International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2015): 6.391

Optimum Warehouse Location Determination in Humanitarian Supply Chain : A Case study of BNPB Indonesia

Christine Natalia[1], Wibawa Prasetya[2], Melina[3]

[1]Industrial Engineering Department, Faculty of Engineering, Atma Jaya Catholic University of Indonesia, Jakarta

[2] Industrial Engineering Department, Faculty of Engineering, Atma Jaya Catholic University of Indonesia, Jakarta

[3] Industrial Engineering Department, Faculty of Engineering, Atma Jaya Catholic University of Indonesia, Jakarta

Abstract: ***Humanitarian Supply Chain is a term used in describing the process to get relief goods from the origin to the recipient at the right time. In Indonesia, BNPB is one of the Governmental non departments that has a duty to assist the President in: coordinating the planning and implementation of activities related to disaster management and emergency, ranging from before, at the time, and also at the time after the occurrence of the disaster which covers prevention, emergency preparedness, response, and recovery also. The use of warehouse for storing relief items has been proven to improve efficiency, effectiveness and responsiveness while decreasing the cost incurred in the process. This research aimed to determine the optimal warehouse location by using the Center of gravity method with the considered alternative location are Palangkaraya, Banjarmasin, and Surabaya. The best results is in the area of Palangkaraya with minimum value of amounting to IDR 1,133,371,000.00. Meanwhile, the development of the model will use the ProModel software to be used in determining the alternative design tests before being implemented. The results of Promodel proved that Palangkaraya is the best alternative to minimize the time distribution of disaster relief goods.***

Keywords: Humanitarian Supply Chain, warehouse location, Centre of Gravity, Promodel

1. Introduction

Indonesia is the largest archipelago, with more than 17.500 island that scattered between 6^o north latitude to 11^o south latitude and from 9^o to 141^o east longitude. Indonesia ranks 12th among countries having relatively high mortality risk from multiple hazards. It is situated in one of the most active disaster hot spots where several type of disasters such as earthquake, tsunami, volcanic eruption, flood, landslide, and drought and forest fires frequently occur. According to a global risk analysis by the World Bank, Indonesia is among the top 35 countries that have high mortality risks from multiple hazards with about 40% population living in risk areas. For a country that has more than 230 million population, this percentage gives a very large nominal number of more than 90 million population potentially at risk creating a major humanitarian catastrophe incase large disaster occur. Data from the United Nations International Strategy for Disaster Reduction (UN-ISDR) mentions that in terms of human exposure, or the number of people present in hazard zones that may lose their lives due to a hazard event, Indonesia ranks 1st out of 265 countries ranked for tsunami hazard, with 5.402.239 people exposed; ranks 1st out of 162 countries for landslide, with 197.372 people exposed; rank 3rd out of 153 countries for earthquake, with 11.056.806 people exposed; rank 6th out of 162 countries for flood, with 1.101.507 people exposed; rank 36th out of 184 countries for drought, with 2.029.350 people exposed. (nidm.gov.in, 2014).

Using and holding responsibility of domestic and international donation are a part of National Disaster Management Agency (BNPB) duties. Both of BNPB and BPBD have also their own warehouse to save logistic and equipment. But all of them mostly are rented warehouse. According to Kovacs and Spens (2007), at this time IFRC (International Federation of Red Cross) the supply network should be able to provide assistance to 5000 families within 5 days, 15000 families within 15 days, and all victims within 2 months. BNPB states that in logistics management, planning, accepting, warehousing, distributing, and transporting are required. Un optimal warehouse can swelling expenses and also inhibiting the distribution process.

BNPB classifies disaster relief levels into three types: emergency disaster relief, institutional strengthening assistance, and national disaster relief, in which the duration of distribution operation is within 3 days for emergency condition, within 1 month for institutional strengthening and within 5 until 7 days for the national disaster. The distribution of relief goods can be done by the flow from BNPB to BPBD, or from BNPB to the direct disaster victims. Distribution system from BNPB to BPBD itself at least will be done once a year or adjusted to existing conditions at that time. While for the carried out system from BNPB to the victims of disaster will be done through the third party.

