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Decision Support System for Aren Sugar Aid Using SMART Method

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Abstract

Sugar palm (Arenga pinnata Merr) is a type of palm plant that is widely found in Indonesia. This plant is able to produce sap liquid from its cut flower bunches. Chemically, sugar palm sap contains 87.2% water, 12.7% carbohydrates, 0.24% ash, 0.2% protein, and 0.02% fat. Simple Multi Attribute Rating Technique is a multi-attribute decision-making method used to assist decision makers in determining several alternative choices. Each alternative is arranged based on a number of attributes, where each attribute has a certain value that is assessed on a certain scale. In addition, each attribute is given a weight that indicates its level of importance compared to other attributes. The application of a Decision Support System with this method can produce more effective, fast, and accurate decisions in the initial selection process for recipients of palm sugar production assistance. The reliability of this system is proven through testing using the White Box Testing and Basis Path Testing methods, which produce a V(G) value of 9.

Keywords— *Sugar Palm, Plant, Smart, Sugar*

1. Introduction

In the digital era, academic data management is essential. Aren (Arenga pinnata Merr) is one type of palm plant that grows abundantly in Indonesia. According to Heryani (2016), fresh nira that has just been tapped has a sweet taste, a distinct natural aroma, an acidity level of around 5–6, a sucrose content of over 12%, and an alcohol content below 5%.

Currently, the aren sugar production business presents a promising entrepreneurial opportunity. However, selecting recipients for aren sugar production aid in villages still faces challenges, as the number of producers continues to grow (Hutami, A., & Budi, S., 2023). Therefore, a proper selection system is needed to ensure that the assistance is genuinely provided to those most in need. Until now, village authorities have relied on outdated data, so some inactive producers are still listed as aid recipients. As a result, new entrepreneurs who are just starting out often do not get the opportunity to receive aid. The SMART (Simple Multi-Attribute Rating Technique) method is a multi-attribute decision-making technique, where each alternative has several criteria with assigned values. Each criterion is given a weight to indicate its importance relative to others (Morton, M. S., 1970). Using this method, the Hulawa Village administration can more easily assign weights to selection criteria, enabling a more objective and accurate selection of aren sugar production aid recipients. Etymologically, the word "system" originates from the Latin *systema* and the Greek *sustēma*, meaning a unity

composed of several interconnected and cooperating components to achieve a specific goal through data, material, or energy processing. A system is also defined as a set of related parts operating within a particular area of work. A Decision Support System (DSS) is a flexible and intelligent data-based system designed to provide, process, and present information to aid decision-making in semi-structured or unstructured situations, where the solution method has not been clearly determined. The concept of DSS was first introduced by Michael Scott Morton in 1970 under the term *Management Decision Systems*. This computer-based system supports management in making decisions by utilizing various data and analytical models to solve complex problems. (kajianpustaka.com).

2. Method

This study applies a descriptive research method to develop a decision support system for selecting aren sugar production aid recipients using the SMART (Simple Multi Attribute Rating Technique) method. The approach aims to provide a systematic and objective analysis of the existing problem and implement a decision-making model to support village authorities in distributing aid fairly and effectively.

2.1 Review Process

The review process begins with the analysis of the current system implemented by the village in selecting recipients for aren sugar aid. Data was collected through field observation and structured interviews with the Village Head and local officials in Hulawa Village. The main issues identified include the use of outdated recipient data and the lack of objective criteria in the selection process.A proposed system was then designed using the SMART method, which allows alternatives (potential aid recipients) to be evaluated based on multiple weighted criteria. Criteria such as production capacity, income level, land ownership, and years of operation were established through stakeholder consultation. Each criterion was assigned a weight based on its importance in the selection process.The system design was illustrated using context diagrams, flowcharts, and structured data tables. The prototype was developed using Microsoft Excel as a calculation tool for SMART scoring, and all figures and data were prepared to ensure black-and-white printing compatibility.

2.1.1 Equations

The SMART method uses a weighted scoring formula to evaluate each alternative. The total score of each alternative is calculated using the following equation:

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

Where:
S_i = total score for alternative i
w_j = weight of criterion j
r_{ij} = normalized rating of alternative iii on criterion j
n = total number of criteria

Each rating r_{ij} is normalized to ensure comparability, and weights w_j are assigned such that the sum of all weights equals 1.

3. Results And Discussion

Presented below is a table of evaluation criteria employed in the assessment and selection of beneficiaries for aren sugar production assistance, utilizing the SMART (Simple Multi-Attribute Rating Technique) method.

