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Comparison of SAW, RAM, and TOPSIS Methods in Multi-Criteria Decision Making: Application in Selecting Waterproofing Materials Imported From Malaysia

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***Abstract*—SAW is the oldest method among the multi-criteria decision-making (MCDM) approaches. On the other hand, RAM is known to be the newest method. TOPSIS is a highly renowned method and is the most widely used among MCDM methods. A question arises as to which method is deemed superior to the other two. The answer to this question is first found in this study. The selection of waterproofing materials is the problem used to compare the three aforementioned methods. The results indicated that RAM and TOPSIS are equally effective and superior to the SAW method.**

***Index Terms*—SAW method, RAM method, TOPSIS method, waterproofing material selection.**

I. Introduction

SELECTING of an option from among many alternatives is a common problem across all fields. To make a choice, various parameters (criteria) of the options must be evaluated. This means that choosing a particular option is a multi-criteria decision-making action [17]. Multi-criteria decision-making is carried out with the assistance of Multi-Criteria Decision-Making (MCDM) methods. There are over 200 different MCDM methods currently in use across various fields [18]. SAW is known to be the oldest method among MCDM approaches [9]. Despite having been around for a long time, its simplicity of application has kept it and its variations favored by scientists. The concept of SAW variations involves combining SAW with fuzzy theory to create the Fuzzy-SAW method for solving problems related to fuzzy sets, while fundamentally based on the original SAW method. In 2023, many studies continue to apply this method in various fields, such as selecting machining processes, milling processes, and evaluating indoor air quality [10], choosing rental cars [11], evaluating online learning platforms [12], selecting medical equipment suppliers [13], etc. RAM is the most recent MCDM method, introduced on September 7, 2023 [4]. According to the proponents of the RAM method, it overcomes the shortcomings of existing MCDM methods. The advantage lies in its ability to balance between beneficial and non-beneficial criteria. Overcoming the issue of reversal is also a strength of RAM [4]. Despite these mentioned advantages, due to its recent introduction, there have been no published studies on its application to date. TOPSIS is one of the most famous methods among MCDM approaches and is considered the most widely applied method [16]. In 2023, numerous studies have applied the TOPSIS method and its variations (Fuzzy-TOPSIS) in various fields, such as selecting businesses for mining investment [14], choosing solutions for grinding the surface of carbide cutting tools [15], selecting the defense strategy of the Serbian army [19], selecting logistics service providers [20], choosing locations for solar energy station construction [21], etc.

The analyses above lead to a question of which method—SAW, RAM, or TOPSIS—should be used. To decide which method to choose, a comparison of these methods is necessary and should be carried out initially. Unfortunately, such a comparison has not been conducted in any documented work. The objective of this article is to address this question. These three methods were simultaneously used to solve the problem of selecting waterproofing materials imported from Malaysia to Vietnam. Comparing the aforementioned three MCDM methods using a single weighting method for criteria may lead to biased conclusions. To achieve generalizable conclusions, the weights of the criteria have been determined using various methods. The summary of the steps for using the SAW, RAM, and TOPSIS methods will be presented in Chapter 2. Chapter 3 will summarize the steps for applying the weighting methods. The comparison of the three MCDM methods in selecting waterproofing materials will be discussed in Chapter 4. The final section of this article contains the scientific conclusions reached and directions for future research.

II. Multi-criteria decision-making methods used

A matrix with m rows and n columns will be established, where m is the number of alternatives to be ranked and n is the number of criteria used to describe each alternative. The value of criterion j for alternative i is denoted as xij, with i = 1 to m and j = 1 to n. Letters B and C are used to signify correspondingly that the higher the criterion, the better (B), and the lower the criterion, the better (C). The weight of criterion j is denoted as wj. The sequence of applying MCDM methods is as follows.

A. The SAW method

The sequence for ranking alternatives using the SAW method is as follows [3]:

Determine the normalized values using the following formula.

$$n_{ij}=\frac{x}{x_{ij}}, if\ j \in B \quad (1)$$

$$n_{ij}=\frac{x_{ij}}{x_{ij}}, if\ j \in C \quad (2)$$

The score Vi for each alternative is calculated using formula (3).

$$V_i=\sum_{j=1}^{n} w_j \cdot n_{ij} \quad (3)$$

The alternative with the highest Vi score is ranked 1. Conversely, the alternative with the lowest Vi score is ranked m.

