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Decision Support System for Prioritizing Road Repairs with Simple Additive Weighting Method

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ABSTRACT

The Decision Support System (DSS) is a technology utilized to address the issue of determining road improvement priorities. In this context, DSS will be used to integrate various road assessment criteria and provide recommendations for repair priorities based on proven methods. The aim of this study is to design a decision support system for prioritizing road repairs in Lamongan Regency and to implement this system effectively. The Simple Additive Weighting (SAW) method was chosen for its ability to handle multiple criteria and provide measurable evaluations of alternative solutions. The criteria used in this research include road condition, traffic volume, and socio-economic impact. The results of this system demonstrate a prioritization order for road repairs that can assist in more efficient decision-making, focusing on the most urgent needs. This research is expected to contribute to improving the efficiency of road infrastructure management and to aid authorities in the planning and execution of road repairs.

Keywords— *Decision Support System; Road Repair Priority; Simple Additive Weighting.*

I. INTRODUCTION

Lamongan is one of the regions in East Java that is experiencing rapid development in various aspects, including infrastructure. Infrastructure development, particularly roads, is crucial for supporting the mobility and economic activities of the community (Kristiano & Suryana, 2019). Good road conditions are a key factor in enhancing productivity and transportation efficiency in this area (Bachtariza et al., 2021). However, with the increasing number of vehicles and the frequency of road use, many roads in Lamongan Regency have suffered damage, necessitating immediate attention and repair (Dewi, 2020). The damage to roads at various points in Lamongan Regency negatively impacts transportation flow and daily activities of the community. This damage not only hinders mobility but also affects the distribution of goods and services, ultimately obstructing regional economic growth (Noviyanti & Putra, 2023). In light of this, the research focuses on determining the priority for road repairs in Lamongan Regency using a systematic, data-driven approach to make the repairs more effective and efficient (Dewi, 2020).

A major issue faced in road repairs in Lamongan is the limitation of budget. The available funding for road repairs is insufficient to address all existing damage, necessitating a system to help prioritize repairs (Mardika et al., 2021). Conventional prioritization processes are often subjective and lack transparency, leading to crucial roads needing attention being overlooked (Fauzah & Iqbal, 2021). Without a supportive system, prioritization often relies on visual observations or community reports, which may not be entirely accurate. This results in inefficient and suboptimal budget utilization. Therefore, there is a need for recommendations regarding an objective road repair prioritization system based on valid data (Lubis et al., 2022). The Decision Support System (DSS) is a technology employed to address the issue of road prioritization (Muhammad et al., 2017). In this context, DSS will be used to integrate various road assessment criteria and provide repair priority recommendations based on proven methods (Komarudin et al., 2021). The system can utilize effective methods such as the Simple Additive Weighting (SAW) method, which allows for weighting each criterion, such as road damage levels, traffic volume, and strategic importance of the roads. The final score for each road alternative will then be calculated (Dewi, 2020).

The system will gather data on road conditions, traffic volume, and other relevant factors for analysis (Bernanda et al., 2023). With this system, it is expected that the prioritization process for road repairs can be conducted more transparently, objectively, and accurately, optimizing budget allocation (Lubis et al., 2022). The solutions offered by this research focus not only on implementing technology but also on developing a proper analytical model. With the SAW-based DSS, local government is anticipated to make better decisions in determining repair priorities, ensuring that the most urgent road damage is addressed promptly. Additionally, this system is expected to enhance accountability and transparency in managing road repair budgets, which will ultimately positively impact the quality of road infrastructure in Lamongan Regency (Dewi, 2020). Based on the discussion above, the author has chosen the title “Decision Support System for Prioritizing Road Improvements Using the SAW Method.” The objective of this research is to design and implement a decision support system for prioritizing road repairs in Lamongan Regency.

II. RESEARCH METHODS

This study requires materials to design and develop a system or application that can provide predictions and recommendations for road repairs. In the research conducted, the author uses two types of tools software and hardware. Below is Figure 1, which illustrates the research procedures undertaken:

