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Design Of A Decision Support System For Prioritizing Village Infrastructure Development Using The SAW Method

(Case Study: Asam Jawa Village , Torgamba District)

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ABSTRACT

Village infrastructure development planning often faces challenges in determining priorities due to limited budget allocations and assessment mechanisms that still tend to be subjective. This study aims to build an objective, transparent, and measurable Decision Support System (DSS) to determine the priority order of infrastructure development proposals in Asam Jawa Village, Torgamba District. The applied solution integrates the Rank Order Centroid (ROC) method to calculate criteria weighting based on relative importance, and the Simple Additive Weighting (SAW) method to process the alternative ranking calculation. The evaluation was conducted on 23 physical infrastructure proposals using four main criteria: urgency level (C1), physical condition (C2), benefits (C3), and population size (C4). The results indicate that alternative A4 (Construction of Borehole Well and Public Toilet at Field) and alternative A18 (Sejahtera Street Concrete Cast) achieved the highest preference score of 1.000000, followed by other infrastructure proposals in a structured manner. The combined use of ROC and SAW methods is proven to be effective and consistent in generating accurate rural development priority rankings. The integration of these two methods facilitates village government officials in making accountable decisions while minimizing cognitive bias risks in optimizing development budget allocation.

Keyword: Decision Support System, Infrastructure Priority, Rank Order Centroid, Simple Additive Weighting, Asam Jawa Village

INTRODUCTION

Developing villages from the grassroots level by strengthening infrastructure is a strategic move toward achieving local economic self-reliance, in line with the mandate of the sixth *Asta Cita* (Eight-Point Agenda). The program focuses primarily on providing modern irrigation systems, connecting bridges that significantly reduce rural logistics costs, and farm access roads. Robust infrastructure support facilitates the distribution of agricultural produce, thereby boosting farmers' welfare [1] . Infrastructure development in rural areas is a crucial factor in enhancing the well-being of rural communities. Adequate infrastructure improves community access, enhances the quality of public services, and creates greater economic opportunities for villagers. In practice, however, rural infrastructure development often faces various obstacles, such as substandard road conditions, limited telecommunications facilities, and the impacts of climate change—including floods and droughts [2]. Infrastructure plays a vital role in driving regional economic growth, serving as a key factor that supports regional productivity [3]. Developing village infrastructure—such as roads, electricity, clean water, and telecommunications—is a strategic approach to fostering economic growth and

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community welfare; this process requires careful planning, adequate human resources, and active resident participation [4]. Yet, success hinges heavily on thorough planning and community engagement. Without these elements, infrastructure projects risk facing setbacks due to low resident participation, negative public perception, and a misalignment between program priorities and the community's actual needs [5]. Asam Jawa Village holds a strategic position in Torgamba District, South Labuhanbatu Regency, North Sumatra Province; it covers an area of approximately 6,600 hectares, is divided into 22 hamlets, and has a population of 18,373 people. Its location along the Trans-Sumatra Highway positions the village as a hub of economic activity driven by oil palm and rubber plantations. During the development planning process, the village government gathers community input through hamlet- and village-level deliberations, resulting in 23 infrastructure proposals. The implementation of infrastructure projects in Asam Jawa Village has adopted a participatory approach—utilizing these deliberations to capture and identify community aspirations. While the practice of gathering input through village deliberations reflects the participatory approach described in [6], it is often hindered by a lack of accurate data.

Despite the assessment of community needs, the final determination of infrastructure priorities across hamlets still relies on the subjective internal judgment of village officials, based solely on urgency and the extent of damage. Consequently, the rationale behind these decisions cannot be quantitatively traced. This creates potential difficulties for the village government in justifying its choice of priority areas, particularly when the number of proposals rises amidst budget constraints and demands for equitable development. Research by Widi [7] in Lebak Anyar Village indicates that reliance on the subjective assessments of village officials complicates the accurate setting of infrastructure priorities, thereby fueling social resentment among residents. This aligns with findings by Deah [8] noting that differing viewpoints in village forums often spark debates that lead to development allocations missing their intended targets. Implementing an information technology-based Decision Support System (DSS) offers a strategic solution to transform village development planning into a process that is objective, measurable, and data-driven.

A Decision Support System (DSS) facilitates organizational decision-making workflows through interactive interfaces accessible to both users and devices, while simultaneously fostering discussion and evaluation regarding various policy options [9]. One approach within Decision Support Systems (DSS) is the Simple Additive Weighting (SAW) method, which determines priority rankings in an objective and measurable manner through criterion weighting and the calculation of preference values for each alternative [10]. This method operates systematically, proceeding from data normalization and final score calculation to preference ranking. Its computational advantages and procedural efficiency make SAW highly reliable and widely applied across various decision support system applications [11]. The application of Decision Support Systems (DSS) based on the Simple Additive Weighting (SAW) method has been widely implemented at the village government level.

