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Decision Support System For Oil Palm Seed Selection Using The Simple Additive Weighting Method

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ABSTRACT (10PT)

The selection of superior oil palm seedlings is a crucial factor in improving plantation productivity. However, the selection process, which often relies on farmers' subjective experience, frequently results in inaccuracies in determining ready-to-plant seedlings. This study aims to develop a Decision Support System (DSS) using the Simple Additive Weighting (SAW) method to assist farmers in selecting high-quality oil palm seedlings based on four main criteria: number of fronds, seedling age, seedling height, and stem diameter.

The SAW method was applied to calculate the preference value of each seedling alternative through normalization and weighting of all criteria. The system was developed as a web-based application using the Laravel framework and tested using the Black-Box Testing method to ensure functionality and accuracy. The testing results showed that the system produced recommendations identical to manual calculations (100% accuracy) and completed data processing in less than 2 seconds for 24 seedling alternatives. This decision support system has proven to be efficient, accurate, and stable in supporting the oil palm seedling selection process. The system's main advantage lies in its ability to automate the evaluation process quickly and objectively, reducing human error and accelerating decision-making for farmers and plantation managers.

1. Introduction

Oil palm is one of the most important plantation commodities in Indonesia's agricultural development. According to the Indonesian Ministry of Agriculture (2014), the total area of oil palm plantations in Indonesia is 11 million hectares, double the area in 2000. This figure is estimated to increase to 13 million hectares by 2020. This increase is reflected in Indonesia's total production and exports, as well as the growth in oil palm plantation area [1]. Indonesia is one of the world's largest producers of palm oil, providing employment for 16 million people, both directly and indirectly. In the food industry, palm oil is often used as a raw material for products such as cooking oil, margarine, cakes, and so on. In the non-food industry, palm oil is usually used as a raw material for the production of soap, detergent, diesel fuel, and cosmetics [2]. The use of high-quality seeds is one of the important factors that determine the growth of oil palm. High-quality seeds are seeds that come from superior varieties, which are of good quality in terms of seed purity, seed cleanliness, germination rate, and seed health. Maximum production can be achieved if the plants come from good, high-quality seeds [3]. The main problem faced by farmers is the lack of a structured system and adequate supporting data in determining the types of food crops to be planted. As a result, decisions are often made based solely on personal experience without clear information. This condition creates uncertainty in the results and has the potential to cause economic losses for farmers [4]. Some of the obstacles often faced by decision makers include inaccurate or incomplete data, difficulties in analyzing complex data, limited access to relevant data, and a lack of understanding of system technology. These factors can hinder the process of making appropriate and effective decisions, requiring data analysis skills and optimal use of technology [5] Therefore, an approach is needed that can assist the decision-making process objectively and systematically, taking into account various measurable criteria.

A Decision Support System is an interactive system that supports decisions in the decision-making process through alternatives obtained from the results of data processing, information, and model design[6]. A Decision Support System (DSS) is an interactive mechanism that provides information, data modeling, and interactive and flexible computer-based data manipulation developed to support an individual or group in finding solutions to specific problems used to assist someone in making decisions in semi-structured and unstructured situations [7]. A Decision Support System (DSS) is a flexible, interactive, and adaptable computer-based information system that supports solutions to unstructured management problems [8]. Decision system design supports every stage of decision making, from identifying problems, selecting relevant data, determining the best approach to decision making, to evaluating alternatives [9]. With the help of technology, the decision-making process can be carried out more efficiently through fast and low-cost computing. This system also plays an important role in increasing productivity and the quality of decisions made. In addition, this system also provides advantages by helping to overcome cognitive limitations, particularly in terms of data processing and information storage [10]. The use of data processing technology can provide solutions for farmers in selecting good seeds [11].

Previous research conducted by [12] entitled Implementation of "Palm Oil Seed Quality Determination System Using the Simple Additive Weighting Method (SAW) (Case Study: CV. Putra Borneo Raya)," applied the SAW method in selecting superior oil palm seedlings based on several criteria that must be met, including leaves, number of fronds, plant height, plant diameter, and leaf blade length. This approach is indeed capable of assessing the physical condition of the seedlings, but it does not consider the age of the seedlings, which plays an important role in determining planting readiness and optimal growth rates in the field.

In this study, a Decision Support System was developed using the Simple Additive Weighting Method, which will help farmers determine quality seedlings ready for planting based on criteria such as number of leaves, seedling age in months, seedling height in centimeters, and stem diameter in millimeters. It is hoped that through this research, farmers can make more accurate decisions in selecting the plant seedlings to be used, by utilizing structured data and support systems. Thus, seedling selection becomes more accurate, the risk of crop failure can be minimized, and farmers' productivity and profits can increase.