Based on this background, warehouse optimization is seen as something that needs to be done. There are several ways that can be used to determine the best facility location such as Factor Rating Method, Center of Gravity Method, and Transportation Model. This paper used the Center of Gravity Method because it is a quantitative technique which is capable of determining the optimal location.

2. Literature Survey

Location problems have a fundamental strategic role on the configuration of a company's supply chain. They are also crucial for finding the optimal location of a set of facilities that minimize the cost of satisfying their markets (Hale & Moberg, 2003).

The Centre of Gravity method is a method of setting a single workshop or warehouse; the main consideration of this method is the distance between the existing facilities and traffic volume of goods, which are often used in the selection of intermediate warehouse or distribution warehouse (Wang, 2008). This method will find the optimal location to be the center of distribution which taking into account the location, the volume of delivered goods, as well as the transportation cost. (Haizer & Render, 2014)

According to Ballou (2004), discrete models are the most realistic, but also the most complex, location models. Therefore, this type of problem modelling has a widespread utilization in location decisions within a microscope context, where it's possible to solve highly complex problems with detailed approaches. In addition, the facility should be based on a series of assessments that represent the source point as well as the point of demand, the transported volume, as well as the associated transport costs, thus the volume at one point can be minimized by multiplying the transportation cost by distance point to obtain the minimum total cost.

The approach will begin by using the formula:

$$\bar{\bar{X}} = \frac{\sum_{i=1} V_i R_i X_i}{\sum_{i=1} V_i R_i} \quad (1)$$

$$\bar{\bar{Y}} = \frac{\sum_{i=1} V_i R_i Y_i}{\sum_{i=1} V_i R_i} \quad (2)$$

Where:

$\bar{X}$ = x – coordinates for the initial location of the facility
$\bar{Y}$ = y – coordinates for the initial location of the facility
V_i = the volume that sent to point - i
R_i = transport costs to send from (to) point - i
X_i = x – coordinates for point - i
Y_i = y – coordinates for point – i

$$d_i = K\sqrt{(X_i - \bar{X})^2 + (Y_i - \bar{Y})^2} \quad (3)$$

Where:

d_i = the distance between facility and warehouse at point - i
K = scale on the grid map
X_i = x – coordinates for point - i
Y_i = y – coordinates for point - i
$\bar{X}$ = x – coordinates for the initial location of the facility
$\bar{Y}$ = y – coordinates for the initial location of the facility

$$\bar{\bar{X}} = \frac{\sum_{i=1} V_i R_i X_i / d_i}{\sum_{i=1} V_i R_i / d_i} \quad (4)$$

$$\bar{\bar{Y}} = \frac{\sum_{i=1} V_i R_i Y_i / d_i}{\sum_{i=1} V_i R_i / d_i} \quad (5)$$

Where:

$\bar{X}$ = x – coordinates for the final location of the facility
$\bar{Y}$ = y – coordinates for the final location of the facility
V_i = the volume that sent to point - i
R_i = transport costs to send from (to) point - i
X_i = x – coordinates for point - i
Y_i = y – coordinates for point - i
d_i = distance between the facility and the warehouse at point – i

$$\min TC = \sum_{i=1} V_i R_i d_i \quad (6)$$

Where:

V_i = the volume that sent to point - i
R_i = transport costs to send from (to) point - i
d_i = distance between the facility and the warehouse at point – i

ProModel is a simulation and animation tool designed to model manufacturing system of all types, particulary supply chain systems (Harrel et al,2000) It allows quick and convenient selection of reports and provides automatic tabular and graphical reports on all system performance measures.

