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Decision Support System for Selection of Internet Services Providers using the ROC and WASPAS Approach

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Abstract−Along with the growth of the internet service provider industry, selecting an Internet Service Provider (ISP) has become an important decision to ensure optimal internet access. However, with so many ISP options available, consumers often face difficulties in choosing the service that best suits their needs. The aim of this research is to produce a decision support system that can help users choose the ISP that best suits their needs and preferences using the ROC (Rank Order Centroid) approach as a weighting technique and the WASPAS (Weighted Aggregated Sum Product Assessment) approach to determine the best alternative. The ROC approach is used to obtain criteria weights based on the ranking order of the importance of the criteria. On the other hand, the WASPAS method is used to determine the best alternative through weighted addition and multiplication, producing a final value that reflects the extent to which each alternative meets the specified criteria. The outcomes of the case study reveal a ranking of alternatives from highest to lowest scores, as follows: First Media (A2) achieving 0.8629, Indihome (A3) at 0.8416, MyRepublic (A5) with 0.7954, Biznet (A1) scoring 0.7844, and Oxygen (A4) at 0.7469. The usability testing yields an average score of 89%, suggesting that the system is apt for utilization, as it aligns with the functionalities users are seeking.

Keywords: DSS; Internet Service Provider; Rank Order Centroid; Weighted Aggregated Sum Product Assessment

1. INTRODUCTION

In the evolving digital era, internet access has become a fundamental necessity for society, catering to both personal and business needs. The internet stands as a cornerstone in the transformation of modern society, playing a crucial role in nearly every aspect of life [1]. Its significance extends beyond being a means of communication; it serves as an information source, a learning center, and a platform for global collaboration. The success of various sectors, including education, business, and research, now heavily relies on fast and reliable internet connectivity [2]. The growing demand has propelled the rapid expansion of Internet Service Providers (ISPs). In this digital age, selecting an ISP has become a critical decision, where the availability of fast and reliable internet access significantly impacts user productivity and comfort. However, with the multitude of ISP options available, consumers often face challenges in choosing services that best suit their needs. Therefore, an effective decision support system is needed to assist consumers in the ISP selection process.

Decision Support Systems (DSS) provide a structured framework for analyzing certain situations or problems, processing relevant information, and producing recommendations or solutions [3]. Previous research related to the selection of internet services has been conducted by several researchers employing various approaches. There is research on the application of the Simple Additive Weighting (SAW) approach to choosing internet service packages [4]. The SAW approach emphasizes the use of summation with its respective weights to determine the best option. Additionally, there is research using the Weighted Product (WP) approach to select an Internet Service Provider (ISP) [5]. This method involves criteria attributes with different weights or levels of importance and then performs calculations by multiplying the criterion values by their respective weights. Subsequent research addresses the selection of telecommunication operator internet packages using the Technique for Order Performance of Similarity to Ideal Solution (TOPSIS) approach [6]. This method combines the concepts of Euclidean distance and ideal distance to establish a preference ranking of evaluated alternatives. Furthermore, there is research using the Analytical Hierarchy Process (AHP) method to determine the best ISP [7]. The approach used presents a systematic framework for organizing and comparing decision factors hierarchically, from main criteria to sub-criteria. Another study utilizes the Multi Factor Evaluation Process (MFEP) approach to select the best internet service [8]. The MFEP approach employs data perturbation techniques using the concept of fuzzy entropy to reduce the risk of individual identification in the dataset.

The distinction between this research and previous studies lies in the fact that this research utilizes two approaches: the Rank Order Centroid (ROC) approach as a technique for determining weights, and the Weighted Aggregated Sum Product Assessment (WASPAS) approach used for identifying the best alternative. The weighting of criteria serves to determine the level of importance or relative contribution of each criterion used in the decision-making process [9]. Criteria weights are determined by the decision-maker, but sometimes the decision-maker faces challenges in assigning the importance level for each criterion. To facilitate decision-makers in determining weights, the ROC technique is employed. With this technique, the decision-maker only needs to rank the criteria to represent the priority of each. The ROC approach derives weight values by

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calculating based on the importance ranking of criteria [10]. Meanwhile, the WASPAS method is used to identify the best alternative through a process of weighted addition and multiplication to produce a final value that reflects the extent to which each alternative meets the established criteria [11]. Therefore, WASPAS provides a systematic and measurable approach to evaluate alternatives based on the preferences and priorities set by the decision-maker. The ROC and WASPAS approaches combined can produce an effective decision support system. This is proven by several studies that lead to better decisions [12]–[14].

Building on the previous discussion, the aim of this study is to develop a system that assists users in selecting the Internet Service Provider (ISP) most suited to their needs and preferences. This is achieved using the Rank Order Centroid (ROC) approach as a technique for determining weightings, and the Weighted Aggregated Sum Product Assessment (WASPAS) approach for identifying the best alternative. The criteria considered in this research include subscription fees, average download speed, average upload speed, coverage area, and customer service. Furthermore, this study involves the development of a web-based decision support system to enhance ease of use, ensuring that it can be accessed anywhere and at any time.