2. Method

Research related to the decision support system for selecting oil palm seedlings using the Simple Additive Weighting (SAW) method consists of five main stages that are interrelated.

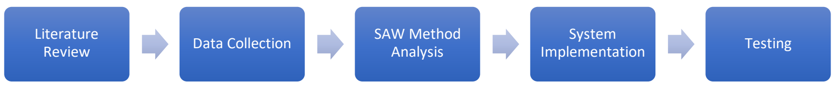

Figure 1. Research Framework

2.1 Type and Approach of Research

The Simple Additive Weighting (SAW) Method is one of the weighted summation methods used in decision support system problem solving, which is relatively simple. The Simple Additive Weighting (SAW) Method is also known as one of the methods used in solving decision-making problems under Multiple Attribute Decision Making (MADM) conditions[13]. The data obtained was then calculated using the SAW method, which begins with the identification of criteria and alternatives, determining the weight of each criterion, (d) normalizing the matrix based on equations adjusted to the type of attribute (cost or benefit) using the SAW method The final result of this process is a total score for each seedling alternative, which is used to rank the seedlings based on the predetermined criteria[14].

The basic concept of how the Simple Additive Weighting (SAW) method works is to find the value by performing weighted summation based on the performance ratings of each alternative for all attributes. This method requires decision makers to determine the weight of each attribute. Each attribute rating must be dimension-free in the sense that it has undergone a normalization process beforehand. The Simple Additive Weighting (SAW) method must be performed by normalizing the decision matrix into a scale that will be compared with each alternative rating [15]. The total score for the alternative maker is obtained by summing all the results of the multiplication between ratings (which can be compared across attributes). The SAW method recognizes two types of criteria, namely cost and benefit. Cost is a type of criterion that prioritizes the lowest value, while benefit is a type of criterion that prioritizes the highest value as a reference for selection [16].

The procedures or steps for applying the SAW method include: (1) Determine the criteria (C) that will be used as a reference for decision making, (2) Assign a weight (W) to each of the specified criteria, (3) Assign a suitability rating to each alternative for all criteria, (4) Calculate the decision matrix based on criteria (C), (5) Matrix normalization calculations based on equations adjusted to the type of attribute (cost or benefit).

(6) Normalization formula for benefit criteria:

$$r_{ij} = \frac{X_{ij}}{max\ (X_{ij})}$$

(7) Normalization formula for cost criteria:

$$r_{ij} = \frac{min(X_{ij})}{X_{ij}}$$

Description:

r_{ij} : Normalized value

X_{ij} : Original value

$max\ (X_{ij})$: Maximum value

$min(X_{ij})$: Minimum value

(8) After the decision matrix has been normalized, the next step is to calculate the preference value for each alternative. The preference value is obtained by summing the results of multiplying the normalization value and the weight of each criterion.

$$V_i = \sum_{j=1}^{n} W_j R_{ij}$$

Descriotion :

V_i : Ranking for each alternative

W_j : Weighting of each criterion

$\boldsymbol{R_{ij}}$: Normalized performance rating value

2.2 Object and Scope of Research

The object of this research is a decision support system (DSS) developed to assist farmers in selecting high-quality and ready-to-plant oil palm seedlings. The system applies the Simple Additive Weighting (SAW) method to evaluate and rank seedling alternatives based on several criteria, including number of leaves, seedling age (in months), seedling height (in centimeters), and stem diameter (in millimeters). The scope of this research is limited to the implementation and evaluation of the DSS within the agricultural domain, particularly in the selection process of oil palm seedlings. This study focuses on data obtained from the observation of seedling characteristics in nurseries and does not cover post-planting growth performance or environmental factors affecting seedling development.

2.3 Data Collection Techniques

Researchers collected data through observation and interviews with palm oil plantation owners who plant seedlings to obtain further information about the quality of good palm oil seedlings ready for planting. This activity was carried out in order to identify problems more accurately and specifically. The data collected included alternative oil palm seedlings and values for each criterion, as well as the weight of each criterion.

2.4 Tools and Materials Used

In developing a web-based Decision Support System (DSS) for selecting oil palm seedlings using the Simple Additive Weighting (SAW) method, hardware and software specifications are required for the system to run optimally. In terms of hardware, the system requires a computer or laptop with at least an Intel Core i3 processor, 4 GB of RAM, 500 GB of storage, as well as a local server or hosting and an internet connection for online access. In terms of software, Windows 10 is used as the operating system, along with HTML, CSS, PHP, and JavaScript programming languages, as well as the Laravel version 10 framework for backend development. The database is managed using MySQL or MariaDB, run through an Apache or Nginx web server, and accessed using Google Chrome or Mozilla Firefox browsers. System development is carried out using Visual Studio Code (VS Code) as the main programming environment.

