Decision Support System for Ranking Active Waste Bank in Makassar City Using TOPSIS and VIKOR Methods

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***Abstract*—In the city of Makassar, there were initially around 1000 waste banks, but this number has decreased significantly, and by 2023 only 381 waste banks remain active. The decline in the number of waste banks is primarily due to the society's lack of knowledge regarding the utilization of waste banks. This research aims to rank active waste banks in Makassar using the MCDM (Multi-Criteria Decision Making) technique. Two MCDM methods will be utilized in this study: the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method and the VIKOR (VIseKriterijumska Optimizacija I Kompromisno Resenje) method. Both methods share a common goal of finding the closest value to the ideal solution, but they differ in their normalization and aggregation functions. TOPSIS calculates the criteria weight values first, followed by the criteria values, whereas VIKOR starts with the highest criteria values and then calculates the criteria weights. The results of this research indicate that some alternatives received the same ranking using TOPSIS and VIKOR methods. The criteria used to calculate data for Waste Banks are Operational Hours, Operational Schedule, Total Customers, Total Employees, and Amount of Collected Waste. These criteria are determined based on Regulation Minister of Environment and Forestry Republic of Indonesia Number 14 of 2021 concerning Waste Management at Waste Banks.**

Keywords—Ranking, Waste Bank, MCDM, TOPSIS, VIKOR

I. INTRODUCTION

Waste banks are facilities designed for sorting and collecting recyclable waste, which can be reused and hold economic value[1]. The Waste Bank Center (BSI) is a local institution authorized to facilitate the formation and management of the Waste Bank Unit (BSU), which then becomes partners with the Environmental and Sanitation Technical Implementation Unit (UPTD) to manage waste by implementing 3R system and making waste have economic value. Waste banks in city of Makassar began operating in 2011 with 9 units, and over 5 years, the Makassar city government gradually targeted 1000 waste banks to be present and spread throughout the neighborhoods (RW) in Makassar[2]. In 2020, the number of waste banks in Makassar was 939 units, with 341 still active and 598 already closed. These waste banks are spread across 15 districts in Makassar[3]. Based on data obtained from the Ministry of Environment and Forestry in 2023, there are at least 381 active waste banks out of the 1000 waste banks that have ever existed [4].

Previous research on this topic includes a study by Fiermanzah in 2021, which indicates the lack of public knowledge about waste utilization. The research aimed to understand the community's behavior regarding waste bank utilization. The results of the study identified that the variables most influential in community behavior toward waste bank utilization are knowledge and family support[5]. Based on that research, it's understood that knowledge about waste banks significantly influences community engagement in waste bank utilization. Therefore, to enhance public knowledge and improve the efficiency and effectiveness of waste banks, a decision support system is needed to rank the most active waste banks in Makassar city.

This research aims to rank active waste banks in Makassar city using the Multi-Criteria Decision Making (MCDM) technique. There are two MCDM methods will be used: Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and VIseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) method. This ranking is conducted to identify the most active waste banks based on specific criteria to enhance the efficiency and effectiveness of waste management in Makassar City. Implementing both TOPSIS and VIKOR methods is deemed appropriate for ranking active waste banks in Makassar city. TOPSIS method operates on the principle that the selected alternative should have the closest distance to the positive ideal solution and the farthest from the negative ideal solution, while the VIKOR method employs Utility Measure and Regret Measure values to prioritize advantages. Both methods are multi-criteria approaches that seek the nearest value to the ideal solution but utilize different normalization and aggregation functions.[6][7].

Although the TOPSIS and VIKOR methods have the same objectives, the rankings obtained using these methods often differ[8]–[11], However, there are also studies indicating that rankings using both the TOPSIS and VIKOR methods yield the same results[10], [12], [13]. In this research, we will compare both methods to calculate waste bank data based on predetermined criteria of the Operational Hours, Operational Schedule, Total Customers, Total Employees, and Amount of

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Collected Waste. This will enable us to generate a ranking system for the most active waste banks in Makassar city.

