Paper 2021 5

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Recommendations for Choosing a Place to Stay in the Greater Malang Area Using SAW and TOPSIS

Abstract*—Developments in an area must increase the number of people visiting the area For example, the Malang area is now growing quite rapidly by becoming a center for tourism, education and business destinations in the southern area of East Java. An important need to support visitors during their visit is a place to stay. The Malang area provides many different types and categories of places to stay, one of which is a sharia accommodation. With so many choices, visitors feel confused about which place to stay according to their needs and desires. To make it easier for visitors to determine where to stay, the authors conducted research by applying the SAW and TOPSIS methods, using the main criteria, namely facilities, price, location, and distance from the city center to provide recommendations for the best place to stay according to the needs and desires of visitors. From the results of the calculation of the highest preference values SAW and TOPSIS then used as a recommendation for choosing a place to stay for visitors.

***Keywords*—SAW, TOPSIS, DSS, Accomodation,**

I. INTRODUCTION

The Greater Malang area which includes three regions, namely Batu City, Regency and Malang City has developed quite rapidly to become a tourism, education and business center located in the southern part of East Java province [1]. Especially with the election of Malang Regency, precisely in the Singosari area, which will be built as a Special Economic Zone in the province of East Java, as well as being selected as one of the Priority Tourism Destinations in the Bromo Tengger Semeru area which will clearly have an impact on increasing visits to the Malang area.

According to data from the Central Statistics Agency or BPS, the level of visits in the greater Malang area has increased from year to year, such as in Malang Regency, from 2010-2018 the average increase in tourists every year is 14%, with a total of domestic and foreign tourists visiting foreign tourists in 2018 reached 7,172,358 tourists [2]. Then tourist visits in the city of Malang spanning 2014-2019 have an average annual increase of 11% and in 2019 the number of visits by 5,186,809 tourists for domestic and foreign tourists [3]. And the city of Batu for visits to tourist attractions in the 2016-2019 range also experienced a fairly large increase with an average increase of 21% per year with the number of visits in 2019 amounting to 6,047,460 tourists [4].

And with the continued development of the Greater Malang area, it will make it a magnet for many people to come to visit with various needs. In supporting the visit, one of the important accommodations is a place to stay, the Malang Raya area provides many choices of categories and types of places to stay, one of which is the type of Sharia. The many choices of places to stay with different facilities offerings and at various prices make many visitors feel confused in determining where to stay.

To help provide these recommendations, research was conducted using a Decision Support System or DSS using the SAW and TOPSIS methods. Simple Additive Weighting or SAW is a method with the main process of adding up the weight values of the criteria on each alternative for all attributes. The SAW method has the advantage of a shorter calculation time so that it has an efficient calculation process in decision making. In addition, the SAW method can also be combined with other methods. Then TOPSIS, introduces two 'reference' points, namely the positive ideal solution and the negative ideal solution. Often used to evaluate various criteria in object evaluation. The TOPSIS method tries to calculate the distance between the evaluation object with a positive ideal solution and a negative ideal solution. If the distance is closer to the positive ideal solution and far from the negative ideal solution, then it can be used as the best alternative solution [5] [6].

This research is expected to provide more knowledge about the application of the SAW and TOPSIS methods. How SAW and TOPSIS modeling are able to help solve the problems of decision makers in making the right decisions. The application of SAW is expected to provide effective results in making decisions. TOPSIS with multi-criteria solving characteristics is able to provide an evaluation of each object to be the best alternative decision. The comparison of the final results of these two methods is expected to be able to contribute to the best decision recommendations for decision makers.

II. DECISION MAKING PHASES

The availability of complete, objective, and reliable information is a condition for making the right decisions and can regulate the development of effective management. In administrative activities within the organization, problems often arise in the implementation of decision making. And for some cases, decision makers in making decisions require indepth analysis. To help make this decision, a decision support system was made [7].

Decision Support System itself is a system that is able to provide problem solving skills and communication skills for problems with semi-structured and unstructured conditions. This characteristic is shown in Figure 1. The system is used to assist decision making in semi-structured and unstructured situations, where no one knows for sure how a decision should be made [8].

