# Development Strategy for the Master Plan of Maize Commodities Supply Chain Network Infrastructure in Madura, Indonesia

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Abstract: The problems faced by maize farmers in Madura are (1) Poor handling of maize post-harvest; (2) Transportation operating costs are expensive; (3) Delay in delivery time. All of these problems can be resolved using the Food Supply Chain Network (FSCN) method. Therefore, it is necessary to develop the FSCN model for maize harvest in Madura. Supply chain performance is measured to determine how optimal marketing activities are carried out by members of the supply chain. The Food Supply Chain Network consists of four elements, which include Network Structure, Chain Business Processes, Chain Management and Chain Resources. This study aims to develop the distribution model for the maize supply chain in Madura, East-Java using the FSCN framework, developing the performance model for the maize supply chain network in Madura. The results can be used as a recommendation to develop an optimal maize supply chain master plan in Madura. The development of a maize supply chain model can be assessed using the FSCN framework which consists of supply chain targets, supply chain structures, supply chain management, supply chain resources, supply chain business processes, and supply chain performance. Meanwhile, the optimization model is solved using the Greenfield Analysis method.

## 1 INTRODUCTION

The logistics of the food supply chain plays an important role in the continuity of business performance in the food sector. After several periods, the food business sector prioritizing responsiveness, they now experience vulnerability to supply chain threats (Bloemhof et al., 2015). The food supply chain network is a framework and tool for the food sector to take steps to change its operational practices. The food supply chain network provides a clear and concise overview of the current state of performance indicators for the food sector in corporate sustainability strategies, supply chain reformulation strategies currently applied in practice for continuous improvement(Sembiring Meliala et al., 2019).

The food product industry still focuses on delivery time to consumers, high quality products and low production costs(Banasik et al., 2017). In order to remain competitive, FSCN is expected to be able to adopt new technologies that can improve the performance of food product companies. Performance improvement can be started with a quantitative assessment of economic, selection of alternative technologies, production options, and environmental benefits(Ferreira and Arantes, 2015). Meanwhile, the adoption of new technology is expected to increase performance levels and facilitate managerial decision making.

The agribusiness sector plays an important role in the national economy, being one of the main contributors to Gross Domestic Product (GDP) in many developing countries including Indonesia, even the share contribution of this sector in GDP reaches as much as 50%(Wajszczuk, 2016). In contrast to the other economic sectors, apart from the need for efficient logistics, food distribution must ensure safe delivery of food to end consumers(Akhmad et al., 2019). In addition, the transportation of food products, especially agricultural products, requires



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the application of a special logistics infrastructure. To overcome this problem, it is necessary to develop a distribution system or special logistics for maize crop commodity. This distribution network system is commonly called the Food Supply Chain Network. It is hoped that the Food Supply Chain Network specifically for maize crop can increase National Gross Domestic Product.

## 2 ACTUAL CONDITIONS OF MAIZE FARMING IN MADURA

An initial survey of maize farming in Madura revealed that maize farmers in Madura had several problems: Harvested maize cannot be sold to the maize processing mill because it does not meet the requirements for the quality of moisture content and levels of afla toxin. The feed processing mill also demands sustainable large quantities while maize production in Madura is only twice a year. Other problems faced by maize farmers in Madura are (1) Low human resource or farmer skills; (2) Low quality of maize seeds; (2) Low productivity; (3) The quantity of maize shipments not as expected; (4) Inadequate agricultural equipment; (5) Poor handling of maize post-harvest; (6) Transportation operating costs are expensive; (7) Unclear payment system (8) Delay in delivery.

The description above indicates the maize supply chain operation in Madura was poor. It is necessary to improve the supply chain in its implementation so that the marketing supply chain is more optimal in delivering products from producers to consumers(Dellino et al., 2015), as well as consumers more easily to get products from producers. Madurese maize must have high competitiveness in order to compete with imported maize. Competitiveness is influenced by the effectiveness and efficiency of supply chain performance(Berti and Mulligan, 2016). So it can be concluded that the supply chain plays an important role in winning the market competition for agricultural products(Akhmad et al., 2020) and (Winarso and Rohim, 2019). To win market competition, it is necessary to optimize distribution channels in the supply chain and added value to institutions related to corn marketing. Therefore, research on the development strategy of a Food Supply Chain Network Model for optimizing Madura maize distribution channels by using the metaheuristic method is necessary.