II. LITERATURE REVIEW

A. MCDM (Multi-Criteria Decision Making)

Multi-Criteria Decision Making (MCDM) is a decision-making method used to determine the best alternative from a set of alternatives based on several specific criteria. The goal of MCDM is to evaluate m alternatives A_i $(i = 1,2, \dots m)$ against a set of criteria C_j $(j = 1,2, \dots n)$. The following is the arrangement of alternatives and criteria into a Decision Matrix (X). The purpose of this process is to facilitate the weighting process and so forth[14].

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

Determining weights for each criteria based on the level of importance between one criteria and another. The comparison values of the importance level between one criteria and another can be expressed as follows[6][15]:

TABLE I. WEIGHT OF IMPORTANCE VALUES

Very Unimportant	=	1
Not Important	=	2
Quite Important	=	3
Important	=	4
Very Important	=	5

B. TOPSIS (Technique for Order Preference by Similarity to Ideal Solution)

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is one of the decision-making methods introduced by hwang and yoon in 1981. The basic concept of TOPSIS is selected alternative should have shortest distance to positive ideal solution and longest distance to negative ideal solution[16], By comparing relative distances, the priority order of alternatives can be determined[17].

Ranking the most active waste bank alternatives using TOPSIS method aims to obtain the best alternative solution, which is the solution with the shortest distance to the positive ideal solution and the farthest distance from the negative ideal solution[18].

The steps for ranking the most active waste banks using the TOPSIS method are as follows :

1) *Making Decision Matrix (X)*
2) *Determining Weight Values*
3) *Making Normalized Decision Matrix*
   The calculation of the normalized decision matrix is carried out using the following formula :

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

r_{ij} = Ranking the performance of-i alternative on-j criteria
x_{ij} = The i alternative on-j criteria
$\sqrt{\sum_{i=1}^{m} x_{ij}^2}$ = The square root of the sum of the squares of each alternative on one criteria

4) *Multiplication Between Weight and Value of Each Attribute*
   The decision matrix is then multiplied by the weight and the value of each attribute, using the following formula :

$$y_{ij} = w_j \times r_{ij} \quad (3)$$

y_{ij} = The normalized weight value of alternative i on j criteria
w_j = Criteria Weight
i = $1,2, \dots m$
j = $1,2, \dots n$

5) *Determining Positive Ideal Solution and Negative Ideal Solution Matrix*

$$A^+ = (y_1^+, y_2^+, y_3^+, \cdots, y_n^+) \quad (4)$$

$$A^- = (y_1^-, y_2^-, y_3^-, \cdots, y_n^-) \quad (5)$$

$y_i^+ = \begin{cases} max\ y_{ij} & = \text{If Attribute } j \text{ is Benefit} \\ min\ y_{ij} & = \text{If Attribute } j \text{ is Cost} \end{cases}$

$y_i^- = \begin{cases} max\ y_{ij} & = \text{If Attribute } j \text{ is Cost} \\ min\ y_{ij} & = \text{If Attribute } j \text{ is Benefit} \end{cases}$

6) *Determining Distance Between Value of Each Alternative and Positive Ideal Solution and Negative Ideal Solution Matrix*
   The distance between the alternative A_i and the positive ideal solution is formulated as follows:

$$D_i^+ = \sum_{j=1}^{n} \left(y_i^+ - y_{ij}\right)^2 \quad (6)$$

   The distance between the alternative A_i and the negative ideal solution is formulated as follows:

$$D_i^- = \sum_{j=1}^{n} \left(y_i - y_{ij}^-\right)^2 \quad (7)$$

   Where D is the value of the distance of the alternative

7) *Determining Preference Value for Each Alternative*
   The preference value for each alternative is calculated using the formula :

$$v_i = \frac{D_i^-}{D_i^- + D_i^+} \quad (8)$$

   Where V represents the preference value.

C. VIKOR (VIseKriterijumska Optimizacija I Kompromisno Resenje)

VIKOR (VIseKriterijumska Optimizacija I Kompromisno Resenje) is one of the decision-making methods introduced by serafim opricovic in 1998. The basic concept of VIKOR is to

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select alternatives that approach ideal solution by optimizing multi-criteria in a complex calculation system, then rank the data by considering values or regrets (R) of each alternative[19][20].