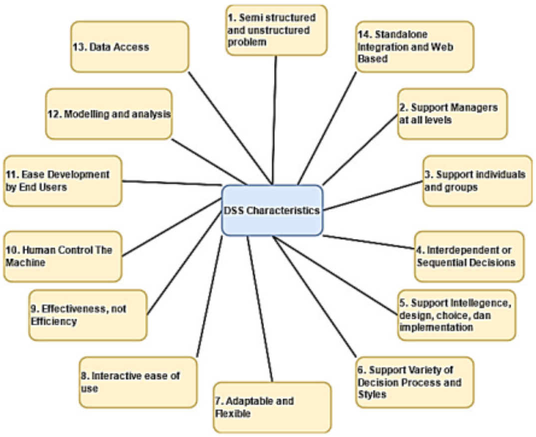

Fig. 1. Characteristics of Decision Support System

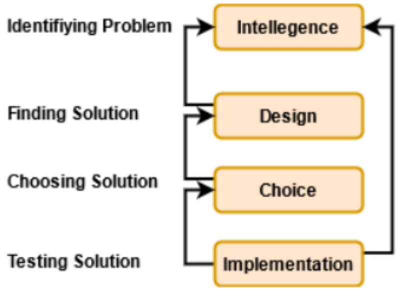

Fig. 2. Decision Making Phases

At the decision-making stage, Simon's model is proposed to represent the decision-making process. As in Figure 2, the first is the intelligence phase, which is the phase of identifying and understanding the problem of organizational goals. Decision makers need to identify the problem and its characteristics, and the problem domain must be traced to the root of the problem. In this intelligence phase, decision makers are required to examine real conditions and try to identify opportunities correctly.

The second is the design stage, trying to define and model the system as a representation of the system. This stage also tries to exemplify alternative decisions that will be chosen by decision makers with designs built by applying several approaches such as the SAW method, TOPSIS, AHP, Promithe, and so on. In this phase, DSS has a role to provide examples of problem preferences that have been determined. Further to the third stage, namely the selection stage, the use of SPK will produce several alternative decisions that have been sorted based on the results of the assessment. At this selection stage, it displays a list of alternative decisions for the decision maker, then the decision maker will choose an alternative decision that is not intuitive but more objective.

The fourth stage is implementation, at this stage attempts to implement alternative decisions that have been chosen by decision makers. The chosen alternative is then applied and observed how the results are to make feedback from the DSS and try to revise if there are deficiencies in the DSS that was built, the revision can be returned to the previous stage or directly to the initial stage [9].

III. SIMPLE ADDITIVE WEIGHTING (SAW)

Simple Additive Weighting (SAW) is one of the most frequently used techniques to solve a spatial decision analysis problem. The decision maker directly assigns a relatively important weight to each attribute. The final value is then obtained for each alternative by multiplying the value of the importance weight assigned to each attribute by the value scale assigned to the alternative for that attribute and summing the results of all attributes [10].

In the calculation of SAW in Figure 3, it starts with performing the required alternative input, then this alternative value is used as an alternative and calculates the weight of the criteria. Next, calculate the Normalized Matrix for positive and negative criteria. The multiplication of the weighted values and the normalization of this matrix will produce the final value for each alternative decision. All alternative decisions are ordered based on the final value [9].

The SAW method consists of three main steps, namely normalizing the decision matrix X, assigning a weighted value of B, and calculating the overall value for each alternative. The detailed calculation flow is as follows in Figure 3. [11].

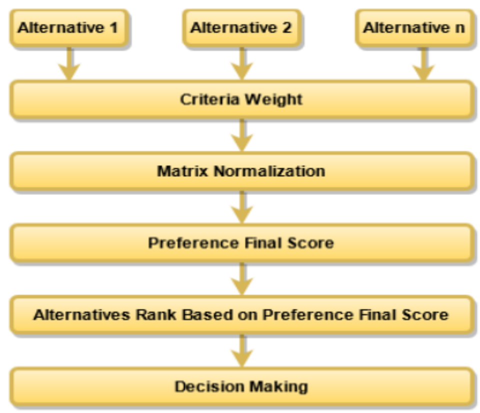

Fig. 3. SAW Calculation Flow

Step 1. Matrix Normalization

The original data must be converted to a balanced value using the normalization procedure. The SAW normalization method has developed and has many procedures, but the Max method is probably the most commonly used normalization method. During the normalization of the matrix, the criteria from costs must be changed to benefits. The matrix normalization steps are as follows in equation 1.

$$r_{ij} = \begin{cases} x_{ij}/x_j^{+}, & j \in \Omega_{max} \\ x_j^{-}/x_{ij}, & j \in \Omega_{min} \end{cases} \quad (1)$$

Where r_{ij} is the value of the *i-th* alternative normalization for the *j-th* criteria, x_j^+ is the maximum number of x_{ij} in column *j* for the benefit criteria, x_j^- is the minimum number of xij in the j-column for the cost criteria, and *max* and *min* are a series of criteria benefits and costs.

