1999). One of these processes is the determination of the new facility location. The right location of the facility ideally minimizes distance, delivery time, and operational costs incurred, as well as being able to optimize company profits.

Several previous studies discuss the location of distribution center (DC) allocation for supply chain networks using the Green Field Analysis (GFA) and Network Optimization (NO) methods with Anylogistix software as in the research entitled "Development Strategy for the Master Plan of Maize Commodities Supply Chain Network Infrastructure in Madura, Indonesia". The study conducted the allocation of four corn warehouses in the Madura area by taking into account the demand until 2022 using the GFA and NO methods for validation (Jakfar, Syarif, & Hidayat, 2020) then in the study entitled "Technical evaluation of the opening of facilities in the pharmaceutical industry: optimization to supply chain in Mexico", they determined the location of medicine warehouse allocation in Mexico with scenarios of increasing and decreasing demand using the GFA and NO methods (Marmolejo-Saucedo, Rodriguez-Aguilar, & Manuell-Barrera, 2010) so that it can be concluded that the use of GFA is intended to determine the new point of the facility that will be built while NO is used to validate whether the point is feasible to acquire in real conditions or not.

The contract period for the distribution center (DC) location of PT Asagri Selaras Asia which is currently being used will soon expire therefore a decision is needed regarding the determination of the next DC to be built, whether the conditions considered are either extending the current contract or moving to a new DC location. This study aims to determine the location of the next DC for PT Asagri Selaras Asia to help them maximize the company's profit by comparing profits between three schemes: existing DC (ex. DC), alternative DC from the company (alt. DC), and DC obtained through the results of experiments using the GFA method (GFA DC). This study also intended for the feasibility determination of the three DC locations using the NO method with Anylogistix software.

This study has several circumstances, namely the demand for products that are taken into account only for rice, and customers that are considered in the model only for hotels and restaurants. This study assumes that there is no penalty fee for late deliveries with suppliers and customers and that deliveries from suppliers are carried out every month.

2. LITERATURE STUDY

The location of a facility plays an important role in the strategic planning of the supply chain network. This role becomes more important with the increasing need for a comprehensive model capable of covering various aspects that are relevant to real-life problems. Determining the optimal location of facilities can provide benefits to all aspects of the supply chain, both for the company, suppliers, and customers. The strategic location of the facility can optimize distance, time, and cost during the distribution process between suppliers and facilities as well as facilities and customers (Melo, Nickel, & Saldanha-da-Gama, 2009).

Anylogistix is software that can be used to make solving various supply chain management problems easier and more attractive as it provides an interesting illustration. In supply chain management theory, quantitative models such as network optimization and simulation can be used to assist decision-making then Anylogistix software is useful for generating the best options based on the components in the supply chain (Marmolejo-Saucedo, Rodriguez-Aguilar, & Manuell-Barrera, 2019).

Under Anylogistix setting, GFA commonly known as center-of-gravity (COG) analysis is explained as a method for determining the best location for DCs. The data used as input for the analysis is data on customer location, demand per customer, number, and location of DCs, and/or service distance. The analysis produces the best location estimate for a manufacturing or warehousing facility where all transportation costs on inbound and outbound processes are minimized. Other than GFA, NO is explained as a quantitative decision support method for supply chain management that allows supply chain managers to assess an alternative network design using a customizable cost objective function. But in contrast to GFA, optimization analysis allows several different alternative supply chain network designs to be compared based on their impact on the efficiency of all aspects of the supply chain. The results of the NO experiment make it possible to get the maximum profit from each alternative network design (Ivanov, 2018).

3. METHOD

There are several stages required to conduct this research. The stages can be seen in the following flow chart in Figure 1. The first stage is the identification of the problem and research objectives. This is done as an effort to ensure that the results of this research can be a solution to the problems being compiled. If the problem identification stage and research objectives have been carried out, the next stage is the literature study stage. The literature study was carried out to increase the provision of understanding as well as knowledge related to ways of solving problems proposed in this study. The literature studies used include the theories on the supply chain network and management, location of facilities, Anylogistix software, GFA, and NO method.