2. RESEARCH METHODOLOGY

2.1 Research Stages

The research stages encompass specific steps that researchers must follow, starting from planning to presenting the results [15]. To facilitate the description of the research process, the research steps are visualized in Figure 1.

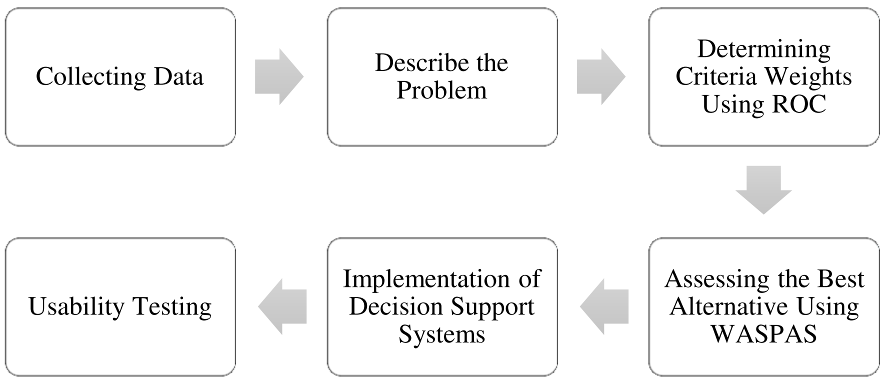

Figure 1. Research Steps

A detailed explanation of the stages in Figure 1 includes the following:

1. Establish Criteria and Alternatives
   In the context of a Decision Support System (DSS), the data used is criteria and alternative data. Criteria and alternatives play an important role as elements that form the basis of analysis and evaluation. Criteria refer to the factors used to assess or measure the quality of an alternative. On the other hand, alternatives represent the choices or options that will be evaluated based on the established criteria. The criteria used for selecting an ISP include subscription fees, average download speed, average upload speed, coverage area, and customer service. Meanwhile, the alternatives considered in this case study include ISPs such as Biznet, First Media, Indihome, Oxygen, and MyRepublic.
2. Describe the Problem
   Identifying the problem is a critical step in the research process as it enables researchers to delve into the root of the issue, detail its impacts, and recognize potential solutions [16]. In this study, the problem was identified through interviews and observations regarding the difficulties in selecting an Internet Service Provider (ISP). Based on the interview and observation results, it is evident that choosing an ISP is a crucial decision in this digital era, where the availability of reliable and fast internet access significantly impacts user productivity and comfort. However, with a plethora of ISP options available, consumers need to individually understand each ISP's service specifications to make an informed choice. This leads to the challenge of finding a service that most closely meets their needs. Therefore, an effective decision support system is required to assist consumers in the ISP selection process.
3. Determining Criteria Weights Using ROC
   Criterion weighting serves to determine the level of importance or relative contribution of each criterion used in the decision-making process [17]. The determination of criterion weights is crucial as it assigns a value or proportion that illustrates the extent to which each criterion influences the final outcome [18]. The decision-maker sets these weights, but sometimes they may struggle to determine the importance level for each criterion. To facilitate this process for the decision-maker, the Rank Order Centroid (ROC) technique is utilized. The ROC technique allows for the determination of criterion weights based on their order in a ranking [10]. This method simplifies the weighting process by translating the rank order of criteria into

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corresponding weights, thus aiding decision-makers in objectively evaluating the relative importance of each criterion.

4. Assessing the Best Alternative Using WASPAS
   In this particular case study, the preferred methodology for identifying the optimal alternative is the Weighted Aggregated Sum Product Assessment (WASPAS) approach. This method identifies the best alternative based on a process of weighted addition and multiplication, yielding a final value that reflects the extent to which each alternative meets the established criteria [19]. The output from the WASPAS approach is a ranking of the evaluated alternatives based on the criteria and the assigned weights. The alternative with the highest ranking is considered the best option and is recommended for selection. This method effectively combines the aspects of additive and multiplicative approaches, providing a comprehensive assessment of each alternative's performance against the criteria, thus aiding in a more informed and balanced decision-making process.
5. Implementation of Decision Support Systems
   This stage refers to the process of transforming a previously created design into a programming language that can be executed by a computer [20]. The outcome of this activity is a decision support system that is ready for user utilization. In this research, the system is developed as a web-based platform, utilizing the Atom code editor and MySQL database.
6. Usability Testing
   Usability testing is an evaluation method focused on the user experience with a product or system [21]. In this context, users are placed in real or near-real situations to measure the usability and comprehensibility of an interface or product. In this research, a sample of users is selected to test the developed system and then asked to fill out a questionnaire based on various aspects of usability. These aspects include understandability, learnability, operability, and attractiveness.