Step 2. Weighting Criteria

$$W = [w_1, w_2, \ldots, w_n] \quad (2)$$

Step 3. Preference Final Score

$$S_i = \sum_{j=1}^{n} w_j r_{ij} \quad (3)$$

IV. Technique for Order Preference by Similarity to Ideal Solutions (TOPSIS)

Technique for Order Preference by Similarity to Ideal Solutions (TOPSIS) is very effective compared to other heuristic methods because of its characteristics, namely fewer parameters, high consistency, and less computational effort. TOPSIS is a method for multi-attribute decision making that converts multiple result values into a single performance value. The TOPSIS algorithm was introduced by Hwang and Yoon in 1981, this algorithm is based on the idea that the chosen alternative must have the shortest Euclidean distance from the ideal solution and the farthest from the negative ideal solution [12].

Figure 4 shows the details of the TOPSIS method steps. The first step is to build an alternative matrix and then normalize the matrix. In the normalization process this matrix involves dividing each element by the square of the element. The normalization of this matrix is indicated by equation 4 where rij shows the normalization value of criteria j for alternative Ai. The next step is to calculate the weights of the normalized decision matrix with equation 4. This normalized matrix is described again to find the value of the positive ideal solution and the negative ideal solution.

Equations 6 and 7 are used to calculate the value of the positive ideal solution and the negative ideal solution. Equation 6 is used to calculate the value of the positive ideal solution and is represented by A+. And equation 7 for negative ideal solution is represented by A-. The positive ideal solution is used to maximize the benefit criteria and minimize the cost criteria, and conversely the negative ideal solution is used to maximize the cost criteria and minimize the benefit criteria. Benefit criteria here are criteria where the value of the benefit criteria is greater, the more feasible it is to be selected. Then for the cost criteria is the opposite of the benefit criteria, where the smaller the value of the cost criteria, the better it is to be selected. In the TOPSIS method, the alternative that is closer to the positive ideal solution and furthest from the negative ideal solution is the optimal alternative.

The value of this calculation is calculated by the rule of approaching the positive ideal solution and knowing the ideal solution, the result of this calculation is the preference value of each alternative. Furthermore, the decision maker can choose a preference with a certain value from each of the existing alternative decisions. [6]. Then, for the calculation process flow from the TOPSIS method is as follows [10][11][12].

Step 1. Normalized Decision Matrix

After determining goals and identifying attributes and then determining the decision matrix, then the decision matrix is normalized with the following equation 4.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \quad (4)$$

$i = 1, \ldots, m$; dan $j = 1, \ldots, n$

where r_{ij} shows normalization score by *j-th criteria* for alternative *i-th* from A_i.

Fig. 4. TOPSIS Calculation Flow

Step 2. Weighting Normalized Decision Matrix

$$v_{ij} = w_j r_{ij},\ i = 1, \ldots, m;\ j = 1, \ldots, n \quad (5)$$

where w_j is weight of criteria *j-th*.

Step 3. Positive and Negative Ideal Solution

$$A^+ = (v_1^+, \ldots, v_n^+) \quad (6)$$

$$A^- = (v_1^-, \ldots, v_n^-) \quad (7)$$

where A^+ shows to positive Ideal Solution, dan A^- shows to negative Ideal Solution. If criteria *j-th is* benefit criteria, then $v_j^+ = max\{v_{ij}, i = 1, \ldots, m\}$ and $v_j^- = min\{v_{ij}, i = 1, \ldots, m\}$. It applies to vice versa, if criteria *j-th*is is cost criteria then $v_j^+ = min\{v_{ij}, i = 1, \ldots, m\}$ dan $v_j^- = max\{v_{ij}, i = 1, \ldots, m\}$.

Step 4. Distance for Positive and Negative Ideal Solution

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2}\ , i = 1, \ldots, m \quad (8)$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2}\ , i = 1, \ldots, m \quad (9)$$

where D_i^+ shows distance between Positive Ideal Solution and alternative *i-th*, dan D_i^- shows distance between Negative Ideal Solution and alternative *i-th*.

Step 5. Preference Score By Each Alternative.

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \quad (10)$$

After calculating alternative distance and C_i score, it does rank alternatives and sort C_i score.

