International Journal of Information System & Technology
Akreditasi No. 158/E/KPT/2021 | Vol. 5, No. 5, (2022): pp. 612-623

Comparison of Final Results Using Combination AHP-VIKOR And AHP-SAW Methods In Performance Assessment (Case Imanuel Lurang Congregation)

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Abstract

Determination of the final result in determining the decision is to determine the best alternative from several existing alternatives based on several predetermined criteria. The criteria are measures, rules, or standards for making decisions. It can be done by combining several Multi Criteria Decision Making (MCDM) methods such as AHP, VIKOR, SAW, TOPSIS and others to get the best decision results. The Analytical Hierarchy Process (AHP) method is one of the MCDM methods with advantages at the criteria weighting stage. It uses a consistency test to see whether the weights obtained are consistent. In comparison, the VIKOR and SAW methods are also one of the MCDM methods but do not apply the weighting consistency test. With the advantages and disadvantages of each MCDM method, it is possible to combine several existing methods to provide better solutions or alternatives. This study compares the ranking results between the combination of the AHP-VIKOR method and the combination of the AHP-SAW method in a performance appraisal case study. The AHP method is used to weight the criteria and sub-criteria, while the VIKOR and SAW methods are used in the alternative ranking process. The test results show differences in the alternative ranking results between the two combinations of MCDM methods used.

Keywords: *MCDM, AHP, VIKOR, SAW, Performance Assessment*

1. Introduction

One method approach in making decisions based on alternatives or solutions from multiple criteria or determining the best alternative from some existing alternatives based on several predetermined criteria is called Multi-Criteria Decision Making (MCDM) [1]. MCDM is part of the scientific field of operations research. The language focus covers both qualitative and quantitative aspects [2]. Technically, MCDM applications generally involve multiple criteria, actors, and objectives. The subject matter includes at least five characteristics, namely: objectives, decision-making preferences, alternatives, criteria, and benefits [3]. So, problems involving decision-making with some rules and alternatives often use this method. The purpose of MCDM is to choose the best Alternative from several mutually beneficial exclusive alternatives based on general performance in various criteria or attributes determined by decision-makers [4]. Several MCDM methods that support problems with several criteria include Simple Additive Weighting (SAW), Weighting Product (WP), Technique For Order Preference by Similarity To Ideal Solution (TOPSIS), Electre, VIsekriterijumsko KOMpromisno Rangiranje (VIKOR), and others. Each MCDM method has unique characteristics that can be applied to find the best Alternative to a problem. Combining several MCDM methods to obtain the best alternative solution is possible. The case study in this study uses seven criteria to be approached by the MCDM method.

The MCDM method used in this study is the AHP method, the VIKOR method, and the SAW method. The three selected methods are then combined to compare the

ISSN : 2580-7250

alternative solutions obtained. The combination of these methods was chosen because each has its advantages. The AHP method has advantages in the weighting criteria stage. Although the weighting of the AHP method still requires an assessment from superiors, the weighting process of the AHP method uses a consistency test to see if the weights obtained are consistent. While the VIKOR method has a weakness at the weighting stage, the weighting process is only given by superiors without any weighting consistency checks such as the AHP method. On the other hand, the AHP method has shortcomings in the ranking process. The AHP ranking process becomes more complex with increasing iterations if there are more alternatives. Meanwhile, the VIKOR method has advantages in the ranking process by having a preference value for ranking. In addition, the VIKOR method has the advantage of overcoming conflicting criteria in ranking. The inconsistent criteria in question are several criteria, but each of these criteria uses a different assessment. The assessment can see the highest score is getting better, or the lowest value is getting better. The SAW method is also limited to the problem of weighting criteria because there is no weighting consistency check, but similar to VIKOR, SAW has the advantage of overcoming conflicting criteria in ranking[5].

A comparison of the combined results is then sought from the advantages and disadvantages of the three methods. The comparison is made by comparing the ranking results of the AHP-VIKOR combination method with the AHP-SAW combination. The application of these three methods is carried out on the staff of the Immanuel Lurang Congregation, especially for organizational positions. Managerial positions at the Immanuel Lurang Congregation are 162 servants consisting of 15 members of the Congregational Council, 7 men's organizers, 14 women's organizers, 42 unit administrators, 20 Sunday School teachers, 8 Tuagama teachers, 6 Multimedia people, 2 sound operators, 12 collectors, 18 office staff, 1 pro office, 15 flute choir, and 2 keyboard players. The AHP method is used to weight the criteria and sub-criteria, while the VIKOR and SAW methods are used when performing alternative rankings.