2.2 Rank Order Centroid (ROC) Method

The Rank Order Centroid (ROC) method, commonly used in multi-criteria decision-making processes, plays a pivotal role in determining the relative weights of various criteria [22]. The essence of the ROC method lies in assigning criterion weights based on their order in a ranking [23]. For each criterion, the weight is calculated by averaging its rank position relative to all possible ranking positions. This means that criteria ranked higher are assigned greater weights, reflecting their increased importance in the decision-making process. This approach is unique because weights are directly calculated from the given rankings, without requiring additional quantitative input from the decision-maker. This makes ROC a simple yet effective method, particularly in situations where decision-makers are unable or unwilling to provide direct estimates of criterion weights. To calculate the weights based on the ROC technique, Equation (1) can be used:

$$w_k = \frac{1}{k}\sum_{i}^{k} = 1\left(\frac{1}{i}\right) \quad (1)$$

where w_k refers to the normalized weight value, i indicates the number of criteria used, while k represents the ranking order of importance of each criterion.

2.3 Weighted Aggregated Sum Product Assessment (WASPAS) Method

The Weighted Aggregated Sum Product Assessment (WASPAS) approach is a multifaceted decision-making method that integrates aspects of both additive and multiplicative evaluation techniques [24]. This approach uses a weighted addition and multiplication process to produce a final value that reflects the extent to which each alternative meets the specified criteria [25]. This method offers the advantage of balancing between simple summative assessments and more complex evaluations, providing more comprehensive and representative results to support the decision-making process [26]. Thus, the WASPAS method not only provides mathematically reliable results but also takes into account qualitative aspects that can influence decisions.

This approach considers the importance of each criterion in the decision-making process and integrates two different ways of evaluating alternatives. The two methods are weighted aggregation of addition and weighted aggregation of multiplication. In the weighted aggregation process of summation, the score for each alternative is calculated by adding up the normalized values of each criterion multiplied by their relative weights. Meanwhile, weighted aggregation from multiplication is the process of multiplying the normalized value of each criterion and also multiplying by its weight. The final value of each alternative in the WASPAS method is obtained by combining the results of the two methods, with certain proportions determined based on the decision context. In detail, the process of the WASPAS approach is explained as follows:

1. Entering alternative values into the initial decision matrix
   The choice matrix is derived by comparing various values with the criterion. Prior to obtaining the decision matrix, it is necessary to identify the criteria, options, and their respective weights. The first choice matrix is derived using equation (2).

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$$x = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ x_{m1} & x_{m1} & \cdots & x_{mn} \end{bmatrix} \quad (2)$$

2. Normalize the decision matrix
   Normalization is carried out on the organized original decision matrix to create a normalized matrix. Prior to constructing the normalized matrix, it is crucial to first choose the category of criteria, which may be classified into two types: benefit and cost criterion. Benefit criteria provide more importance to higher values, whereas cost criteria give greater importance to lower values. the normalized matrix may be computed using equation (3) for benefit criterion and equation (4) for cost criteria.

$$\bar{x}_{ij} = \frac{x_{ij}}{max_i\, x_{ij}} \quad (3)$$

$$\bar{x}_{ij} = \frac{min_i\, x_{ij}}{x_{ij}} \quad (4)$$

   Where the term x_{ij} represents the performance value of the option for each criterion, max_i indicates the highest value among all options, and min_i indicates the lowest value among all options.
3. Calculate the preference value of each alternative
   Following the normalization of each alternative, the subsequent phase involves computing the preference value (Q_i) for every available option. Thus, the calculation of the Q_i value can be achieved utilizing equation (5)

$$Q_i = 0.5 \sum_{j=1}^{n} x_{ij} w + 0.5 \prod_{j=1}^{n} (x_{ij})^{w_j} \quad (5)$$

   Where Q_i is the notation for the preference value obtained, $x_{ij}w$ shows the product ofx_{ij} and w, and 〖 $(x_{ij})^{w_j}$ shows the result of x_{ij} raised to the power of w.
4. Create a ranking list based on preference values
   This ranking is derived by arranging the preference values collected for each possibility in descending order. The initial order preference value denotes the optimal choice.

3. RESULT AND DISCUSSION

In addressing the decision-making process for the case study on selecting an Internet Service Provider (ISP), the initial stage involves establishing the criteria to be used for evaluation and decision-making. The criteria employed in this case study are: subscription costs, average download speed, average upload speed, coverage area, and customer service. Based on these predetermined criteria, decision-makers then determine their respective weights. To simplify the process of assigning weights to the criteria, the Rank Order Centroid (ROC) approach is utilized. The ROC approach assigns weights to the criteria based on their rank order. The weight of each criterion is calculated by averaging its rank position relative to all possible rankings. This implies that criteria ranked higher are assigned greater weights. The order of importance levels used as case studies is arranged in Table 1.