V. METHODOLOGY

In this research, the type of research carried out by researchers is experimental research, where this experimental research uses data in conducting research and produces a conclusion that can be proven by observation or experiment [13]. This research is an experimental type of research using data on Sharia-type lodging places in the Malang area with a total of 22 data on places to stay.

The first stage in this research is to conduct a literature study on the existing conditions, to then collect the required data. The data collection technique used was through questionnaires and observations, observations were made to obtain data about sharia accommodation types in the Malang area. Furthermore, a questionnaire is used to obtain data about what visitors want and need when looking for a place to stay.

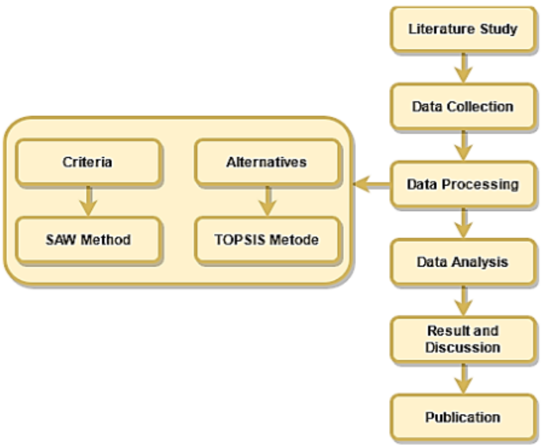

Fig. 5. Research Phases

The next step is to compare the results of the ranking of preference values between the SAW and TOPSIS methods. Then evaluate the preference value to be the best recommendation that can be given for choosing a place to stay. Because the alternatives and the criteria used are the same, a comparison is made to find out the final value of the best preference and adjusted with field data to be used as recommendations.

VI. RESULT AND DISCUSSION

This study uses a category of 5 types, where the data for each category is shown in Table 1. Furthermore, the alternative criteria used in the assessment of the selection of places to stay are shown in Table 2.

The criteria in Table 2 are determined by a criterion importance level with a range of weighted values. The range of weighting values is shown in Table 3. Based on the range of values that have been determined in Table 3, the weighting for each criteria is shown in Table 4.

In determining the value of the preference weight (W) obtained from a questionnaire that was conducted randomly to 30 people who live outside the Greater Malang area, both those who have come, have never, or have plans to come visit the Greater Malang area, and the results obtained are the weight values of preference (W). The preference weights are shown in Table 5.

TABLE I. DATA SAMPLE ACCOMODATION AS ALTERNATIVES

Alternative	Price (thousand)	Distance (km)	Facility	Spot
A1	65-75	6,30	8	5
A2	55-65	2,57	6	6
A3	50-65	2,86	6	5
A4	55-120	3,79	8	5
A5	50-125	5,49	7	6
A6	65-90	6,87	9	7
A7	65-125	3,92	7	5
A8	65-95	6,05	6	5
A9	65-75	5,03	6	5
A10	110	4,94	7	5
A11	120-140	3,2	5	11
A12	75	5,49	4	6
A13	90-120	4,8	8	10
A14	75-90	8,0	7	11
A15	75-90	8,0	5	11
A16	65-130	4,8	7	11
A17	95	6,51	6	7
A18	75	4,29	6	7
A19	75-90	3,84	5	7
A20	75	4,29	4	7
A21	125-175	4,29	4	7
A22	50-70	7,66	5	8

TABLE II. ALTERNATIVES CRITERIA

Criteria	Alternative Criteria
C1	Price of accomodation
C2	Location of accomodation
C3	Availability of Facilities
C4	Arround Spot

TABLE III. WEIGHTING SCORE RANGE

Score	Weight
1	Very Not Importance
2	Not Importance
3	Too Importance
4	Importance
5	Very Importance

TABLE IV. PRICE, LOCATION DISTANCE, NUMBER FACILITIES, AND AROUND SPOT CRITERIA WEIGHT

Weight	Score (Rupiah)	Distance (Km)	Facilities Number	Around Spot
1	C1 >= 451.000	C2 >= 16,1	C3 <= 1	C4 <= 2
2	351.000 – 450.000	12,1 – 16	2 – 3	2 – 4
3	251.000 – 350.000	8,1 – 12	4 – 5	4 – 7
4	151.000 – 250.000	4,1 – 8	6	7 – 9
5	C1 <= 150.000	C2 <= 4	C3 >= 7	C4 >= 10

TABLE V. PREFERENCES SCORES WEIGHT

Criteria	Alternatives Criteria	Weight
C1	Price of Inn	4
C2	Location of Inn	5
C3	Availability Facilities	4
C4	Around Sport	3

Each alternative shown in Table 2 has several criteria. If the weight of the criteria is adjusted to each alternative, the data shown in Table 4 will be continued in the calculation phase using the SAW method. Furthermore, the data in Table 6 was normalized so as to produce the normalized value of the matrix shown in Table 6.