2. Research Methodology

2.1. Decision Support System Overview

The performance appraisal process is carried out using a combination of AHP-VIKOR and a combination of AHP-SAW. The AHP method was used to determine the weight of each criterion or sub-criteria, while the VIKOR method and the SAW method were used for ranking. Furthermore, the sensitivity comparison of these two combinations is carried out to determine the best combination. The service performance assessment process is shown in Figure 1, as follows.

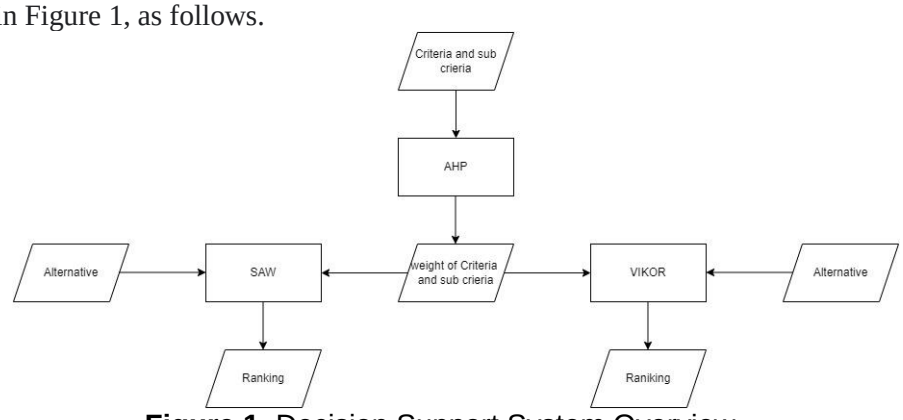

Figure 1. Decision Support System Overview

2.2. *Analytical Hierarchy Process (AHP)*

According to Saaty, AHP is a method aimed at solving complex and unstructured problems, where the criteria or aspects that affect the unstructured problem, uncertainty in the perception of decision-making, or the unavailability of sufficient data/information.

With a hierarchy, a complex and unstructured problem is divided into groups, and then the group is organized into a hierarchical form [6]. The working principle in the AHP method is as follows:

2.2.1. Decomposition (Hierarchical Arrangement)

Decomposition is the process of analyzing a real problem into a hierarchical structure of its supporting elements. In general, the hierarchy consists of three levels: the first level is the decision goal (goal), the second level consists of criteria and sub-criteria (optional), and the third level is the alternative solutions offered. The goal is to decompose the problem into a hierarchical form to overcome various variations to see which elements are appropriate to choose[7].

2.2.2. Pairwise Comparison Matrix

Pairwise comparisons aim to assess the importance between two elements at a certain level which is presented in a matrix with a priority scale. The assessment of the pairwise comparison matrix elements is shown in equation (1)

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \sim \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \frac{1}{a_{21}} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \cdots & 1 \end{bmatrix} \quad (1)$$

Where:

A : Pairwise comparison matrix

a_{ij} : Assessment of the importance of criteria i compared to criteria j.

i, j : 1 … n is the number of criteria

Creating a pairwise comparison matrix requires quantities that can reflect the differences between one factor and another. To compare the importance of one element to another, use the Saaty scale, ranging from 1 to 9.

2.2.3. Priority Determination

After the pairwise comparison matrix is created, the next step is to measure the priority weight of each element. The final result of this calculation is one decimal number below one (e.g., 0.01 to 0.99) with the total priority for the details in a group equal to one. Determination of priority weights using geometric averages[8], by:

a) Multiply the value of each row and calculate the nth root of the product of equation (2).

$$\bar{w}_i = \sqrt[n]{\prod_{j=1}^{n} a_{ij}} \quad (2)$$

Where:

w : weight of the ith criterion that has not been normalized

a_ij : assessment of the importance of factor i compared to factor j

i : 1...n is the number of criteria

b) Normalize the cube root to get the weight (eigenvector) of equation (3).

$$w_i = \frac{\bar{w}}{\sum_{i=1}^{n} \bar{w}_i} \quad (3)$$

where:

w_i : weight of the normalized i-th criterion (eigenvector)

c) Consistency Ratio (CR)

Consistency Ratio (CR) is used to find out how consistent it is when doing pairwise comparisons. Steps to measure the CR value:

1) The values contained in the pairwise comparison matrix are summed, and the number is multiplied by each normalized weight
2) Then the weight values are added up, this value is known as lambda max (maximum eigen value).

