



Implementation of Additive Ratio Assessment (ARAS) in Decision Support Systems for Wi-Fi Repeater Selection

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Abstract

Wi-Fi repeater devices are important tools for individuals, agencies, and companies so that the desired areas can be connected to the internet. To select a Wi-Fi repeater, take care in selecting the right product for your needs. However, not everyone has knowledge regarding the specifications of a Wi-Fi repeater. This resulted in a long process of selecting a Wi-Fi repeater because they had to find information regarding the specifications of the product to be purchased. This has an impact on the length of the process of making decisions. The purpose of this research is to build a decision support system using the Multi-Attribute Decision Making (MADM) approach and the Additive Ratio Assessment (ARAS) method for selecting the right Wi-Fi repeater device as needed. Referring to the utility level of each alternative to determine the ranking, the ARAS technique has the ability to choose the best alternative. Using the ARAS approach for case studies, which is identical to manual calculations, the developed system produces the same results, according to the case studies that have been completed. The DSS developed is website-based, with main features including managing data extraction, data alternatives, value alternatives, ARAS calculation methods, and displaying the best alternative in the form of ranking. Additionally, testing utilizing black-box testing reveals that all of the evaluated functions can function as they should.



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I. INTRODUCTION

Technological developments make the internet seem to be a primary need in human life. This is because almost all human activities cannot be separated from the use of the internet. This internet network connection can be through a wired or wireless network [1]. Currently, in strategic areas or certain places, there is a wireless internet network or commonly known as Wireless Fidelity. Wi-Fi connects devices to the internet wirelessly as an intermediary [2]. A Wi-Fi router provides connectivity in the form of a Wi-Fi signal that can be picked up by other devices that want to connect to the internet. However, the Wi-Fi signal generated by the router has weaknesses and limitations for certain distances or due to other interference factors. For this reason, so that the signal from Wi-Fi can be stronger, a Wi-Fi signal booster device or what is known as a Wi-Fi repeater is usually needed. This device functions as a signal catcher from the router, then spreads the Wi-Fi signal to areas that are not covered by the main router [3]. Wi-Fi repeater is an important device for individuals, agencies, and companies so that the desired area gets an internet connection. So, carefulness is needed in choosing the right Wi-Fi repeater product according to your needs. However, not everyone knows the specifications of the Wi-Fi repeaters on the market. To decide to buy a Wi-Fi repeater product, one must first find information about the product specifications. This has an impact on the length of the decision-making process. In order to resolve this issue, an automated system that can help in making the decision to select a Wi-Fi repeater is required.

Decision support systems (DSS) can be interpreted as a knowledge-based software capable of providing the best solution recommendations in determining a decision [4]. DSS solves decision problems into certain models and through mathematical calculations and statistics to get the best solution [5]. In the case of selecting a Wi-Fi repeater, it involves several criteria with a number of alternatives through subjective assessment. To overcome this, the Multi-Attribute Decision Making (MADM) technique is used. The MADM approach seeks the best solution based on various alternatives and criteria in making decisions [6]. The Additive Ratio Assessment (ARAS) method is one of the MADM approaches that can be used. The ARAS method is considered effective in dealing with decision problems involving multiple criteria because this approach is able to produce alternative rankings based on the highest utility value [7].

There are several previous studies related to decision support systems for selecting devices related to wireless. The first research regarding the application of the Promethee method to the system for choosing a wireless router [8]. In this research, the Promethee method makes decisions based on the dominance of the criteria used for ranking. Subsequent research regarding the application of the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) approach to systems for selecting wireless routers [9]. This method can produce the best alternative based on the shortest and farthest distance between the positive ideal solution and the negative ideal solution. Other research regarding the selection of Wi-Fi service providers using the Weighted Aggregated Sum Product Assessment (WASPAS) method [10]. By optimizing the assessment to acquire the maximum score and the lowest score to determine the optimal option, this study employs the WASPAS approach.

The difference between this research and previous research is the solution to multi-attribute decision problems by applying the Additive Ratio Assessment (ARAS) approach, where this approach has the ability to obtain optimal solutions based on utility level values through comparison of index values on all alternatives obtained from the best index value. Several studies using the ARAS method in the development of decision support systems have shown good results [11]–[13]. In addition, previous studies have solved problems in selecting wireless routers and Wi-Fi service providers, while this research focuses on selecting Wi-Fi repeaters which are important devices in supporting Wi-Fi connections.