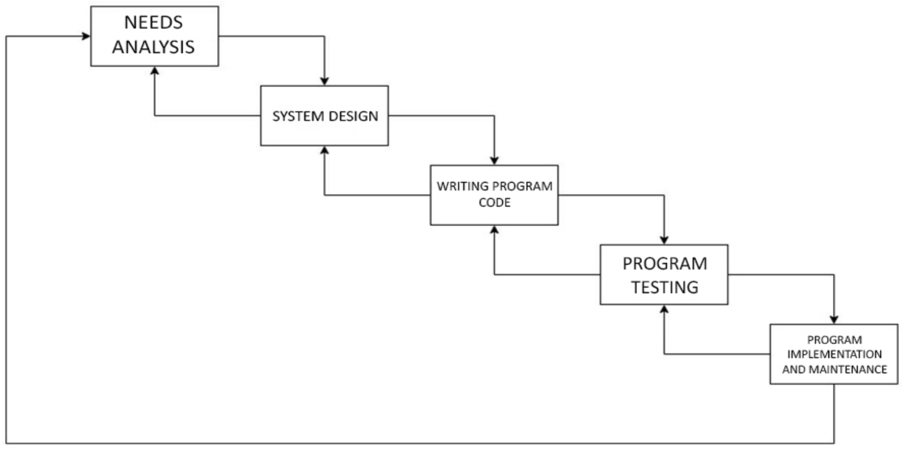

Figure 1. Research Procedures Source: (Hermansyah et al., 2022)

In this research, data collection was obtained through observation and literature review. The results from these activities were utilized to design a database, which is represented in the form of diagrams. This design can use an Entity Relationship Diagram (ERD) model. The next step involves the creation of Unified Modeling Language (UML) diagrams, which reflect the processes involved when using the system (Aprillya & Chasanah, 2022).

The system design required is one that predicts the condition of road damage based on the current state of the roads. The input data includes the percentage of asphalt and concrete roads, vehicle density, soil type, and drainage conditions. This data will then be compared with training data, also known as training datasets. The necessary data includes information on road damage, traffic volume, weather conditions, and the age of the road. Data on road damage is obtained from the Public Works Department of Lamongan Regency, while traffic volume data is collected from traffic monitoring posts. After data collection, validation and normalization are conducted to ensure the data is accurate and consistent.

The next step is the development of the system using the Simple Additive Weighting (SAW) method. This SAW model is used to calculate the priority scores for road repairs based on several criteria, such as the level of damage, traffic volume, and weather conditions. The development process includes designing a database to store the processed data, implementing the SAW algorithm in the software, and developing a user-friendly interface. The system is then tested through functional testing to ensure all features work correctly, validation of prediction results with actual data, and performance testing to ensure the system operates efficiently.

The final stage involves implementation and user training. The system is installed and configured in the working environment of the Public Works Department of Lamongan Regency. Staff who will use the system are trained on how to input data, utilize prediction features, and interpret the results. Comprehensive documentation about the system is also prepared to assist users and developers in the future. After the system is implemented, regular monitoring is conducted, and technical support is provided in case of issues or necessary updates. The testing of the decision support system for prioritizing road repairs in Lamongan Regency begins with functional testing. This testing aims to ensure that all features and functions of the system operate according to the established specifications. The steps in functional testing include checking data input, processing calculations using the Simple Additive Weighting (SAW) method, and verifying the prediction output. Each module within the system is tested to ensure there are no errors and that the system can operate effectively as a whole.

Next is the validation testing phase. In this stage, the predictions generated by the system are compared with actual road damage data to assess the accuracy of the SAW model. Actual road damage data serves as a benchmark to evaluate how accurately the system predicts repair priorities. This testing is conducted using historical data not included in the training dataset to ensure that the model can make accurate predictions on new data. If discrepancies are found, model parameters are adjusted to improve prediction accuracy.

The final stage involves performance testing and field trials. Performance testing is conducted to ensure that the system can handle large data loads and remain responsive under various operational conditions. The system is evaluated for response time and its ability to process large amounts of data without a decline in performance. Following the performance testing, field trials are conducted involving stakeholders such as the Public Works Department and road users. Feedback from real users is gathered to assess the system's usability and effectiveness. Based on the results of the field trials, improvements and refinements are made to ensure the system functions optimally before full implementation.

III. RESULT AND DISCUSSION

A. System Design Analysis

System design analysis begins by identifying user requirements and formulating the desired system specifications. User needs include the ability to input road damage data, traffic volume, and weather conditions, as well as the ability to view prediction results and repair priorities. Based on these needs, both functional and non-functional specifications are created. The functional specifications cover key features such as data input, SAW (Simple Additive Weighting) calculation process, and prediction output. Non-functional specifications cover aspects like system performance, security, and ease of use.

The analysis also includes evaluating the data to be used. Historical data on road damage, traffic volume, and weather conditions are analyzed to ensure their completeness and accuracy. The SAW method is chosen as the primary algorithm to process this data and generate repair priorities. This algorithm is evaluated based on its ability to handle multiple criteria and provide accurate and reliable results.