B. The RAM method

To rank the alternatives using the RAM method, the following steps need to be carried out [4].

Normalize the data using formula (4).

$$n_{ij}=\frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad (4)$$

Calculate the normalized values considering the weights of the criteria according to (5)

$$y_{ij}=w_j \cdot n_{ij} \quad (5)$$

Calculate the sum of normalized scores considering the weights of the criteria as per (6) and (7).

$$S_{+i}=\sum_{j=1}^{n} y_{+ij}, if\ j \in B \quad (6)$$

$$S_{-i}=\sum_{j=1}^{n} y_{-ij}, if\ j \in B \quad (7)$$

Calculate the score for each alternative according to (8).

$$RI_i=\sqrt[2+S_{-i}]{2+S_{+i}} \quad (8)$$

The alternative with the highest RIi score is ranked 1. Conversely, the alternative with the lowest RIi score is ranked m.

C. The TOPSIS Method

The TOPSIS method ranks alternatives in the following order [5]:

Determine the normalized values using formula (9).

$$n_{ij}=\frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \quad (9)$$

Calculate the normalized values considering the weights using formula (10).

$$y_{ij}=w_j . n_{ij} \quad (10)$$

Determine the best solution A^+ and the worst solution A^- for the criteria using the following two formulas.

$$A^+=\left\{y_1^+, y_2^+, \ldots, y_j^+, \ldots, y_n^+\right\} \quad (11)$$

$$A^-=\left\{y_1^-, y_2^-, \ldots, y_j^-, \ldots, y_n^-\right\} \quad (12)$$

Where: y_j^+ and y_j^- are the best and worst values of the normalized value y for criterion j.

Determine the values S_i^+ and S_i^- using the following two formulas.

$$S_i^+=\sqrt{\sum_{j=1}^{n}\left(y_{ij}-y_j^+\right)^2}, \quad i = 1, 2, \ldots, m \quad (13)$$

$$S_i^-=\sqrt{\sum_{j=1}^{n}\left(y_{ij}-y_j^-\right)^2}, \quad i = 1, 2, \ldots, m \quad (14)$$

Calculate the score C_i^* of the alternatives using formula (15).

$$C_i^*=\frac{S_i^-}{S_i^+ + S_i^-}, \quad i = 1, 2, \ldots, m; 0 \le C_i^* \le 1 \quad (15)$$

The alternative with the highest score is ranked 1, and the alternative with the lowest score is ranked m.

III. Used Weight Determination Methods

Three different methods were used in the article to calculate weights for the criteria, including the Equal method, the Entropy method, and the MEREC method. The Equal weight method was used due to its simplicity. The Entropy and MEREC methods were used because they are encouraged to be used [22].

Applying formula (16) to calculate the weights of the criteria using the Equal weight method [6].

$$w_j=\frac{1}{n} \quad (16)$$

The sequence for determining the weights of the criteria using the Entropy method is as follows [7]:

Determine the normalized values for the criteria using formula (17).

$$n_{ij}=\frac{x_{ij}}{m+\sum_{i=1}^{m} x_{ij}^2} \quad (17)$$

Calculate the Entropy measure for the criteria using formula (18).

$$e_j=\sum_{i=1}^{m}\left[n_{ij} \times \ln(n_{ij})\right] - \left(1 - \sum_{i=1}^{m} n_{ij}\right) \times \ln\left(1 - \sum_{i=1}^{m} n_{ij}\right) \quad (18)$$

Calculate the weights for the criteria using formula (19).

$$w_j = \frac{1-e_j}{\sum_{j=1}^{m}\left(1-e_j\right)} \tag{19}$$

The sequence for determining the weights for the criteria using the MEREC method is as follows [8]:

Calculate the normalized values using the following two formulas.

$$n_{ij} = \frac{min\, x_{ij}}{x_{ij}}, if\ j \in B \tag{20}$$

$$n_{ij} = \frac{x_{ij}}{max\, x_{ij}}, if\ j \in C \tag{21}$$

The values Si, S'ij, and Ej are calculated using the respective three formulas (22), (23), and (24)

$$S_i = \ln\left[1+\left(\frac{1}{n}\sum_{j}^{n}\left|\ln\left(n_{ij}\right)\right|\right)\right] \tag{22}$$

$$S_{ij}^{'} = \ln\left[1+\left(\frac{1}{n}\sum_{k,k\neq j}^{n}\left|\ln\left(n_{ij}\right)\right|\right)\right] \tag{23}$$

$$E_j = \sum_{i}^{m}\left|S_{ij}^{'}-S_i\right| \tag{24}$$

The weights for the criteria are determined using formula (25).

