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 community's lack of knowledge regarding the utilization of waste banks. This research aims to rank the 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. The results of this study indicate that the rankings obtained using the TOPSIS and VIKOR methods are consistent. The TOPSIS method calculates the criterion weight values and then the criterion values, while the VIKOR method first considers the highest criterion values and then calculates the criterion weight values.**

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

***Abstrak*—** **Di kota makassar sendiri setidaknya terdapat 1000 bank sampah yang pernah ada, namun hal tersebut terus berkurang hingga tahun 2023 hanya terdapat 381 bank sampah yang aktif. Banyaknya bank sampah yang tutup dikarenakan kurangnya pengetahuan masyarakat terhadap pemanfaatan bank sampah, penelitian ini bertujuan untuk melakukan perankingan pada bank sampah aktif di kota makassar dengan menggunakan teknik MCDM (Multi-Criteria Decision Making) terdapat dua metode MCDM yang akan digunakan yaitu metode TOPSIS (VIKOTR) dan metode VIKOR (VIseKriterijumska Optimizacija I Kompromisno Resenje). Kedua metode ini memiliki kesamaan dimana metode ini sama-sama mencari nilai terdekat ke solusi ideal, namun menggunakan cara normalisasi dan fungsi agregrasi yang berbeda. Hasil dari penelitian ini menujukkan terdapat perangkingan yang sama pada penggunaan metode TOPSIS dan VIKOR. Dimana perhitungan metode TOPSIS meperhitungkan nilai bobot kriteria lalu memperhitungkan nilai kriteria sementara metode VIKOR memperhitungkan nilai kriteria tertinggi lalu memperhitungkan nilai bobot kriteria.**

***Kata Kunci—Perangkingan, Bank Sampah, MCDM, TOPSIS, VIKOR***

# 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 the 3R system and making waste have economic value. Waste banks in the 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.

In this research, the aim is to rank active waste banks in Makassar city using the Multi-Criteria Decision Making (MCDM) technique. Two MCDM methods will be employed: the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and the 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, namely Operational Hours, Operational Schedule, Number of Customers, Number of Employees, and Amount of Collected Waste. This will enable us to generate a ranking system for the most active waste banks in Makassar city.

# LITERATURE REVIEW

## 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 alternatives against a set of criteria . 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].

(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]:

1. WEIGHT OF IMPORTANCE VALUES

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

## 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 first introduced by Hwang and Yoon in 1981. The basic concept of TOPSIS is that the selected alternative should have the shortest distance to the positive ideal solution and the longest distance to the negative ideal solution[16], By comparing the relative distances, the priority order of alternatives can be determined[17].

Ranking the most active waste bank alternatives using the 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 :

### Creating the decision matrix (X)

### Determining the weight values

### Creating the normalized decision matrix

The calculation of the normalized decision matrix is carried out using the following formula :

(2)

|  |  |  |
| --- | --- | --- |
| where : | | |
|  |  | Ranking the performance of- alternative on- criteria |
|  |  | The alternative on- criteria |
|  |  | The square root of the sum of the squares of each alternative on one criteria |

### The multiplication between the weight and the value of each attribute

The decision matrix is then multiplied by the weight and the value of each attribute, using the following formula :

(3)

|  |  |  |
| --- | --- | --- |
|  |  | The normalized weight value of alternative on criteria |
|  |  | Criteria Weight |
|  |  |  |
|  |  |  |

### Determining the positive ideal solution matrix and the negative ideal solution matrix

(4)

(5)

|  |  |  |
| --- | --- | --- |
|  |  | If Attribute is Benefit |
|  | If Attribute is Cost |
|  |  | If Attribute is Cost |
|  | If Attribute is Benefit |

### Determining the distance between the value of each alternative and the positive ideal solution and negative ideal solution matrix

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

(6)

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

(7)

Where is the value of the distance of the alternative

### Determining the preference value for each alternative

The preference value for each alternative is calculated using the formula :

(8)

Where represents the preference value.