The modeling elements of ProModel provide the building blocks for representing the physical and logical components of the system being modeled. Physical elements of the system such as parts, machines, or resources may be referenced either graphically or by name.

a. *Location*

Routing locations are fixed places in the system (e.g. machines, queues, storage areas, work stations, tanks, etc.) to where parts or entities are routed for processing, storage or simply to make some decision about further routing. Routing locations may be either single unit locations (single machine) or multi-unit locations (a group of similar machines performing the same operation in parallel).

b. *Entities*

Entities refer to the items being processed in the system. These include raw material, piece parts, assemblies, loads, work in process, finished products, etc. Entities of the same type or of different types may be consolidated into a single entity, separated into two or more additional entities or converted to one or more new entity types.

c. *Arrivals*

Deterministic, conditional, or stochastic arrivals can be modeled using this element. External files including production schedules or arrival data can be read into ProModel in the Arrivals element. Built-in or user defined distributions or spreadsheet created data can be used to define inter arrival times and quantities.

d. *Processing*

This element defines the processing sequence and flow logic of entities between routing locations. The operation or service times at locations, resource requirements, processing logic, input/output relationship, routing conditions, and move times or requirements can be described using the Processing element.

e. *Path Networks*

Path networks are optional and define the possible paths that entities and resources may travel when moving through the system. Path networks consist of nodes connected by path segments and are defined graphically with simple mouse clicks. Multiple path networks may be defined and one or more resources and/or entities may share the same network. Movement along a path network may be defined in terms of distance and speed or by time. Path distances are automatically computed based on the layout scale defined by the user.

f. *Resources*

A resource may be a person, tool, vechile, or other object that may be used to transport material between routing locations, perform an operation on material at a location, and perform maintenance on a location or other resource that is down. Resources may be either static or assigned to a path network for dynamic movement. A special type of dynamic resource is a crane. Built-in decision rules can be used for allocation of resources and for prioritization of part pick-up and delivery. Motion characteristics of resources such as empty and full speeds, acceleration, deceleration, pickup and delivery time can also be specified.

3. Methodology

The determination of optimal warehouse location is done by using the factors that are used as the parameters. They are the volume of relief items to be moved, the coordinates of each BPBD, and also the cost of the distribution location. The determination of the alternative warehouse location is done by calculating the coordinates of the optimal location. The coordinates are obtained by using equation (1) until equation (5).

Equation (1) and equation (2) are used to estimate the initial center of the Centre of Gravity method by removing the distance (d_i). Equation (3) is done to calculate the distance (d_i). While the equations (4) and (5) are performed to determine the location of the facility. The optimal location is located on the coordinates (-3.592870,114.212060) which is on the Java Sea, thus it is necessary to draw alternative areas around the selected location centers, they are Palangkaraya, Banjarmasin, and Surabaya also. Then the chosen alternative location is done by developing the model of equation (6) with the addition of factors that have become the major requirements of the BNPB itself, which are the land price, the minimum wage of the worker in the alternative area, the cost of the truck and also the transfer cost from the current rental warehouse. Therefore the equation formed is:

$$Total\ cost = \sum_{i=1} V_i R_i + Ca + Ua + Pa + Ta \quad \text{........... (7)}$$

where :

V_i = the volume that sent to point i

R_i = the delivery cost to point i

Ca = land price at the alternative location

Ua = minimum wage in the alternative location

Pa = transfer cost from the current rental warehouse to the alternative location

Ta = trucking costs from alternative location to the near airports or ports

Meanwhile, the model development is done by using the help of ProModel Software by designing the actual model to compare with the proposed results. It’s done by using selected alternative warehouse and estimating demand method.

4. Result and Discussion

Currently, BNPB accommodates the entire existing relief goods by renting a warehouse to PT. Bhanda Ghara Reksa. Therefore, one of the long-term programs that will be implemented by BNPB is to build a fixed warehouse. Location strategy is an important factor to be considered. It is important because it helps in determining the place of warehouse. The place of warehouse needs to have certain qualities of features where warehousing process takes place hassle-free. The Centre of Gravity method is one such method which can determine the effectiveness of a location. This paper aims to determine the location of the warehouse construction without inhibiting the time distribution of relief goods to the BPBD warehouse. The overall cost that used in the calculation is the cost of delivery between BNPB-BPBD warehouses since the all delivery cost from supplier to BNPB warehouse are dependent by the supplier itself based on the previously agreements.