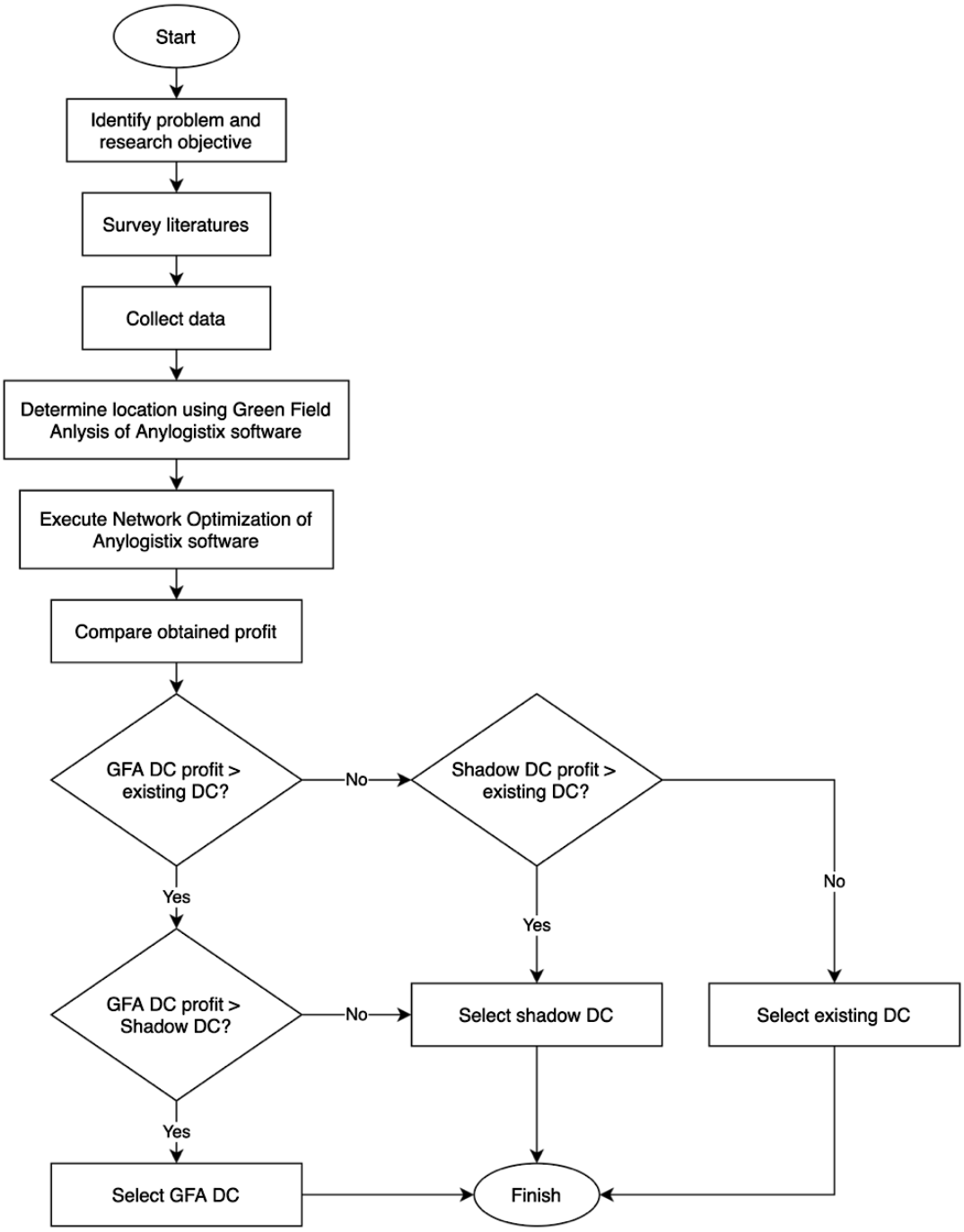

Figure 1. Research Flowchart.