The purpose of this study is to develop a decision support system through multi-attribute solutions using the Additive Ratio Assessment (ARAS) method for selecting Wi-Fi repeater devices, to produce a system capable of providing decision recommendations for selecting the right Wi-Fi repeater as needed.

II. METHODS

In order for the implementation of the research to run as expected, it is necessary to prepare the stages of the research. At this stage contains the methods and approaches used in solving research problems [14]. The research stages contain steps to carry out research that is structured and planned to achieve research objectives [15]. The research stage on the implementation of the ARAS method in selecting Wi-Fi repeaters can be seen in Figure 1.

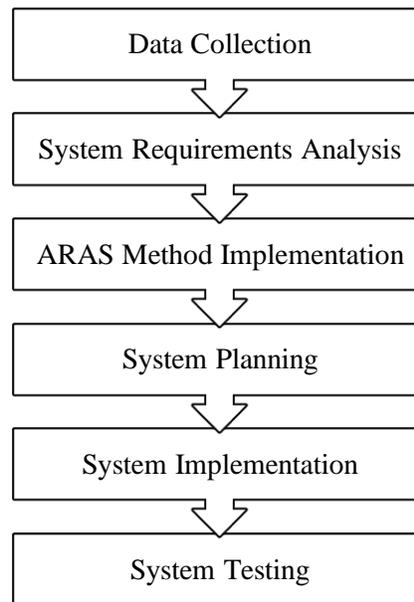


Figure 1. Research Stages

A. Data Collection

Data collection serves to dig up information related to what is the research need. The techniques used to collect data include the following:

1. Observation

Researchers observe directly related problems in selecting Wi-Fi repeater devices.

2. Interview

This technique is carried out through a question-and-answer process to someone who selects a Wi-Fi repeater directly about what are the obstacles in deciding to buy a Wi-Fi repeater device.

3. Literature Study

This data collection technique is used to collect reference sources that are relevant and in accordance with the needs to support research.

B. System Requirements Analysis

Before developing a decision support system, it is necessary to determine system requirements so that the developed system meets the needs and can solve user problems. In order to determine the needs to solve the problem, it is necessary to identify the problem first [16]. After the problem has been found then proceed

with analyzing system requirements. In the need's analysis, statements of the features needed, or what are known as functional requirements, are prepared. Functional requirements analysis is an analysis that produces statements about system services or features needed to solve user problems. So, at this point, it will generate a statement about the features that meet the needs of the user to address user issues.

C. ARAS Method Implementation

Using the Multi-Attribute Decision Analysis (MADM) method, decision-making is completed by selecting the best option from a set of options and criteria. In order to handle selection problems utilizing alternative analysis, this method involves a number of underlying criteria in obtaining a decision from subjective judgment [17]. One of several techniques in MADM that can be used is the Additive Ratio Assessment (ARAS). Zavadskas and Turskis introduced the Additive Ratio Assessment (ARAS) approach in 2010 [18]. The ARAS technique is a multi-criteria approach based on the idea of decision making that takes into account the amount of utility based on a comparison of all alternatives' index values with the best alternatives' index values [19]. Utility is a function value that, when applied to the best option, generates a rather sophisticated efficiency value that affects the significance and worth of the criteria [20]. The ARAS approach, like other Multi-Attribute Decision Making (MADM) techniques, can be used to rank alternatives by resolving dilemmas based on a variety of criteria and options.

The ARAS technique involves numerous steps in the decision-making process. The steps for computing the ARAS technique are as follows:

1. Arrange the attributes in the matrix.

This step begins with compiling a matrix by entering the values for each attribute using equation (1).

$$X = \begin{bmatrix} x_{01} & x_{0j} & \dots & x_{0n} \\ x_{11} & x_{1j} & \dots & x_{1n} \\ \dots & \dots & \dots & \dots \\ x_{n1} & x_{mj} & \dots & x_{mn} \end{bmatrix} \quad (1)$$

Where m denotes the number of alternatives, n denotes the number of criteria, x_{ij} denotes the performance level of alternative i on criterion j , and x_{0j} denotes the optimal value on criterion j .

2. Create a normalized matrix.

At this point, the goal is to be able to harmonize all of the matrix's properties such that the values are consistent. If the criterion is benefit, equation (2) is used to normalize the decision matrix; if the criterion is cost, equation (3) is used.

