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Decision Support System For Natural Disaster Aid Recipients Using VIKOR Method

DECISION SUPPORT SYSTEM FOR NATURAL DISASTER RELIEF RECIPIENTS USING VIKOR METHOD

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Abstract - Indonesia is a tropical country geographically located around the equator or on the equator. Natural disasters often occur in Indonesia because Indonesia is geographically located on four plates of the Asian Continent, the Australian Continent, the Indian Ocean plate, and the Pacific Ocean. Data from the Central Statistics Agency shows that around 1143 villages/areas are affected by natural disasters in North Sulawesi Province, Indonesia. Manado City, which is the capital of North Sulawesi province, has been hit by natural disasters such as floods and landslides or the dry season. Many victims were affected by this natural disaster. In this study, it succeeded in creating a decision support system for natural disaster relief recipients using the VIKOR method. Using the VIKOR method is expected to accelerate decision-making, especially in selecting recipients of natural disaster relief. In addition, the use of this system is more objective because the system makes determinations based on criteria and weights determined by decision-makers.

Keywords–. SPK, Natural Disasters, VIKOR, MADM, MCDM.

I. INTRODUCTION

Indonesia is a tropical country geographically located around the equator or on the equator. Indonesia has two seasons, namely the rainy season and the dry season. The territory of Indonesia gets very high solar irradiation, besides that the territory of Indonesia is a water area so it has a high rainfall intensity.

Law Number 24 of 2007 concerning Disaster Management states, Disasters are events or series of events that threaten and disrupt the lives and livelihoods of the community caused, both by natural factors and/or non-natural factors and human factors resulting in human casualties, environmental damage, property losses, and psychological impacts. Natural disasters are disasters caused by events or a series of events caused by nature, including earthquakes, tsunamis, erupting mountains, floods, droughts, typhoons, and landslides. [1]

Geographically, Indonesia is an archipelagic country located at the confluence of four tectonic plates, namely the Asian Continental plate, the Australian Continent, the Indian Ocean plate, and the Pacific Ocean. In the southern and eastern parts of Indonesia, there is a volcanic belt (volcanic arc) that extends from the island of Sumatra - Java - Nusa Tenggara - Sulawesi, whose sides are old volcanic mountains and lowlands that are partly dominated by swamps. This condition is very potential as well as prone to disasters such as volcanic eruptions, earthquakes, tsunamis, floods, and landslides. [2]

According to the Central Statistics Agency, data on the number of villages/villages affected by natural disasters calculated per the last three years, namely from 2018 to 2021, shows that North Sulawesi Province is 1143. Manado City is the capital of North Sulawesi province. According to several articles published on the BNPB website, in recent years Manado has been flooded almost every year. On January 15, 2014, was the worst flood in the city of Manado. At that time the height of flooding in some places exceeded the roofs of houses and reached 3-4 meters which caused damage to no less than 1000 houses, 15 people were killed and 40 thousand residents were forced to evacuate. The next occurs on January 22, 2021, and on January 26, 2023. The flood occurred due to high rainfall accompanied by strong gusts of wind so the water in the watershed overflowed because it could no longer be accommodated. [3] [2]

Disaster management activities will usually focus on evacuation and distribution of assistance for victims of natural disasters. In this study, a Decision Support System (SPK) will be built for recipients of natural disaster assistance using the VIKOR method. The use of DSS is expected to accelerate decision-making, especially in determining recipients of natural disaster relief. In addition, the use of this system is more objective because the system makes determinations based on criteria and weights determined by decision-makers.

A. Related Research

There have been several previous studies related to both the subject of research and the methods used.

Cavdur. F and Sebatli conducted research related to disaster response by creating a decision support system for the

allocation of temporary disaster response facilities. The system consists of 3 main components, namely, database, decision engine, and user interface. The results of this study show that the system built can help decision-makers determine temporary facilities related to disasters based on several existing criteria. [4]

In research conducted by Napitupulu, et al. Natural disaster management requires considerable time, energy, and finances to assist in an area that occurs. In disaster management, the process of allocating aid funds is one of the important aspects to be carried out in disaster management. This research, uses the Analytic Hierarchy Process (AHP) and Factor Rating methods, these two methods can pay attention to the criteria in the ranking process and compare the criteria with the results obtained. [5]

Pathan et al used the AHP and TOPSIS methods to conduct an assessment related to flood risk in India. This study used GIS to map flood risk areas. Ramkar and Yadav's research also used the AHP method and GIS approach to conduct flood risk assessment studies. In this study, the dataset was processed using AHP and combined with GIS for criteria and sub-criteria, for weighting using survey questionnaires. Other research related to flood natural disasters with [6] [7]
using the AHP method, namely Cenan et al. This study compared the AHP and Fuzzy AHP methods to determine the area in the Western Ghats hills associated with flood threat. [8]

Fariza et al conducted research related to Spatial Flood Risk Mapping in East Java using the AHP method. This study succeeded in calculating flood risk in East Java using the AHP method using three criteria, namely threat, vulnerability, and capacity index. This system can help related parties connect with flood disasters to provide flood disaster mitigation planning and reconstruction phases. [9]

