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Simple Additive Weighting (SAW) Mathematics Method for Warehouse Disaster Location Selection In Central Jakarta, Indonesia

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Abstract :

DKI Jakarta has a five-year major flood cycle, where floods that occurred in Jakarta in 2007 is one of the largest flood ever recorded. One of the important activities in disaster management is logistics activities. Success or failure of a disaster management activity depends on the applied logistics management. One of the activities that can be done to improve disaster preparedness is by providing logistics warehouses as a means of saving aid. This research was conducted to determine the location of disaster emergency warehouse, using Simple Additive Weighting (SAW) method. The grouping is done per administrative city in DKI Jakarta province. There are 8 criteria and 19 sub-criteria used to determine disaster emergency warehouse location in four administrative cities in DKI Jakarta Province. By using Simple Additive Weighting (SAW) method, the best location of disaster emergency warehouse is Senen Area located in Central Jakarta.

Keywords: Simple Additive Weighting (SAW), Disaster Emergency Warehouse

Introduction

DKI Jakarta province has a five-year major flood cycle, where floods that occurred in Jakarta in 2007 is one of the largest flood ever recorded. Almost 60% of Jakarta area is flooded. In addition, the flood disaster in 2007 was the most deadly flood disaster, which amounted to 8 people died during the flood disaster, which then increased to 19 people after the disaster (BNPB, 2014). Increasing the number of casualties is caused by things that arise after the disaster, such as the emergence of disease outbreaks, famine, and delayed evacuation and distribution of assistance. Besides casualties, floods are also disadvantageous in some sectors. In addition to material losses, the flooding of office facilities, access roads, and educational facilities certainly disrupt economic and social activities in the Province of DKI Jakarta (BNPB, 2014; United Nations Development Program, 2007).

One of the important activities in disaster management is logistics activities. This is confirmed by (Ozdamar, et al., 2004), (Yuan and Wang, 2009), (Wassenhove, 2006). About 80% of disaster management activities are logistic activities. In dealing with disasters, logistics activities for humanitarian aid have two main functions: disaster preparedness and response (Thomas, 2003). Success or failure of a disaster management activity depends on the applied logistics management. In logistics management applied. In the logistics management of good humanitarian aid, there are a number of things to take into account: efficiency, effectiveness, timeliness (Nappi and Souza., 2015), and speed (Sheu., 2007). One of the activities that can be done to improve disaster preparedness is by providing logistics warehouses as a means of saving aid or so-called preposiotioning. This can be done by making disaster emergency warehouse policy as some countries have done (Spirit, et al., 2013; Turgut, et al., 2011). The emergency disaster warehouse as a means of storing relief supplies is a storage area created as first aid in case of disaster (Ye, et al., 2015).

This research was conducted to determine the location of disaster emergency warehouse, using Simple Additive Weighting (SAW) method. The grouping is done per administrative city in DKI Jakarta province.

Theoritical Setting

Warehouse

Warehouse is a fixed special facility designed to achieve service level targets. (Stock and Lambert, 2001). Warehouses are part of a logistics system that stores products at and between source and point of consumption, and provides information to management regarding the status, condition and disposition of stored items (Stock and Lambert, 2001).

Logistic

Logistics is the direction of all activities that occur within the organization in terms of material acceptance up to product delivery, the supply chain focuses on the management of relationships between the various parts or entities involved (Roh, et al., 2013).

Decision Support System

Decision Support System (DSS) (Ramakrishnan.M, and Nalini.C) is a specific information system that is intended to assist the management of decision-making processes in making informed decisions. Decision support system combines the intellectual resources of individuals with computer capabilities to improve the quality of the decisions.

Some components in the DSS include (Kusrini, 2007):

1. Subsystem data management
2. Subsystem model management
3. Subsystem user interface
4. Knowledge-based management subsystem

1. Fuzzy Sets and Fuzzy Numbers

Definitions 1 :

A fuzzy set in X is defined by : $A = \{x, \mu A(x)\}, x \in X$ ....**Equation 1**

in which $\mu A(x) : X \rightarrow [0, 1]$ is the membership function of A and $\mu A(x)$ is the degree of membership of x in A. If $\mu A(x)$ equals 1, x completely belongs to fuzzy set A. Unlike in classical set theory, $\mu A(x)$ may be a value between zero and one, capturing partial membership of x in the fuzzy set A (L. Zadeh,1965).