METHODOLOGY

Research Stages

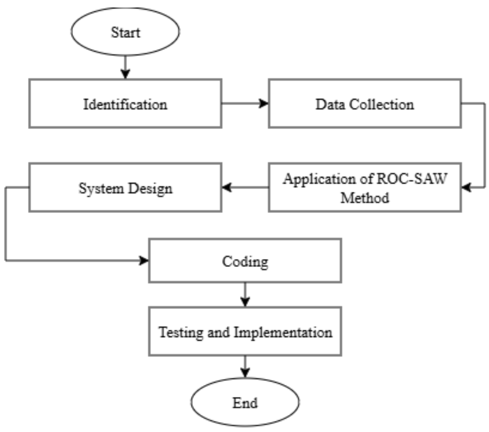

Figure 1. Research Stages

The research stages are structured to ensure an efficient system development process and to produce an accurate set of priorities. The overall workflow of the research stages is presented in Figure 1.

Based on Figure 1, the detailed explanation of each research stage is as follows:

a) Problem Identification: This stage aims to analyze obstacles in village infrastructure development planning, such as social friction and debates during village deliberation meetings (*Rembuk Desa*) arising from subjective assessment methods.
b) Data Collection: This stage involves conducting interviews with village officials and performing a literature review to gather data on proposed infrastructure projects and relevant assessment criteria.
c) Application of the ROC-SAW Method: This stage integrates the Rank Order Centroid (ROC) method to calculate criterion weights based on their level of importance, and the Simple Additive Weighting (SAW) method to objectively determine the priority ranking of final recommendations.
d) System Design: This stage involves designing the decision support system architecture using Unified Modeling Language (UML) modeling, encompassing Use Case Diagrams, Activity Diagrams, and interface designs.
e) Coding: This stage translates the design into a web-based programming language (PHP) and a MySQL database.
f) Testing and Implementation: This final stage involves system testing to ensure the application functions according to requirements before full implementation.

Data Collection

The process of collecting supporting data was carried out using two primary techniques:

a. Interviews: Direct discussions with village officials to identify criterion variables and gather 23 infrastructure development proposals.

Literature Review: Reviewing books, scientific journals, and relevant references regarding the application of ROC and SAW methods in Decision Support Systems.

Rank Order Centroid (ROC) Method

The systematic resolution of multi-criteria priority determination problems can be supported by a quantitative approach known as the Rank Order Centroid (ROC) method. This technique maps complex criteria preferences into an organized ranking structure and subsequently converts them into numerical weights based on their order of importance [12]. By formulating this priority hierarchy, the ROC method yields proportional and objective weight values for each criterion, thereby facilitating decision-makers in formulating transparent, evidence-based policies [13].

The basic steps for determining criterion weights using the ROC method are as follows:

a. Determine the level of importance and rank all criteria from highest to lowest priority (j=1, 2, ..., n).
b. Calculate the weight value for each criterion position using the following centroid formula:

$$W_j = \frac{1}{n}\sum_{i=j}^{n}\frac{1}{i} \quad (1)$$

Notation:
W_j : Weight of the criterion at position/rank j
n : Total number of criteria evaluated
i : Index of the criterion's rank position
j : Priority order of the criterion (1, 2, ..., n)

Simple Additive Weighting (SAW) Method

The Simple Additive Weighting (SAW) method is recognized as an efficient and flexible weighted summation concept within the field of Decision Support Systems. This technique evaluates each alternative by calculating the weighted sum of performance ratings across all criteria, thereby yielding objective, precise, and measurable decision recommendations [14].

The SAW method is implemented through the following stages:

a) Criterion Identification: Determining relevant criterion variables with clear quantitative indicators to measure alternative performance.
b) Criterion Weight Assignment (W_j): Allocating importance weights to each criterion (this study integrates calculation results from the ROC method).
c) Alternative Data Collection: Compiling criterion value data for all alternatives into a decision matrix X_{mxn}.
d) Matrix Normalization (R): Transforming the decision matrix X into a normalized matrix R so that all criteria are on a comparable scale. For benefit criteria:

$$r_{ij} = \frac{x_{ij}}{\max_i(x_{ij})} \tag{2}$$

For Cost Criteria (*cost*):

$$r_{ij} = \frac{\min_i(x_{ij})}{x_{ij}} \tag{3}$$

Notation:
r_{ij} : Normalized performance value of alternative i for criterion j
x_{ij} : Original value of alternative i for criterion j in decision matrix X
$\max_i(x_{ij})$:Highest value among all alternatives for criterion j
$\min_i(x_{ij})$: Lowest value among all alternatives for criterion j

e. Preference Value (Vi): Multiply the normalized matrix *R* by the weights W_j, then sum the results to determine the final score for each alternative:

$$V_i = \sum_{j=1}^{n} w_j \cdot r_{ij} \tag{4}$$

Notation:
V_i : Final preference score for alternative *i* (the highest value represents the top priority)
w_j : Weight of criterion j derived from the weighting calculation
r_{ij} : Normalized matrix value of alternative *i* for criterion j
n : Total number of evaluation criteria

The assessment of infrastructure priorities is conducted based on established criteria—including specific indicators, weightings, and mappings. Details of these criteria are presented in Table 1.