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

$$x_{ij} = \frac{1}{x_{ij}^*}; x_{ij}^* = \frac{X_{ij}}{\sum_{i=1}^m X_{ij}} \quad (3)$$

3. Find the normalized matrix values with their weights.

The next step is to find a weighted normalized matrix by calculating it with equation (4).

$$D_{ij} = x_{ij} \times w_{ij} \quad (4)$$

4. Get optimal value and utility value.

To get the optimal value can be calculated by equation (5).

$$S_i = \sum_{j=1}^n D_{ij} \quad (5)$$

Where, S_i denotes the optimal function value of alternative i .
After acquiring the S_i value, use equation (6) to calculate the utility value.

$$K_i = \frac{S_i}{S_0} \quad (6)$$

D. System Planning

At this stage, modeling will be made that can represent the circumstances and facts of the problem to be solved. The modeling used is illustrated through a use case diagram. The interaction between the actor and the system, which illustrates the functioning of the system being constructed, will be depicted in the diagram [21]. Design using use case diagrams will show the functionality or facilities or features that can be carried out by actors in the system.

E. System Implementation

Implementation, also referred to as the code stage, is the process of transforming the design into a computer-readable form through the use of a programming language [22]. The decision support system built is website-based, so that in the coding process the PHP programming language is used through the Komodo Edit text editor and for data storage it uses MySQL.

F. System Testing

This test is the stage for conducting an evaluation to ascertain whether the proposed system has good performance [23]. The technique used is black-box testing. Black-box testing is an approach used to test the functionality of the system whether it is running properly [24]. The output at this point is the black-box testing results, which include a list of test features and the outcomes of the tests run.

III. RESULTS AND DISCUSSIONS

In developing a decision support system for selecting a Wi-Fi repeater, it begins with problem identification. The main problem in this research is how to help decision makers in selecting Wi-Fi repeaters in obtaining the best solution that is right and in accordance with what is needed through the application of the Additive Ratio Assessment (ARAS) method. After the main problem has been obtained, then develop functional requirements. The functional requirements of the developed Wi-Fi repeater selection system include:

1. The system can manage criteria data, such as adding, deleting and changing criteria data.
2. The system can manage alternative data, such as adding, deleting and changing alternative data.
3. The system can manage value data for each alternative, such as adding, deleting and changing alternative value data
4. The system can display the process of calculating the ARAS method.
5. The system can display alternative rankings.

Next, the system design is carried out based on the functional requirements that have been determined using use case diagrams. The use case diagram of the developed system is presented in Figure 2.

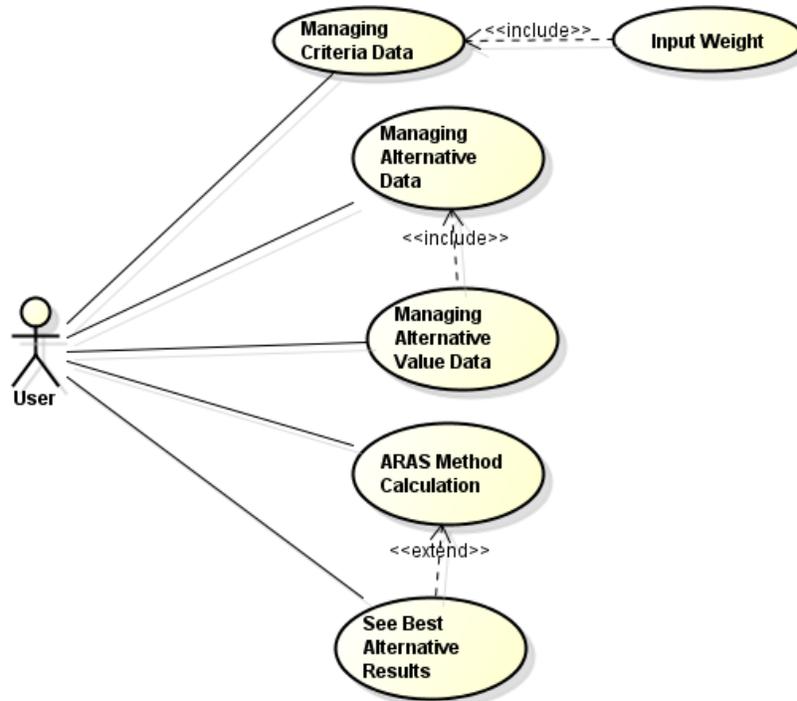


Figure 2. Use Case Diagram of a Decision Support System for Selection of Wi-Fi Repeaters

After designing before implementing a decision support system to choose a Wi-Fi repeater with the ARAS method, then an analysis of the use of the ARAS method is carried out first. The criteria used for selecting a Wi-Fi repeater came from an expert software engineer, namely Yosua Surojo, who took the website page as a result of his review [15]. The criteria used include: standard speed, security system, power consumption and price. After determining the criteria, it is continued by determining the range of criteria values and converting the values for each of these criteria. Table 1 below is the criteria, the criteria values and the conversion values for each criterion.