3) Calculating the Consistency Index (CI) using the following equation (4)

$$CI = \frac{\lambda_{maks} - n}{n-1} \quad (4)$$

Where:
CI : Consistency Index
λ_{maks}: maximum eigenvalue
n : the number of criteria

4) Calculating the Consistency Ratio using the following equation (5)

$$CR = \frac{CI}{RI} \quad (5)$$

Where:
CR : Consistency Ratio
CI : Consistency Index
RI : Index Random Consistency

If the value of CR < 0.1, it can be said that the pairwise comparison matrix made is consistent. However, if the value is more than 0.1, the criteria assessment must be improved.

2.2.4. Global Prioritization

The last stage in AHP is the global priority calculation process to determine the priority order by performing a location priority matrix operation from the lowest level to the level above it, to the top level of the hierarchy.

The initial step is the same as the conventional AHP method, while the difference is how to get the RI value. In conventional AHP, the RI value has been determined by the Saaty table which displays the RI value up to 15. Meanwhile, Alonso and Lamata's research adds several equations to get the RI value, as follows[9]:

$$RI = \frac{\bar{\lambda}max - n}{n-1} \quad (6)$$

$$\bar{\lambda}max = 2{,}7699n - 4{,}3513 \quad (7)$$

After getting the RI value, then look for the weighting consistency ratio or (CR) using equation (5).

2.3. *VIsekriterijumsko KOmpromisno Rangiranje* (VIKOR)

VIKOR means optimization of several criteria into a compromise ranking. VIKOR is used to determine the list of ranked solutions, compromise solutions, and the range of weight stability that is the basis for the strength of the compromise solution obtained from the initial weight (initialization weight). Yu and Zeleny introduced the idea of ranking compromise. Opricovic and Tzeng introduced the VIKOR method as a compromise ranking method [10]. A compromise solution is a feasible solution closest to the ideal solution, whereas a compromise means an agreement made by mutual consent.

The focus of the VIKOR method is to rank and choose a solution from a set of alternatives in situations where the reference criteria contradict each other). The ranking of alternative solutions is based on proximity to the ideal solution. The procedure for calculating the VIKOR method, according to Opricovic and Tzeng, follows the steps below:

a) Develop Criteria and Alternatives in the form of a matrix
At this stage, each criterion and Alternative are arranged in the form of an F matrix, Ai represents the i-th Alternative, with i=1,2,3,...,m and Cj is the jth criterion, with j=1,2, 3,..,n

$$F = \begin{bmatrix} & C_1 & C_2 & \cdots & C_n \\ A_1 & x_{11} & x_{12} & \cdots & x_{1n} \\ A_2 & x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ A_m & x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}$$

b) Calculating the Normalization of the Decision Matrix

The calculation of the normalization of the decision matrix for each data follows equation (9).

$$f_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{n} x_{ij}^2}}, i = 1,2,\dots,m\,; j = 1,2,\dots,n \quad (9)$$

Where:

x_{ij} : The Value of each attribute against the criteria
f_{ij} : Normalized value
m : m-th Alternative
n : m-th Criteria

It will be obtained a matrix containing the entire value of the normalized elements, shown by equation (10)

$$F = \begin{bmatrix} f_{11} & \cdots & f_{1n} \\ \vdots & \ddots & \vdots \\ f_{m1} & \cdots & f_{mn} \end{bmatrix} \quad (10)$$

c) Determine the best value(f_j^*) and the worst value(f_j^-) for each criterion. f_j^* is a positive ideal solution for the jth criterion, while f_j^- it is a negative ideal solution for the jth criterion.

The criteria that have the higher the more optimal value are the benefit criteria, while the criteria that have the lower the more optimal values are the cost criteria. Determination of the value f_j^* and f_j^- all criterion functions is carried out successively through equations (11) and (12).