Table 1. Criteria Criterion

Criteria	Criteria Code
Level of Urgency	C1
Physical Condition	C2
Benefits	C3
Population Size	C4

The criteria were selected to establish the key variables serving as the foundation for evaluating infrastructure development priorities in the village. These criteria were identified through primary data collection, involving interviews and focused discussions with the Head of the Village Development Division (Kaur Pembangunan) of Asam Jawa Village. This contextual approach ensures that the formulated criteria accurately reflect actual needs and objective conditions on the ground. Simplifying the assessment structure also serves to reduce the complexity of data entry and minimize the risk of subjective assessment bias.

RESULTS AND DISCUSSION

Criteria and Alternatives

Evaluation indicators were determined through primary data collection involving the Head of Development Affairs and a review of supporting literature. The assessment of infrastructure priorities employs four main criteria—Level of Urgency (C1), Physical Condition (C2), Benefits (C3), and Population Size (C4)—all of which are classified as benefit-type attributes. Data collection encompassed 23 proposed physical infrastructure projects for the village, derived from the Village Deliberation (Rembuk Desa) outcomes.

Criterion weights were established using the Rank Order Centroid (ROC) approach based on the order of priority (n=4). The weight calculations for each criterion are detailed as follows:

Criterion Weight 1 (W_1)

$$W_1 = \frac{1}{4}\left(1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4}\right) = \frac{1}{4}(2{,}083333) = 0{,}520833$$

Criterion Weight 2 (W_2)

$$W_2 = \frac{1}{4}\left(0 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4}\right) = \frac{1}{4}(1{,}083333) = 0{,}270833$$

Criterion Weight 3 (W_3)

$$W_3 = \frac{1}{4}\left(0 + 0 + \frac{1}{3} + \frac{1}{4}\right) = \frac{1}{4}(0{,}583333) = 0{,}145833$$

Criterion Weight 4 (W_4)

$$W_4 = \frac{1}{4}\left(0 + 0 + 0 + \frac{1}{4}\right) = \frac{1}{4}(0{,}2500) = 0{,}062500$$

Table 2 presents a complete decision matrix illustrating the preferences of each development candidate regarding the established criteria. The variation in values among the proposals within the matrix serves as the computational basis for calculating weights and objectively establishing a priority ranking.

Table 2. Decision Matrix — Data Values of 23 Alternatives

Alternative	C1	C2	C3	C4
A1 – Ditch Cleaning	2	2	2	2
A2 – Field Fencing	1	3	1	3
A3 – Alley One Concrete Paving	3	3	3	1
A4 – Construction of Borehole Well and Public Toilet at Field	3	3	3	3
A5 – Pagaran Pisang Road Hardening	2	3	3	2
A6 – Construction of Borehole Well at Pondok Seng	3	3	3	2

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Alternative	C1	C2	C3	C4
A7 – Road Hardening	2	3	2	3
A8 – Road Hardening	2	3	2	3
A9 – Concrete Ditch Construction	2	3	2	2
A10 – Tanah Wakaf Road Concrete Cast	3	3	2	2
A11 – Field Maintenance	1	2	1	2
A12 – Volleyball Court Construction	1	3	1	2
A13 – Dame Road Hardening	2	3	3	2
A14 – Ditch Cleaning	2	2	2	2
A15 – Borehole Well Construction	3	3	3	2
A16 – Road Hardening at Pasar 3 A	2	3	3	3
A17 – Ditch Cleaning	2	2	2	3
A18 – Sejahtera Street Concrete Cast	3	3	3	3
A19 – Borehole Well Maintenance	2	2	2	2
A20 – Borehole Well Construction	3	3	3	2
A21 – Drainage Channel Construction	2	3	2	2
A22 – Well Construction	2	3	2	1
A23 – Culvert Construction	2	3	2	3

Table 2 presents the initial evaluation data for 23 village infrastructure proposals assessed across four criteria: Urgency (C1), Physical Condition (C2), Benefits (C3), and Population (C4). The score variations reflect the actual conditions captured through village planning forums (Rembuk Desa). Utilizing exact quantitative data from direct field assessments overcomes the limitations of subjective village deliberations. This structured decision matrix forms a solid computational foundation, ensuring that all physical infrastructure alternatives are objectively evaluated before weight assignment and matrix normalization

Normalization of Matrix Values

The next step is to transform the decision matrix into a normalized matrix, R, using the benefit criteria equation. The results of the matrix normalization are presented in Table 3.

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Table 3. Matrix Normalization