Ranking the most active waste bank alternatives using VIKOR method aims to obtain a ranking result of alternatives that approach the ideal solution by proposing compromise solutions [18].

The steps for ranking the most active waste banks using the VIKOR method are as follows :

1) *Making Decision Matrix (X)*
2) *Determining Weight Values*
3) *Determining Maximum and Minimum Values of Ideal Solution for Each Criteria to create a Normalization Matrix*

$$N_{ij} = \frac{\left(f_j^+ - x_{ij}\right)}{\left(f_j^+ - f_j^-\right)} \quad (9)$$

N_{ij} = Elements of Normalized Matrix
f_j^+ = Best/Positive Element of Criteria *j*
f_j^- = Worst/Negative Element of Criteria *j*

Determining positive ideal value (f_j^+) and negative ideal value (f_j^-) as ideal solutions

4) *Performing Weighting of Each Alternative and Normalized Criteria*

Performing multiplication of normalized data (N) with predetermined criteria weights (W)

$$F_{j=1}^* = W_j \times N_{ij} \quad (10)$$

F_{ij}^* = The value of the data that has been normalized and weighted for alternative i on criteria *j*
W_j = The weight value for criteria *j*
N_{ij} = The normalized data value for i and *j*

5) *Calculating Utility Measure (S) and Regret Measure (R) Values*

Utility Measure (S) and Regret Measure (R) are calculated using following formulas :

$$S_i = \sum_{j=1}^{n} w_j \frac{\left(f_j^+ - x_{ij}\right)}{\left(f_j^+ - f_j^-\right)} \quad (11)$$

S_i is Manhattan distance normalized and weighted

$$R_i = max_j \left[w_j \frac{\left(f_j^+ - x_{ij}\right)}{\left(f_j^+ - f_j^-\right)} \right] \quad (12)$$

R_i is Chebyshev distance normalized and weighted

6) *Calculating VIKOR index (Q)*

Afterward, the VIKOR index for alternative i is calculated using the following formula :

$$Q_i = v\left[\frac{S_i - S^-}{S^+ - S^-}\right] + (1 - v)\left[\frac{R_i - R^-}{R^+ - R^-}\right] \quad (13)$$

S^- = $min_i(S_i)$
S^+ = $max_i(S_i)$
R^- = $min_i(R_i)$
R^+ = $max_i(R_i)$

v represents the strategic weight value ranging from 0 to 1, with a value of v assumed to be 0,5. After finding the value of Q_i, the ranking of alternatives is determined from the lowest value. This is because the value of S_j is measured from the farthest point of the ideal solution, while the value of R_j is measured from the nearest point of the ideal solution.

III. RESEARCH METHODOLOGY

A. TOPSIS and VIKOR Method

The TOPSIS and VIKOR methods are Multi-Criteria Decision Making (MCDM) methods, used to select among multi-criteria. TOPSIS and VIKOR focus on ranking results by discussing the outcomes of different alternatives and criteria that have been calculated. They also have simple concepts and calculation processes. This system is web-based, and intended to facilitate access for users.

B. Method of Data Collecting

1) Questionnaire

A questionnaire is a tool for collecting data by providing a list of questions to individuals who will provide responses or answer questions in research. The individuals who respond to the questions are called respondents. The list of questions provided can be closed-ended (answer options are provided, and respondents choose from provided answers) open-ended (respondents can answer according to their preference regarding the question, and respondents directly answer about themselves or others), or a combination of both[21].

2) Interview Technique

The interview technique involves collecting data through direct or indirect communication by the researcher to respondents/informants, providing a list of questions to be answered directly or at another opportunity[21].

3) Literature Review

Literature review tries to recognize the ordinances to be used to complete the cases under supervision and get the basis of reference for applying the methods to be used, being a study of books, articles, and papers that can be referenced on the topic to be lifted.

C. Research Stages

In Fig. 1, the research stage of this study is presented, starting from data collection, data processing, and manual calculations using the TOPSIS and VIKOR methods. The manual calculations are conducted to align with the calculations that will be designed in the system to be developed.