For the benefit criteria function:

$$f_j^* = max_i f_{ij},\ f_j^- = min_i f_{ij} \quad (11)$$

For the cost criteria function:

$$f_j^* = min_i f_{ij},\ f_j^- = max_i f_{ij} \quad (12)$$

d) Calculating the Value of Utility Measures

To get the value of utility measures, it is necessary to value the weight of the criteria (w_j). The weight of the criteria aims to represent the relative importance. Utility measures of each Alternative were calculated using equations (13) and (14).

$$S_i = \sum_{i=1}^{n} w_j \frac{(f_j^* - f_{ij})}{(f_j^* - f_j^-)} \quad (13)$$

$$R_i = max_j \left[w_j \frac{(f_j^* - f_{ij})}{(f_j^* - f_j^-)} \right] \quad (14)$$

S_i (maximum group utility) and R_i (minimum individual regret of the opponent), both state utility measures measured from the farthest point and closest to the ideal solution.

Where:

S_i : The value of the alternative distance to the positive ideal solution
R_i : The value of the alternative distance to the negative ideal solution
w_j : The weight value obtained from the calculation in equation (3)

e) Calculating VIKOR Value (Q_i)

Equation (15) describes the process of obtaining VIKOR scores for each Alternative for Sunday School Teacher performance. To calculate the VIKOR

value, a variable known as the strategic weight of most criteria is needed, where the value ranges from 0-1 (generally, it is 0.5). The smaller the VIKOR index value, the better the alternative solution.

$$Q_i = v\frac{(S_i - S^*)}{S^- - S^*} + (1-v)\frac{(R_i - R^*)}{(R^- - R^*)} \quad (15)$$

Where:

S^* : $min_i\, S_i$ (The smallest value of alternatives)
S^- : $max_i S_i$ (The largest value of alternatives)
R^* : $min_i\, R_i$ (The smallest value of alternatives)
R^- : $max_i R_i$ (The The most significant value of alternatives)
v : Representation of the value that ranges from 0 -1 (generally it is 0,5)

f) Ranking the Value of Utility Measure (S_i), Regret Measure (R_i) and the Value of VIKOR (Q_i)

Ranking of the three values, namely , and S_i, R_i and Q_i is carried out based on the most significant value to the smallest value (ascending order), with the smallest value being the best candidate. Thus, three ranking lists/versions will be obtained.

2.4 Simple Additive Weighting (SAW)

The basic concept of the SAW method is to find the weighted sum of the performance ratings for each Alternative on all criteria [11]. The stages in the SAW method are as follows[12]:

a) Determines alternatives and criteria values
b) Create Decision Matrix
c) Normalize the decision matrix by calculating the normalized performance rating values using equation (16).

$$r_{ij} = \begin{cases} \frac{x_{ij}}{Max\, x_{ij}} & if\ j\ is\ benefit\ attribute \\ \frac{min x_{ij}}{x_{ij}} & if\ j\ is\ cost\ attribute \end{cases} \quad (16)$$

The results of this rating value, then implemented in a normalized matrix (R), which is shown in the following matrix form.

$$R = \begin{bmatrix} r_{11} & \cdots & r_{1j} \\ \cdots & \cdots & \cdots \\ r_{i1} & \cdots & r_{ij} \end{bmatrix} \quad (17)$$

d) Calculate The Final Result of the Ranking Values

The final result of the preference value is obtained from the sum of the normalized row elements multiplication with the preference weights corresponding to the matrix column elements. It is described in the following equation.

$$V_i = \sum_{j=1}^{n} w_j r_{ij} \quad (18)$$

The calculation result of the larger Vi value indicates that the Alternative Ai is the best Alternative.

3. Result and Discussion

3.1. Determination of Criteria and Sub-Criteria

In this study, several performance appraisal criteria were used, and each Criteria had sub-criteria. It can be seen in Table 1 below.