Tabel 1. Evaluation Criteria (Including Initial Weights – which can be adjusted):

No	Criterion	Description	Type	Weight (%)
1	Land Area for Aren Plantation	The larger the land area, the greater the production potential	Benefit	25%
2	Number of Productive Aren Trees	Productive trees indicate high sap production potential	Benefit	20%
3	Monthly Income of Farmers	Farmers with lower income are prioritized	Cost	15%
4	Number of Family Dependents	The more dependents, the higher the aid requirement	Benefit	10%
5	Availability of Traditional Production Tools	Whether the farmer already owns the production tools (without previous aid)	Cost	10%
6	Activity in Farmer Groups	Activeness indicates commitment and sustainability	Benefit	10%
7	Accessibility Location	The distance to the distribution center or market (the farther, the higher the priority).	Cost	10%

Based on the table, several individuals have been identified as alternatives (potential aid recipients), as presented in the following table.

Tabel 2. Alternatives (Potential Recipients):

No	Name
A1	Mr. Ahmad
A2	Mrs. Siti
A3	Mr. Ridwan
A4	Mrs. Lestari
A5	Mr. Yusuf

The following table presents the criteria used in evaluating potential recipients of aren sugar production aid, including the type of each criterion, its weight in percentage, and its decimal equivalent. These weights reflect the relative importance of each criterion in the decision-making process using the SMART (Simple Multi-Attribute Rating Technique) method.

Tabel 3. Define Criteria and Weights

No	Criterion	Type	Weight (%)	Decimal Weight
C1	Land Area for Aren Plantation (hectares)	Benefit	25	0.25
C2	Number of Productive Aren Trees	Benefit	20	0.20
C3	Monthly Income (IDR)	Cost	15	0.15
C4	Number of Dependents	Benefit	10	0.10
C5	Ownership of Traditional Production Tools	Cost	10	0.10

C6	Activity in Farmer Groups (1–5)	Benefit	10	0.10
C7	Accessibility Location (km)	Cost	10	0.10

This table presents the data of each alternative or potential aid recipient based on the seven predefined criteria. These values are used in the SMART method calculation to identify the most eligible recipients for assistance.

Tabel 4. Data for Alternatives

Alternative	C1 (Ha)	C2 (Trees)	C3 (IDR)	C4	C5 (1–5)	C6 (1–5)	C7 (km)
A1	1.5	40	1,500,000	4	2	4	12
A2	1.0	30	1,000,000	5	3	5	20
A3	0.8	25	2,000,000	2	4	3	10
A4	1.2	35	1,200,000	3	2	4	15
A5	1.7	50	900,000	6	1	5	25

Normalization (SMART Method)

- Untuk **Benefit Criteria**:
  $R_{ij} = \frac{x_{ij}}{\max(x_j)}$
- Untuk **Cost Criteria**:
  $R_{ij} = \frac{\min(x_j)}{x_{ij}}$

Contoh Normalisasi untuk A1:

- C1 (Benefit): $\frac{1.5}{1.7} = 0.882$
- C2 (Benefit): $\frac{40}{50} = 0.800$
- C3 (Cost): $\frac{900000}{1500000} = 0.600$
- C4 (Benefit): $\frac{4}{6} = 0.667$
- C5 (Cost): $\frac{1}{2} = 0.500$
- C6 (Benefit): $\frac{4}{5} = 0.800$
- C7 (Cost): $\frac{10}{12} = 0.833$

Normalization for A1:
Do the same for all alternatives.
Calculate the SMART Final Value

$$\begin{aligned}\text{Skor A1} =& (0.882 \times 0.25) + (0.800 \times 0.20) + (0.600 \times 0.15) + \\ & (0.667 \times 0.10) + (0.500 \times 0.10) + (0.800 \times 0.10) + (0.833 \times 0.10) \\ =& 0.2205 + 0.160 + 0.090 + 0.0667 + 0.050 + 0.080 + 0.0833 \\ =& **0.7505**\end{aligned}$$

The following are the final results of the SMART method calculation to determine potential recipients of palm sugar production assistance:

Table 5. Alternative Rankings Based on Final Scores

Ranking	Alternative	Final Score
1	A5	0.9400
2	A1	0.7506
3	A4	0.6756
4	A2	0.6687
5	A3	0.5035

For a clearer understanding, this can be seen in the graph that illustrates the results of the table.