B. Proposed System Diagram Design

The design of the proposed system diagram begins with the creation of a flowchart that illustrates the entire process from data collection to the presentation of prediction results. The flowchart shows the main steps such as inputting road damage data, traffic volume, and weather conditions, as well as the calculation process using the SAW method.

Next, a context diagram is created to illustrate the interaction between the system and the users. This context diagram shows that users (e.g., Public Works Department staff) can input data and receive system output in the form of prediction reports and road repair priorities. A Data Flow Diagram (DFD) is also created to depict the flow of data within the system in more detail. DFD level 0 provides an overview of how data flows from the user to the system and back to the user after processing. DFD levels 1 and 2 offer more detailed insights into internal processes, such as data validation, data normalization, SAW calculations, and the presentation of results.

Finally, an Entity-Relationship (ER) diagram is designed for the database to be used in the system. This ER diagram represents the main entities, such as road damage data, traffic volume data, and weather condition data, as well as the relationships between these entities. The database is designed to store data efficiently and support quick and accurate processing and presentation of prediction results.

The database design serves as a medium to store the data that the system will use, as illustrated in the following figure.

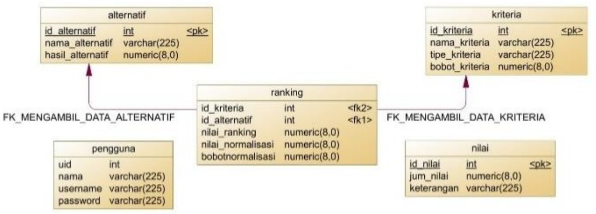

Figure 2. Database Design

The activity diagram is used to depict the flow of activities within the system. Below is the activity diagram for the Decision Support System (DSS) application to determine road repair priorities using the SAW (Simple Additive Weighting) method.

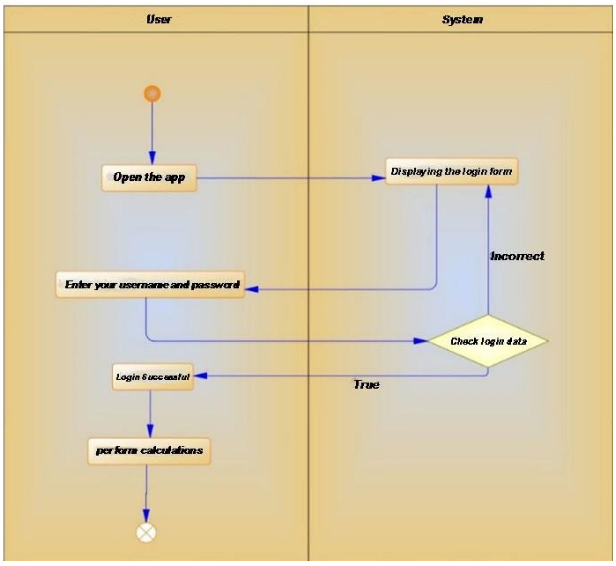

Figure 3. Activity Diagram

In Figure 3, the login process is depicted, where users must enter their username and password to access the application further.

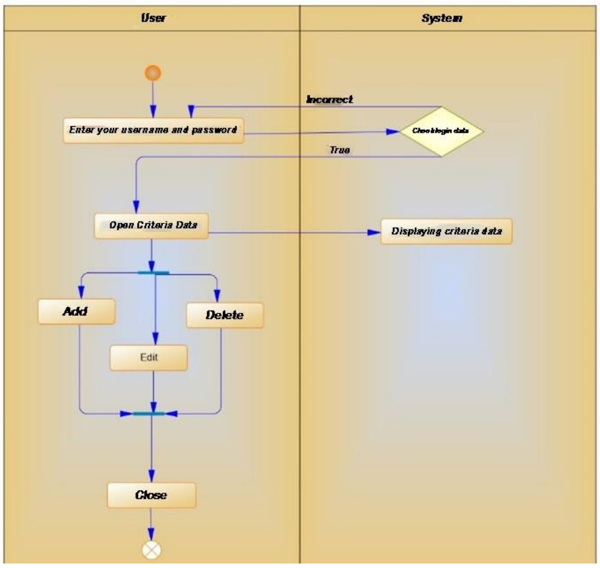

Figure 4. Activity Diagram Preference Value

Figure 4 illustrates the activities that occur when accessing the preference value menu. Through this interface, users can delete, modify, or add data.