## 3 RESEARCH PROBLEMS AND THE OBJECTIVES

The problems faced in developing the Madura maize business are as follows: (a) How is the mid-range master plan for the Madura maize business? (b) How to prepare supporting facilities, especially facilities for the distribution of maize, from farmers to consumers?

Table 1: The farmer’s location data snippets.

| No | Farmer | Coordinate | | Village | Sub-District | District |
|---|---|---|---|---|---|---|
| | | Latitude | Longitude | | | |
| 1 | Tunas Muda | -6.951992 | 112.847800 | Arosbaya | Arosbaya | Bangkalan |
| 2 | Renggujeng Tani | -6.949366 | 112.837712 | Arosbaya | Arosbaya | Bangkalan |
| 3 | Omber Ramah Luhur Manis | -6.979578 | 112.831809 | Balung | Arosbaya | Bangkalan |
| 4 | Makmur I | -7.003364 | 112.848950 | Batonaong | Arosbaya | Bangkalan |
| 5 | Makmur II | -7.007311 | 112.854367 | Batonaong | Arosbaya | Bangkalan |
| 6 | Makmur III | -7.015500 | 112.856059 | Batonaong | Arosbaya | Bangkalan |
| 7 | Makmur IV | -7.000672 | 112.847046 | Batonaong | Arosbaya | Bangkalan |
| 8 | Tani Sejahtera | -7.003527 | 112.858652 | Batonaong | Arosbaya | Bangkalan |
| 9 | Gerbung | -7.005282 | 112.851820 | Batonaong | Arosbaya | Bangkalan |
| 10 | Berbeluk Timur | -6.964212 | 112.852019 | Berbeluk | Arosbaya | Bangkalan |
| 11 | Pancor Emas | -6.957035 | 112.863154 | Berbeluk | Arosbaya | Bangkalan |
| … | … | … | … | … | … | … |
| … | … | … | … | … | … | … |
| … | … | … | … | … | … | … |
| 1628 | Cinta Damai Nonggunong | -7.116775 | 113.886881 | Tanjung | Pragaan | Sumenep |
| 1629 | Indah Jaya Tanjung | -7.126045 | 113.890709 | Tanjung | Pragaan | Sumenep |
| 1630 | Sekar Wangi Tanjung | -7.128898 | 113.890878 | Tanjung | Pragaan | Sumenep |
| 1631 | Karya Usaha Nonggunong | -7.120453 | 113.882070 | Tanjung | Pragaan | Sumenep |

The general objectives of this study are to prepare a master plan for the Madura maize business 2020-2030, while the specific objectives are: (1) Develop a Madura maize Supply Chain Network model. (2) Determine the location of the Aggregation warehouse in the Madura maize distribution line. (3) Determine the minimum distribution channel for Madura maize.

# 4 RELATED WORK

Supply Chain Management (SCM) has been part of the corporate management agenda since the 1990s, especially in the retail industries and manufacturing(Chopra and Meindl, 2013). More recently, interest in SCM has also grown in the agri-food industry, in developed and developing countries(Bustos et al., 2017). Bloemhof et al., (2015) and Banasik et al., (2017) state that agrifood company executives realize that the successful coordination, integration, and management of key business processes in the supply chain network will determine the success of their market competitiveness. Sustainable Food Supply Chain Management (SFSCM) refers to all forward processes in the food chain, such as material procurement, production and distribution, as well as reverse processes for collecting and reprocessing used and unused products.