Table 1. Criteria and Sub-Criteria

No	Criteria	Sub-Criteria
1	Loyalty	Basic Service according to the teachings of the Bible
		Hold on to the promises
		Do not change
		Do not complaints

No	Criteria	Sub-Criteria
2	Responsibility	Responsibility for God
		Responsibility for self and family
		Responsibility for the Church
		Responsibility for assignments and calls as caregivers.
3	Discipline	Attendance
		Working time
		Obedience
		Dress code
4	Obedience	Obedience to the rules set by the Church
		Implementing regulations in daily life
		Work based on the job description given
		Respect local customs/culture
		Keep Words
5	Cooperation	Cooperation between servers
		Cooperation with other service areas.
		Become an active member in several church organizations.
		Mutual trust and mutual support
6	Achievement	Initiative
		Perform and complete tasks and responsibilities
		Decision to deal with an emergency situation
		Mastery of material
7	Leadership	Decision making and realizing the decision
		Motivate

3.2. Calculation Value of the Weight Criteria Using AHP Method

In this process, each criterion is compared with a pairwise comparison matrix until a consistent value is obtained. It can be seen in Table 2 below.

Table 2. Pairwise Comparison Matrix

Criteria	A	B	C	D	E	F	G
A	1	3	2	2	3	5	5
B	0,33	1	0,33	0,2	0,5	0,5	0,5
C	0,5	3	1	0,5	3	3	3
D	0,5	5	2	1	3	5	5
E	0,33	2	0,33	0,33	1	2	0,5
F	0,2	2	0,33	0,2	0,50	1	2
G	0,2	2	0,33	0,2	2	0,5	1
Total	3,07	18	6,33	4,43	13,00	17	17

Then look for the priority weights by performing calculations according to equation (2) with the following example calculation:

$\overline{w_1} = \sqrt[7]{1 \times 3 \times 2 \times 2 \times 3 \times 5 \times 5} = \sqrt[7]{900} = 2{,}64$

The following calculation until the 7th criterion is done in the same way. Next, look for the eigenvectors from the comparison matrix of criteria using equation (3) with the following calculations:

$$\sum_{i=1}^{7} w_i = 2{,}64 + 0{,}43 + 1{,}54 + 2{,}33 + 0{,}69 + 0{,}6 + 0{,}6 = 8{,}82$$

$$w_1 = \frac{2{,}64}{8{,}82} = 0{,}3$$

$$w_2 = \frac{0{,}43}{8{,}82} = 0{,}05$$

In the same way, the calculation is continued up to the 7th criterion. The value of w_i is the priority weight of the i-th importance. The complete calculation results are shown in Table 3 below:

Table 3. Criteria Weight

Criteria	Geometric Mean (w)	Criteria Weight
A	2,64	0,30
B	0,43	0,05
C	1,54	0,17
D	2,33	0,26
E	0,69	0,08
F	0,60	0,07
G	0,60	0,07

The process continues with consistency checks. If the check results show that the pairwise comparisons are inconsistent, then the pairwise comparison process must be repeated. To check the consistency of the weights, start by calculating the maximum eigenvalue (λ_{max}) by accumulating the number of multiplication results between the number of each column in pairwise comparisons with criterion weights.

$$\lambda_{max} = (3{,}07 \times 0{,}30) + (18 \times 0{,}05) + (6{,}33 \times 0{,}17) + (4{,}43 \times 0{,}26) + (13 \times 0{,}08) + (17 \times 0{,}07) + (17 \times 0{,}07)$$
$$= 7{,}38$$

Then calculate the consistency index (CI) for the number of criteria (n = 7), using equation (4)

$$CI = \frac{7{,}38-7}{7-1} = 0{,}06$$

After obtaining the CI value, the consistency ratio (CR) value will be calculated. The CR value is obtained by dividing the CI value by the RI value. Meanwhile, based on equation (6), to get the value of RI, you must first calculate the value of $\overline{\lambda}max$. $\overline{\lambda}max$ Value can be calculated as equation (7). The following shows the results of the calculation of the value of $\overline{\lambda}max$, RI dan CR.

$$\overline{\lambda}max = 2{,}7699.7 - 4{,}3513 = 15{,}04$$
$$RI = \frac{15{,}04 - 7}{7 - 1} = 1{,}34$$
$$CR = \frac{0{,}06}{1{,}34} = 0{,}048$$

From the calculation results, the consistency ratio value of 0.048 is less than 0.1 so that it is said to be consistent and thus, the pairwise comparisons carried out on the assessment of the weight of the criteria can be used.

Table 4 below shows the results of the calculation to get the weight of the criteria using the AHP method.