Table 1. Order of Importance of Criteria Used

Criteria Code	Criteria Used	Order of Importance
C1	Subscription Fees	1
C2	Average Download Speed	2
C3	Average Upload Speed	3
C4	Coverage area	4
C5	Customer service	5

Table 1 displays the ranking order of importance for each criterion used. The next step is to determine the weights for each criterion based on their priority order using the Rank Order Centroid (ROC) method through Equation (1). The calculation process to obtain the weight values for each criterion using the ROC method is outlined as follows:

$$w_1 = \frac{1+\frac{1}{2}+\frac{1}{3}+\frac{1}{4}+\frac{1}{5}}{5} = 0.4567$$

$$w_2 = \frac{0+\frac{1}{2}+\frac{1}{3}+\frac{1}{4}+\frac{1}{5}}{5} = 0.2567$$

$$w_3 = \frac{0+0+\frac{1}{3}+\frac{1}{4}+\frac{1}{5}}{5} = 0.1567$$

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$$w_4 = \frac{0+0+0+\frac{1}{4}+\frac{1}{5}}{5} = 0.0900$$

$$w_5 = \frac{0+0+0+0+\frac{1}{5}}{5} = 0.0400$$

After the weight calculation process using the ROC method, the resulting values are then applied as weights for each criterion, as listed in Table 2.

Table 2. Results of Criteria Weight Values Using the ROC Approach

Criteria Code	Criteria Used	Value Weight
C1	Subscription Fees	0.4567
C2	Average Download Speed	0.2567
C3	Average Upload Speed	0.1567
C4	Coverage Area	0.0900
C5	Customer Service	0.0400

Table 2 represents the criterion weights that will be utilized in decision-making. The next step involves determining the grouping of values for each alternative. This is employed to facilitate calculations. The value groupings used in this case study are arranged in Table 3.

Table 3. Grouping of Values for Each Criteria

Criteria Code	Criteria Used	Grouping	The Value
C1	Subscription Fees	< 250,000,000	1
		>= 250,000 and < 350,000	2
		>= 350,000 and < 450,000	3
		> 500,000	4
C2	Average Download Speed	< 15 Mbps	1
		>= 15 Mbps and <20 Mbps	2
		>= 20 Mbps and < 25 Mbps	3
		> 25 Mbps	4
C3	Average Upload Speed	< 5 Mbps	1
		>= 5 Mbps and <10 Mbps	2
		>= 10 Mbps and < 15 Mbps	3
		> 15 Mbps	4
C4	Coverage Area	< 50 Cities	1
		>= 50 Cities and < 150 Cities	2
		>= 150 Cities and < 250 Cities	3
		> 250 Cities	4
C5	Customer Service	Not Good	1
		Pretty Good	2
		Good	3
		Very Good	4

In Table 3, each criterion value is categorized to simplify the calculation process. The next stage involves determining the alternatives that serve as options for the decision-maker. In this case study, the alternatives include Biznet (A1), First Media (A2), Indihome (A3), Oxygen (A4), and MyRepublic (A5). Values are assigned to these alternatives according to the product specifications and offerings provided by each Internet Service Provider (ISP) based on the pre-established criteria. The values for each alternative are then displayed in Table 4, representing an evaluation of their performance in the aspects measured by the predetermined criteria.

Table 4. Alternative Values Based on Existing Criteria

Alternative Code	Alternatives to Use	Criteria Used				
		C1	C2	C3	C4	C5
A1	Biznet	375,000	26.9 Mbps	18.4 Mbps	100 Cities	Pretty good
A2	Fist Media	315,000	26.1 Mbps	9.8 Mbps	180 Cities	Pretty good
A3	Indihome	350,000	25.6 Mbps	15.2 Mbps	500 Cities	Very good
A4	Oxygen	306,000	16.8 Mbps	10.4 Mbps	50 Cities	Pretty good
A5	MyRepublic	325,000	20.7 Mbps	13.8 Mbps	30 Cities	Good

Table 4 provides a clear depiction of the comparative values among the alternatives, aiding the decision-maker in evaluating the available options. Subsequently, the values of these alternatives are grouped or converted, resulting in criterion values that will be presented in Table 5.