2. Fuzzy Attribute Decision Making (FMADM)

Fuzzy Fuzzy Multi-Attribute Decision Making is a method used to find the optimal alternative from a number of alternatives for certain criteria. FMADM is the core from determining the value of the weights for each attribute, followed by a ranking process that will select the alternative that has been given. Basically, there are three approaches to find the weights of attributes, namely the approaches of subjective and objective and the approach of integration between the subjective and objective. Each approach has advantages and disadvantages. In the subjective approach, the weights are determined based on the subjectivity of decision makers, so that some of the factors in the alternative ranking can be determined independently. While the objective approach, the weights are mathematically calculated that ignore the subjectivity of the decision makers.There are several methods that can be used to solve the problems of FMADM namely ((Kusumadewi, Hartati,. Harjoko, and Wardoyo, 2006):

1.Simple Additive Weighting (SAW)
2. Weighted Product (WP)
3. ELECTRE
4. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)
5. Analytic Hierarchy Process (AHP)

3. Simple Additive Weighting (SAW)

The SAW method is probably the best known and widely used for multiple attribute decision making MADM. Because of its simplicity, SAW is the most popular method in solving MADM problems (W. Deni., 2013). SAW method is often known as the term of weighted summation method as well. The basic concept of SAW method is to find a weighted sum of performance rating on each alternative in all attributes. SAW method requires a process of decision matrix normalizing (X) to a scale that can be compared with all the rating of the alternatives. To calculate the attribute of benefit, it is used the formula as in equation 1 :

To calculate the attribute of cost, it is used the formula as in Equation 2.

with :

: The normalized performance rating of alternative on attribute

: 1,2,3, … m.

: 1,2,3, … n.

: maximum value of each row and column.

: minimum value of each row and column.

: rows and columns of a matrix.

To calculate the value of the preference for each alternative, it is used the formulas in Equation 3

=

This research uses FMADM SAW method. The steps are:

Step 1 : Determining the criteria that will be used as a reference in decision-making, namely .

Step 2 : Determining the suitability rating of each alternative on each criterion.

Step 3 : Making decisions based on criteria matrix ().

Step4 :Normalizing matrix based on the adapted equation with the type of benefit attribute (attribute or cost attribute) so that it is obtained normalized matrix R.

Step5 :The final results are obtained from the ranking process, namely, the sum of normalized matrix R with the weight vector in order to obtain the greatest value which is selected as the best alternative () as the solution.

2. Research Methodology

2.1. Data

Disaster recapitulation data from the National Disaster Management Agency (BNPB) shows that, during the period 1985-2014, floods were the most frequent disaster in Indonesia. In this case, flood ranks first with 3,990 events (39%), followed by tornado with 1,771 incidents (17%) and landslides with 1,600 occurrences (16%). Furthermore, among all provinces in Indonesia, the province of DKI Jakarta is the area most often affected by floods. DKI Jakarta is the capital city of Indonesia with the largest population density in Indonesia, which is 13.9 thousand inhabitants / km2. The flood disaster that took place in the province of DKI Jakarta was mainly due to the geographical condition of the province and the high rainfall, 40% of the total area of DKI Jakarta is below sea level and there are 13 rivers passing through DKI Jakarta province which leads to Bay of DKI Jakarta (BPBD DKI Jakarta Province, 2014).

3.2. Methodology

Criteria and sub-criteria used to determine the location of the emergency disaster warehouse (Turgut, et al., 2011) and (Degener, et al., 2013) The following is the methodology in this study: the first stage it was the study of the literature related to the research, The second stage, it determined the criteria and sub-criteria that would be used as cost (investment cost, maintenance cost, operational cost), transportation(land line, sea line), infrastructure (information technology, energy, water), geographical location(proximity with central of city, probability with potential disaster location), climate (temperature, rain fall, humidity) , delivery time (delivery time), economy aspect(crime level ,political stability, employee availability, communication access) ,personal related aspect (environmental health around building).The next stages, it determined the conformity assessment of every alternative at each criterion based on FMADM. Preference weights and calculation of decision matrix and forming the normalized matrix (R) were based on the attributes of Max benefit, the maximum value of each row and column so that it was obtained the normalized matrix (R). The ranking process of the normalized matrix (R) was to obtain the biggest value that would be the best option.

3. Resultw

3.1. Determining Criteria

The belowmentioned table shown Criteria and Sub-criteria weighted method for warehouse disaster selection(Susanty at el., 2016):

Table 1 : Criteria and Sub-criteria weighted method for warehouse disaster selection

Criteria	Weighted	Sub criteria	Weighted	Score
	Criteria		Local	Global
Cost	0.048	Investment cost	0.297	0.0143
		Maintenance cost	0.170	0.0082
		Operational cost	0.533	0.0256
Transportation	0.15	Land line	0.865	0.1298
		Sea line	0.135	0.0203
Infrastructure	0.133	Information technology	0.215	0.0286
		energy	0.135	0.0553
		water	0.369	0.0491
Geographical location	0.174	Proximity with central of city	0.230	0.0491
		Probability with potential disaster location	0.770	0.1339
Climate	0.174	Temperatur	0.451	0.0230
		Rain fall	0.310	0.0158
		Humidity	0.239	0.0122
Delivery time	0.354	Delivery time	1.000	0.354
Economy aspect	0.034	Crime level	0.360	0.0122
		Political stability	0.200	0.0068
		Employee availability	0.338	0.0115
		Communication access	0.102	0.0035
Personal related aspect	0.055	Environmental health around building	1.000	0.0550

3.2. Alternative

Table 2. Alternative Location,(Susanty at el., 2016)