Parallel or sequential processes can occur simultaneously in the food supply chain so that more than one business process in the food supply chain network can be identified(Cruz and Rosado da Cruz, 2019). For example, the business process of maize for animal feed is channeled from farmers to various parties such as middleman traders and then forwarded to the final consumer. In the flow process, the supply chain members involved carry out the business process as needed. Suppose a middleman trader carries out a different process with regard to maize being sent to the livestock industry and maize to be sent to the food industry.

The diversity of supply chain structures can be analyzed qualitatively, including in analyzing the resulting performance. Qualitative supply chain performance analysis needs to be supported by quantitative performance measures in order to produce more measurable and objective performance results. As an integrated process between members who are joined, supply chain performance measurement needs to use a certain approach. Supply chain performance is defined as the break event point between consumers and stakeholders where both requirements have been met with the relevance of the attributes of performance indicators over time. Increasing the added value of primary agricultural commodities is one step in order to increase farmers' income, especially in rural areas(Desiana and Aprianingsih, 2018).

A supply chain that is incorporated in a complex network is called the Food Supply Chain Network. To analyze a complex supply chain, a term that can describe the supply chain, the parties involved, the process, the product, the resources, management, the relationship between attributes and other things is defined. Network and chain management is the coordination of the network management structure that facilitates related institutions in the supply chain to make decisions using chain resources so that the objectives of FSCN can be achieved(Taghikhah et al., 2020).

Asmarantaka et al., (2018) stated that the characteristics of agricultural products are broadly large volume, take up large space, and perishable. It can be concluded that the characteristics of agricultural supply chains in particular are: perishable products; short shelf life of products; production depending on the season, harvest and famine; long production time; need storage handlers; the quality and quantity of production is affected by weather and season, plant diseases and pests; and consumer demand for food safety(Xue et al., 2019). Characteristics like these need special handling in Supply Chain Management (Dou et al., 2020).

# 5 RESEARCH METHODS

Supply chain management for agricultural products represents the management of the entire production process from plantation, processing activities, to distribution, marketing, until the desired product reaches consumers. Agricultural supply chain management is different, more complex, probalistic and dynamic compared to non-agricultural supply chain management. The differences are in the characteristics of perishable agricultural products and varying product sizes, production processes that depend on seasons and climate, and changes in consumer behavior towards food safety.

As a description of the supply chain scheme, each actor is in the network layer that has at least one supply chain. Each supply chain usually has suppliers and consumers at the same time and at different times. Other actors in the network affect the performance of the supply chain. Each actor may enforce different rules in different chains and cooperate with different chains which may become competitors in other chains. Therefore, a supply chain analysis that is evaluated in the context of a complex network in the food supply chain is called the Food Supply Chain Network (FSCN).

## 5.1 Research Time and Location

The research begins by identifying how the Madurese maize distribution channels flow, through in-depth interviews with the farmers and the stakeholders involved in the Madura maize distribution channel. The research was conducted in 4 Districts in Madura, namely: Bangkalan, Sampang, Sumenep and Pamekasan. The research was carried out in May - December 2020. All the required data and information are obtained through the following steps:

- Observation, making direct observations of the socio-economic conditions of the community and maize farmer groups. So that we get an overview of the patterns of life of the maize farming community.
- Interviews, conducting a series of in-depth interviews with key informants. Interview activities were carried out in depth by adhering to the guidelines so that the information obtained was focused on the research focus. The interview activity was carried out in a friendly atmosphere in order to obtain in-depth information.
- Focus Group Discussion, conduct a series of discussions with related stakeholders, including the local community, corn farmers, local governments. This method was effective in obtaining an overview of the problems faced and leading to the formation of the Madura FSCN model.