The next stage is the data collection stage. Primary data collection is done through interviews with the informant to find out information about customer data, demand, costs, selling prices, suppliers, and so on. The informant in this interview is an employee of PT Asagri Selaras Asia. Meanwhile, the secondary data collection is obtained from the website. The secondary data referred to are additional data, such as those related to vehicle specifications and updated facility rental fees.

After the required data have been collected, the next step will be to input them into Anylogistix software. The data that is inputted and analysed in Anylogistix software begins with the determination of the location of the proposed DC using the GFA method. After that, the DC location obtained from the results of GFA (GFA DC), existing DC (ex. DC), and alternative DC (alt. DC) will be validated for their feasibility using the NO method. The feasibility is assessed based on the accessibility of the distribution route contained in the results of NO. Furthermore, the profit value between the three facilities will be compared to be then selected the facility that has the highest profit. This DC location will be recommended to PT Asagri Selaras Asia in determining their next DC location.

4. RESULTS AND DISCUSSION

Data Collection

This section will explain the data collected for the research to be processed further. Experiment data were collected from PT Asagri Selaras Asia for a period of one month. The following lists are the data that have been collected and utilized for this research.

1. Customer Location

   In Table 1 below, we collect information on the latitude and longitude of each customer that is useful for plotting the location of the customer in Anylogistix software therefore it can be considered in the determination process of the proposed DC location point using the GFA method.

Table 1. *Customer Location*

No.	Customer Name	Latitude	Longitude
1	Agneya	-6.249002298	106.8037408
2	Super Grains Grand Indonesia	-6.194837897	106.8214302
3	Super Grains Central Park	-6.176309963	106.7910398
4	Terra	-6.231242992	106.8132596
5	Legend of Noodle	-6.232691725	106.8123053
6	Sotis Kemang Hotel	-6.254710501	106.8090176
7	Sotis Blok M Hotel	-6.242695748	106.8014006
8	Ambhara Hotel	-6.243216296	106.8036692
9	Tanamera Coffee & Roastery	-6.245028642	106.7949939
10	Acacia Hotel	-6.188861938	106.8469597
11	Luberger	-6.244090183	106.7996172
12	Atjeh Connection Kitchen	-6.218268447	106.7627769
13	Kepiting Emas	-6.234200519	106.9017802
14	Dipuri	-6.277868986	106.8095676
15	Temu	-6.275574989	106.8086602
16	Rempah Wangi	-6.281672285	106.7964632
17	Umara Catering	-6.300642379	106.7981433
18	Sayurbox	-6.285320265	106.8248309
19	Kedai Tjikini Cikini Raya	-6.187515834	106.8367822
20	Kedai Tjikini M Bloc	-6.241757791	106.7985529
21	Mr. Roastman	-6.240807125	106.7987382
22	NoMiNoMi Delight Penggilingan	-6.214822146	106.9398813

2. Customer Demand

   In Table 2, there is information on customer demand for one period which should be fulfilled through

the simulation and influence the determination of the customer location in Anylogistix using the GFA method. Demand data is the average demand data per month from January to December 2021 and it is assumed to be able to represent demand patterns in the next year.

3. Supplier

Information on the name, location of the supplier, and the cost to send the product per one-way trip is required. The supplier's name is APOKAT which is located in Karanganyar, Indonesia. This supplier incurs a distribution cost per trip of IDR1,000,000.

Table 2. *Customer Demand*

No.	Customer Name	Rice Brand	Demand/Month (kg)
1	Agneya	Pandan Wangi	125
2	Super Grains Grand Indonesia	Organic Brown	75
3	Super Grains Central Park	Organic Brown	40
		Organic Red	20
4	Terra	Organic Brown	100
		Shirataki	80
		Organic Black	30
5	Legend of Noodle	Japan	100
6	Sotis Kemang Hotel	Premium	500
7	Sotis Blok M Hotel	Premium	300
8	Ambhara Hotel	Premium	500
9	Tanamera Coffee & Roastery	Yasmin	80
		Pera	30
10	Acacia Hotel	Premium	250
11	Luberger	Pandan	100
12	Atjeh Connection Kitchen	Premium	200
13	Kepiting Emas	Premium	200
14	Dipuri	Pandan Wangi	50
15	Temu	Premium	60
		Pera	30
16	Rempah Wangi	Premium	200
17	Umara Catering	Organic Brown	20
		Organic Black	10
18	Sayurbox	Organic Brown	300
		Milk Menthik	250
19	Kedai Tjikini Cikini Raya	Premium	75
20	Kedai Tjikini M Bloc	Premium	100
21	Mr. Roastman	Premium	60
		Pera	30
22	NoMiNoMi Delight Penggilingan	Premium	300