Table 1. Wi-Fi Repeater Selection Criteria

Criteria	Criteria Value	Conversion
Standard Speed (C1)	< 200 Mbps	1
	>= 200 Mbps dan < 400 Mbps	2
	>= 400 Mbps dan < 800 Mbps	3
	>= 800 Mbps	4
Security System (C2)	< 2 Security System	1
	>= 2 Security Systems and < 4 Security Systems	2
	>= 4 Security Systems and < 6 Security Systems	3
	>= 6 Security System	4
Power Consumption (C3)	< 0,3 A	1
	>= 0,3 A dan < 0,6 A	2
	>= 0,6 A dan < 1,2 A	3
	>= 1,2 A	4
Price (C3)	< Rp. 200.00,-	1
	>= Rp. 200.00,- dan < Rp. 400.00,-	2
	>= Rp. 400.00,- dan < Rp. 800.00,-	3
	>= Rp. 800.00,-	4

The established criteria then offer an evaluation of the importance or weight of each condition. The decision maker assigns each criterion a percentage weight, or level of importance, with a maximum weight of 100%. In this case study, the weight of the predetermined criteria can be seen in Table 2.

Table 2. Weight of Each Criterion

Criteria Code	Criteria Name	Weight
C1	Standard Speed	30%
C2	Security System	30%
C3	Power Consumption	20%
C4	Price	20%

As a case study for choosing a Wi-Fi repeater in this study, the products used as alternatives include: Xiaomi Range Extender Pro (A1), TP-Link Range Extender (A2), Asus N300 Range Extender (A3), Prolink Wireless Extender (A4) and Tenda AP4 Wireless (A5). Then the next is to determine the value of the criteria for each alternative. The results of the assessment of each alternative are presented in Table 3.

Table 3. Value for Each Alternative

Alternative Code	Alternative	Criteria			
		C1	C2	C3	C4
A1	Xiaomi Range Extender Pro	300 Mbps	2 Sistem Keamanan	0,3 A	Rp. 190.000,-
A2	TP-Link Range Extender	300 Mbps	3 Sistem Keamanan	0,6 A	Rp. 285.000,-
A3	Asus N300 Range Extender	867 Mbps	5 Sistem Keamanan	0,3 A	Rp. 495.000,-
A4	Prolink Wireless Extender	433 Mbps	4 Sistem Keamanan	0,3 A	Rp. 490.000,-
A5	Tenda AP4 Wireless	300 Mbps	3 Sistem Keamanan	0,6 A	Rp. 260.000,-

Furthermore, the values for each alternative in Table 3 are converted to values based on the conversion values in Table 1. The conversion criteria values for each alternative are presented in Table 4.

Table 4. Convert Value for Each Alternative

Alternative Code	Alternative	Criteria			
		C1	C2	C3	C4
A1	Xiaomi Range Extender Pro	2	2	2	1
A2	TP-Link Range Extender	2	2	3	2
A3	Asus N300 Range Extender	4	3	2	3
A4	Prolink Wireless Extender	3	3	2	3
A5	Tenda AP4 Wireless	2	2	3	2

The case study of selecting the Wi-Fi repeater above was completed using the Additive Ratio Assessment (ARAS) approach through the following steps:

1. Arrange the attributes in the matrix.

In order to obtain the initial matrix displayed below, this stage will input all the values of the attributes for which solutions will be sought into the decision matrix using equation (1).

$$X = \begin{bmatrix} 4 & 3 & 2 & 1 \\ 2 & 2 & 2 & 1 \\ 2 & 2 & 3 & 2 \\ 4 & 3 & 2 & 3 \\ 3 & 3 & 2 & 3 \\ 2 & 2 & 3 & 2 \end{bmatrix}$$

2. Create a normalized matrix.

Before making a normalized matrix, it is necessary to determine whether the criteria used are benefit criteria or cost criteria. Benefit criteria are criteria that seek the highest value, whereas cost criteria are criteria that seek the lowest value. In this case study, there are two benefit criteria, namely: Standard Speed (C1) and Security System (C2). As for the cost criteria, there are two criteria, namely Power Consumption (C3) and Price (C4). If the criterion is benefit, use equation (2) to create the normalized decision matrix; if the criterion is cost, use equation (3). Therefore, the normalized matrix can be calculated as follows.

