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The Combination of AHP (Analytic Hierarchy Process) and SAW (Simple Additive Weighting) Methods in the Selection of Business Locations

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Abstract

Choosing a strategic business location is the dream of entrepreneurs. Site selection can also consider several criteria, namely the bustling market, rental prices, and building area. These criteria become important guidelines in choosing the number of business locations offered. It takes one or several methods used in the decision support system to assist in determining the location of the business. The method used is a combination of AHP (Analytic Hierarchy Process) and SAW (Simple Additive Weighting) which can rank business locations based on predetermined criteria weights. The first step in these methods is the weighting of the criteria based on their level of importance, then proceed with selecting the best alternative by ranking obtained from the results of calculations with both methods. The AHP (Analytic Hierarchy Process) method is used to calculate the weight of each criterion which will be calculated using the normalization matrix of the SAW (Simple Additive Weighting) method. The result of combining these two methods is the best location with the first ranking, namely Poris with a preference value of 0.96. The next ranking is Gondrong, Sipon, Royal, Dadap, Teluk Naga, and the last ranking is Rawa.

Keywords: *business location, AHP, SAW, criteria, ranking*

1. Introduction

A system is basically a group of elements that are closely related to one another that function together to achieve certain goals [1]. Decision support system (DSS) is a system that supports managers in making decisions for semi-structured problems with the aim of being a tool for managers to expand their capabilities in decision making and not to replace managers [2]. The use of the methods contained in the decision support system, is expected to help in problem solving [3]. One of the characteristics of a decision support system is that it can solve problems with semi-structured or unstructured properties [4]. Decision support systems can assist entrepreneurs in determining the location of their business by calculating one or more decision support system methods. The purpose of this decision support system (DSS) is to support decisions in the decision-making process using alternatives obtained from the results of data processing, information and model design [5]. Using the concept of a Decision Support System (DSS) will help humans to make decisions easily [6].

Business location is closely related to the success of a business activity because it affects the number of rankings from customers [7]. Therefore, entrepreneurs are required to determine the right and the ideal location to avoid and minimize losses [8]. In choosing a location, must consider many things. Determining the right location is able to minimize the burden of expenses and get as much profit as possible. It is not easy to determine the appropriate business location, so various selections are needed so as to be able to measure the feasibility of the location [9]. There are many criteria in choosing a business location, the problem is that entrepreneurs have limits or constraints, especially capital constraints, including rental costs and renovation costs if needed. In addition, the location of the

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business itself also has its own conditions. Cheap business locations, but the roads are not paved or the availability of clean water is not good enough. Or a business location with residents around it is already crowded, but the rental price is expensive. Increasing the value of the profit criteria will also increase the value of the cost criteria, resulting in conflicting interests [10]. To be able to fulfill this, it is necessary to have information on business location data accompanied by rankings that will help determine the feasibility of the various alternative choices of business locations offered, so that decisions can be made by entrepreneurs according to their needs [11].

To be able to produce accurate rankings, of course we need a method that can involve many components or criteria being assessed (multi-criteria), so that in its completion a decision support system with multi-criteria are needed [12]. In the decision support system there are several methods, including AHP (Analytic Hierarchy Process) and SAW (Simple Additive Weighting) [13]. The advantage of the AHP method is that it is able to process qualitative data and takes into account the validity up to the tolerance limit for the inconsistencies of various criteria and alternatives chosen by decision makers. The advantage of the SAW method is that it is simple and easy to calculate [14]. The weakness of the AHP method is the dependence of the AHP model on its main input. While the weakness of the SAW method is that it is used for local weighting [15]. The SAW method is often also known as the weighted addition method [16]. In calculations with both methods using the specified criteria [17]. AHP is proven to be very good in terms of determining the weight of the criteria because it can guarantee consistency with the importance of the weights themselves. The execution time required for the SAW method is relatively less than the execution time for other decision support system methods [18]. The decision support system uses the AHP and SAW methods to obtain computerized results with high accuracy and validity [19]. The AHP method is used to determine the weight of the criteria, and the SAW method is used to determine the best business location by generating alternative rankings [20]. With the collaborative application of the Simple Additive Weighting (SAW) method and the Analytical Hierarchy Process (AHP) method, it is able to analyze large amounts of data in both quantitative and qualitative forms, and is able to produce a computerized system for decision making [21].