4. Product

In Table 3, there is information on the type of product, the selling price of the product to the customer, and the purchase price of the product to the supplier so that it becomes additional data to determine the optimal profit from the scenario that will be executed.

Table 3. *Product Detail*

No.	Rice Brand	Selling Price (IDR)	Buying Price (IDR)
1	Pandan Wangi	20,000	10,000
2	Organic Brown	34,000	17,000
3	Organic Red	33,000	16,500
4	Organic Black	35,000	17,500
5	Shirataki	220,000	110,000
6	Japan	90,000	45,000
7	Premium	22,000	11,000
8	Yasmin	19,000	9,500
9	Milk Menthik	28,000	14,000
10	Pera	15,000	7,500

5. Additional Data
   There is some additional data for NO formulation which will be carried out using Anylogistix simulation. Additional data is required as portrayed in the following Table 4. Additional data is required, such as order interval, time period, other facility costs (fixed costs), cost calculation parameters, variable cost transportation, fixed cost transportation, vehicle capacity, and vehicle speed (Paul, 2021; Pertamina, 2021; Sanjaya, 2020; Handayani, 2022).

Table 4. *Additional Data*

Order Interval	30 days
Time Period	January 1st - December 31st, 2021
Other Costs (GFA DC)	IDR100,000,000/year
	IDR273,973/day
Other Costs (ex. DC)	IDR350,000,000/year
	IDR958,904/day
Other Costs (alt. DC)	IDR125,000,000/year
	IDR342,465/day
Cost Calculation Parameters	
APOKAT – GFA DC	Fixed delivery (IDR1,000,000/trip) (FTL)
GFA DC – All Customers	Distance-based with fixed cost (695.45 * distance + 25,000 per trip (LTL)
Variable Cost Transportation	IDR7,650/11 km
	IDR695.45/km
Fixed Cost Transportation	IDR25,000/trip
Truck Capacity	10,000 kg
Operational Car Capacity	1,000 kg
Vehicle Speed	50 km/h

Data Processing

Data processing begins with finding the proposed DC latitude and longitude points using the GFA method through Anylogistix software. The data requirements of the GFA include customer, product, and supplier data. After feeding the data into the software and running the GFA experiment with the number of sites equivalent to one facility, the following results are obtained:

1. Green Field Analysis Experiment
   Data processing begins with finding the proposed DC latitude and longitude points using the GFA method using Anylogistix software. The data requirements of the GFA include customer, product, and supplier data in which network distribution is shown in Figure 2.

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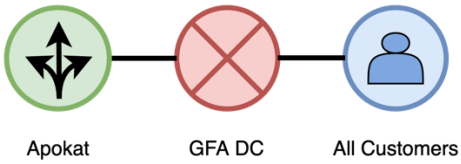

Figure 2. Distribution Network

The results produced for GFA DC are located at latitude -6.2729150574 and longitude 106.8230798418 or more precisely at the West Pejaten area, South Jakarta as illustrated in Figure 3. However, further validation steps are needed to check whether the results from the GFA experiment are feasible if applied in real conditions or not, so it is necessary to use the NO method.