$$X_{01} = \frac{4}{4 + 2 + 2 + 4 + 3 + 2} = 0.2353$$

$$X_{11} = \frac{2}{4 + 2 + 2 + 4 + 3 + 2} = 0.1176$$

$$X_{21} = \frac{2}{4 + 2 + 2 + 4 + 3 + 2} = 0.1176$$

$$X_{31} = \frac{4}{4 + 2 + 2 + 4 + 3 + 2} = 0.2353$$

$$X_{41} = \frac{3}{4 + 2 + 2 + 4 + 3 + 2} = 0.1765$$

$$X_{51} = \frac{2}{4 + 2 + 2 + 4 + 3 + 2} = 0.1176$$

Then, calculations are performed up to all attributes or up to X_{54} . After all attributes have been normalized, then the values obtained are entered in the normalized matrix. The following is the result of the normalized matrix.

$$X_{ij} = \begin{bmatrix} 0.2353 & 0.2 & 0.1875 & 0.2727 \\ 0.1176 & 0.1333 & 0.1875 & 0.2727 \\ 0.1176 & 0.1333 & 0.125 & 0.1364 \\ 0.2353 & 2 & 0.1875 & 0.0909 \\ 0.1765 & 2 & 0.1875 & 0.0909 \\ 0.1176 & 0.1333 & 0.125 & 0.1364 \end{bmatrix}$$

3. Find the normalized matrix values with their weights.

Once you have a normalized matrix, use equation (4) to find a weighted normalized matrix. The weighted normalized matrix is calculated using the criterion weights specified in Table 2 in the manner shown below.

$$D_{01} = 0.2353 \times 0.3 = 0.0706$$

$$D_{11} = 0.1176 \times 0.3 = 0.0353$$

$$D_{21} = 0.1176 \times 0.3 = 0.0353$$

$$D_{31} = 0.2353 \times 0.3 = 0.0706$$

$$D_{41} = 0.1765 \times 0.3 = 0.0529$$

$$D_{51} = 0.1176 \times 0.3 = 0.0353$$

Once all qualities have been multiplied by each criterion's weight, or up to D_{54} , the calculation continues. Additionally, a weighted, normalized decision matrix with these results is organized as follows.

$$D_{ij} = \begin{bmatrix} 0.0706 & 0.06 & 0.0375 & 0.0545 \\ 0.0353 & 0.04 & 0.0375 & 0.0545 \\ 0.0353 & 0.04 & 0.0250 & 0.0273 \\ 0.0706 & 0.06 & 0.0375 & 0.0182 \\ 0.0529 & 0.06 & 0.0375 & 0.0182 \\ 0.0353 & 0.04 & 0.0250 & 0.0273 \end{bmatrix}$$

4. Get optimal value and utility value.

Next, use equation (4) to determine the optimal value, and then equation (5) to determine the utility value. The calculation to determine S_i value is as follows.

$$S_0 = 0.0706 + 0.06 + 0.0375 + 0.0545 = 0.2226$$

$$S_1 = 0.0143 + 0.04 + 0.0375 + 0.0545 = 0.1673$$

$$S_2 = 0.0571 + 0.04 + 0.0250 + 0.0273 = 0.1276$$

$$S_3 = 0.0143 + 0.04 + 0.0375 + 0.0182 = 0.1863$$

$$S_4 = 0.0571 + 0.06 + 0.0375 + 0.0182 = 0.1686$$

$$S_5 = 0.0571 + 0.04 + 0.0250 + 0.0273 = 0.1276$$

Then, based on the value of S_i , the value of the degree of utility (K_i) can be calculated as follows.

$$K_1 = \frac{0.1673}{0.2226} = 0.75164$$

$$K_2 = \frac{0.1276}{0.2226} = 0.57299$$

$$K_3 = \frac{0.1863}{0.2226} = 0.83667$$

$$K_4 = \frac{0.1686}{0.2226} = 0.75740$$

$$K_5 = \frac{0.1276}{0.2226} = 0.57299$$

Using these findings, a utility value (K_i) has been calculated. Then, as indicated in Table 5 below, organize the utility values in the ranking table that is ordered progressively based on high value to low value.

Table 5. Result of the Ranking of Utility Value (K_i) for Each Alternative

Alternative Code	Alternative	K_i Value	Rank
A3	Asus N300 Range Extender	0.83667	1
A4	Prolink Wireless Extender	0.75740	2
A1	Xiaomi Range Extender Pro	0.75164	3

A2	TP-Link Range Extender	0.57299	4
A5	Tenda AP4 Wireless	0.57299	5

The Asus N300 Range Extender (A3) in Table 5 has the highest utility value (K_i), measuring 0.83667. This demonstrates why the alternative is the greatest option.