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Table 5. Results of Giving Values After Conversion

Alternative Code	Alternatives to Use	Criteria Used				
		C1	C2	C3	C4	C5
A1	Biznet	3	4	4	2	3
A2	Fist Media	2	4	2	3	2
A3	Indihome	3	4	4	4	4
A4	Oxygen	2	2	3	2	2
A5	MyRepublic	2	3	3	1	3

To resolve the decision-making problem in this case study, the Weighted Aggregated Sum Product Assessment (WASPAS) method is employed. The initial step involves constructing the initial decision matrix using Equation (2). This initial decision matrix is derived from the evaluation of each alternative listed in Table 5. Thus, the formulation of the initial decision matrix can be outlined as follows:

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

Following the construction of the initial decision matrix, the ensuing step involves the determination of normalized values. To obtain the normalized matrix values, the first task is to identify the types of criteria being used. In this context, benefit criteria include C2, C3, C4, and C5, while the cost criterion is represented by C1. The next phase entails the computation of the normalization matrix. This is achieved by applying Equation (3) to the benefit criteria and Equation (4) for the cost criteria. The steps for calculating the normalized matrix values can be outlined as follows:

C1:

$$\bar{x}_{11} = \frac{\min\{3;2;3;2;2\}}{3} = \frac{2}{3} = 0.67$$

$$\bar{x}_{21} = \frac{\min\{3;2;3;2;2\}}{2} = \frac{2}{2} = 1$$

$$\bar{x}_{31} = \frac{\min\{3;2;3;2;2\}}{3} = \frac{2}{3} = 0.67$$

$$\bar{x}_{41} = \frac{\min\{3;2;3;2;2\}}{2} = \frac{2}{2} = 1$$

$$\bar{x}_{51} = \frac{\min\{3;2;3;2;2\}}{2} = \frac{2}{2} = 1$$

C2:

$$\bar{x}_{12} = \frac{4}{\max\{4;4;4;2;3\}} = \frac{4}{4} = 1$$

$$\bar{x}_{22} = \frac{4}{\max\{4;4;4;2;3\}} = \frac{4}{4} = 1$$

$$\bar{x}_{32} = \frac{4}{\max\{4;4;4;2;3\}} = \frac{4}{4} = 1$$

$$\bar{x}_{42} = \frac{2}{\max\{4;4;4;2;3\}} = \frac{2}{4} = 0.50$$

$$\bar{x}_{52} = \frac{3}{\max\{4;4;4;2;3\}} = \frac{3}{4} = 0.75$$

C3:

$$\bar{x}_{13} = \frac{4}{\max\{4;2;4;3;3\}} = \frac{1}{4} = 1$$

$$\bar{x}_{23} = \frac{2}{\max\{4;2;4;3;3\}} = \frac{2}{4} = 0.50$$

$$\bar{x}_{33} = \frac{4}{\max\{4;2;4;3;3\}} = \frac{4}{4} = 1$$

$$\bar{x}_{43} = \frac{3}{\max\{4;2;4;3;3\}} = \frac{3}{4} = 0.75$$

$$\bar{x}_{53} = \frac{3}{\max\{4;2;4;3;3\}} = \frac{3}{4} = 0.75$$

C4:

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$\bar{x}_{14} = \frac{2}{\max\{2;3;4;2;1\}} = \frac{2}{4} = 0.50$

$\bar{x}_{24} = \frac{3}{\max\{2;3;4;2;1\}} = \frac{3}{4} = 0.75$

$\bar{x}_{34} = \frac{4}{\max\{2;3;4;2;1\}} = \frac{4}{4} = 1$

$\bar{x}_{44} = \frac{2}{\max\{2;3;4;2;1\}} = \frac{2}{4} = 0.50$

$\bar{x}_{54} = \frac{1}{\max\{2;3;4;2;1\}} = \frac{1}{4} = 0.25$

C4:

$\bar{x}_{15} = \frac{3}{\max\{3;2;4;2;3\}} = \frac{3}{4} = 0.75$

$\bar{x}_{25} = \frac{2}{\max\{3;2;4;2;3\}} = \frac{2}{4} = 0.50$

$\bar{x}_{35} = \frac{4}{\max\{3;2;4;2;3\}} = \frac{4}{4} = 1$

$\bar{x}_{45} = \frac{2}{\max\{3;2;4;2;3\}} = \frac{2}{4} = 0.50$

$\bar{x}_{55} = \frac{3}{\max\{3;2;4;2;3\}} = \frac{3}{4} = 0.75$

After the normalization process is completed, these values are then input into the normalized matrix, which can be represented as follows:

$$x = \begin{bmatrix} 0.67 & 1 & 1 & 0.50 & 0.75 \\ 1 & 1 & 0.50 & 0.75 & 0.50 \\ 0.67 & 1 & 1 & 1 & 1 \\ 1 & 0.50 & 0.75 & 0.50 & 0.50 \\ 1 & 0.75 & 0.75 & 0.25 & 0.75 \end{bmatrix}$$