Table 2: The grouping location center of maize farmers.

| District | Sub-District | Coordinate | |
|---|---|---|---|
| | | Latitude | Longitude |
| Bangkalan | Arosbaya | -6,980555 | 112,847817 |
| | Bangkalan | -7,020299 | 112,749148 |
| | Blega | -7,136924 | 113,035548 |
| | Burneh | -7,021733 | 112,819757 |
| | Galis | -7,085200 | 112,956128 |
| | Kamal | -7,133042 | 112,727939 |
| | Klampis | -6,929446 | 112,853194 |
| | Kokop | -6,974531 | 113,042999 |
| | Konang | -7,048266 | 113,063518 |
| | Labang | -7,146231 | 112,815210 |
| | Modung | -7,161283 | 112,989492 |
| | Sepulu | -6,918702 | 112,976240 |
| | Socah | -7,080662 | 112,715850 |
| | Tanah Merah | -7,063186 | 112,877926 |
| | Tanjungbumi | -6,902865 | 113,078371 |
| | Tragah | -7,094972 | 112,827788 |
| Sampang | Sampang | -7,203033 | 113,240466 |
| | Camplong | -7,187072 | 113,342021 |
| | Omben | -7,107241 | 113,340859 |
| | Karang Penang | -7,028188 | 113,345422 |
| | Torjun | -7,160078 | 113,205537 |
| | Pangarengan | -7,203075 | 113,191925 |
| | Jrengik | -7,117839 | 113,140954 |
| | Sreseh | -7,213517 | 113,096182 |
| | Tambelangan | -7,038848 | 113,161989 |
| | Kedungdung | -7,073639 | 113,228110 |
| | Robatal | -6,996763 | 113,298816 |
| | Ketapang | -6,918296 | 113,298476 |
| | Banyuates | -6,912160 | 113,176141 |
| | Sokobanah | -6,917964 | 113,427267 |
| Pamekasan | Kadur | -7,086042 | 113,568466 |
| | Palengaan | -7,083073 | 113,458160 |
| | Pagantenan | -7,042138 | 113,473011 |
| | Pakong | -7,042297 | 113,569862 |
| | Proppo | -7,133964 | 113,416850 |
| | Pademawu | -7,188069 | 113,508544 |
| | Pasean | -6,919443 | 113,589822 |
| | Pamekasan | -7,153247 | 113,467242 |
| | Galis | -7,144900 | 113,537533 |
| | Larangan | -7,119570 | 113,560821 |
| | Batumarmar | -6,945935 | 113,494126 |
| | Tlanakan | -7,188081 | 113,440215 |
| | Waru | -6,963174 | 113,560993 |
| Sumenep | Ambunten | -6,910381 | 113,769384 |
| | Batang-batang | -6,960218 | 114,018546 |
| | Batuan | -7,019821 | 113,811711 |
| | Batuputih | -6,902189 | 113,905390 |
| | Bluto | -7,098494 | 113,788739 |
| | Dungkek | -6,985624 | 114,057068 |
| | Ganding | -7,062776 | 113,705115 |
| | Gapura | -6,996853 | 113,945768 |
| | Guluk-guluk | -7,028275 | 113,616856 |
| | Sumenep | -7,019545 | 113,857827 |
| | Lenteng | -7,039805 | 113,744712 |
| | Manding | -6,958953 | 113,879039 |
| | Pasongsongan | -6,983611 | 113,697441 |
| | Pragaan | -7,096747 | 113,721167 |

## 5.2 Mapping the Location of Farmers and Farmers Grouping

We obtained the initial data for maize farmers from the Government of the Food Crops, Horticulture and Plantation Service. Then, we completed data on maize farmer land area, farmer annual production tonnage, geotagging location for each farmer, by site visiting each corn farmer's location. The total number of farmer groups was 1631 farmer groups. A total of 1631 farmer groups are the research objects discussed in this study. Mapping data snippets are shown in table 1.