2.5 Research Procedures or Stages

The development of the SAW method was implemented in a Decision Support System. Software development in this study used the Agile Development method. One of its advantages is that it allows for collaboration and mutual correction among team members, with a tendency for shorter information system development times and the ability to adapt quickly to any changes in development without compromising the quality of the information system[17].

2.6 Data Analysis Techniques

Testing was conducted to ensure that the system functions according to user requirements and produces accurate outputs. The system testing employed the Black-Box Testing method, which focuses on the system's functionality without considering the internal structure of the program code. This approach is commonly used in Decision Support System (DSS) research because it ensures that the system generates outputs consistent with user expectations. The study by [18]. demonstrated that the Black-Box method is effective for testing the functional accuracy of web-based decision support systems. Similar findings were reported by [19], who applied the Equivalence Partitioning technique to test a DSS-based civil servant selection system and proved that functional testing can accurately detect input-output errors.

Furthermore, [20]. conducted Black-Box testing on a decision support system for scholarship recipients, showing that this method effectively identifies logical and data validation errors. Therefore, the Black-Box Testing method was chosen in this study as it is considered the most appropriate approach for testing system stability and result accuracy. Testing was carried out on several main features, including input of criteria and alternatives, the SAW calculation process, result ranking, dashboard visualization, and report export in PDF format. In addition, manual calculation validation was performed to ensure the consistency between the system's results and manual SAW computations. This validation aimed to guarantee the accuracy of the implemented algorithm and confirm that the system can provide consistent and reliable recommendation results.

3. Results and Discussion

3.2 Implementation of the SAW Method in System

The following is the implementation of the decision support system for oil palm seedlings with the SAW method

Figure 2. Palm Seedling Selection Decision Support System Dashboard

Figure 3. Alternative Input Page

Figure 4. Criteria Input Page

Figure 5. Assessment Page

Figure 6. Sub Criteria Determination Page

Figure 7. Calculation Page

3.2 Calculation using the SAW method

There are 24 seedlings that will be considered as alternatives in the selection of oil palm seedlings using the SAW method.

Table 1. Oil Palm Seedling Alternative Data

Code	*Alternative*
A1	DxP PPKS 239 3
A2	DxP PPKS 239 2
A3	DxP PPKS 239 1
A4	DxP PPKS 540 3
A5	DxP PPKS 540 2
A6	DxP PPKS 540 1
A7	DxP PPKS 718 3
A8	DxP PPKS 718 2
A9	DxP PPKS 718 1
A10	DxP Yangambi 3
A11	DxP Yangambi 2
A12	DxP Yangambi 1
A13	DxP Avros 3

A14	DxP Avros 2
A15	DxP Avros 1
A16	DxP Langkat 3
A17	DxP Langkat 2
A18	DxP Langkat 1
A19	DxP Simalungun 3
A20	DxP Simalungun 2
A21	DxP Simalungun 1
A22	DxP SP-1 Dumpy 3
A23	DxP SP-1 Dumpy 2
A24	DxP SP-1 Dumpy 1

Based on the data, there are six different types of oil palm seedlings, namely PPKS 239, PPKS 540, PPKS 718, Yangambi, Avros, Langkat, Simalungun, and SP-1 Dumpy. The steps involved in selecting oil palm seedlings using the SAW method are as follows:

Determination of Assessment Criteria

Table 2. Assessment Criteria

Criteria	Code
Number of Fronds	K1
Umur bibit (bulan)	K2
Tinggi bibit (cm)	K3
Diameter Batang (mm)	K4

Weighting of Each Assessment Criteria

Table 3. Weight of criteria

Criteria	Attributes	Weight (%)
Number of Fronds	Benefit	20
Seedling Age (months)	Benefit	30
Seedling Height (cm)	Benefit	25
Stem Diameter (mm)	Benefit	25

Each criterion is assigned a sub-criterion and weighted with values from 1 to 5, with 1 being poor and 5 being excellent.