No.	Location	District	Sub District	Coordinate

1.	Jakarta (North)	Tanjungpriok	Sunter	(16,81 ; 11,50)
2.	Jakarta (East)	Makasar	Halimperdanakusuma	(9,07 ; 13,53)
3.	Jakarta (Central)	Senen	Senen	(9,5; 14,39)
4.	Jakarta (West)	KebonJeruk	Kedoya Utara	(9,55;12,37)
5.	Jakarta (South)	Cilandak	Cipete Selatan	(10,5;13,85)

3.3. Results

Results of Warehouse Location for Disaster

Table3.:Decision Making Matrix

Subkriteria	Tanjung Priok (Sunter)	Makasar (Halimperda nakusuma)	Senen (Senen)	KebonJeru k (Kedoya Utara)	Cilandak (Cipete)
Investment cost	5	3	3	4	3
Maintenance cost	3.3	3.15	3.46	3.3	3.73
Operational cost	3100000	3100000	3100000	3100000	3100000
Land line	3.2 km	1.2 km	3.6 km	3.2 km	4.8 km
	(Ancolti mur)	(Pintutolhali m)	(TolCaw ang)	(TolKebunje ruk)	(Pondokl abu)
Sea line	7.1 km	26 km	15.4 km	11.3 km	22.8 km
	(Tanjung priok)	(Sundakelap a)	(Sundak elapa)	(Sundakela pa)	(Sundak elapa)
Information technology	4	2	2	4	4
Energy	1	1	1	1	1
Water	1	1	1	1	1
Proximity with central of city	0.85 km	4 km	0.3 km	0.5 km	1.9 km
	(North Sunter Lake)	(Halim Airport)	(Salemba Raya Street)	(Panjang Street)	(ITC Fatmawati)
Probability with potential disaster location	7.3 km	4.2 km	7.7 km	5.7 km	11.9 km
	(Kelapag ading)	(Kampungm elayu)	(Tanah abang)	(Grogolpeta mburan)	(Bukit duri)
Temperature	28.7	28.2	28.13	28.13	28.2
Rain fall	196.34	209.9	203.1	209.02	223.05
Humidity	75	77.4	74.7	77.41	77.41
Delivery time	12.51 seconds	7.20 seconds	13.2 seconds	9.77 seconds	20.40 seconds

Crime level	2.94	3	3.81	4	2.8
Political stability	3.63	3.63	3.63	3.63	3.63
Employee availability	9.67	9.67	8.6	8.69	8.56
Communication access	3.46	3.3	3.46	3.63	3.81
Environmental health around building	4	3.81	3.15	4	4

Table 4.,Matrix Normalizationusing equation 2 and applied SAW as mentioned below:

Table 5.: Normalized Matrix Result

	0.6000	0.9545	1.000	0.0000	1.000	0.6667	1.000	1.000	0.3529
	1.0000	1.000	1.000	0.3750	0.2731	0.5000	1.000	1.000	0.0750
R=	1.0000	0.9104	1.000	0.3333	0.4610	0.5000	1.000	1.000	1.000
	0.7500	0.9545	1.000	0.3750	0.6283	1.000	1.000	1.000	0.6000
	1.0000	0.8445	1.000	0.2500	0.3114	1.000	1.000	1.000	0.6000

0.5753	0.9801	1.000	0.9960	0.5755	0.7350	1.0000	1.0000	0.9081	0.9525
1.000	0.9975	0.9354	0.9651	0.5755	0.7500	1.0000	1.0000	0.8661	0.7875
0.5455	1.0000	0.9667	1.0000	0.5455	0.9525	1.0000	0.8893	0.9081	1.0000
0.7368	1.0000	0.9393	0.9650	0.7369	1.000	1.0000	0.8987	0.9528	1.0000
0.3529	0.9975	0.8803	0.9650	0.3529	0.7000	1.0000	0.8852	1.0000	1.0000

Normalized Matrix resulted Ranks in Decision Making

Table 6 : Alternative Scores for Decision Making Process

No.	Alternative	Preferences (V)	Results	Rank
1.	TanjungPriok(Sunter)	V_1	0.6140	5
2	Makasar (HalimPerdanaKusuma)	V_2	0.7724	4
3.	Senen (Senen)	V_3	0.9037	1
4.	KebonJeruk (Kedoya Utara)	V_4	0.8794	2
5.	Cilandak (Cipete Selatan)	V_5	0.8532	3

Based on the best alternative value of emergency emergency warehouse location is Senen (Central Jakarta) followed by KebonJeruk (North Kedoya), Cilandak (South Cipete), Makasar (HalimPerdanaKusuma), and TanjungPriok (Sunter).

5. Conclusion

This research was conducted to determine the location of disaster warehouse in DKI Jakarta province for first aid during flood. There are 8 criteria and 19 sub criteria used to determine the location of disaster emergency warehouse in four administrative cities in DKI Jakarta Province. Using SAW method of determining the location of disaster emergency warehouse is the best Senen located in Central Jakarta. This study still has shortcomings so it can be followed up for future research. For further research can use fuzzy multi criteria other decision making method, so can know the comparison of result from each method.

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