## VIKOR (VIseKriterijumska Optimizacija I Kompromisno Resenje)

VIKOR (VIseKriterijumska Optimizacija I Kompromisno Resenje) is one of the decision-making methods first introduced by Serafim Opricovic in 1998. The basic concept of VIKOR is to select alternatives that approach the ideal solution by optimizing multi-criteria in a complex calculation system, then rank the data by considering the Values or Regrets (R) of each alternative[19][20].

Ranking the most active waste bank alternatives using the 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 :

### Creating the decision matrix (X)

### Determining the weight values

### Determining the maximum and minimum values of the ideal solution for each criteria to create a normalization matrix

(9)

|  |  |  |
| --- | --- | --- |
| where : | | |
|  |  | Elements of the Normalized Matrix |
|  |  | The Best/Positive Element of Criteria |
|  |  | The Worst/Negative Element of Criteria |

Determining the positive ideal value () and negative ideal value () as the ideal solutions

### Performing weighting of each alternative and normalized criteria

Performing multiplication of the normalized data () with the predetermined criteria weights ()

(10)

|  |  |  |
| --- | --- | --- |
| where : | | |
|  |  | The value of the data that has been normalized and weighted for alternative on criteria |
|  |  | The weight value for criteria |
|  |  | The normalized data value for and |

### Calculating the Utility Measure () and Regret Measure () values

The Utility Measure () and Regret Measure () are calculated using the following formulas :

(11)

is the Manhattan distance normalized and weighted

(12)

is the Chebyshev distance normalized and weighted

### Calculating the VIKOR index (Q)

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

(13)

|  |  |  |
| --- | --- | --- |
| where : | | |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

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

# RESEARCH METHODOLOGY

## 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.

## Method of Data Collecting

### 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 the 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 the 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].

### 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].

### Literature Review

A literature review is attempted to recognize the procedures to be used to resolve the case under surveillance and obtain reference basics in applying the method to be used, by reviewing books, articles, and journals that can be used as references on the topic to be addressed.

# RESEARCH RESULT AND DISCUSSION

## Criteria and Alternative

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

1. 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 |
| Number of Customers | <= 50 Household | 1 |
| Number of Customers | > 50 Household to 100 Household | 2 |
| Number of Customers | > 100 Household to 150 Household | 3 |
| Number of Customers | > 150 Household to 200 Household | 4 |
| Number of Customers | >= 200 Household | 5 |
| Number of Employees | <= 5 Employees | 1 |
| Number of Employees | > 5 Employees to 10 Employees | 2 |
| Number of Employees | > 10 Employees to 15 Employees | 3 |
| Number of Employees | > 15 Employees to 20 Employees | 4 |
| Number 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 |

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

1. 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 |

## Creating the 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 :

1. 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 |

## Determining the Weight Values

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

1. WEIGHT VALUES

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

## Calculation of the TOPSIS Method

### Creating The Normalized Decision Matrix

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

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

1. 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 |

### The Multiplication Between Weight and Value of Each Attribute

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

The process continues until the following matrix is ​​obtained :

1. 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 |

### Determining the Positive Ideal Solution Matrix and the Negative Ideal Solution Matrix

1. AND VALUES

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 2.7735 | 2.1380 | 3.5355 | 2.0647 | 3.5921 |
|  | 0.5547 | 1.0690 | 0.7071 | 0.6882 | 0.8980 |

### Determining the Distance Between the Value of Each Alternative and the Positive Ideal Solution and the Negative Ideal Solution Matrix

The positive ideal solution is calculated as follows :

The negative ideal solution is calculated as follows :

### Determining the preference value for each alternative

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

The process continues until it produces rankings as shown in the table below :

1. TOPSIS RANGKING 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 |

## Calculation of the VIKOR Method

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

1. MAXIMUM AND MINIMUM VALUES

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Max | 5 | 2 | 5 | 3 | 4 |
| Min | 1 | 1 | 1 | 1 | 1 |