Alternative	C1	C2	C3	C4
A1 – Ditch Cleaning	0.666667	0.666667	0.666667	0.666667
A2 – Field Fencing	0.333333	1.000000	0.333333	1.000000
A3 – Alley One Concrete Paving	1.000000	1.000000	1.000000	0.333333
A4 – Construction of Borehole Well and Public Toilet at Field	1.000000	1.000000	1.000000	1.000000
A5 – Pagaran Pisang Road Hardening	0.666667	1.000000	1.000000	0.666667
A6 – Construction of Borehole Well at Pondok Seng	1.000000	1.000000	1.000000	0.666667
A7 – Road Hardening	0.666667	1.000000	0.666667	1.000000
A8 – Road Hardening	0.666667	1.000000	0.666667	1.000000
A9 – Concrete Ditch Construction	0.666667	1.000000	0.666667	0.666667
A10 – Tanah Wakaf Road Concrete Cast	1.000000	1.000000	0.666667	0.666667
A11 – Field Maintenance	0.333333	0.666667	0.333333	0.666667
A12 – Volleyball Court Construction	0.333333	1.000000	0.333333	0.666667
A13 – Dame Road Hardening	0.666667	1.000000	1.000000	0.666667
A14 – Ditch Cleaning	0.666667	0.666667	0.666667	0.666667
A15 – Borehole Well Construction	1.000000	1.000000	1.000000	0.666667
A16 – Road Hardening at Pasar 3 A	0.666667	1.000000	1.000000	1.000000
A17 – Ditch Cleaning	0.666667	0.666667	0.666667	1.000000
A18 – Sejahtera Street Concrete Cast	1.000000	1.000000	1.000000	1.000000
A19 – Borehole Well Maintenance	0.666667	0.666667	0.666667	0.666667
A20 – Borehole Well Construction	1.000000	1.000000	1.000000	0.666667
A21 – Drainage Channel Construction	0.666667	1.000000	0.666667	0.666667
A22 – Well Construction	0.666667	1.000000	0.666667	0.333333
A23 – Culvert Construction	0.666667	1.000000	0.666667	1.000000

Table 3 details the outcome of applying the benefit normalization formula to the decision matrix. All criteria values were successfully transformed into a standardized scale between 0.333333 and 1.000000. This procedural step is vital for eliminating unit scale disparities across different criteria. Matrix normalization in the SAW method ensures high computational reliability and procedural clarity. This step guarantees that each infrastructure proposal can be evaluated impartially during the subsequent preference scoring and ranking processes.

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Tie-Breaking Mechanism

When multiple alternatives obtain identical final preference values (V_i), a structured tie-breaking rule is applied systematically:

1. Primary Rank Parameter (Preference Value V_i): Alternatives are primarily ordered according to their accumulated SAW preference score.
2. Secondary Rank Parameter (Highest-Weighted Criterion Performance - C1): In cases of identical preference values, the system compares performance ratings on Criterion C1 (Urgency Level), which holds the highest ROC importance weight ($W_1 = 0.520833$).
3. Tertiary Rank Parameter (Sequential Criterion Priority - C2 to C4): If values on C1 remain identical, sequential evaluation proceeds through C2 (Physical Condition, $W_2 = 0.270833$), C3 (Benefits, $W_3 = 0.145833$), and C4 (Population Size, $W_4 = 0.062500$).
4. Final Administrative Parameter (Proposal Entry Order): If alternatives possess identical performance scores across all four criteria (such as A4 and A18, which both scored 3 across C1–C4), the system assigns priority based on administrative registration order (proposal ID sequence).

Calculation and Ranking Results

The final ranking results for all infrastructure proposals in Asam Jawa Village, based on accumulated preference scores, are presented in Table 4.

Table 4. Calculation Results and Ranking

Code	Proposed Infrastructure Name	Preference Value	Rank
A4	Construction of Borehole Well and Public Toilet at Field	1.000000	1
A18	Sejahtera Street Concrete Cast	1.000000	2
A6	Construction of Borehole Well at Pondok Seng	0.979167	3
A15	Borehole Well Construction	0.979167	4
A20	Borehole Well Construction	0.979167	5
A3	Alley One Concrete Paving	0.958333	6
A10	Tanah Wakaf Road Concrete Cast	0.930556	7
A16	Road Hardening at Pasar 3 A	0.826389	8
A5	Pagaran Pisang Road Hardening	0.805556	9
A13	Dame Road Hardening	0.805556	10
A7	Road Hardening	0.777778	11
A8	Road Hardening	0.777778	12
A23	Culvert Construction	0.777778	13
A9	Concrete Ditch Construction	0.756944	14

Code	Proposed Infrastructure Name	Preference Value	Rank
A21	Drainage Channel Construction	0.756944	15
A22	Well Construction	0.736111	16
A17	Ditch Cleaning	0.687500	17
A1	Ditch Cleaning	0.666667	18
A14	Ditch Cleaning	0.666667	19
A19	Borehole Well Maintenance	0.666667	20
A2	Field Fencing	0.555556	21
A12	Volleyball Court Construction	0.534722	22
A11	Field Maintenance	0.444444	23

Table 4 displays the final preference scores and priority ranks, placing Alternative A4 (Borehole Well & Public Toilet) and A18 (Sejahtera Street Concrete Cast) at the top with a score of 1.000000. These findings emphasize that prioritizing basic sanitation and primary transport links directly accelerates rural economic productivity and welfare. Furthermore, the hybrid ROC-SAW model provides precise, data-driven recommendations that successfully eliminate cognitive bias and prevent social friction in village budget allocations.

The accumulated preference values derived from the Simple Additive Weighting (SAW) method serve as the basis for determining the priority order of infrastructure development allocations in Asam Jawa Village. Proposals with the highest preference values are ranked at the top and prioritized for implementation, while those with lower preference values are ranked lower.

Application Interface

The home screen features several main menus used to operate the system for the development prioritization process.