Farmer grouping designs to facilitate the supply chain structure. Grouping is done to select a communal warehouse point that represents farmer groups in each village. Grouping uses the Center of Gravity method. The data required for grouping are: (1) The volume of maize transported from the point of the farmer group to the communal warehouse. (2) Transportation costs. (3) Coordinate of maize farmer and communal warehouse points. The calculation of location coordinates uses the following equation(Uitenbroek, 2003):

- The coordinates of the selected communal warehouse location.

$$x = \frac{\sum_i V_i X_i C_i}{\sum_i V_i C_i} \; ; \; y = \frac{\sum_i V_i Y_i C_i}{\sum_i V_i C_i} \qquad (1)$$

- The distance between maize farmers location to the candidate communal warehouse location.

$$Dn = \Sigma\sqrt{(x - X_i)^2 + (y - Y_i)^2} \qquad (2)$$

- The transport cost for maize aggregation

$$\mathrm{TC} = \sum_{n=1}^{k} V_i D_n C_i \qquad (3)$$

where:

$x$ = latitude of the selected location as the communal warehouse.

$y$ = longitude of the selected location as the communal warehouse.

$i$ = index of maize farmer members.

$n$ = iteration index

$X_i$ = latitude of the i^th^ maize farmer.

$Y_i$ = longitude of the $i^{th}$ maize farmer.

$V_i$ = Tonnage of the $i^{th}$ farmers' maize production.

$C_i$ = Transportation rate of location I

$D_n$ = Distance of the $i^{th}$ farmer member to the selected communal warehouse location in $n^{th}$ iteration.

TC = Total cost.

## 5.3 Determining the Location Point of Aggregation Warehouse

The location point of aggregation warehouse is determined using the Greenfield Analysis method, then corrected using the Network Optimization method. The data required for the Greenfield Analysis method are:

- The coordinates of the farmer groups
- Maize crop tonnage for each farmer group
- The number of aggregation warehouses required

After obtaining the location of the aggregation warehouse placement using the Greenfield Analysis method, it is continued to improve the coordinate points using the Network Optimization method. This method is conducted by adding alternative aggregation warehouses as a comparison to the initial warehouse location, as well as additional maize processing mill location data to be able to run this method.

Table 3: The moving average forecast table for maize production.

| Periode | Year | Maize Production (Ton/year) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Bangkalan | Sampang | Pamekasan | Sumenep | Total | Forecast |
| 1 | 2007 | 140,984 | 141,679 | 76,339 | 298,880 | 657,882 | |
| 2 | 2008 | 148,463 | 176,095 | 92,443 | 314,855 | 731,856 | |
| 3 | 2009 | 151,933 | 116,462 | 114,856 | 353,022 | 736,273 | |
| 4 | 2010 | 159,748 | 120,285 | 110,494 | 529,258 | 919,785 | 761,449 |
| 5 | 2011 | 174,455 | 113,265 | 147,192 | 310,056 | 744,968 | 783,221 |
| 6 | 2012 | 120,993 | 161,738 | 150,308 | 420,795 | 853,834 | 813,715 |
| 7 | 2013 | 127,527 | 108,645 | 95,338 | 359,689 | 691,199 | 802,447 |
| 8 | 2014 | 136,712 | 95,332 | 113,245 | 324,330 | 669,619 | 739,905 |
| 9 | 2015 | 132,884 | 98,332 | 93,793 | 396,067 | 721,076 | 733,932 |
| 10 | 2016 | 144,752 | 124,145 | 135,993 | 339,254 | 744,144 | 706,510 |
| 11 | 2017 | 132,586 | 149,219 | 187,672 | 325,384 | 794,861 | 732,425 |
| 12 | 2018 | | | | | | 748,127 |
| 13 | 2019 | | | | | | 754,889 |
| 14 | 2020 | | | | | | 757,575 |
| 15 | 2021 | | | | | | 748,254 |
| 16 | 2022 | | | | | | 752,249 |

# 6 RESULTS AND DISCUSSION

The harvest of Madura maize by farmer groups is usually sold to middlemen, farmers do not get a price deal from the company but rather from the middleman. The middlemen offer prices ranging from 3000 to 3500 IDR / kg for whole corn and IDR. 4000 - Rp. 4200 / kg for shelled corn. Middlemen sell corn to producers in the form of shelled corn for around 5000 to 5500 IDR / kg. Farmers sell to middlemen, because they give cash in cash.