Additionally, the PHP programming language is employed with the Komodo Edit text editor to implement the ARAS approach in a decision support system, and MySQL is utilized for data storage. The decision support system for choosing a Wi-Fi repeater using the ARAS method, before entering the system, users must log in first. After the user has successfully logged in by entering the username and password, the user will enter the main page or dashboard of the Wi-Fi repeater selection decision support system as shown in Figure 3.

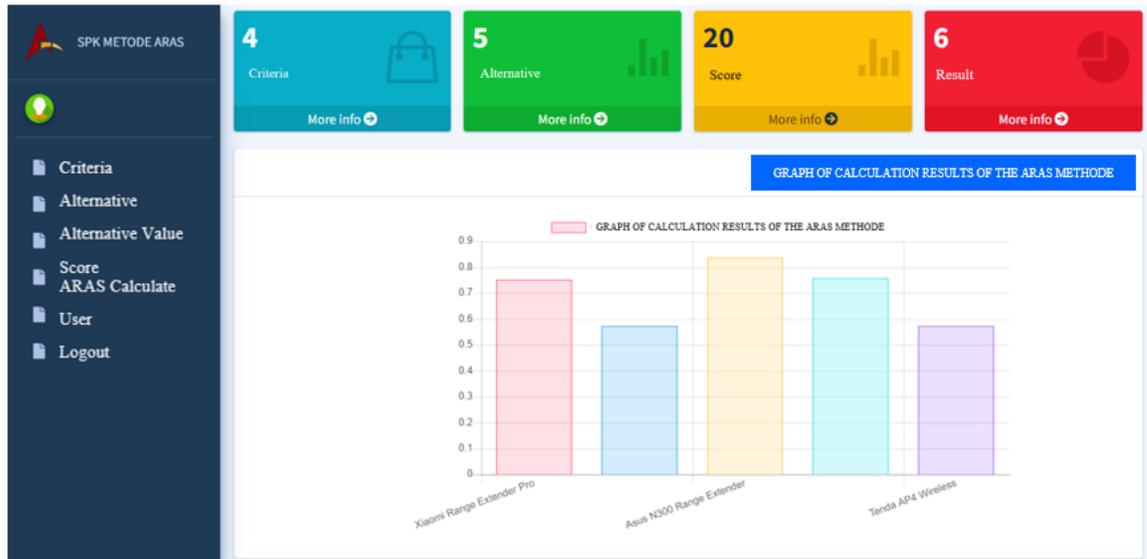


Figure 3. Main Menu Interface

The main page of the decision support system for choosing a Wi-Fi repeater displays a graph of the results of the ARAS calculation and other main features, such as: Criteria Menu, Alternative Menu, Alternative Value Menu, ARAS Calculation Menu and User Menu. On the Criteria menu, users can manage criteria data such as adding, deleting and changing criteria data. The Criteria menu display can be seen in Figure 4 below.