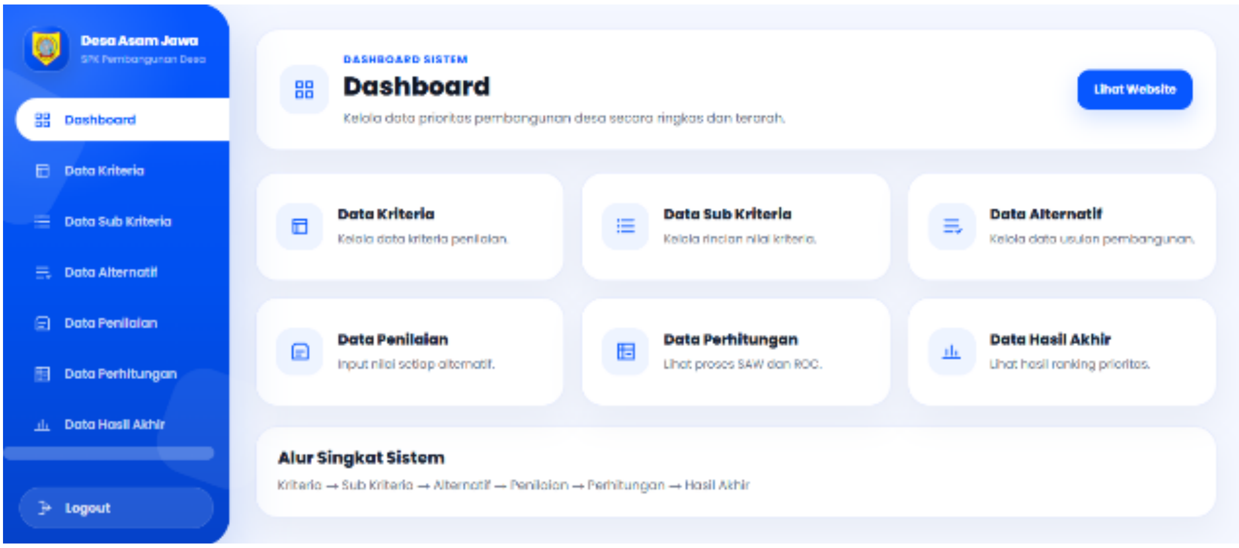

Figure 2. Home Screen

Figure 2 shows the main home dashboard, offering centralized access to system menus, including Criteria, Sub-Criteria, Alternatives, Evaluation, Calculation, and Final Results. This intuitive layout ensures that interactive decision support systems facilitate efficient user navigation and operational workflows. The clear sequence guides village administrators seamlessly through every analytical phase, turning complex mathematical steps into an accessible tool for rural development planning.On the criteria data page, the admin can manage the criteria used for assessment and determine initial weight values using the ROC method.

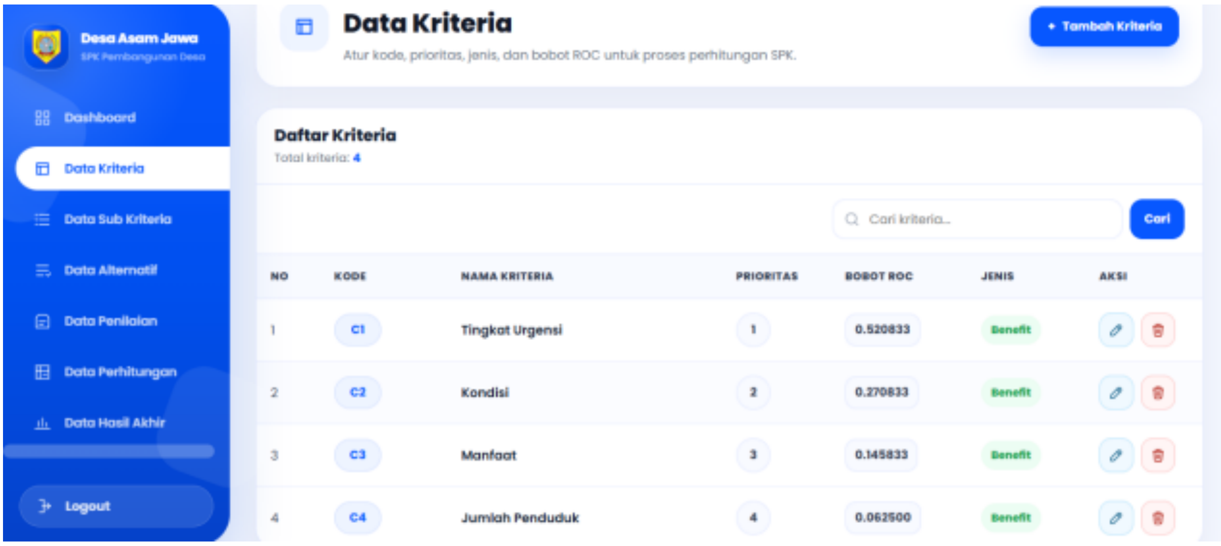

Figure 3. Criteria Page

Figure 3 displays the criteria management page where administrators set criteria priorities and compute ROC weights. The system assigns the highest weight to Urgency (C1 = 0.520833), followed by Physical Condition, Benefits, and Population. This structured setup demonstrates that the ROC method effectively generates objective, proportional weights that accurately reflect the decision-makers' strategic priorities.
On the sub-criteria page, the admin can define parameter values or categories for each criterion to refine the assessment.