Table 4. Weighting Result of AHP Method

CRITERIA	A	B	C	D	E	F	G	Weight Vector	Eigen Vector
A	1	3	2	2	3	5	5	2,64	0,30
B	0,33	1	0,33	0,2	0,5	0,5	0,5	0,43	0,05
C	0,5	3	1	0,5	3	3	3	1,54	0,17
D	0,5	5	2	1	3	5	5	2,33	0,26
E	0,33	2	0,33	0,33	1	2	0,5	0,69	0,08
F	0,2	2	0,33	0,2	0,50	1	2	0,60	0,07
G	0,2	2	0,33	0,2	2	0,5	1	0,60	0,07
TOTAL	3,07	18	6,33	4,43	13,00	17	17	8,82	1,00
λ_{max}	7,38								
CI	0,06								

$\bar{\lambda}max$	15,04
RI	1,34
CR	0,048

After getting consistent weights from the criteria, look for the weights for each of the existing sub-criteria. The steps for finding the weights on this sub-criteria are the same as the steps for finding the weights on the previous criteria. However, it should be noted that the determination of the eigenvectors in each sub-criteria must be adjusted to the value of the eigenvectors in the previous criteria. In Figure 2 below, the AHP weighting values for each sub-criteria are shown which will later be used in the ranking process using the VIKOR and SAW methods.

Figure 2. Calculation of the weight of each Alternative on each criterion

3.3. Rank Calculation Process Using Vikor Method

3.3.1. Calculation of Criteria Alternative Weight

Each alternative value for each criterion and sub-criteria is calculated in this process. The weight value of the criteria for each Alternative is shown in Table 5. Below.

Table 5. Criteria Alternative Weight

Alternatif	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	D1	D2	D3	D4	D5	E1	E2	E3	E4	F1	F2	F3	F4	G1	G2	G3	G4	G5
P1	5	2	2	3	4	4	4	4	2	2	4	2	3	2	5	4	5	2	5	4	5	4	2	4	4	5	4	4	2	3
P2	3	2	3	4	5	4	4	3	2	2	2	5	3	2	4	4	2	5	2	2	2	5	2	2	4	4	3	3	3	4
P3	5	5	3	4	4	4	4	4	2	3	5	3	2	2	2	2	4	3	2	3	4	2	5	5	2	2	2	2	2	3
P4	2	2	2	3	4	5	5	3	2	2	2	2	5	5	2	2	3	2	4	4	3	4	4	2	2	2	2	2	2	5
P5	5	4	4	2	5	5	4	3	3	3	2	2	3	5	4	2	3	5	2	5	3	3	2	2	2	4	2	2	3	4

3.3.2. Perform Weighted Normalization

The normalization results of the criteria weights for each Alternative are shown in Table 6 below.

Table 6. Weighted Normalization

Alternatif	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	D1	D2	D3	D4	D5	E1	E2	E3	E4	F1	F2	F3	F4	G1	G2	G3	G4	G5
P1	0.248	0.099	0.099	0.149	0.199	0.199	0.199	0.199	0.099	0.099	0.199	0.099	0.149	0.099	0.248	0.199	0.248	0.099	0.248	0.199	0.248	0.199	0.099	0.199	0.199	0.248	0.199	0.199	0.099	0.149
P2	0.164	0.109	0.164	0.219	0.273	0.219	0.219	0.164	0.109	0.109	0.109	0.273	0.164	0.109	0.219	0.219	0.109	0.273	0.109	0.109	0.109	0.273	0.109	0.109	0.219	0.219	0.164	0.164	0.164	0.219
P3	0.272	0.272	0.163	0.217	0.217	0.217	0.217	0.217	0.109	0.163	0.272	0.163	0.109	0.109	0.109	0.109	0.217	0.163	0.109	0.163	0.217	0.109	0.272	0.272	0.109	0.109	0.109	0.109	0.109	0.163
P4	0.115	0.115	0.115	0.172	0.229	0.286	0.286	0.172	0.115	0.115	0.115	0.115	0.286	0.286	0.115	0.115	0.172	0.115	0.229	0.229	0.172	0.229	0.229	0.115	0.115	0.115	0.115	0.115	0.115	0.286
P5	0.264	0.211	0.211	0.106	0.264	0.264	0.211	0.159	0.159	0.159	0.106	0.106	0.159	0.264	0.211	0.106	0.159	0.264	0.106	0.264	0.159	0.159	0.106	0.106	0.106	0.211	0.106	0.106	0.159	0.211

3.3.3. Weighted Normalized Matrix Multiplication

The results of the weighted normalization for each Alternative are shown in Table 7 below.