After obtaining the normalization matrix, the next step is to calculate the preference values (Qi) for each alternative. This calculation process utilizes equation (5). The weights used in the calculation are obtained through weighting using Rank Order Centroid (ROC), as specified in Table 2, namely C1 = 0.4567; C2 = 0.2567; C3 = 0.1567; C4 = 0.0900; C5 = 0.0400. The calculation steps can be explained as follows:

$$Q_1 = 0.5 \times (0.67 \times 0.4567) + (1 \times 0.2567) + (0.67 \times 0.0900) + (1 \times 0.0400) + (1 \times 0.1) + (0.67^{0.4567}) + (1^{0.2567}) + (0.67^{0.1567}) + (1^{0.0900}) + (1^{0.0400}) = 0.7844$$

$$Q_2 = 0.5 \times (1 \times 0.4567) + (1 \times 0.2567) + (0.50 \times 0.0900) + (0.75 \times 0.0400) + (0.50 \times 0.1) + (1^{0.4567}) + (1^{0.2567}) + (0.50^{0.1567}) + (0.75^{0.0900}) + (0.50^{0.0400}) = 0.8629$$

$$Q_3 = 0.5 \times (0.67 \times 0.4567) + (1 \times 0.2567) + (1 \times 0.0900) + (1 \times 0.0400) + (1 \times 0.1) + (0.67^{0.4567}) + (1^{0.2567}) + (1^{0.1567}) + (1^{0.0900}) + (1^{0.0400}) = 0.8416$$

$$Q_4 = 0.5 \times (1 \times 0.4567) + (0.50 \times 0.2567) + (0.75 \times 0.0900) + (0.50 \times 0.0400) + (0.50 \times 0.1) + (1^{0.4567}) + (0.50^{0.2567}) + (0.75^{0.1567}) + (0.50^{0.0900}) + (0.50^{0.0400}) = 0.7469$$

$$Q_5 = 0.5 \times (1 \times 0.4567) + (0.75 \times 0.2567) + (0.75 \times 0.0900) + (0.25 \times 0.0400) + (0.75 \times 0.1) + (1^{0.4567}) + (0.75^{0.2567}) + (0.75^{0.1567}) + (0.25^{0.0900}) + (0.75^{0.0400}) = 0.7954$$

The outcomes of the calculations act as a directive for identifying the optimal alternative, with the highest Q_i value signaling the preferable choice. Following this, the preference values of the leading alternatives are systematically organized in a descending sequence, thus establishing a hierarchical ranking. This comprehensive ranking, detailing the results, is subsequently exhibited in Table 6.

Table 6. Preference Values Obtained

Alternative Code	Alternatives Used	Preference Value	Rankings
A2	Fist Media	0.8629	1
A3	Indihome	0.8416	2
A5	MyRepublic	0.7954	3
A1	Biznet	0.7844	4
A4	Oxygen	0.7469	5

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The values in Table 6 represent the preferences for each alternative, where the highest value is the best option. The best preference value obtained was 0.8629, namely First Media (A2); then 0.8416, namely Indihome (A3); 0.7954, namely MyRepublic (A5); 0.7844, namely Biznet (A1); and 0.7469, namely Oxygen (A4).

The outcomes of the conducted analysis and modeling have been materialized into a decision support system through a programming phase. This system is structured as an online platform, crafted utilizing the Atom code editor and MySQL database. The system, designed for selecting Internet Service Providers (ISP), features a mandatory login form to facilitate user access. Upon successful authentication, users are navigated to the principal menu interface. This interface showcases a dashboard, encompassing accessible system functionalities and visual representations of data processed via the WASPAS approach. The visual layout of this dashboard within the developing system is depicted in Figure 3.