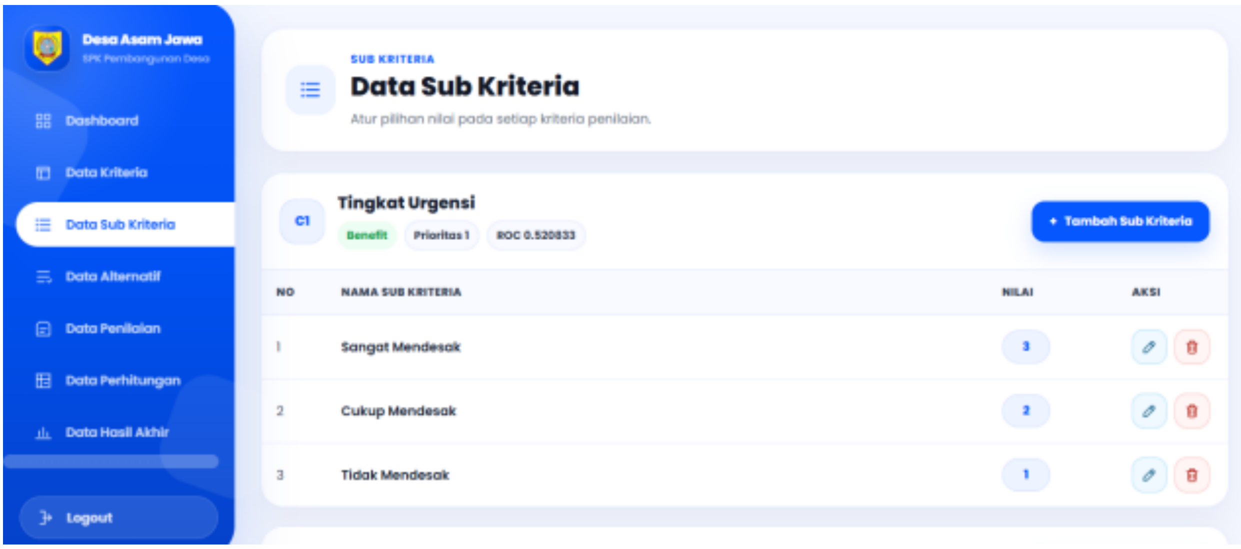

Figure 4. Sub-criteria Page

Figure 4 presents the sub-criteria management page, defining evaluation scales (e.g., Very Urgent = 3, Moderately Urgent = 2, Not Urgent = 1) for criterion C1. Sub-criteria parameters simplify

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scoring by standardizing data entry. This feature prevents vague, unstandardized parameters that often lead to subjective interpretations during project evaluations. Clear scoring scales ensure consistent assessments across all village alternatives.

On the alternatives page, the admin can input data regarding proposed infrastructure projects in Asam Jawa Village to be evaluated.

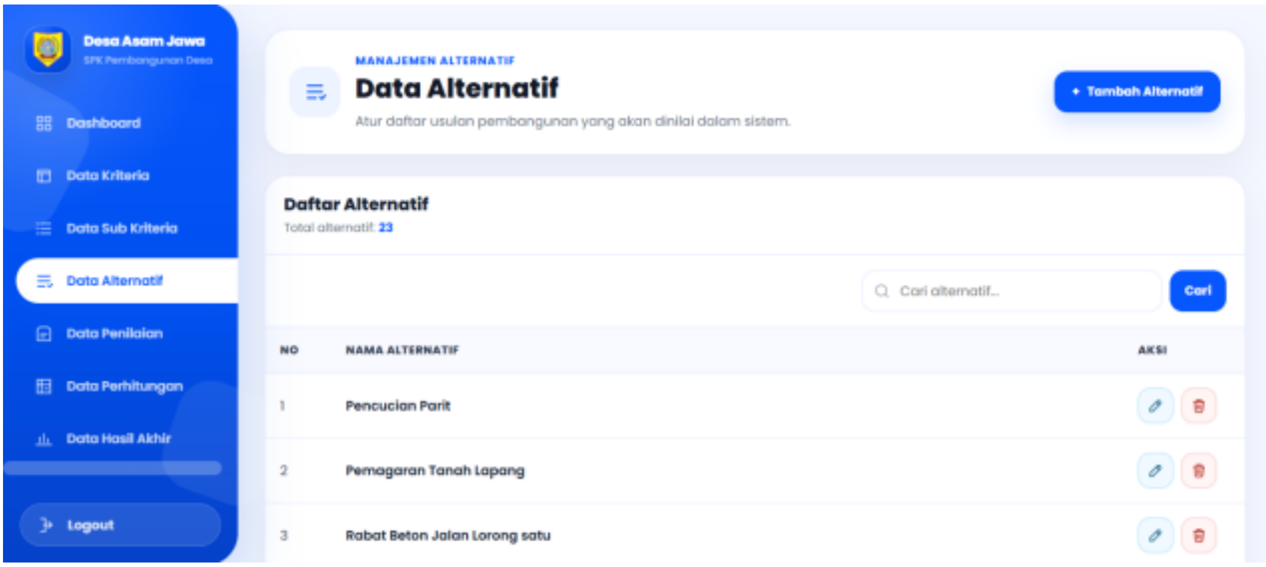

Figure 5. Alternatives Page

Figure 5 illustrates the alternatives management interface, listing all 23 infrastructure proposals gathered from village assemblies. It allows administrators to add, edit, or search proposals efficiently. Providing a centralized database for proposals ensures that participatory planning maintains organized data management to align community needs with actual government execution, avoiding unaligned program allocations.