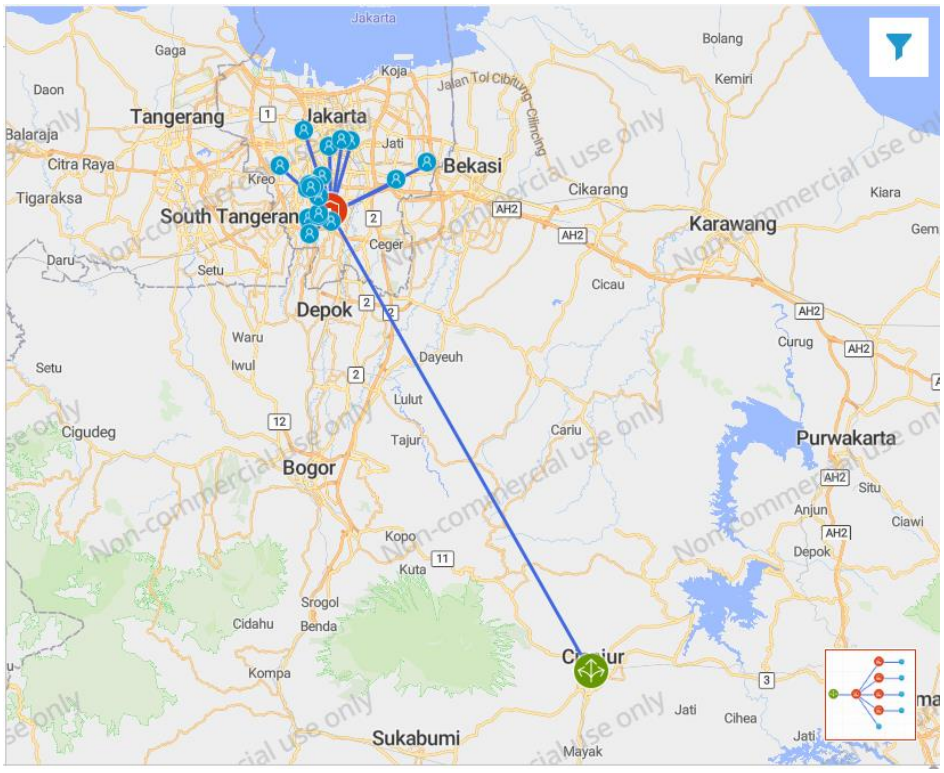

Figure 3. GFA Experiment Results

2. Network Optimization Experiment

With the results data that have been obtained through the GFA experiment, then we proceed to the NO experiment to see if the results from the GFA experiment are valid or not. The aspect of the assessment carried out from the results of the NO analysis is the financial aspect by making a comparison of each scenario. The NO experiment was carried out by requiring additional data from the GFA experiment as previously mentioned covering order interval, time period, other facility costs (fixed cost), cost calculation parameters, variable cost transportation, fixed cost transportation, vehicle capacity, and vehicle speed. In this NO experiment, a comparison of the net profit generated between GFA DC and existing DC is calculated in which the purpose of this comparison is to assess whether the transfer of DC to a new location is preferable to increase the company's net profit or not.

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Experiment Analysis

Further experiment analysis was run to get the details of the proposed schemes of each facility, they are:

1. GFA DC

By inputting data that are needed for the NO experiment, the following results are obtained, as illustrated in Figure 4 and Figure 5. The data requirements of the GFA include customer, product, and supplier data in which network distribution is shown in Figure 4 where NO experiment result is shown in the map in Figure 5. NO experiment is used to specify the most optimal locations for distribution facilities considering profit-maximized objective.

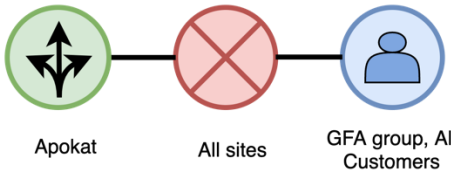

Figure 4. Distribution Network (GFA DC)

Scenario comparisons on NO were carried out using profit parameters with transportation costs as a trade-off variable. Using the GFA DC attained in previous studies, there is a distribution line in the Product Flows section of AnyLogistix simulation that can be formed so that the GFA DC is considered feasible to be applied in real situations with flows amounting to 109,590 units. From the cost calculation shown in Table 5, it is known that other costs per day would be IDR273,973 and the resulting total annual amount per year is IDR100,000,145.