And so on until it produces the following normalization values

1. MATRIX NORMALIZATION

|  | | | | |
| --- | --- | --- | --- | --- |
| 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 |

### Performing Weighting of Each Alternative and Normalized Criteria

The next step is to calculate the multiplication of the matrix by in each column

1. W MATRIX

|  | | | | |
| --- | --- | --- | --- | --- |
| 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 |

### Calculating the Utility Measure (S) and Regret Measure (R)

1. UTILITY VALUES (S) AND REGRET MEASURE (R)

| **R Values** | **S Values** |
| --- | --- |
| 4 | 9.167 |
| 4 | 14.333 |
| 4 | 7 |
| 5 | 18.5 |
| 5 | 9 |

### Calculating the VIKOR Index (Q)

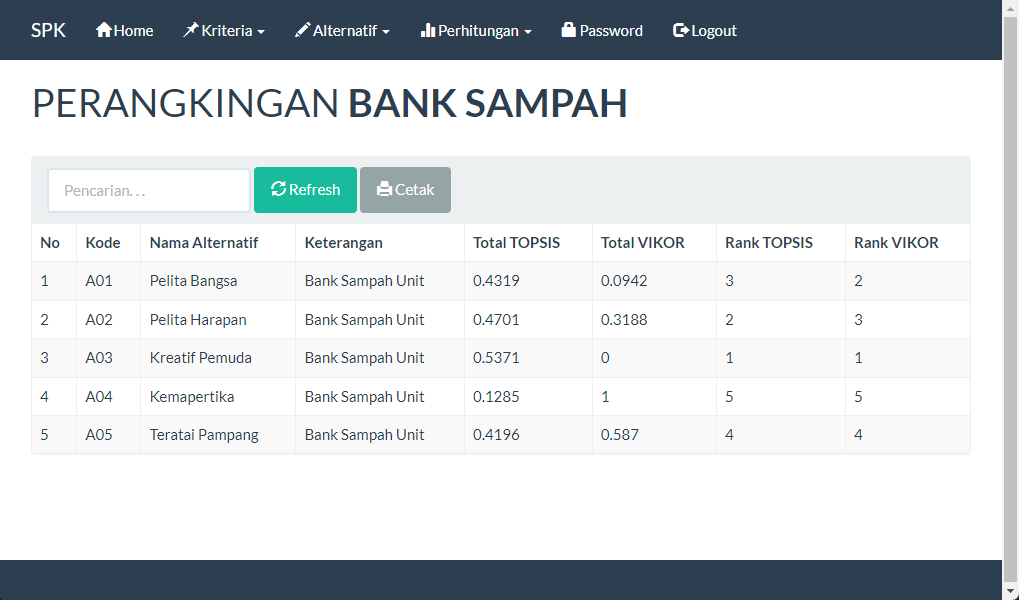
The process continues until it produces rankings as shown in the table below :

1. VIKOR RANGKIN 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 |

## Main Page

Figure 1 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



1. Main Page

##### CONCLUSION

The use of TOPSIS and VIKOR methods in ranking waste banks resulted in alternatives dan , and obtaining the same ranking. Where is the most active waste bank unit, while is the less active waste bank unit in Makassar city.

Ranking with the TOPSIS method has a low level of risk because it considers the distance of alternatives from the non-ideal solution. On the other hand, ranking with the VIKOR method has a higher level of risk because it only measures the proximity of values ​​to its ideal solution. The calculation using the TOPSIS method shows that alternative achieved a preference value of 0.5371, which is the highest among the alternatives, thus securing the top ranking. Meanwhile, the VIKOR method calculation for alternative resulted in an index value of 0, the lowest among the alternatives, also securing the top ranking.

The TOPSIS method first considers the criterion weight values before calculating the criterion values. In contrast, the VIKOR method first considers the highest criterion values and then calculates the criterion weight values.

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