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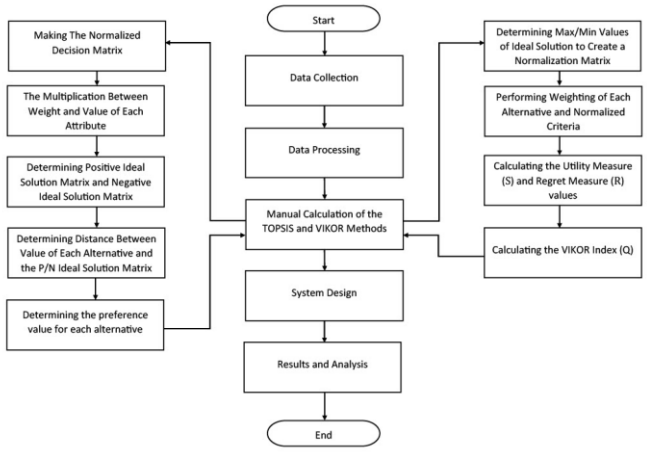

Fig. 1. Research Stages

IV. Research Result And Discussion

A. Criteria and Alternative

In this research, the criteria used for ranking the most active waste banks are operational hours, operational schedule, total customers, total employees, and amount of collected waste. The determination of these criteria is based on Regulation Minister of Environment and Forestry Republic of Indonesia Number 14 of 2021 concerning Waste Management at Waste Banks. The following table represents the data values of the criteria :

TABLE II. Criteria Data Values

Criteria Name	Crips Name	Values
Operational Hours	<= 2 Hours	1
Operational Hours	> 2 Hours to 4 Hours	2
Operational Hours	> 4 Hours to 6 Hours	3
Operational Hours	> 6 Hours to 8 Hours	4
Operational Hours	>= 8 Hours	5
Operational Schedule	1 Day	1
Operational Schedule	2 Days	2
Operational Schedule	3 Days	3
Operational Schedule	4 Days	4
Operational Schedule	5 Days	5
Total of Customers	<= 50 Household	1
Total of Customers	> 50 Household to 100 Household	2
Total of Customers	> 100 Household to 150 Household	3
Total of Customers	> 150 Household to 200 Household	4
Total of Customers	>= 200 Household	5
Total of Employees	<= 5 Employees	1
Total of Employees	> 5 Employees to 10 Employees	2
Total of Employees	> 10 Employees to 15 Employees	3
Total of Employees	> 15 Employees to 20 Employees	4
Total of Employees	>= 20 Employees	5
Amount of Collected Waste	<= 20 KG/ Week	1
Amount of Collected Waste	> 20 KG to 40 KG/ Week	2
Amount of Collected Waste	> 40 KG to 60 KG/ Week	3
Amount of Collected Waste	> 60 KG to 80 KG/ Week	4
Amount of Collected Waste	> 80 KG/ Week	5

Alternatives to be selected for ranking the most active waste banks are :

TABLE III. Alternative

ID	Code	Alternative	Information
1	A01	Pelita Bangsa	BSU
2	A02	Pelita Harapan	BSU
3	A03	Kreatif Pemuda	BSU
4	A04	Kemapertika	BSU
5	A05	Teratai Pampang	BSU

B. Making Decision Matrix (X)

The following table shows the statistical relationship between alternatives and criteria. The following are the values given to form the decision matrix (X) based on the preference values of each criteria for all alternatives :

TABLE IV. Decision Matrix (X)

Alternative	Criteria				
	C1	C2	C3	C4	C5
Pelita Bangsa	3	2	1	2	3
Pelita Harapan	1	1	5	1	2
Kreatif Pemuda	5	2	1	1	4
Kemapertika	1	1	1	2	1
Teratai Pampang	4	2	2	3	1

C. Determining Weight Values

The preference weight values range from 1 to 5. The higher the preference value of a criteria, higher the level of importance of that criteria in making a decision. The preference values for each criteria are determined as follows :