2. Research Methodology

The research method carried out using several stages which can be seen in Figure 1 below:

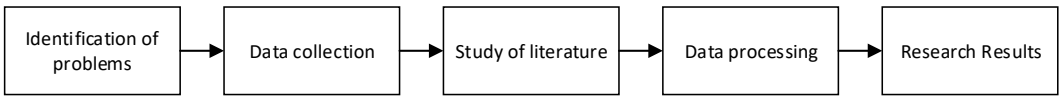

Figure 1. Research Methodology

a) Identification of Problems

After observing and interviewing shop owners, problems were found, namely: many strategic locations so that it takes a long time and makes it difficult for shop owners to make decisions, location searches are only based on one criterion and pay less attention to other important criteria so that location selection decisions are not appropriate.

b) Data Collection

Collecting data using interview techniques as instrumentation and questionnaires presented in the application of the AHP and SAW methods. Interviews and questionnaires were distributed to shop owners as users or users who determine the selection of store locations.

c) Study of Literature

Analytical Hierarchy Process (AHP) Is a method for solving a complex unstructured situation into several components in a hierarchical arrangement, by assigning a subjective value to the relative importance of each variable, and determining which variable has the highest priority in ranking to affect the results in the situation. The Analytical Hierarchy Process (AHP) decision-making process is basically choosing the best alternative [22].

The steps taken in the AHP method are [23] :

1) Normalization on the pairwise comparison matrix which is intended as follows :
   a) The sum of each value in the columns of the comparison matrix.
   b) Each value in the column is divided by the value that has been added using the equation 1 :

$$\bar{a}_{jk} = \frac{a_{jk}}{\sum_{l=1}^{m} a_{lk}} \quad (1)$$

   Information :
   $\bar{a}_{jk}$ = matrix value
   a_{jk} = the value of each pairwise comparison
   a_{lk} = the sum of the values of each pairwise comparison
2) The values in all rows are added up and divided by the number of criteria used to get the weight values using equation 2 :

$$w = \frac{\sum_{l=1}^{m} \bar{a}_{jk}}{m} \quad (2)$$

   Information :
   w = priority weight value
   $\bar{a}_{jk}$= normalized matrix value
   m = many criteria used
3) Consistency tests so that the values used have a high level of consistency using equation 3 :

$$CI = (\lambda_{maks} - n)/(n-1) \quad (3)$$

   Information :
   CI = consistency index
   λ_{maks} = eigen value
   n = matrix size
   Then, the consistency ratio (CR) is calculated using the equation 4 :

$$CR = \frac{CI}{RI} \quad (4)$$

   Information :
   CR = consistency ratio
   CI = consistency index
   RI = random consistency
4) If the CR value is less than 0.1 then the resulting value is consistent. On the other hand, if the CR value is greater than 0.1, the resulting value is inconsistent.

a) The SAW method is often also known as the weighted addition method. The basic concept of the SAW method is to find the weighted sum of the performance ratings on each alternative of all attributes [24].

   The steps taken in the SAW method are:
   1) Make a normalization matrix obtained from the equation 5 [20] :

$$R_{ij} = \begin{cases} \frac{x_{ij}}{Max_i \ x_{ij}}, & if\ j\ is\ profit \\ \frac{Min_i \ x_{ij}}{x_{ij}}, & if\ j\ is\ cost \end{cases} \quad (5)$$

Information :
i = 1,2,...,m
j = 1,2,...,n

2) Preference calculation is the final result of the SAW calculation process obtained from equation 6 [9] :

$$V_i = \sum_{j=1}^{n} W_j R_{ij} \quad (6)$$

Information :
V_i : preference value
W_i: ranking weight
R_{ij}: normalized work rating
A larger Vi value indicates that alternative Ai is preferred.

b) Data Processing

The data processing technique used the AHP method and the SAW method. The AHP method is used to find the weight of the criteria, and the SAW method is used to determine the ranking of the locations from the largest value to the smallest value so that results can be obtained to determine the desired location.

c) Research Results

The results of the study are in the ranking of locations according to calculations using the AHP and SAW methods which will be used as a guide in making decisions by shop owners.