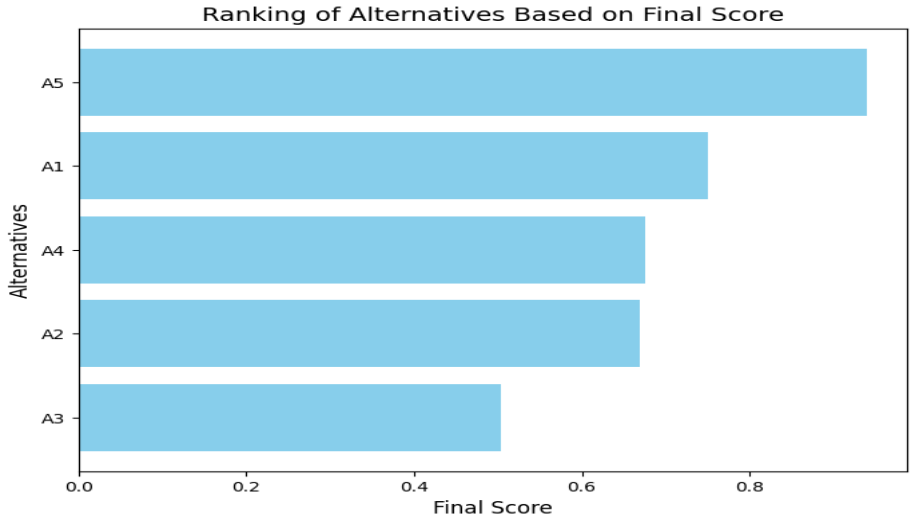

Figure 1. Rangking Of Alternatives Based on Final Score

- A5 is the top priority candidate for assistance because it has the highest score.
- Other alternatives can be prioritized according to the score order.

System testing is conducted after all modules have been developed and the system is functioning as expected. Component and integration testing are performed using both white box and black box testing techniques. White box testing is used to examine basis paths and calculate the Cyclomatic Complexity. On the other hand, black box testing focuses on functional requirements of the multimedia learning interface.
White box testing is a software testing method conducted at the level of program code flow to verify whether the inputs and outputs match the required specifications. In white box testing using the basis path approach, several steps are involved, including constructing a flowgraph for the function to be tested, calculating the Cyclomatic Complexity (CC), and performing unit testing.
After the testing was conducted, the following values were found:

- Region (R) = 9
- Node (N) = 20
- Edge (E) = 27
- Predicate Node (P) = 8

$$V(G) = E - N + 2$$

The Cyclomatic Complexity of the program can be calculated using the following formulas:

- **V(G)**: Cyclomatic complexity
- **E**: Total number of edges
- **N**: Total number of nodes

Based on the flowgraph, the Cyclomatic Complexity is:

V(G) = 27 – 20 + 2 = 9
or

V(G) =8+1=9
The resulting value of 9 indicates the number of independent paths for basis path testing. In other words, this represents the number of test cases needed to ensure that every statement in the program is executed at least once.
List of Independent Paths:

- R1 : 1-2-3-4-5-6-2
- R2 : 1-2-3-4-5-6-7-8-9-10-2
- R3 : 1-2-3-7-8-9-10-2
- R4 : 1-2-3-7-12-13-14-2
- R5 : 1-2-3-7-12-16-17-18-2
- R6 : 1-2-3-7-12-16-17-19-20
- R7 : 1-2-3-7-8-9-11-20
- R8 : 1-2-3-7-12-13-14-15-2
- R9 : 1-2-3-7-12-16-20

Notes:

- An independent path is any path through the program that introduces at least one new set of processing statements or a new condition.
- Each independent path must traverse at least one edge that has not been covered by any previous path.
- Independent paths must always begin at the start node and end at the end node.
- The first identified path is typically the shortest independent path.

4. Conclusions

Based on the research findings, the Decision Support System (DSS) for the initial selection of palm sugar production aid recipients produced the following results:

1. A method has been developed to design and engineer a decision support system for the initial selection of palm sugar production aid recipients using the SMART method. This system is designed to assist the Hulawa Village administration in selecting eligible aid recipients, ensuring that the aid distribution is more targeted and aligned with the needs of the rightful beneficiaries.
2. The decision support system built using the SMART method has been successfully implemented in Hulawa Village. The effectiveness of the system is demonstrated through testing using the White Box method, where the calculated V(G) 9 value indicates that the designed system functions optimally and is well computerized.

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