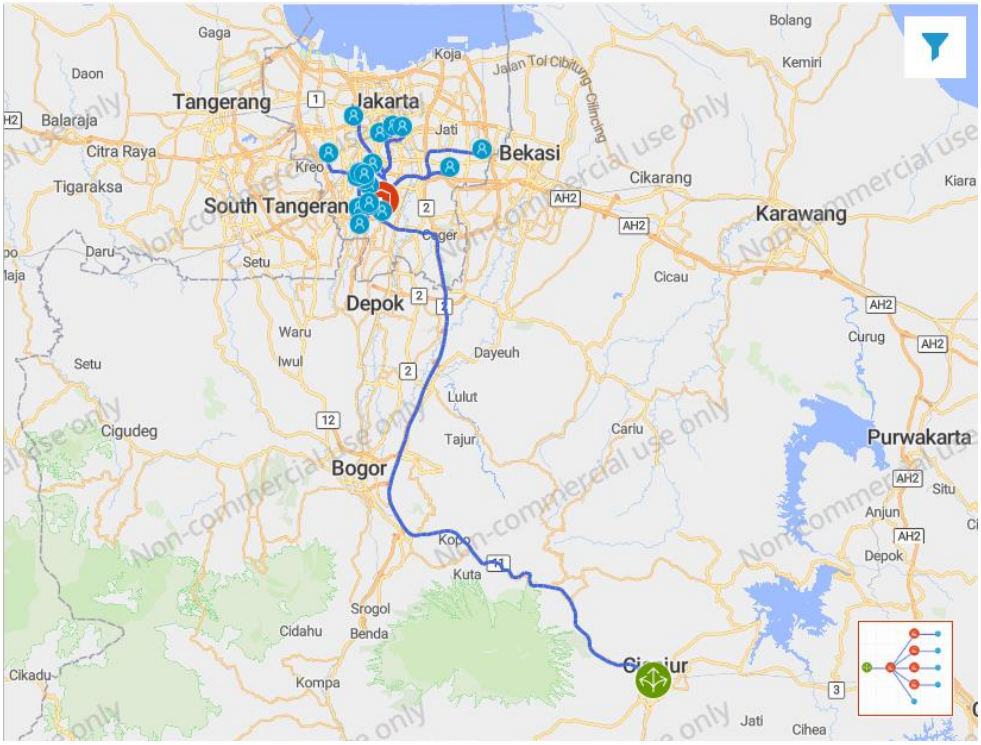

Figure 5. NO Experiment Results (GFA DC)

The numerical details as presented in Table 5 with GFA DC according to the data that has been obtained, namely other facility costs (fixed cost) of IDR273,973 per day, the objective or company profit is IDR560,284,984,803. Where the calculation of profit is not only found from the calculation of revenue minus other costs but also other costs, such as supply costs of IDR832,065,000 and also transportation costs of IDR7,979,906.297.

Table 5. NO *Experiment Results* (GFA DC)

Supply Cost	IDR832,065,000
Revenue	IDR1,500,330,000
Transportation Cost	IDR7,979,906.297
Other Cost	IDR100,000,145
Objective (Profit)	IDR560,284,948.703

2. Alternative DC

The same experiment was carried out, but the DC was used according to the company's alternative option. This experiment was then run with the same input data, but different details of other costs. Here are the experimental results for the alternative DC. With this alternative DC, it is known that the other facility cost (fixed cost) of IDR342,465 per day, and the objective or company profit is IDR532,703,611.339, the details are shown in Table 6. The principle of profit calculation is the same as that used for the 1st scheme considering supply and transportation costs. Based on the results of the NO Experiment, the alternative DC is considered feasible to be implemented by the company as we can draw such fine distribution lines, as in Figure 6. The network details for this scheme are then presented in Figure 7.