TABLE V. Weight Values

ID	Code	Criteria Name	Attribute	Weight
1	C1	Operational Hours	Benefit	4
2	C2	Operational Schedule	Benefit	4
3	C3	Total of Customers	Benefit	4
4	C4	Total of Employees	Benefit	3
5	C5	Amount of Collected Waste	Benefit	5

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D. TOPSIS Method Utilization

1) Making Normalized Decision Matrix

The values of each reference point (X_{ij}) for all alternatives are summed, then value of each criteria m is divided by the total sum of the criteria. With the equation as follows :

$$[X1] = \sqrt{(3)^2 + (1)^2 + (5)^2 + (1)^2 + (4)^2} = 7.211$$

$$r11 = \frac{3}{7.211} = 0.416$$

And so on until the value (R) is obtained as follows :

TABLE VI. R MATRIX

R1	R2	R3	R4	R5
0.416	0.534	0.176	0.458	0.538
0.138	0.267	0.883	0.229	0.359
0.693	0.534	0.176	0.229	0.718
0.138	0.267	0.176	0.458	0.179
0.554	0.534	0.353	0.688	0.179

2) Multiplication Between Weight and Value of Each Attribute

After obtaining normalized matrix, values in the normalization matrix are then multiplied by the preference values for each criteria :

$$w = (4, 4, 4, 3, 5)$$

$$y_{11} = w_1 \times r_{11} = 4 \times 0.416 = 1.6641$$

Process continues until the following matrix is obtained :

TABLE VII. Y MATRIX

Y1	Y2	Y3	Y4	Y5
1.6641	2.1380	0.7071	1.3764	2.6940
0.5547	1.0690	3.5355	0.6882	1.7960
2.7735	2.1380	0.7071	0.6882	3.5921
0.5547	1.0690	0.7071	1.3764	0.8980
2.2188	2.1380	1.4142	2.0647	0.8980

3) Determining Positive Ideal Solution and Negative Ideal Solution Matrix

TABLE VIII. A^+ AND A^- VALUES

A^+	2.7735	2.1380	3.5355	2.0647	3.5921
A^-	0.5547	1.0690	0.7071	0.6882	0.8980

4) Determining Distance Between Value of Each Alternative with Positive Ideal Solution and Negative Ideal Solution Matrix

Positive ideal solution is calculated as follows :

$$D_1^+ = \sqrt{\begin{matrix}(1.6641 - 2.7735)^2 + (2.1380 - 2.1380)^2 \\ +(0.7071 - 3.5355)^2 + (1.3764 - 2.0647)^2 \\ +(2.6940 - 3.5921)^2\end{matrix}}$$

$$= 3.242$$

Negative ideal solution is calculated as follows :

$$D_1^- = \sqrt{\begin{matrix}(1.6641 - 0.5547)^2 + (2.1380 - 1.0690)^2 \\ +(0.7071 - 0.7071)^2 + (1.3764 - 0.6882)^2 \\ +(2.6940 - 0.8980)^2\end{matrix}}$$

$$= 2.464$$

5) Determining preference value for each alternative

A larger value of V_i indicates that alternative V_i is more preferred. Calculating the preference value :

$$v_1 = \frac{2.464}{2.464 + 3.242} = 0.4319$$

Process continues until it produces rankings as shown in the table IX or Fig. 2:

TABLE IX. TOPSIS RANKING RESULTS

Alternative	Name	V	Rank
A01	Pelita Bangsa	0.4319	3
A02	Pelita Harapan	0.4701	2
A03	Kreatif Pemuda	0.5371	1
A04	Kemapertika	0.1285	5
A05	Teratai Pampang	0.4196	4

E. VIKOR Method Utilization

1) Determining Maximum and Minimum Values of Ideal Solution for Each Criteria to Create a Normalization Matrix