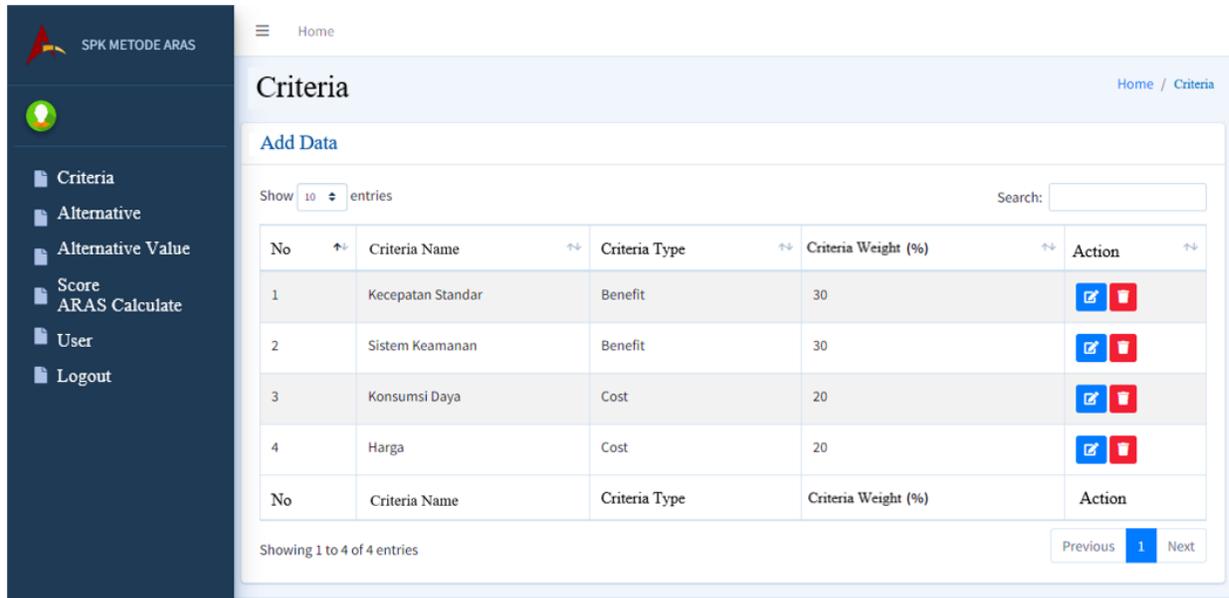


Figure 4. Criteria Menu Interface

Next, after the criteria data has been added the user can manage alternative data on the Alternative menu. Through this feature users can add, delete, and change alternative data. After the alternative has been filled in, the user can then give a value to the alternative through the Alternative Value menu. In this menu, the user gives a value to each alternative or Wi-Fi repeater product based on predetermined criteria. Figure 5 below is a display menu for inputting alternative value data.

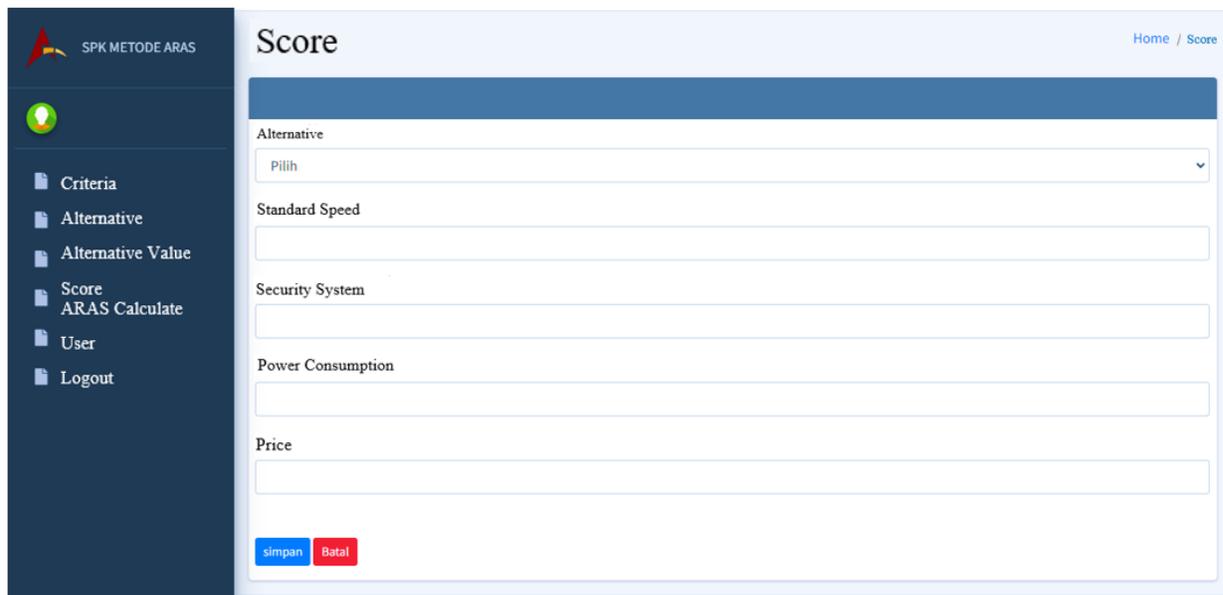


Figure 5. Alternative Value Input Menu Interface

After all alternatives are scored, then the user can perform the calculation process using the ARAS approach on the ARAS Calculation form. Through this feature, the stages of implementing the ARAS method will be displayed. In addition, this menu displays the ranking of the best alternative results based

on the calculation of the ARAS method. Display of the calculation results of the ARAS method is presented in Figure 6.