$$w_j = \frac{E_j}{\sum_{k}^{m} E_k} \tag{25}$$

IV. Waterproofing Material Selection

Vietnamese import a number of waterproofing materials from Malaysia, which have corresponding product codes: Solmax 440-900, Solmax 420-900, Solmax 480-900, Solmax 430-900, and Solmax 460-900. Many details about these products have been provided by the manufacturer, such as waterproofing capability, durability, flexibility, adhesion, chemical resistance, etc. There are several parameters with identical values across all product codes. Therefore, comparing options does not require consideration of those parameters. Only the parameters with varying values across the options need to be examined. Six technical parameters have been selected from the options, including average thickness, minimum thickness, tensile strength at flexure, tensile strength at break, tear strength, and puncture resistance. All six parameters fall under category B. Selecting a type of waterproofing material based solely on technical criteria would be a limitation. Procurement costs, processing costs, and time are factors that significantly impact both the economic and technical aspects of the project. Hence, factors related to processing time and processing costs should also be considered. A field survey identified three parameters: construction time, processing cost, and price. All three parameters are calculated per square meter of waterproofing material and fall under category C. Table 1 summarizes the data for the various options.

The Solmax 480-900 waterproofing material meets all six initial criteria and ranks highest compared to the other four remaining products. On the other hand, the Solmax 420-900 has the lowest values for all three criteria among the rest of the options. This necessitates the application of the MCDM technique to select the best waterproofing material. Firstly, determining the weights for the criteria is essential.

According to the Equal weight method, each criterion has an equal weight of 0.1111. When using the Entropy method, the normalized values calculated according to (17) have been synthesized in Table 2. The values Ej and weights wj were calculated using the respective formulas (18) and (19), and the results have been summarized in Table 3.

When using the MEREC method, the normalized values were calculated using the formulas (20) and (21), and the results are shown in Table 4.

Table 1. Types of waterproofing materials [1, 2]

Order	Average thickness (mm)	Minimum thickness (mm)	Tensile strength at flexure (kN/m)	Tensile strength at break (kNm)	Tear strength (N)	Puncture resistance (N)	Construction time (h)	Processing cost (Thousand Vietnamese dong)	Price (Thousand Vietnamese dong)
	C1	C2	C3	C4	C5	C6	C7	C8	C9
Solmax 440-900	1	0.9	15	28	130	355	0.37	34	272
Solmax 420-900	0.5	0.45	8	14	65	176	0.26	20	165
Solmax 480-900	2	1.8	31	57	250	705	0.43	42	366
Solmax 430-900	0.75	0.68	11	21	93	265	0.32	21	200
Solmax 460-900	1.5	1.35	23	43	187	540	0.39	36	285

Table 2. Normalized values in the Entropy weight method.

	C1	C2	C3	C4	C5	C6	C7	C8	C9
Solmax 440-900	0.0766	0.0780	0.0079	0.0043	0.0010	0.0003	0.0656	0.0067	0.0008
Solmax 420-900	0.0383	0.0390	0.0042	0.0021	0.0005	0.0002	0.0461	0.0040	0.0005
Solmax 480-900	0.1531	0.1560	0.0163	0.0087	0.0020	0.0007	0.0762	0.0083	0.0010
Solmax 430-900	0.0574	0.0589	0.0058	0.0032	0.0007	0.0003	0.0567	0.0041	0.0006
Solmax 460-900	0.1148	0.1170	0.0121	0.0066	0.0015	0.0005	0.0691	0.0071	0.0008

Table 3. Ej values and weights of the criteria calculated using the Entropy method.

	C1	C2	C3	C4	C5	C6	C7	C8	C9
Ej	-0.6968	-0.7049	-0.1661	-0.1049	-0.0323	-0.0135	-0.6056	-0.1234	-0.0224
wj	0.1479	0.1486	0.1017	0.0963	0.0900	0.0884	0.1400	0.0979	0.0891

Table 4. Normalized values in the MEREC weight method.