Table 7. Weighted Normalized Matrix

Alternatif	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	D1	D2	D3	D4	D5	E1	E2	E3	E4	F1	F2	F3	F4	G1	G2	G3	G4	G5
P1	0.010	0.007	0.017	0.004	0.006	0.002	0.001	0.001	0.002	0.002	0.017	0.005	0.009	0.005	0.006	0.023	0.004	0.001	0.002	0.004	0.011	0.002	0.001	0.006	0.004	0.004	0.003	0.001	0.003	0.000
P2	0.006	0.007	0.028	0.005	0.008	0.002	0.001	0.001	0.003	0.002	0.009	0.013	0.010	0.005	0.005	0.025	0.002	0.002	0.001	0.002	0.005	0.003	0.001	0.003	0.005	0.004	0.002	0.001	0.005	0.001
P3	0.010	0.018	0.027	0.005	0.007	0.002	0.001	0.001	0.003	0.003	0.023	0.008	0.007	0.005	0.003	0.012	0.004	0.001	0.001	0.003	0.009	0.001	0.002	0.008	0.002	0.002	0.001	0.001	0.003	0.001
P4	0.004	0.008	0.019	0.004	0.007	0.002	0.002	0.001	0.003	0.002	0.010	0.006	0.018	0.013	0.003	0.013	0.003	0.001	0.001	0.004	0.007	0.002	0.002	0.003	0.002	0.002	0.001	0.001	0.003	0.001
P5	0.010	0.014	0.036	0.003	0.008	0.002	0.001	0.001	0.004	0.003	0.009	0.005	0.010	0.012	0.005	0.012	0.003	0.002	0.001	0.005	0.007	0.002	0.001	0.003	0.002	0.004	0.001	0.001	0.004	0.001

3.3.4. Calculation of Max and Min Values

The calculation max and min results are shown in Table 8 as follows.

Table 8. Weighted Normalized Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
fmax	0.010	0.018	0.036	0.003	0.008	0.002	0.002	0.001	0.004	0.003	0.023	0.013	0.018	0.013	0.006	0.025	0.004	0.002	0.002	0.005	0.011	0.003	0.002	0.008	0.005	0.004	0.003	0.001	0.005	0.001
fmin	0.004	0.007	0.017	0.005	0.006	0.002	0.001	0.001	0.002	0.002	0.009	0.005	0.007	0.005	0.003	0.012	0.002	0.001	0.001	0.002	0.005	0.001	0.001	0.003	0.002	0.002	0.001	0.001	0.003	0.000

3.3.5. Calculation of utility measure values (Si and Ri), VIKOR Index (Qi), and alternative Ranking.

The results of the calculation of the max value and utility measure value, Vikor index, and alternative ranking results are shown in Table 9.

Table 9. Si, Ri, Qi values and Alternative Rank

ALTERNATIF	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	D1	D2	D3	D4	D5	E1	E2	E3	E4	F1	F2	F3	F4	G1	G2	G3	G4	G5	SI	RI	QI	RANK
P1	0.006	0.068	0.169	0.009	0.030	0.009	0.006	0.001	0.025	0.018	0.037	0.048	0.047	0.046	0.000	0.020	0.000	0.009	0.000	0.008	0.000	0.004	0.007	0.013	0.004	0.000	0.000	0.000	0.028	0.003	0.615	0.169	0.782	4
P2	0.026	0.064	0.071	0.024	0.000	0.007	0.005	0.004	0.021	0.015	0.081	0.000	0.042	0.044	0.005	0.000	0.018	0.000	0.006	0.019	0.043	0.000	0.007	0.029	0.000	0.004	0.005	0.003	0.000	0.002	0.545	0.081	0.136	1
P3	0.000	0.000	0.073	0.024	0.023	0.007	0.005	0.000	0.021	0.000	0.000	0.030	0.061	0.044	0.025	0.111	0.004	0.006	0.006	0.013	0.010	0.010	0.000	0.000	0.020	0.017	0.012	0.007	0.024	0.003	0.555	0.111	0.327	3
P4	0.038	0.062	0.146	0.014	0.018	0.000	0.000	0.003	0.019	0.014	0.079	0.044	0.000	0.000	0.024	0.105	0.010	0.008	0.001	0.004	0.024	0.003	0.002	0.028	0.019	0.016	0.011	0.006	0.022	0.000	0.720	0.146	0.869	5
P5	0.002	0.024	0.000	0.000	0.004	0.002	0.005	0.004	0.000	0.001	0.083	0.046	0.044	0.005	0.007	0.114	0.011	0.000	0.006	0.000	0.028	0.007	0.007	0.030	0.021	0.004	0.013	0.007	0.002	0.002	0.480	0.114	0.187	2