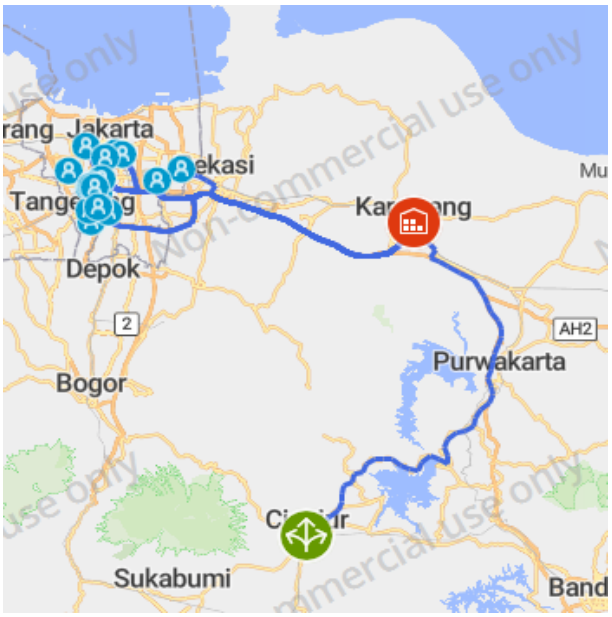

Figure 6. NO Experiment Results (Alt. DC)

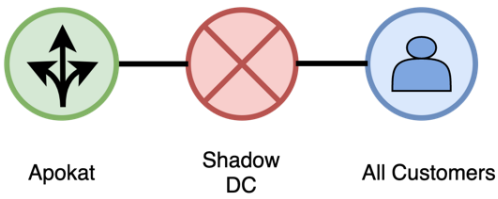

Figure 7. Network Distribution (Alt. DC)

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Table 6. NO *Experiment Results* (GFA DC)

Supply Cost	IDR832,065,000
Revenue	IDR1,500,330,000
Transportation Cost	IDR10,561,663.661
Other Cost	IDR124,999,725
Objective (Profit)	IDR532,703,611.339

3. Existing DC

The same experiment was carried out for the existing DC scheme, the current one. With a similar approach but different numerical details, the experimental results are illustrated in the following Figures 7 and 8. Using the existing DC, known that other facility costs (fixed cost) of IDR958,904 per day, and the objective or company profit is IDR310,353,195.51 (more detail in Table 7). With profit calculation, a comparison between GFA DC, alternative DC, and existing DC can be seen as follows in Table 8.

Table 7. Overall Stats (Ex. DC)

Supply Cost	IDR832,065,000
Revenue	IDR1,500,330,000
Transportation Cost	IDR7,911,844.49
Other Cost	IDR349,999,960
Objective (Profit)	IDR310,353,195.51

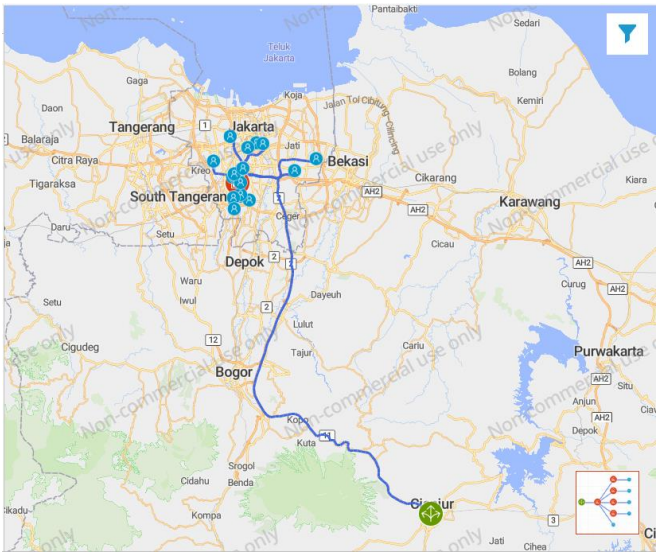

Figure 8. NO Experiment Results (Alt. DC)

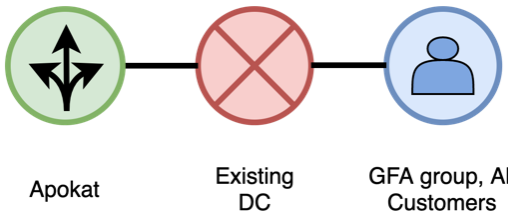

Figure 9. Network Distribution (Alt. DC)