	C1	C2	C3	C4	C5	C6	C7	C8	C9
Solmax 440-900	0.5000	0.5000	0.5333	0.5000	0.5000	0.4958	0.8605	0.8095	0.7432
Solmax 420-900	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.6047	0.4762	0.4508
Solmax 480-900	0.2500	0.2500	0.2581	0.2456	0.2600	0.2496	1.0000	1.0000	1.0000
Solmax 430-900	0.6667	0.6618	0.7273	0.6667	0.6989	0.6642	0.7442	0.5000	0.5464
Solmax 460-900	0.3333	0.3333	0.3478	0.3256	0.3476	0.3259	0.9070	0.8571	0.7787

Table 5. Si and S'ij values in the MEREC weight method.

	Si	S'ij								
		C1	C2	C3	C4	C5	C6	C7	C8	C9
Solmax 440-900	0.4246	0.4377	0.4377	0.4353	0.4377	0.4377	0.438	0.4115	0.4152	0.4201
Solmax 420-900	0.2045	0.5457	0.5457	0.5457	0.5457	0.5457	0.5457	0.5708	0.5788	0.5804
Solmax 480-900	0.6515	0.3878	0.3878	0.3872	0.3881	0.387	0.3878	0.3296	0.3296	0.3296
Solmax 430-900	0.3602	0.4567	0.457	0.4524	0.4567	0.4544	0.4569	0.4512	0.4683	0.4651
Solmax 460-900	0.5788	0.3847	0.3847	0.3836	0.3853	0.3837	0.3853	0.3404	0.3443	0.3505

Table 6. Ej values and weights of the criteria calculated using the MEREC method.

	C1	C2	C3	C4	C5	C6	C7	C8	C9
Ej	0.9085	0.9089	0.9036	0.9076	0.9081	0.9084	1.0308	1.0483	1.0356
wj	0.1061	0.1062	0.1056	0.1060	0.1061	0.1061	0.1204	0.1225	0.1210

Table 7. Weights of the criteria.

Weight method	C1	C2	C3	C4	C5	C6	C7	C8	C9
Equal	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111
Entropy	0.1479	0.1486	0.1017	0.0963	0.0900	0.0884	0.1400	0.0979	0.0891
MEREC	0.1061	0.1062	0.1056	0.1060	0.1061	0.1061	0.1204	0.1225	0.1210

Table 8. Normalized values in the SAW method.

	C1	C2	C3	C4	C5	C6	C7	C8	C9
Solmax 440-900	0.5000	0.5000	0.4839	0.4912	0.5200	0.5035	0.7027	0.5882	0.6066
Solmax 420-900	0.2500	0.2500	0.2581	0.2456	0.2600	0.2496	1.0000	1.0000	1.0000
Solmax 480-900	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.6047	0.4762	0.4508
Solmax 430-900	0.3750	0.3778	0.3548	0.3684	0.3720	0.3759	0.8125	0.9524	0.8250
Solmax 460-900	0.7500	0.7500	0.7419	0.7544	0.7480	0.7660	0.6667	0.5556	0.5789

Table 9. Scores and rankings of the options using the SAW method.

	Equal weight		Entropy weight		MEREC weight	
	Vi	rank	Vi	rank	Vi	rank
Solmax 440-900	0.5440	3	0.5461	3	0.5480	4
Solmax 420-900	0.5015	5	0.4966	5	0.5243	5
Solmax 480-900	0.8369	1	0.8444	1	0.8218	1
Solmax 430-900	0.5349	4	0.5304	4	0.5501	3
Solmax 460-900	0.7013	2	0.7049	2	0.6966	2

Table 10. Normalized values in the RAM method.

	C1	C2	C3	C4	C5	C6	C7	C8	C9
Solmax 440-900	0.1739	0.1737	0.1705	0.1718	0.1793	0.1739	0.2090	0.2222	0.2112
Solmax 420-900	0.0870	0.0869	0.0909	0.0859	0.0897	0.0862	0.1469	0.1307	0.1281
Solmax 480-900	0.3478	0.3475	0.3523	0.3497	0.3448	0.3454	0.2429	0.2745	0.2842
Solmax 430-900	0.1304	0.1313	0.1250	0.1288	0.1283	0.1298	0.1808	0.1373	0.1553
Solmax 460-900	0.2609	0.2606	0.2614	0.2638	0.2579	0.2646	0.2203	0.2353	0.2213

Table 11. Normalized values considering the weights of the criteria in the RAM method.