The research of Septian et al implemented the *Simple Additive Weighting* (SAW) method for determining the recipients of earthquake victims in West Lombok. This research uses the SAW method, which is one of the *Multi-Attribute Decision Making* (MADM) methods. Manual data collection on victims of natural disasters takes a lot of time so it can slow down the process of distributing aid to victims of natural disasters, based on these problems, Septian, et al made SPK to facilitate data filling, using the SAW method. In Septian's research, et al said that the use of this method is very suitable for the cases raised. [10]

Ghadamode et al researched spatial analysis techniques for threats and mapping tsunami inundation using remote sensing with GIS, AHP, and fuzzy logic methods. The results of this research can be used in tsunami natural disaster management and land use planning. Wang et al conducted a comprehensive evaluation of the selection of highways used as rescue routes after the earthquake occurred. This study used entropy and TOPSIS methods. [11] [12]

There is also research related to decision support systems using the VIKOR method. Research Lengkong et al, made a decision support system for the selection of scholarship recipients. There is also Lengkong's research on making decision support systems for COVID-19 beneficiaries. [13] [14]

From several literature reviews above, this study will use the VIKOR method for recipients of natural disaster relief.

II. METHOD

A. VIKOR

The VIKOR method is one of the methods in *Multi-Criteria Decision Making* (MCDM). MCDM is divided into two, namely Multi-Attribute *Decision Making (MADM) and* Multi Objective Decision Making (MODM). decision-making system. In MADM, there are several decision-making methods, one of which is the VIKOR Method. The VIKOR method consists of five steps, namely: [14] [15]

1. In the first step, several criteria and alternatives are arranged into the form of a paired matrix. The matrix expressed equation 1 as follows:

$$A = [a_{ij}]_{mxn} \quad (1)$$

AIJ is the value of each alternative against eachexisting criteria, AI is expressed in equation 2 as follows:

$$a_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, i = 1,2, \dots m \quad (2)$$

2. In the second step determine positive or negative values as the ideal solution for each criterion
This step looks at a criterion whether it is measured based on the highest value being better or the lowest value being better. If measured based on the highest value is better, a positive value will be used for the criterion, while if measured based on the lowest value, it will be used for the criterion.
3. Calculate *utility measures*.
The utility measures of each alternative are calculated using the following equation:

$$S_i = \sum_j^n = 1\, w_j \frac{(f_j^* - f_{ij})}{(f_j^* - f_j^-)} \quad (3)$$

$$R_i = Max_j \left[w_j \frac{(f_j^* - f_{ij})}{(f_j^* - f_j^-)} \right] \quad (4)$$

Si and Ri in equation 4 are *utility measures* and wj is the weight given to each jth criterion.

TABLE I. CRITERIA FOR THE IMPACT OF NATURAL DISASTER LOSSES ON A SCALE OF 1-5

1	2	3	4	5
very low	low	keep	tall	very high

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4. Calculates the VIKOR index.

$$\mathbf{Q_i = v\left[\frac{S_i - S^*}{S^- - S^*}\right] + (1 - v)\left[\frac{R_i - R^*}{R^- - R^*}\right]} \quad (5)$$

S* = Mini(Si), S- = Maxi(Si); R* = Mini(R), R- = Maxi(R); and v is the weight of the group maximum (generally 0.5).
The VIKOR index is calculated using Equation 5.

5. Alternative ranking.
The selection of the best alternative is done by looking at the value of the VIKOR(Qi) index. If the lower the VIKOR index value, the better the alternative.

B. CRITERIA AND WEIGHTS

MADM uses several criteria and several alternatives in determining the goals to be achieved. The criteria in this study are several rules or requirements determined by the leadership for the determination of the selection of recipients of natural disaster relief, in addition to the criteria, the weight of the assessment is also determined by the leader for each existing criterion. The weight used can usually range from 0 -100%. But in this method, the value will be normalized to 0-1.

This study uses four criteria as follows:
K1 = Student Semester (20%)
K2 = Number of families (10%)
K3 = Impact of natural disaster losses on a scale of 1 – 5, which can be seen in Table I. (35%)
K4 = student GPA (35%)

The alternative in this study is prospective recipients of natural disaster assistance, namely students. This study used 30 prospective recipients for alternative trials.

TABLE II. ALTERNATIVE VALUES AGAINST CRITERIA

Ai	Semester	Number of families	Impact of natural disaster losses	GPA
1	2	3	5	3,29
2	2	6	2	3,29
3	8	4	2	3,14
4	6	4	2	3,41
5	4	6	4	3,51
...	...	...	...	...
26	8	3	5	3,58
27	8	6	1	3,26
28	8	5	3	3,44
29	6	6	5	3,08
30	4	5	2	3,64

III. RESULTS AND DISCUSSION

This chapter will show the results of the selection of decision support systems for recipients of natural disaster relief using 4 criteria with 30 alternatives.