TABLE X. MAXIMUM AND MINIMUM VALUES

Max	5	2	5	3	4
Min	1	1	1	1	1

$$N_{11} = \frac{(5-3)}{(5-1)} = \frac{(2)}{(4)} = 0.5$$

And so on until it produces the following normalization values

TABLE XI. MATRIX NORMALIZATION

N_{ij}				
0.5	0	1	0.5	0.333
1	1	0	1	0.667
0	0	1	1	0
1	1	1	0.5	1
0.25	0	0.75	0	1

2) Performing Weighting of Each Alternative and Normalized Criteria

The next step is to calculate multiplication of matrix N_{ij} by

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W_{ij} in each column

TABLE XII. W MATRIX

W_{ij}				
2	0	4	1.5	1.667
4	4	0	3	0.667
0	0	4	3	0
4	4	4	1.5	5
1	0	3	0	5

3) Calculating Utility Measure (S) and Regret Measure (R)

$$R^1 = 2\ ;\ 0\ ;\ 4\ ;\ 1.5\ ;\ 1.667 = 4$$

$$S^1 = 2 + 0 + 4 + 1.5 + 1.667 = 9.167$$

TABLE XIII. UTILITY VALUES (S) AND REGRET MEASURE (R)

R Values	S Values
4	9.167
4	14.333
4	7
5	18.5
5	9

4) Calculating VIKOR Index (Q)

$$Q_1 = 0.5\left[\frac{9.167 - 7}{18.5 - 7}\right] + (1 - 0.5)\left[\frac{4 - 4}{5 - 4}\right]$$

$$= 0.5\left[\frac{2.167}{11{,}5}\right] + (0.5)\left[\frac{0}{1}\right] = 0.094$$

Process continues until it produces rankings as shown in the table XIV or Fig. 2:

TABLE XIV. VIKOR RANKING RESULTS

Alternative	Name	V	Rank
A01	Pelita Bangsa	0.094	2
A02	Pelita Harapan	0.319	3
A03	Kreatif Pemuda	0	1
A04	Kemapertika	1	5
A05	Teratai Pampang	0.587	4

F. Main Page

Fig. 2 depicts the main page view after the user successfully logs into the system. It displays the ranking results of active waste banks with calculations using the TOPSIS and VIKOR methods

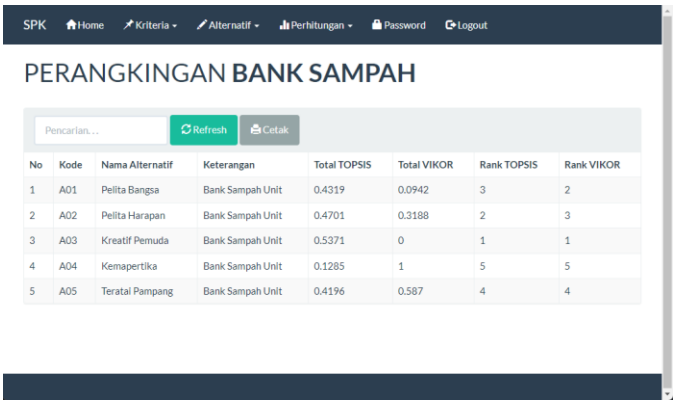

Fig. 2. The main page shows the results of ranking active waste banks

V CONCLUSION

The use of TOPSIS and VIKOR methods in ranking waste banks resulted in alternatives BSU kreatif pemuda, BSU kemapertika and BSU teratai pampang obtaining the same ranking. Where BSU kreatif pemuda is the most active waste bank unit, while BSU kemapertika is the less active waste bank unit in Makassar city. This research demonstrates that using the TOPSIS and VIKOR methods is effective for ranking waste banks. Although both methods seek the closest value to the ideal solution, they differ in their approaches to determining preference values and indices.

The calculation using the TOPSIS method for alternative BSU kreatif pemuda results in a preference value of 0.5371, which is the highest among the alternatives, thus achieving the highest ranking. Meanwhile, the calculation using the VIKOR method for alternative BSU kreatif pemuda results in an index value of 0, the lowest among the alternatives, thus also achieving the highest ranking.

The calculation using the TOPSIS method first considers the criteria weight values and then the criteria values, whereas the VIKOR method first calculates the highest criteria values and then the criteria weight values. This approach makes ranking with the TOPSIS method have a lower level of risk because it considers the distance of alternatives from the non-ideal solution. Conversely, ranking with the VIKOR method carries a higher level of risk because it only measures the proximity of values to the ideal solution.

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