3. Results and Discussion

Alternatives will be tested in 7 areas, namely Teluk Naga, Poris, Dadap, Gondrong, Royal, Rawa, and Sipon. The criteria in determining the location to be selected are based on the bustling market, rental prices, and building area. The weight given to each criterion is taken from the AHP calculation. The market and building area are the benefits, while the rental price is the cost.

a) Calculation with AHP

The hierarchical structure of store location selection based on several criteria is shown in Figure 2.

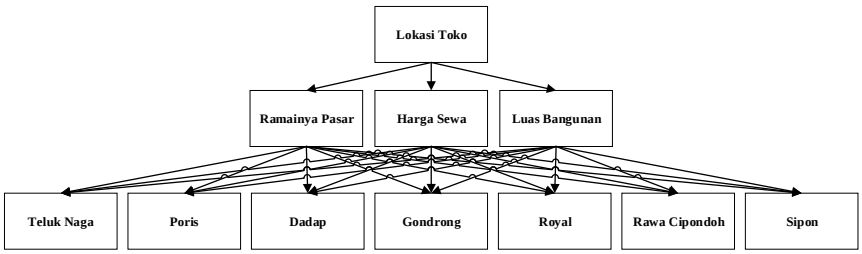

Figure 2. Store Location Selection Hierarchy Structure

The pairwise comparison matrix obtained from the results of filling out the questionnaire to the shop owner can be seen in table 1.

Table 1. Pairwise Comparison Matrix

Criteria	Busy Market	Rental Price	Building Area
Busy Market	1	3	5
Rental Price	0,33	1	3
Building Area	0,2	0,33	1
Amount	1,53	4,33	9

An example of calculating the normalization of a paired matrix with the criteria of the crowded market generated by using equation 1 is : $\frac{1}{1,53}$ = 0,65.
The normalized pairwise comparison matrix can be seen in table 2.

Table 2. Pairwise Comparison Matrix Normalization

Criteria	Busy Market	Rental Price	Building Area	Amount
Busy Market	0,65	0,69	0,56	1,9
Rental Price	0,22	0,23	0,33	0,78
Building Area	0,13	0,08	0,11	0,32

The calculation of the weight of the criteria can use equation 2 with an example of calculating the weight of the criteria for the crowded market, namely : $\frac{1.9}{3}$ = 0,63 (number 3 comes from the number of criteria)
The overall calculation of the weight of the criteria can be seen in table 3.

Table 3. Criteria Weight

Criteria	Weight
Busy Market	0,63
Rental Price	0,26
Building Area	0,11

Maximum Eigen calculation (λmax) is obtained from the process of calculating the comparison matrix multiplied by the weights and then added to each column. (λmax) is the value of importance on each criterion used in the calculation of the matrix [23].
The maximum eigen calculation step is :

b) Weighted sum vector (overall calculation in table 4).
Busy Market : (1*0,63)+(3*0,26)+(5*0,11) =1,96.

Table 4. Weighted Sum Vector

Criteria	Weighted Sum Vector
Busy Market	1,96
Rental Price	0,8
Building Area	0,32

c) Consistency vector (overall calculation in table 5).
Busy Market : $\frac{1.96}{0,63}$ = 3,11

Table 5. Consistency Vector

Criteria	Consistency Vector
Busy Market	3,11
Rental Price	3,08
Building Area	2,91
Amount	9,1

d) The maximum eigen (λmax) can be calculated by: $\frac{9,1}{3}$ = 3,03.

The calculation of the Consistency Index (CI) uses equation 3, namely : (3,03-3) / (3-1) = 0,015.
Furthermore, the calculation of the Consistency Ratio (CR) uses equation 4, namely : $\frac{0,015}{0,58}$ = 0,03.
The value of 0.58 can be seen from the value of the Random Index (RI) in table 6 [23].