There are 3 alternative locations which is located near the coordinated that based on the calculation, they are Palangkaraya, Banjarmasin, and Surabaya. Table 1 shows the results of the calculations of the 3 alternatives.

Tabel 1 : Total minimum cost for each alternative location

Alternative	*Minimum cost*
Palangkaraya	IDR 1.133.371.000
Banjarmasin	IDR 7.036.813.000
Surabaya	IDR 7.524.952.220

Based on the calculation, the selected location for BNPB warehouse is Palangkaraya. However, the calculations that are performed based by the general and major requirements only. Hence it is needed to proved that the proposed location is better to fasten the relief goods delivery process. It is done using Promodel simulation software as shown in figure 1.

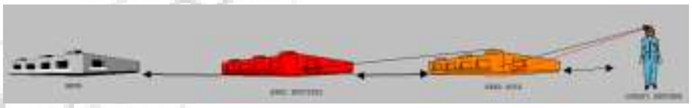

Figure 1: Simulation Model to improve delivery time of relief goods

The improvement model is done by estimating the number of request, so the distribution time of relief goods will become faster than using the actual system. The average of the utility has been significantly increased, althought there is an increased of the empty average but the difference does not have a significant impact to the distribution process that occurs. The results of improvement modeling can be seen in the following table.

Table 2: Performance comparison

Criteria	*Actual*	*Alternative*
Execution time	2.32 days	2.27 days
Average utility	5.82%	9.51%
Empty average	70.0425	72.73

5. Conclusion

The main purpose of this study was to find the optimal location for BNPB warehouse and to determine how to minimize the time distribution of the relief goods. The most optimal location for BNPB warehouse is done by using center of gravity method where the determinant variable is the cost and he volume of relief goods to determine the coordinate of the alternative location. The calculation results are located in the area of Palangkaraya with approximately 6 billion of differences which is obtained from the difference of land prices that are very deviant.

By changing the demand pattern of distribution from waiting for request to predict the amount of the relief goods, the process can be more accelerated. Moreover, the change of BNPB warehouse location proved to have a significant impact on the distribution process due to the delivery time, therefore the location of the proposed warehouse can be considered by BNPB.

References

[1] Ballou, R. H., Business Logistics/Supply Chain Management 5ed, Pearson PLC, 2004.
[2] Gov.in [Internet]. India : Country Profile – Indonesia. Available from: March 2014. [Online]. Available: http://nidm.gov.in/easindia2014/err/pdf/country_profile/Indonesia.pdf. [Accessed: May. 12, 2017]
[3] Hale, T., & Moberg, C.,"Location Science Research : A Review," Annals of Operations Research, 123(1), pp. 21-35, 2003.
[4] Harrel, C., Ghosh, Biman K., Bowden, R., Simulation Using ProModel. McGraw Hill, New York, 2000.
[5] Heizer, Render, Barry, Operation Management Sustainability and Suply Chain Management: 11th Edition, Pearson, 2014.
[6] Kovacs, G., Spens, K. M., "Humanitarian Logistics in Disaster Relief Operation. *International Journal Physics Distribution Logistic Management, 37*(2), 99-114, 2007.
[7] Wang, J., "Research and Application of Distribution Center Location Based on Center-of-Gravity Method." Journal of Yangtze University, pp. 36-39, 2008

Author Profile

Christine Natalia is a Lecturer in Department of Industrial Engineering, Faculty of Engineering, Atma Jaya Indonesia Catholic University. She was born on December 16, 1979. She graduated from Institut Teknologi Bandung and received her Magister Teknik (M.T) Degree with Honour. Her interest is mainly in System Modeling and Quality Improvement. Right now, she act as Head of Statistic Industry and Decision Support.

Wibawa Prasetya is a Lecturer in Department of Industrial Engineering, Faculty of Engineering, Atma Jaya Indonesia Catholic University. He was born on June 30, 1960 and received her Master of Science from School of Science Management in 1998. His research interest are in the area of Management and Human Resources.