The results of the weighting of the criteria in Table 6 are then multiplied by the preference weights with equation (3).

The results of the calculations and their ranking of each alternative are shown in Table 11.

The results of calculations with SAW are shown in Table 12. Each alternative has its own ranking according to the final value of the calculation. Furthermore, the weighted data in Table 11 need to be calculated using TOPSIS.

TABLE VI. WEIGHTING SCORE AND NORMALIZED MATRIX

Alternatives	Weighted Score				Normalized Matrix			
	Criteria				Criteria			
	C1	C2	C3	C4	C1	C2	C3	C4
A1	5	4	5	3	0,8	0,8	1	0,6
A2	5	5	4	3	0,8	1	0,8	0,6
A3	5	5	4	3	0,8	1	0,8	0,6
A4	4	5	5	3	1	1	1	0,6
A5	4	4	4	3	1	0,8	0,8	0,6
A6	5	4	5	4	0,8	0,8	1	0,8
A7	4	5	4	3	1	1	0,8	0,6
A8	5	4	4	3	0,8	0,8	0,8	0,6
A9	5	4	4	3	0,8	0,8	0,8	0,6
A10	4	4	4	3	1	0,8	0,8	0,6
A11	4	5	3	5	1	1	0,6	1
A12	5	4	3	3	0,8	0,8	0,6	0,6
A13	4	4	5	5	1	0,8	1	1
A14	5	4	4	5	0,8	0,8	0,8	1
A15	5	4	3	5	0,8	0,8	0,6	1
A16	4	4	4	5	1	0,8	0,8	1
A17	5	4	4	4	0,8	0,8	0,8	0,8
A18	5	4	4	4	0,8	0,8	0,8	0,8
A19	5	4	3	4	0,8	0,8	0,6	0,8
A20	5	4	3	4	0,8	0,8	0,6	0,8
A21	4	4	3	4	1	0,8	0,6	0,8
A22	5	4	3	4	0,8	0,8	0,6	0,8

From the weighted score in Table 6, the normalized matrix is calculated using equation (4), and then the weighted thermalization matrix is calculated using equation (5) with the results in table 7 and table 8.

Then search for the value of y max (y+) and the value of y min (y-) with equations and conditions (6)(7). Then proceed with calculations to find alternative distances A¬¬i with positive ideal solutions (A+) and negative ideal solutions (A-) with equations (8) and (9) which are illustrated in Table 15 and Table 16.

Then search for the value of *y max (y+)* and the value of *y min (y-)* with equations and conditions (6)(7). Then proceed with calculations to find alternative distances A_i with positive ideal solutions (*A+*) and negative ideal solutions (A-) with equations (8) and (9) which are illustrated in Table 9 and Table 10.

TABLE VII. NORMALIZED MATRIX (R)

	C1	C2	C3	C4
A1	0,22869	0,20075	0,27156	0,16590
A2	0,22869	0,25094	0,21725	0,16590
A3	0,22869	0,25094	0,21725	0,16950
A4	0,18296	0,25094	0,21725	0,16950
A5	0,18296	0,20075	0,21725	0,16950
A6	0,22869	0,20075	0,27156	0,22120
A7	0,18296	0,25094	0,21725	0,16950
A8	0,22869	0,20075	0,21725	0,16950
A9	0,22869	0,20075	0,21725	0,16950
A10	0,18296	0,20075	0,21725	0,16950
A11	0,18296	0,25094	0,16294	0,27650
A12	0,22869	0,20075	0,16294	0,16590
A13	0,18296	0,20075	0,27156	0,27650
A14	0,22869	0,20075	0,21725	0,27650
A15	0,22869	0,20075	0,16294	0,27650
A16	0,18296	0,20075	0,21725	0,27650
A17	0,22869	0,20075	0,21725	0,22120
A18	0,22869	0,20075	0,21725	0,22120
A19	0,22869	0,20075	0,16294	0,22120
A20	0,22869	0,20075	0,16294	0,22120
A21	0,18296	0,20075	0,16294	0,22120
A22	0,22869	0,20075	0,16294	0,22120