Table II is the score of 30 students against 4 criteria. Table 3 shows that the values from Table II are changed according to the positive or negative value of the criteria, meaning that if criteria such as GPA scores are assessed, the higher the better, these are positive value, while if the criteria are judged the lower the better these are negative value. Table IV represents the normalized results.

After that, the results from Table IV are multiplied by the weight of the assessment criteria. The results are shown in Table V. The next step calculates *the utility measure*, namely the values of Si and Ri, the results are shown in Table VI. The values

TABLE III. DETERMINATION OF POSITIVE OR NEGATIVE VALUES FOR CRITERIA

Ai	Semester	Number of families	Impact of natural disaster losses	GPA
1	-2	3	5	3,29
2	-2	6	2	3,29
3	-8	4	2	3,14
4	-6	4	2	3,41
5	-4	6	4	3,51
...	...	...	...	...
26	-8	3	5	3,58
27	-8	6	1	3,26
28	-8	5	3	3,44
29	-6	6	5	3,08
30	-4	5	2	3,64
MIN/MAX	-1	1	1	1

TABLE IV. MATRIX NORMALIZATION AND WEIGHTING CRITERIA

	Semester	Number of families	Impact of natural disaster losses	GPA
1	0	1	0	0,771739
2	0	1	0	0,771739

3	0	0	0,75	0,771739
4	1	0,666667	0,75	0,934783
5	0,666667	0,666667	0,75	0,641304
...	...	...	...	...
25	0,666667	0,666667	1	0,576087
26	0,666667	0,333333	0,75	0,728261
27	1	1	0	0,456522
28	1	0	1	0,804348
29	1	0,333333	0,5	0,608696
30	0,666667	0	0	1
Weight	0,2	0,1	0,35	0,35

TABLE V. RESULTS OF WEIGHTING

No	Semester	Number of families	Impact of natural disaster losses	GPA
1	0	0,1	0	0,270109
2	0	0,1	0	0,270109
3	0	0	0,2625	0,270109
4	0,2	0,066667	0,2625	0,327174
5	0,133333	0,066667	0,2625	0,224457
...	...	...	...	...
25	0,133333	0,066667	0,35	0,20163
26	0,133333	0,033333	0,2625	0,254891
27	0,2	0,1	0	0,159783
28	0,2	0	0,35	0,281522
29	0,2	0,033333	0,175	0,213043
30	0,133333	0	0	0,35

TABLE VI. CALCULATING SI AND RI VALUES

	S	R	QS	QR
1	0,370109	0,270109	0,409201	0,747712
2	0,370109	0,270109	0,409201	0,747712
3	0,532609	0,270109	0,6066476	0,747712
4	0,856341	0,327174	1	0,927918
5	0,686957	0,2625	0,7941889	0,723684
...	...	...	...	...
25	0,75163	0,35	0,8727713	1
26	0,684058	0,2625	0,790667	0,723684
27	0,459783	0,2	0,5181598	0,526316
28	0,831522	0,35	0,9698437	1
29	0,621377	0,213043	0,7145058	0,567506
30	0,483333	0,35	0,5467753	1
MIN	0,033333	0,033333		
MAX	0,856341	0,35		
R	0,823007	0,316667		

TABLE VII. VIKOR INDEX (QI)

Ai	Qi	Rank
1	0,578456	13
2	0,578456	14
3	0,67718	19
4	0,963959	29
5	0,758937	22
6	0,428366	6
7	0,636683	15
8	0,664871	18
9	0	1
10	0,864077	26
11	0,765243	24
12	0,137596	3
13	0,494186	9
14	0,285869	4
15	0,454259	7
16	0,949703	28
17	0,48867	8
18	0,679711	20
19	0,56507	12
20	0,763251	23
21	0,505399	10
22	0,314438	5

23	0,660103	17
24	0,072883	2
25	0,936386	27
26	0,757176	21
27	0,522238	11
28	0,984922	30
29	0,641006	16
30	0,773388	25

of Si and Ri were then calculated in the VIKOR index shown in Table VII.

Table VII shows the results of the selection of potential recipients of natural disaster aid. The selection result with the lowest Qi index is the best alternative from a number of existing alternatives.

Based on the selection results shown in Table VII, alternative 9 (A9) got first place, alternative 24 (A24) got second place and alternative 12 (A12) got third place.

The results of this selection show that the VIKOR method can assist decision making in determining recipients of natural disaster aid objectively based on alternative values against the criteria and weights determined by the decision maker.

IV. CONCLUSION

A. *Conclusion*

This study succeeded in making a decision support system to select recipients of natural disaster assistance using the VIKOR method. With mathematical calculations like this, it is hoped that the selection process for assisting victims affected by natural disasters will be more objective by taking into account a number of criteria and weights determined.

B. *Suggestion*

For future research, you can try other MADM methods as a result of the comparison of selection from several existing alternatives. In addition, future research can also apply to the case of *multi-criteria decision-making selection*.

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