On the assessment page, the admin can enter values for each alternative based on the previously established criteria.

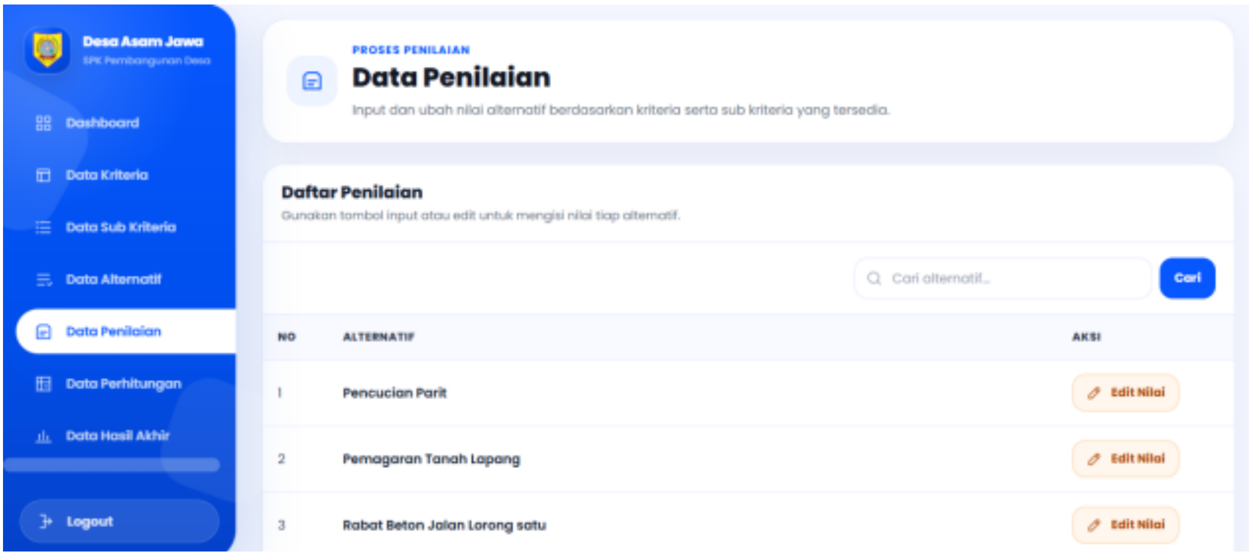

Figure 6. Assessment Page

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Figure 6 shows the evaluation page where administrators input specific ratings for each infrastructure proposal based on defined sub-criteria. This structured data input replaces loose verbal agreements with measurable inputs. Replacing intuitive, subjective reviews with explicit quantitative entries prevents heated debates and misallocations during village decision-making forums.

On the calculation page, the system performs the SAW method calculations, ranging from the construction of the decision matrix to the normalization process.