TABLE VIII. NORMALIZED MATRIX WEIGHTED

	C1	C2	C3	C4
A1	1,14347	0,80302	1,35781	0,49770
A2	1,14347	1,25471	0,86900	0,49770
A3	1,14347	1,25471	0,86900	0,49770
A4	0,73182	1,25471	1,35781	0,49770
A5	0,73182	0,80302	0,8690	0,49770
A6	1,14347	0,80302	1,35781	0,88480
A7	0,73182	1,25471	0,86900	0,49770
A8	1,14347	0,80302	0,86900	0,49770
A9	1,14347	0,80302	0,86900	0,49770
A10	0,73182	1,25471	0,86900	0,49770
A11	0,73182	0,80302	0,48881	1,38250
A12	1,14347	0,80302	0,48881	0,49770
A13	0,73182	0,80302	1,35781	1,38250
A14	1,14347	0,80302	0,86900	1,38250
A15	1,14347	0,80302	0,48881	1,38250
A16	0,73182	0,80302	0,86900	1,38250
A17	1,14347	0,80302	0,86900	0,88480
A18	1,14347	0,80302	0,86900	0,88480
A19	1,14347	0,80302	0,48881	0,88480
A20	1,14347	0,80302	0,48881	0,88480
A21	0,73182	0,80302	0,48881	0,88480
A22	1,14347	0,80302	0,48881	0,88480

TABLE IX. POSITIVE (A+) DAN NEGATIVE (A-) IDEAL SOLUTION SCORE

	Y1	Y2	Y3	Y4
A^+	0,73182	1,25471	1,35781	1,38250
A^-	1,14347	0,80302	0,48881	0,49770

TABLE X. DISTANCE OF POSITIVE (A+) DAN NEGATIVE (A-) -) IDEAL SOLUTION

	A^+	A^-		A^+	A^-
D1	1,07534	0,86900	D12	1,38258	0
D2	1,09145	0,59040	D13	0,45170	1,30671
D3	1,09145	0,59040	D14	0,78258	0,96303
D4	0,88480	1,06238	D15	1,06238	0,88480
D5	1,10718	0,56036	D16	0,66556	1,04732
D6	0,78816	0,95132	D17	0,92743	0,54258
D7	1,01085	0,71974	D18	0,92743	0,54258
D8	1,18123	0,38019	D19	1,17318	0,38710
D9	1,18123	0,38019	D20	1,17318	0,38710
D10	1,10718	0,56036	D21	1,09859	0,56507
D11	0,86900	1,07534	D22	1,17318	0,38710

After knowing the value of the distance of the positive ideal solution (A+) and the distance of the negative ideal solution (A-) proceed with the calculation to find the value of preference with equation (10) for further ranking for each alternative value. The results are in Table 10. After the calculation is complete, the results of the ranking of preference values between the SAW and TOPSIS methods will be compared as shown in Table 11. The final preference value for the SAW method is 0.93800 and the final preference value for the TOPSIS method is 0.74312.

TABLE XI. COMPARISSON OF SAW DAN TOPSIS FINAL SCORE

Alternatives	SAW		TOPSIS	
	Scores	Rank	Scores	Rank
A1	0,81200	10	0,44694	8
A2	0,82400	8	0,35104	12
A3	0,82400	8	0,35104	12
A4	0,92400	2	0,54560	6
A5	0,81200	10	0,33604	15
A6	0,85000	6	0,54690	5
A7	0,87400	5	0,41589	9
A8	0,76200	17	0,24349	20
A9	0,76200	17	0,24349	20
A10	0,81200	10	0,33604	15
A11	0,90000	3	0,55306	3
A12	0,71200	22	0	22
A13	**0,93800**	**1**	**0,74312**	**1**
A14	0,83800	7	0,55169	4
A15	0,78800	16	0,45440	7
A16	0,88800	4	0,61144	2
A17	0,80000	13	0,36910	10
A18	0,80000	13	0,36910	10
A19	0,75000	19	0,24810	17
A20	0,75000	19	0,24810	17
A21	0,80000	13	0,33965	14
A22	0,75000	19	0,24810	17

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VII. CONCLUSION

Recommendations for choosing a place to stay for visitors to the Malang area can use the Decision Support System. The DSS method used is SAW and TOPSIS. SAW with a shorter calculation step makes the calculation efficient, in SAW there is also a weight value for each criterion. TOPSIS with longer steps and is able to make multi-criteria calculations but is dynamic so that it can provide the best alternative. The results of calculations using the same alternative and criteria SAW have a higher preference value than TOPSIS. SAW with 0.93800 and TOPSIS with 0.74312 for the same alternative.

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