	C1	C2	C3	C4	C5	C6	C7	C8	C9
Solmax 440-900	0.0193	0.0193	0.0189	0.0191	0.0199	0.0193	0.0232	0.0247	0.0235
Solmax 420-900	0.0097	0.0097	0.0101	0.0095	0.0100	0.0096	0.0163	0.0145	0.0142
Solmax 480-900	0.0386	0.0386	0.0391	0.0389	0.0383	0.0384	0.0270	0.0305	0.0316
Solmax 430-900	0.0145	0.0146	0.0139	0.0143	0.0143	0.0144	0.0201	0.0153	0.0173
Solmax 460-900	0.0290	0.0290	0.0290	0.0293	0.0287	0.0294	0.0245	0.0261	0.0246

Table 12. Some parameters in the RAM method and rankings of the options (when weights were calculated using the Equal weight method).

	S_{+i}	S_{-i}	RI_i	rank
Solmax 440-900	0.1159	0.0714	1.4360	3
Solmax 420-900	0.0585	0.0451	1.4234	5
Solmax 480-900	0.2319	0.0891	1.4686	1
Solmax 430-900	0.0860	0.0526	1.4307	4
Solmax 460-900	0.1744	0.0752	1.4540	2

The values of Si and S'ij were calculated using the respective formulas (22) and (23), and the results are shown in Table 5.

The Ej values and weights wj were calculated using the respective formulas (24) and (25), and the results have been synthesized in Table 6.

Weight determination for the criteria using three methods - Equal, Entropy, and MEREC - has been completed. In Table 7, the data from these calculations have been compiled.

The normalization of data for ranking the options using the SAW method was performed by applying formulas (1) and (2), and the results have been summarized in Table 8.

The Vi scores for the options were calculated using formula (3). These scores were used for ranking the options. These two steps were repeated three times corresponding to three different weight sets, and the results are presented in Table 9.

The normalization of data when using the RAM method for ranking the options was carried out by applying formula (4), and the results were compiled in Table 10.

The normalized values considering the weights of the criteria were calculated using formula (5). First, the weights of the criteria calculated using the Equal weight method were used, and the results are presented in Table 11.

The values S+i, S-i, and RIi were calculated using the respective formulas (6), (7), and (8). The RIi values were also used for ranking the options and are summarized in Table 12.

When the weights of the criteria were determined using the Entropy and MEREC methods, the ranking of the options using the RAM method was also carried out similarly. In Table 13, the RIi scores and rankings of the options are summarized for all three weight determination methods.

TABLE 13. SCORES AND RANKINGS OF THE OPTIONS USING THE RAM METHOD.

	Equal weight		Entropy weight		MEREC weight	
	RI_i	rank	RI_i	rank	RI_i	rank
Solmax 440-900	1.4360	3	1.4367	3	1.4326	3
Solmax 420-900	1.4234	5	1.4236	5	1.4215	5
Solmax 480-900	1.4686	1	1.4701	1	1.4631	1
Solmax 430-900	1.4307	4	1.4311	4	1.4282	4
Solmax 460-900	1.4540	2	1.4549	2	1.4496	2

TABLE 15. NORMALIZED VALUES CONSIDERING THE WEIGHTS OF THE CRITERIA IN THE TOPSIS METHOD.

	C1	C2	C3	C4	C5	C6	C7	C8	C9
Solmax 440-900	0.0391	0.0391	0.0382	0.0385	0.0405	0.0391	0.0512	0.0531	0.0506
Solmax 420-900	0.0196	0.0196	0.0204	0.0193	0.0202	0.0194	0.0360	0.0312	0.0307
Solmax 480-900	0.0783	0.0782	0.0790	0.0784	0.0779	0.0777	0.0595	0.0656	0.0681
Solmax 430-900	0.0293	0.0296	0.0280	0.0289	0.0290	0.0292	0.0443	0.0328	0.0372
Solmax 460-900	0.0587	0.0587	0.0586	0.0592	0.0582	0.0595	0.0540	0.0562	0.0530

TABLE 16. A+ AND A- VALUES IN TOPSIS.