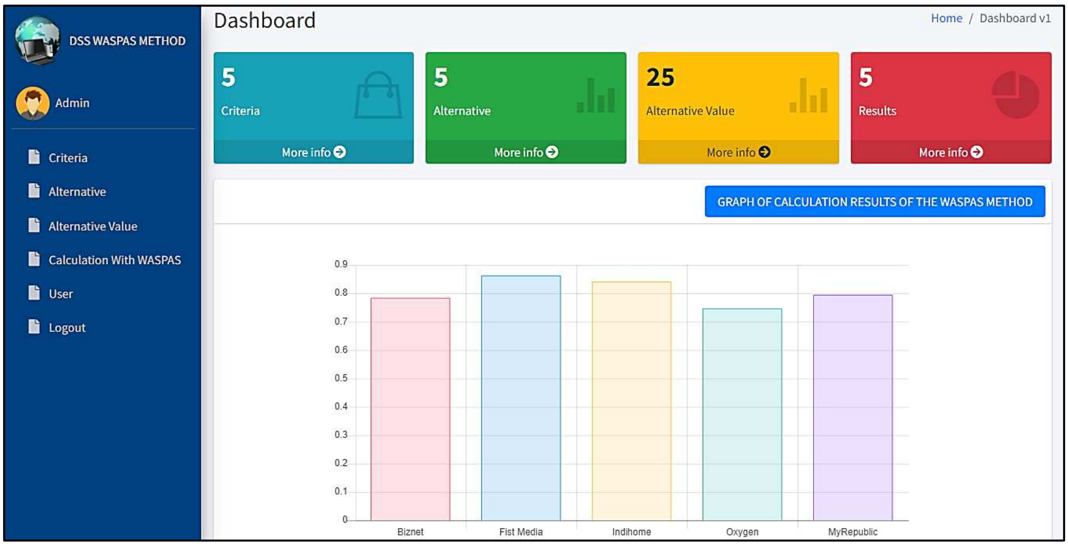

Figure 3. Developed System Dashboard User Interface

The description for Figure 3 illustrates the main menu interface of the system, where users can select from various features available within the system. The main features in this system include criteria data management, alternatives, calculation processes and ranking results of the best options. To select an ISP, the user must first enter the criteria data in the criteria feature. In this feature, users can manage criteria data, including adding, changing and deleting information related to criteria. After the users input the criteria data, such as the name of the criterion, type of criterion, and weight of the criterion, this information is stored in the database and displayed in the criteria form, as seen in Figure 4.

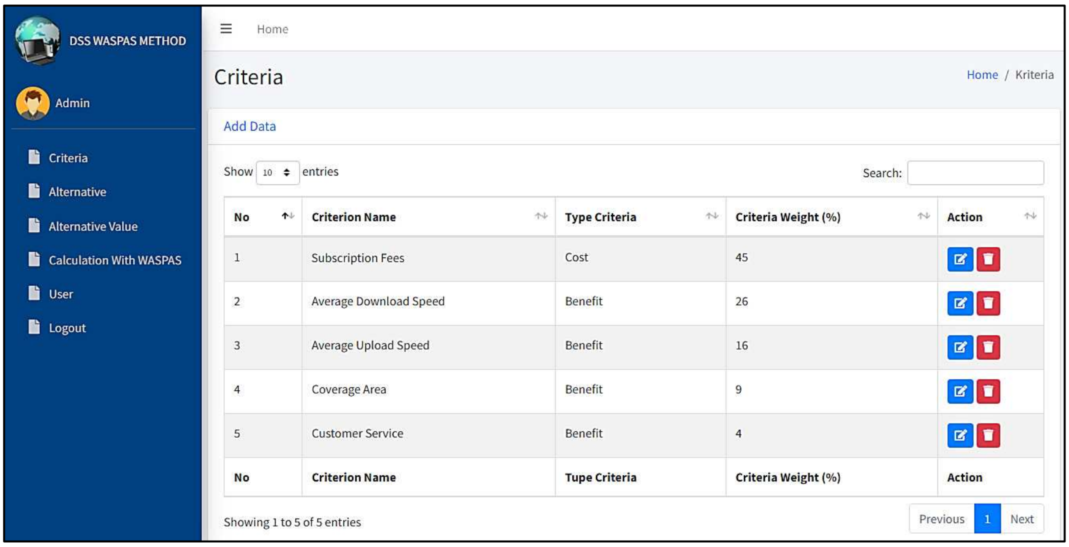

Figure 4. Criteria Feature Interface

Figure 4 displays the criterion data supplied by the user. Users may thereafter oversee alternate data using the Alternatives functionality. Users are able to include, change, and remove alternate data using this functionality. After inputting the alternative data, users may assess the alternatives using the Alternative Values functionality. Within this functionality, users have the ability to allocate values according to the criteria that were

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inputted before. Once the alternative value data is entered, the WASPAS Calculation function allows users to see the findings for the most optimal option. This feature showcases the sequential stages involved in implementing the WASPAS technique. Additionally, it also presents a ranking of alternatives based on preference values, arranged from highest to lowest. This comprehensive and interactive interface facilitates a thorough analysis of alternatives, aiding users in making well-informed decisions based on the systematic application of the WASPAS method. The output calculation results of this system are visualized in Figure 5.

Normalization Matrix

No	Alternative	Subscription Fees	Average Download Speed	Average Upload Speed	Coverage Area	Customer Service
-	Bobot	45 % (Cost)	26 % (Benefit)	16 % (Benefit)	9 % (Benefit)	4 % (Benefit)
1	Biznet	0.666666666667	1	1	0.5	0.75
2	Fist Media	1	1	0.5	0.75	0.5
3	Indihome	0.666666666667	1	1	1	1
4	Oxygen	1	0.5	0.75	0.5	0.5
5	MyRepublic	1	0.75	0.75	0.25	0.75

Preference Value

No	Alternative	Results
1	Biznet	0.784435599888
2	Fist Media	0.86290004646
3	Indihome	0.84160927818
4	Oxygen	0.746899781734
5	MyRepublic	0.795395345357

Figure 5. Calculation Output and Ranking of Alternatives from the WASPAS Method

Figure 5 displays the results of system calculations for this case study, producing a ranking of preference scores produced by the system in accordance with the results of manual calculations, so that the system output is reliable. Upon completion of the system development, it progresses to the testing phase through usability testing to ensure the software's suitability for use. Usability testing seeks to assess the degree to which the program may be used with effectiveness, efficiency, and satisfaction by end-users. This method provides a clear and quantifiable measure of the system's usability, ensuring that the software meets the users' needs and preferences effectively. The sub-criteria involved in usability testing include understandability, learnability, operability, and attractiveness. This testing involves distributing a questionnaire to users who will be making ISP selections. The questionnaire utilizes a Guttman scale with two response options, agree and disagree, to elicit extreme responses. It comprises 10 questions and is completed by 25 respondents. The questionnaire results are tabulated by tallying the agree and disagree replies, and the findings are shown in the form of a graph in Figure 6.