Sub-criterion weights of the number of fronds criterion

Table 4. Weighting of Sub Criteria K1

K1	Value

3-4,5 fronds	1
5-9,5 fronds	2
10-12,5 fronds	3
13-15,5 fronds	4
16-18,5 fronds	5

Sub-criterion weights of seedling age criteria

Table 5. Weighting of Sub Criteria K2

K2	Value
3-4 months	1
5-6 months	2
7-8 months	3
9-10 months	4
11-12 months	5

Sub-criterion weights of seedling height criteria

Table 6. Weighting of Sub Criteria K3

K3	Value
13-35 cm	1
36-60 cm	2
61-85 cm	3
86-110 cm	4
111-135 cm	5

Sub-criterion weights of stem diameter criteria

Table 7. Weighting of Sub Criteria K4

K4	Value
10-16 mm	1
17-24 mm	2
25-39 mm	3
40-57 mm	4
58-75 mm	5

Giving a match value to each alternative. Based on the data obtained from each oil palm seedling, a value is determined based on the four criteria.

Table 8. Weight Assessment of Criteria for Each Alternative

Alternative	K1	K2	K3	K4
A1	1	1	1	1
A2	3	3	2	3
A3	4	5	4	5
A4	1	1	1	1
A5	3	3	3	3
A6	4	5	5	5
A7	1	1	1	1
A8	3	3	3	3
A9	4	5	5	5
A10	1	1	1	1
A11	3	3	3	3
A12	4	5	5	5
A13	1	1	1	1
A14	3	3	3	4
A15	4	5	5	5
A16	1	1	1	1
A17	3	3	3	3
A18	5	5	5	5
A19	1	1	1	1
A20	3	3	3	3
A21	4	5	5	5
A22	1	1	1	1
A23	3	3	3	4
A24	4	5	5	5

Calculation of decision matrix normalization based on the type of cost or benefit criteria.

Table 9. Normalization Results

Alternative	K1	K2	K3	K4
A1	0.2	0.2	0.2	0.2

A2	0.6	0.6	0.4	0.6
A3	0.8	1	0.8	1
A4	0.2	0.2	0.2	0.2
A5	0.6	0.6	0.6	0.6
A6	0.8	1	1	1
A7	0.2	0.2	0.2	0.2
A8	0.6	0.6	0.6	0.6
A9	0.8	1	1	1
A10	0.2	0.2	0.2	0.2
A11	0.6	0.6	0.6	0.6
A12	0.8	1	1	1
A13	0.2	0.2	0.2	0.2
A14	0.6	0.6	0.6	0.8
A15	0.8	1	1	1
A16	0.2	0.2	0.2	0.2
A17	0.6	0.6	0.6	0.6
A18	1	1	1	1
A19	0.2	0.2	0.2	0.2
A20	0.6	0.6	0.6	0.6
A21	0.8	1	1	1
A22	0.2	0.2	0.2	0.2
A23	0.6	0.6	0.6	0.8
A24	0.8	1	1	1

Preference Value Calculation

Table 10. Result of Preference Value Calculation

Alternative	**Manual Calculation**	**Preference**
A1	(0.2×20)+(0.2×30) +(0.2×25)+(0.2×25)	20
A2	(0.6×20)+(0.6×30) +(0.4×25)+(0.6×25)	55
A3	(0.8×20) + (1×30) + (0.8×25) + (1×25)	91
A4	(0.2×20)+(0.2×30) +(0.2×25)+0.2×25)	20
A5	(0.6×20) + (0.6×30) +(0.6×25)+(0.6×25)	60
A6	(0.8×20) + (1×30) + (1×25) + (1×25)	96

A7	(0.2×20) + (0.2×30) +(0.2×25)+(0.2×25)	20
A8	(0.6×20) + (0.6×30) +(0.6×25)+(0.6×25)	60
A9	(0.8×20) + (1×30) + (1×25) + (1×25)	96
A10	(0.2×20) + (0.2×30) +(0.2×25)+(0.2×25)	20
A11	(0.6×20) + (0.6×30) +(0.6×25)+(0.6×25)	60
A12	(0.8×20) + (1×30) + (1×25) + (1×25)	96
A13	(0.2×20) + (0.2×30) +(0.2×25)+(0.2×25)	20
A14	(0.6×20) + (0.6×30) +(0.6×25)+(0.8×25)	65
A15	(0.8×20) + (1×30) + (1×25) + (1×25)	96
A16	(0.2×20) + (0.2×30) +(0.2×25)+(0.2×25)	20
A17	(0.6×20) + (0.6×30) +(0.6×25)+(0.6×25)	60
A18	(1×20) + (1×30) + (1×25) + (1×25)	100
A19	(0.2×20) + (0.2×30) +(0.2×25)+(0.2×25)	20
A20	(0.6×20) + (0.6×30) +(0.6×25)+(0.6×25)	60
A21	(0.8×20) + (1×30) + (1×25) + (1×25)	96
A22	(0.2×20) + (0.2×30) +(0.2×25)+(0.2×25)	20
A23	(0.6×20) + (0.6×30) +(0.6×25)+(0.8×25)	65
A24	(0.8×20) + (1×30) + (1×25) + (1×25)	96