## 6.1 Data on Maize Farmers in Madura

After conducting interviews with the Government of the Food Crops, Horticulture and Plantation Service in each four District. Data were obtained consisting of farmer groups, cultivated land area and annual production crop. The total number of farmer groups was 1631 farmer groups.

## 6.2 Maize Farmer Grouping

We conducted site surveys in determining the point of the maize farmer groups and recapitulated the latitude and longitude coordinate data of each farmer group. The determination of the coordinates of each farmer group is conducted with the Google Maps application on a Smartphone device. This data is needed in the calculation of the Center of Gravity using a mathematical model (1-3). The grouping results of maize farmers can be seen in table 2.

## 6.3 Forecast of Maize Production

The maize production data that we have obtained was only up to 2017. Meanwhile, the construction and the use of aggregated warehouses is projected for 2022. Therefore, forecasts of maize production are carried out until 2022. Forecasts are carried out using the 4-period moving average method. The moving average forecast table for maize production is shown in Table 3. Based on the specified warehouse capacity and maize corp, we set the warehouse capacity to be 200,000 tons/warehouse. Based on forecasting in 2022 of 752,249 tons/year with a warehouse capacity of 200,000 tons, it can be determined that 4 aggregation warehouses will be needed.

## 6.4 Location Point of Aggregation Warehouse

Based on the GFA method using Anylogistix software, the coordinates of each aggregation warehouse were found, along with the coverage area of the maize farmer groups. A summary of the aggregation warehouse contained in the table 4. Based on the forecast that has been done, it is estimated that in 2022 the Madura maize corp will be 752,249 tons/year. It has been determined the number of warehouses of 4 with a capacity of 200 tons each. After determining the number of aggregation warehouses and the center point of farmers in 57 farmer groups, then the next step is to determine the coordinates of the aggregation warehouse. Here we use Anylogistix software with the Greenfield Analysis (GFA) method. A summary of the aggregation warehouse contained in the table 4 and figure 1.

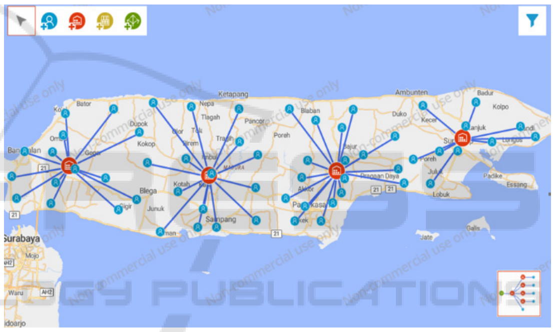

Figure 1: The location of each aggregation warehouse and the coverage area.

Table 4: The coordinates of each aggregation warehouse and the coverage area.

| Aggregation Warehouse | Latitude | Longitude | Warehouse Coverage |
|---|---|---|---|
| GFA DC 1 | -7,055735 | 112,862790 | Blega |
| | | | Tragah |
| | | | Arosbaya |
| | | | Tanah Merah |
| | | | Sepulu |
| | | | Kamal |
| | | | Labang |
| | | | Bangkalan |
| | | | Burneh |
| | | | Galis |
| | | | Klampis |
| | | | Kokop |
| | | | Socah |
| | | | Modung |
| GFA DC 2 | -6,989219 | 113,870459 | Batuan |
| | | | Sumenep |
| | | | Ambunten |

| Aggregation Warehouse | Latitude | Longitude | Warehouse Coverage |
|---|---|---|---|
| | | | Batang-batang |
| | | | Gapura |
| | | | Lenteng |
| | | | Manding |
| | | | Dungkek |
| | | | Bluto |
| | | | Batuputih |
| GFA DC 3 | -7,078855 | 113,220558 | Banyuates |
| | | | Tambelangan |
| | | | Robatal |
| | | | Tanjungbumi |
| | | | Omben |
| | | | Karang Penang |
| | | | Camplong |
| | | | Kedungdung |
| | | | Pangarengan |
| | | | Jrengik |
| | | | Konang |
| | | | Sampang |
| | | | Torjun |
| | | | Sreseh |
| | | | Ketapang |
| GFA DC 4 | -7,068322 | 113,548234 | Galis |
| | | | Ganding |
| | | | Waru |
| | | | Sokobanah |
| | | | Guluk-guluk |
| | | | Batumarmar |
| | | | Proppo |
| | | | Pasean |
| | | | Pagantenan |
| | | | Pasongsongan |
| | | | Tlanakan |
| | | | Palengaan |
| | | | Pamekasan |
| | | | Pakong |
| | | | Pademawu |
| | | | Larangan |
| | | | Pragaan |
| | | | Kadur |