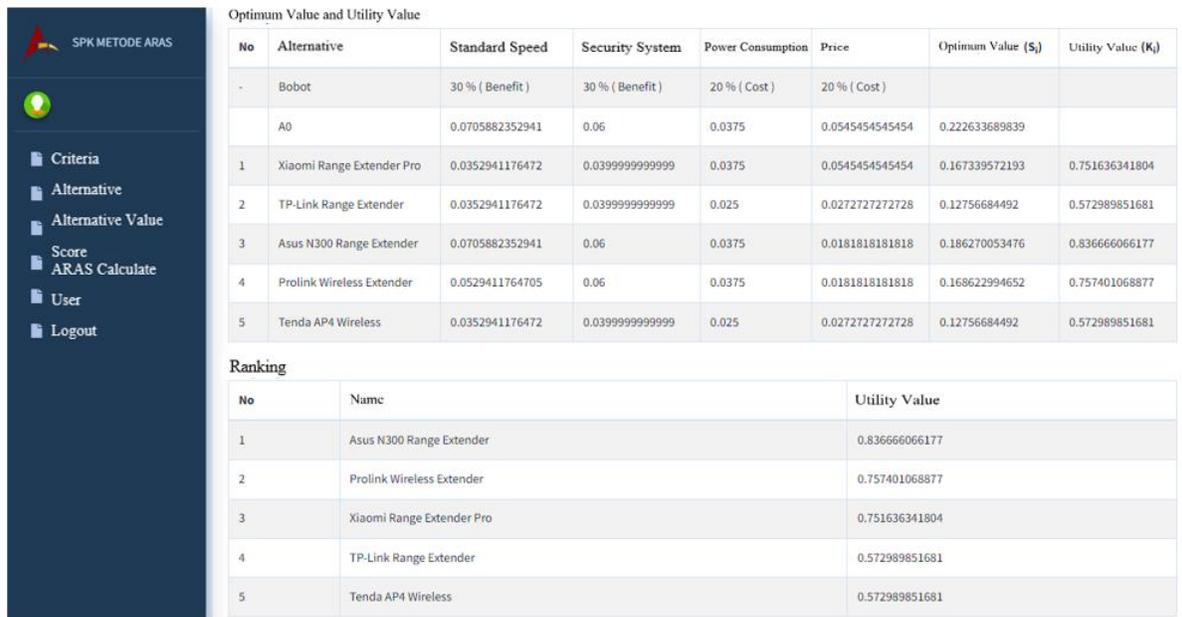


Figure 6. ARAS Method Calculation Process Interface

Based on Figure 6, using the same case study as manual calculations, it can be seen that the calculation results of the ARAS method obtained from the developed system show the same results.

Furthermore, the system that has been built is tested so that it can be ensured that the system can function as it should and there are no errors using a black-box testing approach. This test is carried out by carrying out the functions of the developed system features. Table 6 below is the result of the tests performed.

Table 5. Black-Box Testing Results

No	Test Cases	Functionality	Result
1	Login Menu	Users enter the username and password to enter the system and can enter the system by entering the username and password.	Valid
2	Main Menu	Users can view the main menu by displaying a graph of the calculation of the ARAS method and other main menus.	Valid
3	Criteria Menu	Users can process criteria data, including adding, changing and deleting criteria data.	Valid
4	Alternative Menu	Users can perform alternative data processing such as adding, changing and deleting alternative data.	Valid
5	Alternative Value Menu	Users can enter values for each alternative and can modify and delete them.	Valid
6	ARAS Method Calculation Menu	Users can see the calculation process for choosing a Wi-Fi Repeater using the ARAS method and the system can display the best alternative and alternative ranking.	Valid

No	Test Cases	Functionality	Result
7	User Menu	Users can add, modify and delete user data that will use the system.	Valid

Based on the test results in Table 6, it can be seen that all the test features have run as they should with the status of “Valid” test cases as straight. These results show that the system has been running well.

IV. CONCLUSIONS AND RECOMMENDATIONS

This research implements the Multi-Attribute Decision Making (MADM) approach using the Additive Ratio Assessment (ARAS) on a decision support system for selecting a Wi-Fi repeater. Based on the utility level of each alternative to establish the best ranking or alternative, the ARAS technique has the capacity to choose the best alternative. Using the ARAS approach for case studies which is identical to manual calculations and the system built gives the same results, according to the case studies that have been completed. The DSS developed is built on a website basis, with the main features including managing criteria data, alternative data, alternative values, calculating the ARAS method and displaying the best alternative in the form of ranking. The results of testing using black-box testing indicate that all of the features evaluated have been deemed legitimate or are capable of functioning as they should.

For further research, it can be developed with other MADM methods and make comparisons to get the best model. In addition, a website-based system can be developed based on Android so that it makes it easier for users to access without having to open a browser first.

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