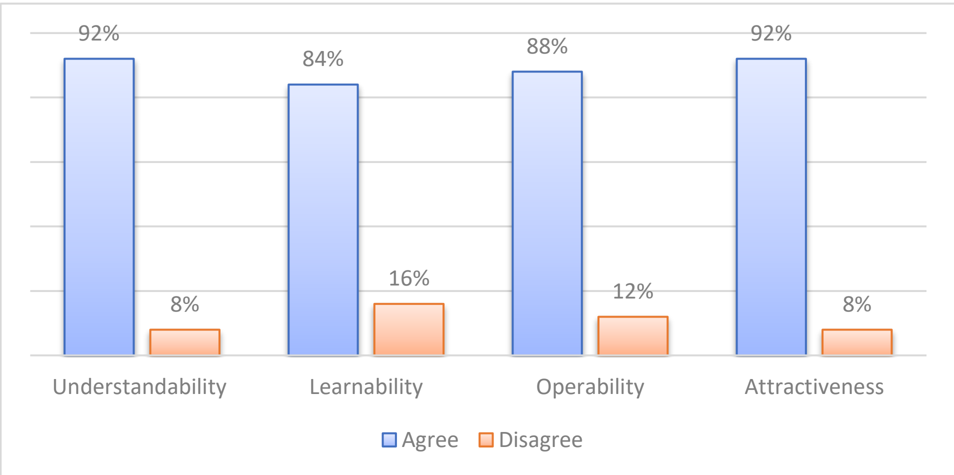

Figure 6. Usability Testing Percentage Graph

Figure 6 displays a graph illustrating the proportion of respondents' replies regarding usability testing in relation to the existing sub-criteria. Subsequently, the outcomes of the usability test are analyzed based on the following criteria: "Good" if the value is in the range of 76% to 100%; “Fair” if the value is in the range 56% to

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75%; “Not Good” if the value is in the range of 40% to 55%, and “Not Good” if the value is less than 40% [27]. Consequently, based on the average usability testing score of 89%, it can be concluded that this decision support system falls into the "Good" category in terms of usability. This suggests that the system is appropriate for usage, since it is considered to have the required features by the users. The examination of the data from the performed case study shows that the Weighted Aggregated Sum Product Assessment (WASPAS) approach is highly adaptable to different kinds of criteria and weights. The use of the Rank Order Centroid (ROC) technique for assessing criteria weights facilitates the identification of the most significant components or those exhibiting superior performance, depending on the existing data. However, it should be noted that the ROC approach has a limitation in terms of subjectivity in ranking, as the rankings are assigned based on the subjective preferences of the decision-maker. This potential bias should be considered when interpreting the results and making decisions based on this system.

4. CONCLUSION

The paper effectively developed a system that aids in decision-making for selecting an Internet Service Provider (ISP). This was achieved by implementing two distinct methodologies: the Rank Order Centroid (ROC) approach for determining the weights of various criteria and the Weighted Aggregated Sum Product Assessment (WASPAS) method for deriving the optimal recommendation. The ROC approach was used to obtain the weights of the criteria based on their order of importance. On the other hand, the WASPAS method was employed to determine the best alternative through weighted addition and multiplication, resulting in a final score that reflects how well each alternative meets the set criteria. The case study results ranked the alternatives from highest to lowest, with First Media (A2) leads with a score of 0.8629, followed by Indihome (A3) with a score of 0.8416, MyRepublic (A5) achieving a value of 0.7954, Biznet (A1) obtaining a score of 0.7844, and Oxygen (A4) receiving a value of 0.7469. The validity of the system's output is affirmed due to its consistency with manual calculations. The developed decision support system features key functionalities, including managing alternative data, managing alternative values, performing alternative selection, and displaying calculation results and recommendations for the best alternative. Usability testing yielded an average score of 89%, indicating that the system is fit for use as it meets the desired functionalities of the users. However, there are some recommendations for future research. First, the ROC weighting technique is prone to subjectivity in ranking, which could be improved by incorporating fuzzy logic for more logical reasoning. Additionally, the categorization of values susceptible to imbalance should be addressed by implementing specific methods to determine value ranges for each group.

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