From the calculations in Table 9 using that the value V = 0,5, so that the value of S- = 0,720, S*= 0,480, R-= 0,169, and R*=0,081. Calculation of alternative values using the VIKOR method can be seen in table 10 below.

Table 10. Alternative Final Rank

Alternatives	Q1Value	Rank
P1	0,782	4
P2	0,136	1
P3	0,327	3

Alternatives	Q1Value	Rank
P4	0,869	5
P5	0,187	2

3.4. Ranking with SAW Method

3.4.1. Alternative Weighting

The alternative weighting data for each criterion uses the same data in Table 3.

3.4.2. Normalizing the Decision Matrix

The normalization results of the decision matrix are shown in Table 11 as follows.

Table 11. Normalizing the Decision Matrix

Alternatif	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	D1	D2	D3	D4	D5	E1	E2	E3	E4	F1	F2	F3	F4	G1	G2	G3	G4	G5
P1	1	0.4	0.4	0.6	0.8	0.8	0.8	0.8	0.4	0.4	0.8	0.4	0.6	0.4	1	0.8	1	0.4	1	0.8	1	0.8	0.4	0.8	0.8	1	0.8	0.8	0.4	0.6
P2	0.6	0.4	0.6	0.8	1	0.8	0.8	0.6	0.4	0.4	0.4	1	0.6	0.4	0.8	0.8	0.4	1	0.4	0.4	0.4	1	0.4	0.4	0.8	0.8	0.6	0.6	0.6	0.8
P3	1	1	0.6	0.8	0.8	0.8	0.8	0.8	0.4	0.6	1	0.6	0.4	0.4	0.4	0.4	0.8	0.6	0.4	0.6	0.8	0.4	1	1	0.4	0.4	0.4	0.4	0.4	0.6
P4	0.4	0.4	0.4	0.6	0.8	1	1	0.6	0.4	0.4	0.4	0.4	1	1	1	0.4	0.4	0.6	0.4	0.8	0.8	0.6	0.8	0.8	0.4	0.4	0.4	0.4	0.4	1
P5	1	0.8	0.8	0.4	1	1	0.8	0.6	0.6	0.6	0.4	0.4	0.6	1	0.8	0.4	0.6	1	0.4	1	0.6	0.6	0.4	0.4	0.4	0.8	0.4	0.4	0.6	0.8

3.4.3. Calculate Preference Value or Alternative Ranking

The results of alternative ranking with the SAW method are shown in Tabel 12 below.

Table 12. Alternative Final Rank

Alternatives	Value	Rank
P1	0,6445	2
P2	0,60972	4
P3	0,64285	3
P4	0,52228	5
P5	0,64751	1

In the final process, the results of the ranking calculations using the VIKOR method are compared with the results of the ranking calculations using the SAW method. The results of the ranking differences are obtained from each ranking. The results of the comparison can be seen in the following Table 13.

Table 13. Comparison AHP-VIKOR and AHP-SAW Result Rank

Alternatives	AHP-VIKOR Result Rank	AHP-SAW Result Rank
P1	**4**	**2**
P2	**1**	**4**
P3	**3**	**3**
P4	**5**	**5**
P5	**2**	**1**

4. Conclusion

Calculation results show differences in alternative ranking between the combination of the AHP-VIKOR method and the combination of the AHP-SAW method. In combining alternative AHP-VIKOR methods, P2 has the highest ranking, P5 is ranked 2nd, P3 is ranked 3rd, P1 is ranked 4th, and P4 is ranked 5th. Meanwhile, in the combination of alternative AHP-SAW methods, P5 has the highest ranking, P1 is ranked 2nd, P3 is ranked 3rd, P2 is ranked 4th and P4 is ranked 5th. With this difference in performance ranking values, it is suggested that further research can use sensitivity analysis to determine the best combination that is suitable for use in a particular case.

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