Table 8 shows the comparison between each option in terms of the related cost and profit generated. Based on the NO experiment that has been carried out on the three facilities at different

locations, there are quite different results in the profit among them, where GFA DC with a profit of IDR560,284,948.803 per year, whereas alternative DC with a profit of IDR532,703,611,339 per year, and existing DC with a profit of only IDR310,353,195.51 per year. Then when viewed based on the comparison of profit between alternative DC and existing DC, and profit between GFA DC and existing DC, GFA DC produces a higher percentage, which is 80.53%, higher than alternative DC which is only 71.64%.

Table 8. *Comparison Results of Existing DC, Alternative DC, and GFA DC*

In IDR	Existing DC	Alternative DC	GFA DC
Other Cost Facility/Day	958,904	342,465	273,973
Other Cost Facility/Year	349,999,960	124,999,725	100,000,145
Transportation Cost	7,911,844.49	10,561,663.661	7,979,906.297
Profit	310,353,195.51	532,703,611.339	560,284,948.803
Profit (%)	N/A	71.64 %	80.53 %

Based on Table 9, in term of total distance, the existing DC gives the best shortest distance 1,237.8 km, then followed by GFA DC with the total distance 1,258.7 km, and the least result is alternative DC that give total distance 3,055.3 km. The distance is correlate with transportation cost but in this case, we can see that the transportation cost is cheaper that other facility cost therefore the transportation cost is less significant in contributing the total profit.

Table 9. *Comparison Results of Existing, Alternative, and GFA DC*

	Existing DC	Alternative DC	GFA DC
Total Distance (km)	1,237.8	3,055.3	1,258.7

This difference among alternatives may occur due to the big difference in fixed cost facilities to be paid every day because the existing DC is located in the North Cipete area, South Jakarta with a fairly high annual rental fee, while the alternative DC is located in the satellite area of Karawang, West Java, and GFA DC is located in the West Pejaten area, South Jakarta which has a lower annual rental fee too. It can be seen from the comparison of the total distance traveled in a year that alternative DC has the highest distance compared to GFA DC and existing DC. Therefore, there is a variance in transportation costs where the existing DC is lower than the alternative DC and GFA DC therefore the transportation cost becomes a trade-off among all alternatives: the existing DC, alternative DC, and GFA DC. However, we should keep in mind that the difference is within 1 year of operation so the trade-off does not have much effect on the company's overall profit, considering the difference in profit between GFA DC is almost 2 times the profit of existing DC and is also higher than the alternative DC.

The results of this study indicate a DC GFA scenario of 80.53% in the observed object's supply chain network. The process of creating a supply chain network utilizing Ivanov's [7] network design concept begins with determining the location of one of the facilities involved in the supply chain network, in this case the Distribution Center. In this study, the Green Field Analysis used to determine DC can provide location proposal results that account for consumer distance, consumer demand, and supplier distance. The results of calculating the total distance to the current Distribution center location, however, are marginally closer than those of the proposed Green Field Analysis. Therefore, the total transportation cost provided by the scenario with the current location of the DC is marginally lower. However, according to Ivanov's [7] theory regarding network design, the costs considered include not only transportation costs but also facility costs. In this study, facility costs have a much greater value than transportation costs, so this value becomes more significant when

developing supply chain networks. In this study, the company can also consider this further in the future development of its supply chain network.

5. CONCLUSION

Through this study, the selected DC location points for PT Asagri Selaras Asia were obtained using the GFA method, specifically the GFA DC of Anylogistix software. The location point for GFA DC is at latitude -6.2729150574 and longitude 106.8230798418 or located in West Pejaten, South Jakarta, Indonesia. Based on the NO results that have been carried out, information is attained that the location of GFA DC is considered feasible. This is because the location already has a clear and accessible distribution channel. In addition, based on the increase in profits generated, the GFA DC location has the largest increase in profit with a value of 80.53% when compared to the existing DC location. This value is more attractive than the percentage increase in the profit of choosing

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