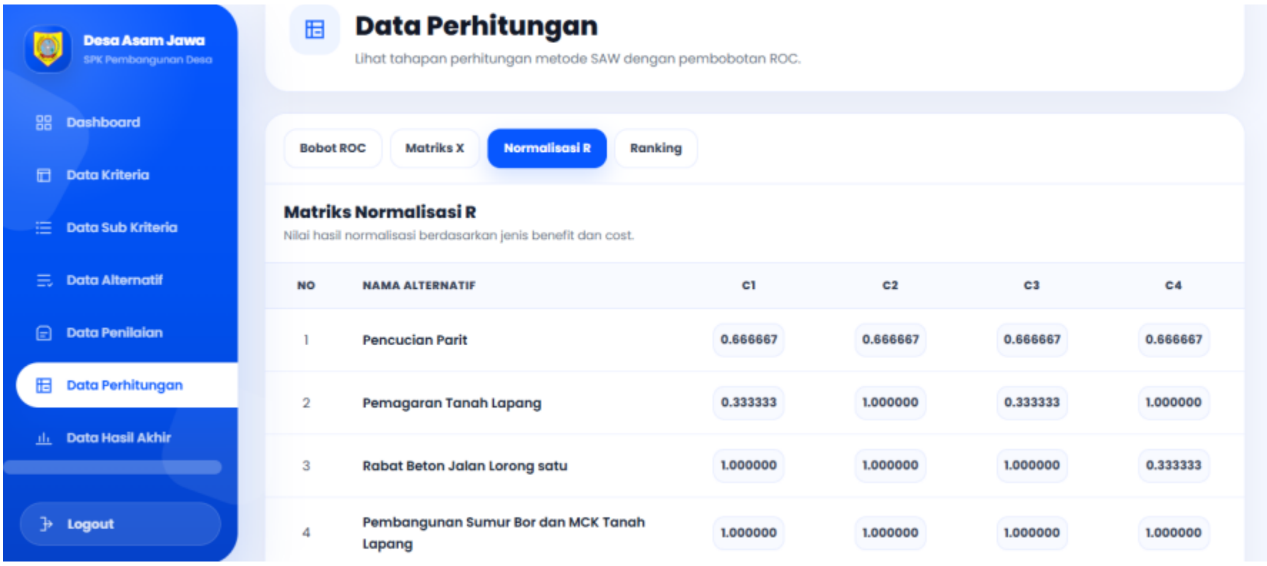

Figure 7. Calculation Page

Figure 7 features the calculation page displaying step-by-step SAW processing, including the normalized matrix (R). Showing explicit intermediate calculations ensures complete algorithmic transparency, as the SAW method offers clear and traceable computational steps. Transparency builds trust among village stakeholders by making every step of the decision readable and verifiable.

On the final results page, the admin can view the development priority ranking based on the highest scores achieved by each alternative.

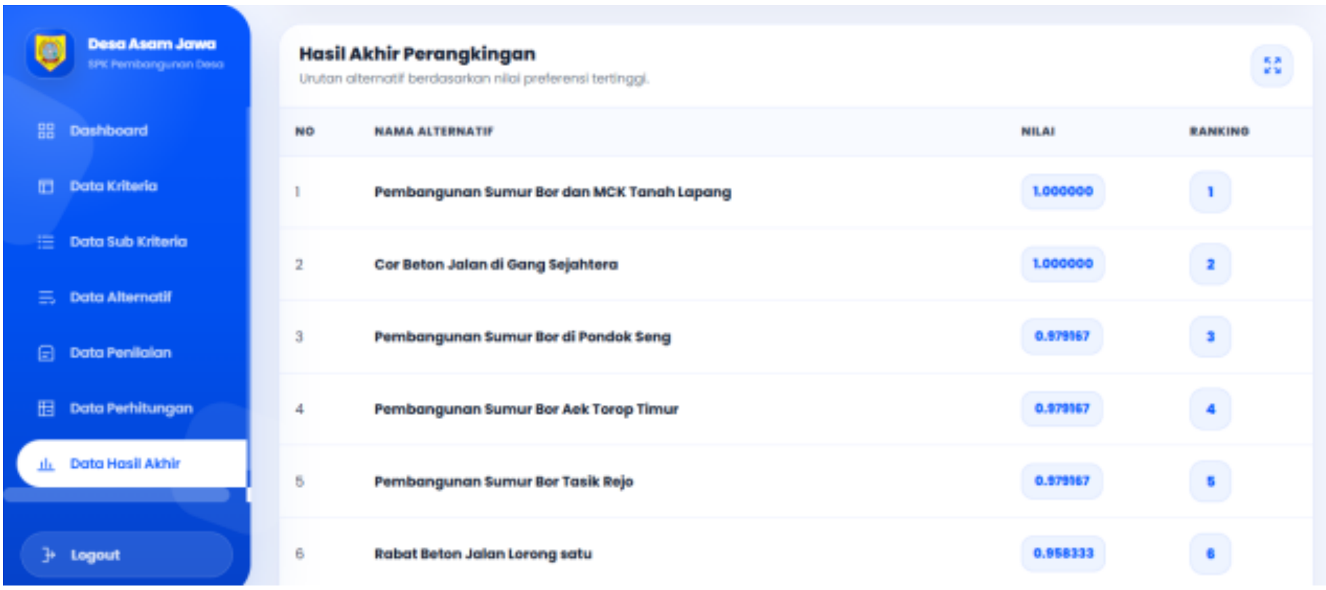

Figure 8. Ranking Page

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Figure 8 presents the final ranking page, displaying alternatives ordered by preference score, with A4 and A18 leading. This automated ranking provides clear guidance for budget allocation. Automated DSS outputs deliver evidence-based recommendations that minimize cognitive bias, streamline governance, and ensure accountable, data-backed village infrastructure investments.

CONCLUSION

The application of a combined Rank Order Centroid (ROC) and Simple Additive Weighting (SAW) method has proven effective and reliable in supporting the decision-making process for prioritizing village infrastructure development. The ROC method successfully established objective and structured weight allocations for criteria based on importance levels agreed upon by decision-makers. Subsequently, the SAW method accurately processed matrix normalization calculations and ranked 23 proposed development alternatives based on final preference values. Integrating these two methods into an information technology-based Decision Support System (DSS) yielded consistent, accurate, and transparent infrastructure rankings. Evaluation results indicated that proposal alternative A4 (Construction of a Borehole Well and Public Sanitation Facility/MCK at the Open Field) achieved the highest preference value, making it the recommended top priority for implementation in Asam Jawa Village. Implementing this system proved effective in minimizing the risks of cognitive bias and budget misallocation, while also mitigating potential social conflict during village deliberation meetings. This DSS assists the village government in achieving accountable, measurable, and data-driven development planning governance. The study was limited to using primary criteria based on urgency, physical condition, benefits, and population size. Therefore, future research is advised to expand the scope of criteria variables—such as detailed cost estimates and environmental impacts—and to test the performance of other multi-criteria method combinations to continuously enhance the precision of recommendations.

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