	C1	C2	C3	C4	C5	C6	C7	C8	C9
A+	0.0783	0.0782	0.079	0.0784	0.0779	0.0777	0.036	0.0312	0.0307
A-	0.0196	0.0196	0.0204	0.0193	0.0202	0.0194	0.0595	0.0656	0.0681

TABLE 17. SOME PARAMETERS IN THE TOPSIS METHOD AND RANKINGS OF THE OPTIONS (WHEN WEIGHTS WERE CALCULATED USING THE EQUAL WEIGHT METHOD).

	Si+	Si-	Ci*	rank
Solmax 440-900	0.1015	0.0528	0.3420	3
Solmax 420-900	0.1433	0.0560	0.2809	5
Solmax 480-900	0.0560	0.1433	0.7191	1
Solmax 430-900	0.1211	0.0527	0.3034	4
Solmax 460-900	0.0610	0.0975	0.6154	2

TABLE 18. SCORES AND RANKINGS OF THE OPTIONS USING THE TOPSIS METHOD.

	Equal weight		Entropy weight		MEREC weight	
	RI_i	rank	RI_i	rank	RI_i	rank
Solmax 440-900	0.3420	3	0.3385	3	0.3448	3
Solmax 420-900	0.2809	5	0.2589	5	0.3091	5
Solmax 480-900	0.7191	1	0.7411	1	0.6909	1
Solmax 430-900	0.3034	4	0.2810	4	0.3278	4
Solmax 460-900	0.6154	2	0.6207	2	0.6031	2

When applying the TOPSIS method to rank the options, data normalization was conducted using formula (9), and the results are shown in Table 14.

The normalized values, considering the weights of the criteria, were calculated using (10). The weight set calculated using the Equal weight method was used first, and the results are summarized in Table 15.

The values A+ and A- were calculated using the respective formulas (11) and (12), and the results are shown in Table 16.

The values Si+, Si-, and Ci* were calculated using the respective formulas (13), (14), and (15). The ranking of the options was based on their Ci* scores. The results are shown in Table 17.

Ranking the options using the TOPSIS method when the weights of the criteria were determined using the Entropy and MEREC methods was also performed in a similar manner. In Table 18, the Ci* scores and rankings of the options are summarized for all three weight determination methods.

Table 19. Ranking of the options using different methods.

	SAW & Equal	SAW & Entropy	SAW & MEREC	RAM & Equal	RAM & Entropy	RAM & MEREC	TOPSIS & Equal	TOPSIS & Entropy	TOPSIS & MEREC
Solmax 440-900	3	3	4	3	3	3	3	3	3
Solmax 420-900	5	5	5	5	5	5	5	5	5
Solmax 480-900	1	1	1	1	1	1	1	1	1
Solmax 430-900	4	4	3	4	4	4	4	4	4
Solmax 460-900	2	2	2	2	2	2	2	2	2
S	0.9÷1			1			1		

Table 20. Ranking of the options after excluding Solmax 440-900.

	SAW & Equal	SAW & Entropy	SAW & MEREC	RAM & Equal	RAM & Entropy	RAM & MEREC	TOPSIS & Equal	TOPSIS & Entropy	TOPSIS & MEREC
Solmax 420-900	4	4	4	4	4	4	4	4	4
Solmax 480-900	1	1	1	1	1	1	1	1	1
Solmax 430-900	3	3	3	3	3	3	3	3	3
Solmax 460-900	2	2	2	2	2	2	2	2	2
S	1			1			1		

Table 21. Ranking of the options after excluding Solmax 420-900.

	SAW & Equal	SAW & Entropy	SAW & MEREC	RAM & Equal	RAM & Entropy	RAM & MEREC	TOPSIS & Equal	TOPSIS & Entropy	TOPSIS & MEREC
Solmax 440-900	4	3	4	3	3	3	4	4	4
Solmax 480-900	1	1	1	1	1	1	1	1	1
Solmax 430-900	3	4	3	4	4	4	3	3	3
Solmax 460-900	2	2	2	2	2	2	2	2	2
S	0.8÷1			1			1		

Thus, the ranking of the options using the three methods - SAW, RAM, and TOPSIS - has been completed. To facilitate result analysis, the data in Tables 9, 13, and 18 have been compiled in Table 19.