Ranking Result

Table 11. Ranking Result

Rangking	Alternative	Preference Value
1	A18	100
2	A6	96
2	A9	96
2	A12	96
2	A15	96
2	A21	96
2	A24	96
8	A3	91
9	A14	65
9	A23	65
11	A5	60

11	A8	60
11	A11	60
11	A17	60
11	A20	60
16	A2	55
17	A1	20
17	A4	20
17	A7	20
17	A10	20
17	A13	20
17	A16	20
17	A19	20
17	A22	20

Based on the results of calculations with the SAW method, the type of seedling DxP PPKS 718 3 is the most superior type of seedling for ready planting with a preference value of 100, followed by the type of seedling Dxp Simalungun 3 with a total preference of 96. Meanwhile, the DxP PPKS 239 1 seedling type is the worst quality seedling among 24 alternatives with a total preference of 20.

3.3 Testing

System testing was conducted to evaluate the performance of the developed Decision Support System, including functionality, computational accuracy, and user convenience. The main objective of this phase was to ensure that all system features operated correctly according to the design specifications and produced accurate outputs based on user input.MThe testing method used was Black-Box Testing, which focuses on verifying the system's external behavior without examining its internal code structure. This approach ensures that each module produces the correct output in response to various user inputs. The testing covered several main features, including data input for criteria and alternatives, the SAW calculation process, result ranking, dashboard visualization, and report export to PDF format.

Table 12. Black-Box Testing Results of the DSS for Oil Palm Seedling Selection

No	Feature Tested	Test Description	Expected Result	Actual Result	Status
1	Criteria Data Input	Add a new criterion into the system	Criterion data saved and displayed in the table	As expected	Passed
2	Alternative Data Input	Add a new seedling alternative	Alternative data saved and accessible	As expected	Passed
3	Alternative Evaluation	Enter scores for each criterion per alternative	Scores saved and displayed correctly	As expected	Passed

4	SAW Calculation Process	Perform normalization and preference calculations	System generates preference values for all alternatives	As expected	Passed
5	Ranking Results	Sort results by highest preference value	Ranking table displayed correctly	As expected	Passed
6	Dashboard Visualization	Display graphical representation of ranking results	Graph displayed correctly according to data	As expected	Passed
7	Report Export	Generate SAW results report in PDF format	PDF file generated successfully	As expected	Passed
8	Input Validation	Ensure the system rejects empty input	System shows error message "Data cannot be empty"	As expected	Passed
9	Manual Calculation Validation	Compare system output with manual SAW calculation	Results are identical to manual computation	As expected	Passed
10	System Performance	Measure processing time with larger dataset	Process completed in under 2 seconds without errors	As expected	Passed

Based on the testing results shown in Table 12, all system features functioned properly and produced outputs consistent with the expected results. No logical or display errors were found during data input, computation, or result visualization. The system successfully performed all processes and delivered accurate computation outcomes. A manual calculation validation was also carried out to verify the consistency between the system's results and manual calculations using the Simple Additive Weighting (SAW) method. The validation showed a 100% match, confirming that the normalization, weighting, and preference calculation processes were correctly implemented and functioning as intended. In addition, system performance testing was conducted by increasing the number of alternatives and criteria to assess system stability and efficiency. The results indicated that the system was able to complete the computation process in less than 2 seconds without any errors or crashes, proving its stability and high performance.

Overall, the testing results demonstrate that the Decision Support System for selecting ready-to-plant oil palm seedlings using the SAW method performs accurately and reliably. The system provides consistent recommendations and can be effectively used as a practical and efficient decision-making tool for farmers and related stakeholders.

4. Conclusion

This study successfully implemented the Simple Additive Weighting (SAW) method in a Decision Support System (DSS) for selecting ready-to-plant oil palm seedlings. The developed system demonstrated high computational accuracy, with results fully matching manual calculations (100% consistency). Performance evaluation also indicated strong computational efficiency, completing data processing in under 2 seconds for a dataset containing 24 seedling alternatives and 4 evaluation criteria. This efficiency highlights the system's capability to handle data rapidly and accurately, providing users with reliable decision-making support. The DSS thus offers a tangible benefit by reducing human error and decision-making time in seed selection, ultimately improving plantation productivity. In conclusion, the DSS developed using the SAW method not only provides accurate and consistent recommendations but also showcases computational efficiency and operational stability. These qualities make it a valuable tool for agricultural decision-making, particularly for farmers and plantation managers seeking data-driven accuracy in seed selection.

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