## 6.5 Correction of Aggregation Warehouse Location

The GFA method provides coordinate location for aggregation warehouses along with the coverage of farmer groups, where the resulting coordinate was the optimal point based on maize crop tonnage and the distance between aggregation warehouse coordinates to farmer groups. The calculated distance was the euclidian distance between coordinates, not based on the actual distance. Therefore it is necessary to improve using the Network Optimization (NO) method using the same software, Anylogistix.

Improvement is done by providing alternative warehouse points which are then compared with warehouse points generated by the GFA method. The NO method requires the coordinates of the maize processing mill as the final destination for the maize to be distributed. We set the maize processing mill PT. Charoen Pokphand Indonesia Tbk. In improving the placement of aggregation warehouse points with the NO method, we set 3 alternative warehouses for each initial warehouse as a comparison to the determination of 4 warehouses.

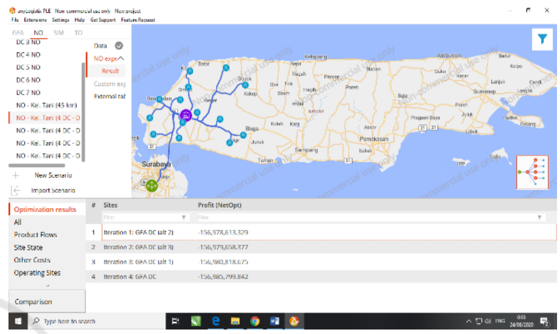

Figure 2: The location of GFA DC1 (alt2) aggregation warehouse and the coverage area.

The coordinates of the GFA DC 1 warehouse were obtained by the GFA method at -7.056, 112.863. As candidates, alternative warehouse 1 was assigned at coordinates -7.084, 112.876; alternative warehouse 2 at coordinates -7.073, 112.84; alternative warehouse 3 at coordinates -7.079, 112.855. The results of the NO method show that the best warehouse location is in alternative warehouse 2, namely GFA DC 1 (alt 2) at the coordinate point -7.073, 112.84. The warehouse location on the map can be seen in the figure 2.

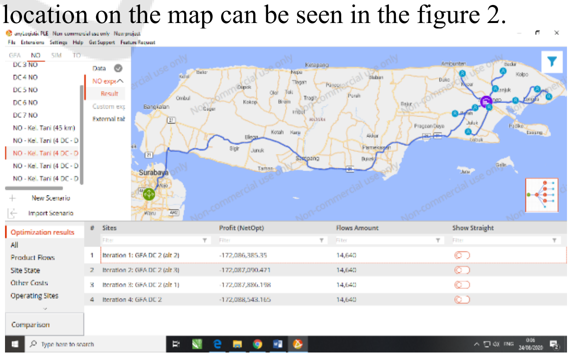

Figure 3: The location of GFA DC2 (alt2) aggregation warehouse and the coverage area.

The coordinates of the GFA DC 2 warehouse were obtained by the GFA method at -6.989, 113.87. As candidates, alternative warehouse 1 was assigned at coordinates -7.001, 113.871; alternative warehouse 2 at coordinates -7.003, 113.849; alternative warehouse 3 at coordinates -7.013, 113.859. The results of the NO method show that the best warehouse location is in alternative warehouse 2, namely GFA DC 2 (alt 2) at the coordinate point -7.003, 113.849. The warehouse location on the map can be seen in the figure 3.