Observing Table 19, it can be seen that when using the RAM and TOPSIS methods, the rankings of the options are entirely consistent and independent of the weighting method used. These rankings also match exactly with the two cases of using the SAW method combined with the Equal weight method and when using the SAW method combined with the Entropy weight method. If the SAW method is combined with the MEREC weight method, the rankings of the options do not entirely match with the other combinations. This shows that the stability in ranking the options using the SAW method is slightly lower compared to using the RAM and TOPSIS methods.

The Spearman's rank correlation coefficient has also been used to analyze sensitivity [23-25], which is calculated using formula (26). Here, Di represents the rank difference of the options for a specific scenario compared to another scenario.

$$S = 1 - \frac{6\sum_{i=1}^{m} D_i^2}{m\left(m^2-1\right)} \tag{26}$$

The values of the Spearman coefficient have been calculated and placed in the last row of Table 19. It is observed that the Spearman coefficient is 1 when using both the RAM and TOPSIS methods. However, when using the SAW method, the coefficient ranges from 0.9 to 1. This further confirms the perception that ranking the options using the SAW method is slightly less stable compared to using the RAM and TOPSIS methods. Nevertheless, in all cases studied, Solmax 480-900 has been identified as the best waterproofing material.

TABLE 22. RANKING OF THE OPTIONS AFTER EXCLUDING SOLMAX 480-900.

	SAW & Equal	SAW & Entropy	SAW & MEREC	RAM & Equal	RAM & Entropy	RAM & MEREC	TOPSIS & Equal	TOPSIS & Entropy	TOPSIS & MEREC
Solmax 440-900	2	2	2	2	2	2	2	2	2
Solmax 420-900	4	4	4	4	4	4	4	4	4
Solmax 430-900	3	3	3	3	3	3	3	3	3
Solmax 460-900	1	1	1	1	1	1	1	1	1
S	1			1			1		

TABLE 23. RANKING OF THE OPTIONS AFTER EXCLUDING SOLMAX 430-900.

	SAW & Equal	SAW & Entropy	SAW & MEREC	RAM & Equal	RAM & Entropy	RAM & MEREC	TOPSIS & Equal	TOPSIS & Entropy	TOPSIS & MEREC
Solmax 440-900	3	3	3	3	3	3	3	3	3
Solmax 420-900	4	4	4	4	4	4	4	4	4
Solmax 480-900	1	1	1	1	1	1	1	1	1
Solmax 460-900	2	2	2	2	2	2	2	2	2
S	1			1			1		

TABLE 24. RANKING OF THE OPTIONS AFTER EXCLUDING SOLMAX 460-900.

	SAW & Equal	SAW & Entropy	SAW & MEREC	RAM & Equal	RAM & Entropy	RAM & MEREC	TOPSIS & Equal	TOPSIS & Entropy	TOPSIS & MEREC
Solmax 440-900	2	2	3	2	2	2	2	2	2
Solmax 420-900	4	4	4	4	4	4	4	4	4
Solmax 480-900	1	1	1	1	1	1	1	1	1
Solmax 430-900	3	3	2	3	3	3	3	3	3
S	0.8÷1			1			1		

To accurately conclude that the stability of ranking the options using the SAW method is slightly lower than using the other two methods, further investigation in different scenarios is necessary. Five different scenarios were created, and in each scenario, one option was excluded from the list. The rankings of the options in these five scenarios are presented in Tables 20 to 24. In each of these tables, the Spearman coefficient has also been calculated and placed in the last row of each table.

In all five scenarios mentioned above, when using both the RAM and TOPSIS methods, the Spearman coefficient is always 1. In this case, when using the SAW method, the Spearman coefficient ranges from 0.8 to 1. This once again affirms that the RAM and TOPSIS methods have very high correlation consistency in ranking the options and perform better than SAW method.

V. CONCLUSION

An investigation to compare three methods - SAW, RAM, and TOPSIS - has been conducted in this article. The comparison of these three methods was carried out in ranking various waterproofing materials imported to Vietnam from Malaysia. Some conclusions are drawn as follows:

A. The rankings of the options completely match when ranked using both the RAM and TOPSIS methods, regardless of the weighting method used.

B. When using the SAW method to rank the options, the rankings also completely match when usingeither the Equal or Entropy weight determination methods.

C. The option identified as the best does not depend on the MCDM method or the weighting method used.

D. The stability in ranking the options using the SAW method is slightly lower compared to using the RAM and TOPSIS

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