Table 6. Random Index

Size	1 and 2	3	4	5	6	7	8	9	10	11
RI	0	0,58	0,9	1,12	1,24	1,32	1,41	1,45	1,49	1,51

The value of CR = 0.03 means CR 0.1, it is stated that the weight calculation is feasible to use. Then the weights generated using the AHP calculation will be used in the SAW calculation.

e) Calculation with SAW

Location data were taken as many as 7 (seven) alternatives as examples for the application of the SAW method in determining the best location. Where the data is the result of a questionnaire filled out by the shop owner as shown in table 7.

Table 7. Criteria Value

Alternative	Criteria		
	Busy Market	Rental Price	Building Area
Teluk Naga	2	1	2
Poris	3	3	2
Dadap	2	2	2
Gondrong	3	2	1
Royal	2	3	2
Rawa	1	2	2
Sipon	2	3	3

Calculation of the criteria using equation 5 to form a normalization matrix. Example of calculating busy market criteria for Teluk Naga : $\frac{2}{3}$ = 0,67 (The value of 3 comes from the maximum value of the busy market column).

After calculating all the criteria, the resulting normalization matrix value in table 8 is :

Table 8. Normalization Matrix

Alternative	Criteria		
	Busy Market	Rental Price	Building Area
Teluk Naga	0,67	0,33	0,67
Poris	1	1	0,67
Dadap	0,67	0,67	0,67
Gondrong	1	0,67	0,33
Royal	0,67	1	0,67
Rawa	0,33	0,67	0,67
Sipon	0,67	1	1

Calculation of preferences using equation 6 with an example of calculating preferences for Teluk Naga alternative is : (0,67x0,63)+(0,33x0,26)+(0,67x0,11)=0,58

From the results of the calculation of the preferences of each alternative, the resulting sequence of locations in table 9 is as follows :

Table 9. Location Ranking

1.	Poris	0,96
2.	Gondrong	0,84
3.	Sipon	0,79
4.	Royal	0,76
5.	Dadap	0,67
6.	Teluk Naga	0,58
7.	Rawa	0,46

The final result obtained from the ranking is the preference value. So that the largest value obtained will be chosen as the best alternative as a solution. Based on the preference results obtained in table 9, the best location in the first ranking is Poris with a preference value of 0.96. The next ranking is Gondrong, Sipon, Royal, Dadap, Teluk Naga, and the last ranking is Rawa. The ranking will be seen more clearly by referring to the preference value in figure 3 below.

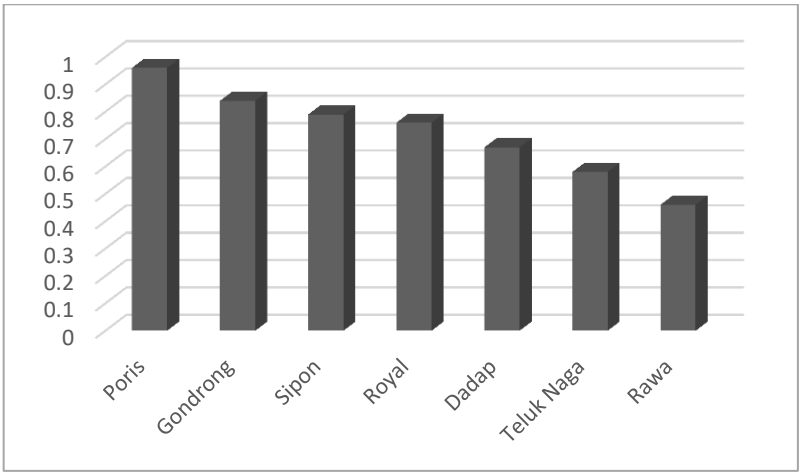

Figure 3. Preference Value Chart

4. Conclusion

Shop owners can make decisions correctly and easily in finding a business location by combining the AHP and SAW methods according to the expected criteria. The calculation is very effective because it takes into account the validity up to the tolerance limit for the inconsistency of various criteria and alternatives chosen by decision makers also using a simple and fast formula. The results of the combined calculation of the AHP and SAW methods prove that from the 7 (seven) alternative data specified, the best location is determined according to the ranking, namely Poris with a preference value of 0.96. Followed by Gondrong, Sipon, Royal, Dadap, Teluk Naga, and the last ranking is Rawa. Further research will compare the effectiveness of the SAW, AHP, and the combination of the two methods with different research problems.

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