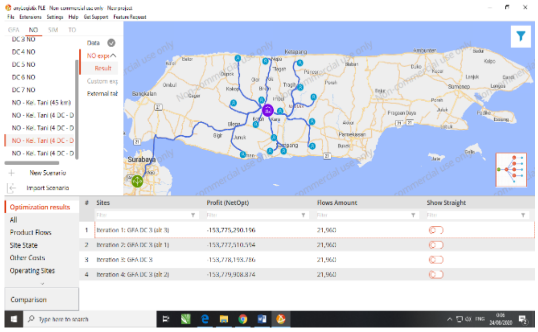

Figure 4: The location of GFA DC3 (alt3) aggregation warehouse and the coverage area.

The coordinates of the GFA DC 3 warehouse were obtained by the GFA method at -7.079, 113.221. As candidates, alternative warehouse 1 was assigned at coordinates -7.08, 113.208; alternative warehouse 2 at coordinates -7.09, 113.253; alternative warehouse 3 at coordinates -7.072, 113.184. The results of the NO method show that the best warehouse location is in alternative warehouse 3, namely GFA DC 3 (alt 3) at the coordinate point -7.072, 113.184. The warehouse location on the map can be seen in the figure 4.

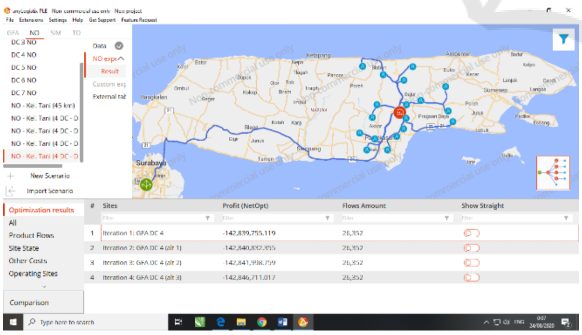

Figure 5: The location of GFA DC4 aggregation warehouse and the coverage area

The coordinates of the GFA DC 4 warehouse were obtained by the GFA method at -7.068, 113.548. As candidates, alternative warehouse 1 was assigned at coordinates -7.045, 113.59; alternative warehouse 2 at coordinates -7.046, 113.57; alternative warehouse 3 at coordinates -7.045, 113.59. The results of the NO method show that the best warehouse location is in initial GFA DC 4 warehouse at the coordinate point -7.068, 113.548. The warehouse location on the map can be seen in the figure 5.

# 7 CONCLUSION AND THE FUTURE WORK

It has been determined the coordinates of the aggregation warehouse using the GFA method and corrections to find the optimal point using the NO method. Based on the calculation using these two methods, the coordinates of the proposed aggregation warehouse locations are obtained. Following in table 5 and figure 6, a summary of the coordinates location of aggregation warehouse. The location of the aggregation warehouse is located in the highlands. In fact, this location makes transportation difficult. Further research can be carried out by adding priority constraints for coastal areas for the location of aggregation warehouses.

Table 5: The coordinates of the proposed aggregation warehouse locations.

| Aggregation Warehouse | Coordinate Location | |
|---|---|---|
| | Latitude | longitude |
| GFA DC1 (alt2) | -7.073 | 112.840 |
| GFA DC2 (alt2) | -7.003 | 113.846 |
| GFA DC3 (alt3) | -7.072 | 113.184 |
| GFA DC4 | -7.068 | 113.548 |

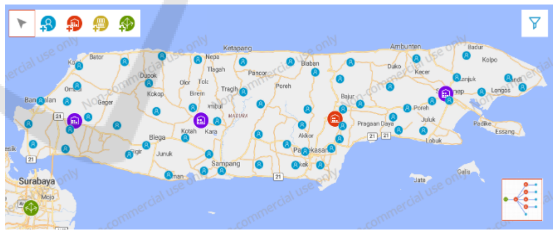

Figure 6: The coordinates of the proposed aggregation warehouse locations.

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