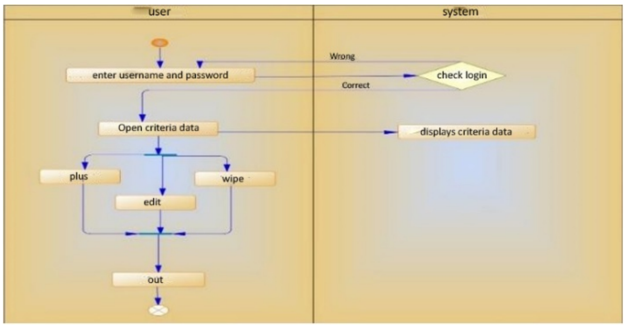

Figure 5. Activity Criteria Diagram

Figure 5 displays the criteria data menu. In this interface, users can manage criteria data, including deleting, modifying, and adding new data.

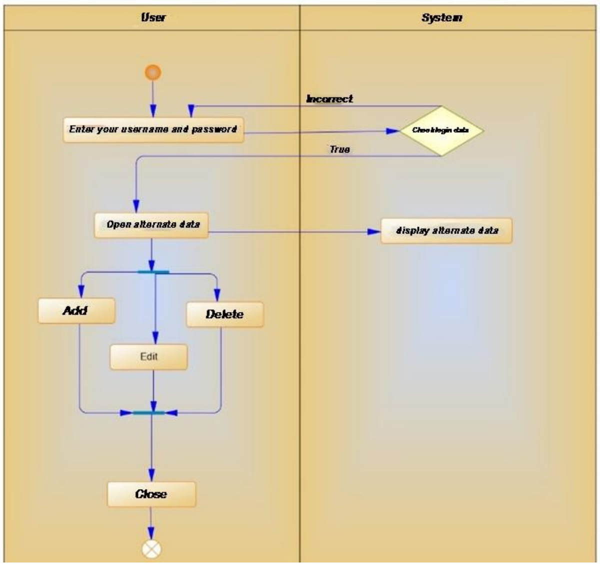

Figure 6. Activity Diagram Alternatives

Figure 6 illustrates the activities that occur when the user interacts with the system. In this interface, users can manage alternative data, including deleting, modifying, and adding data.

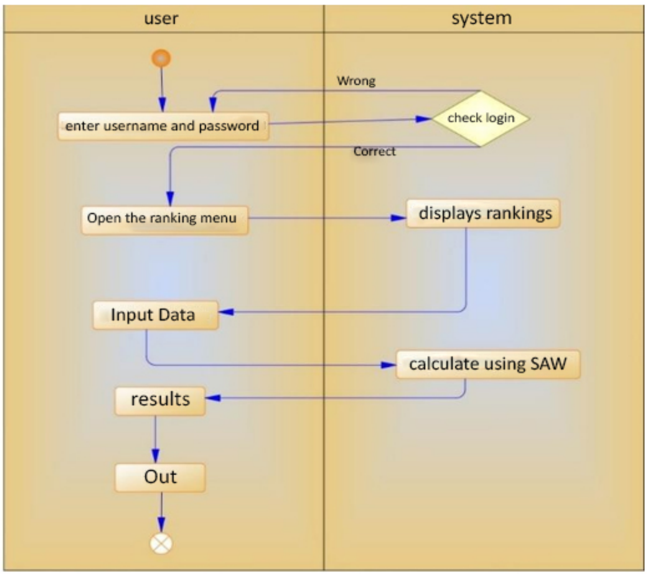

Figure 7. Activity Diagram Ranking

The activity shows the system performing a ranking process aimed at selecting the most damaged road segment among all the road data entered by the user. Before the system performs the calculation, the user must first input all the criteria data for each road segment to be evaluated. In the class diagram, objects, attributes, and classes are described, with relationships involving association, containment, and inheritance. The following figure presents the class diagram for this research, which includes:

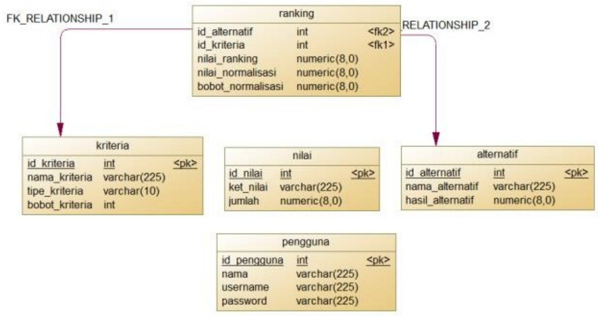

Figure 8. Class Diagram

A. System Interface

The following is an image depicting the login page:

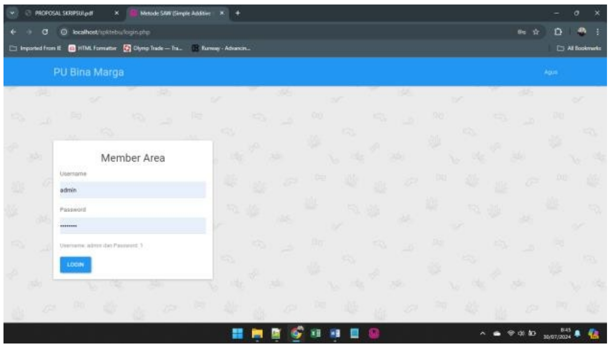

Figure 9. Login Page

The login page is the first screen that appears when the user accesses the system. This page will redirect the user to the main page if the username and password are correct. If the credentials are incorrect, an error message will appear on the login page.

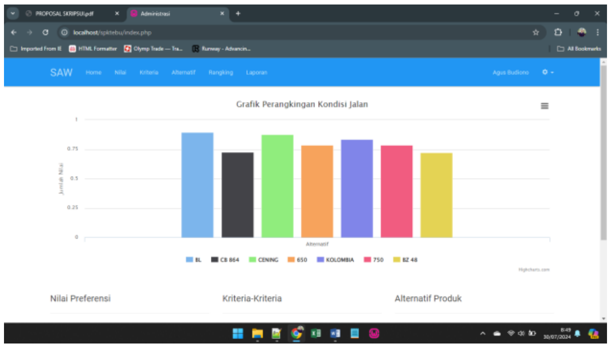

Figure 10. Preference Value Page

On the preference value page, several data elements are presented for managing preference values. Users can also manage these values by deleting, modifying, or adding data

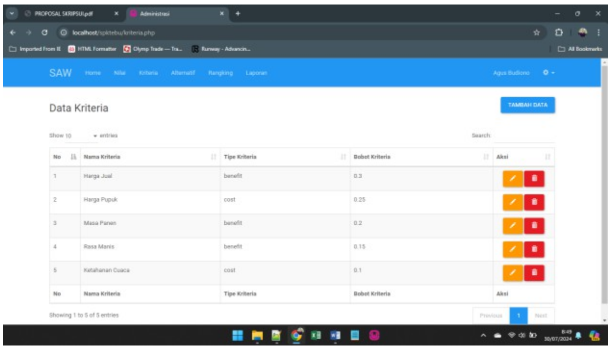

Figure 11. Criteria Page

On the criteria management page, users can manage various criteria data, such as deleting, modifying, or adding data.

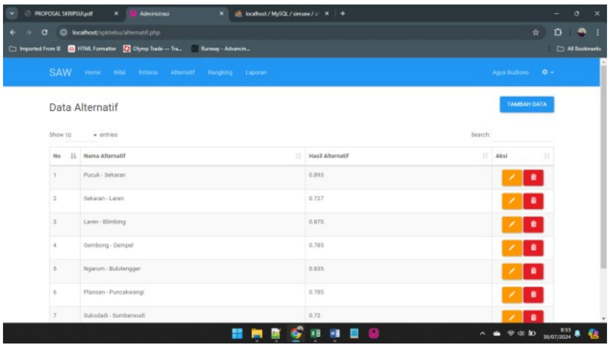

Figure 12. Alternatives Page

On the alternatives page, users can manage data related to different alternatives, such as deleting, modifying, or adding data. The alternative data refers to the road segments that will be compared and ranked.

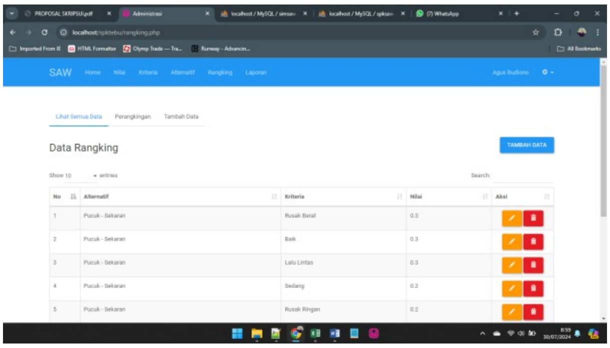

Figure 13. Ranking Page

The ranking page implementation allows for inputting alternatives along with the evaluation criteria and the weight values for each attribute. For example, an input model for this page could be an alternative road segment with a selling price criterion having a value of 30. The data will then be processed using the SAW (Simple Additive Weighting) method to obtain the ranking.

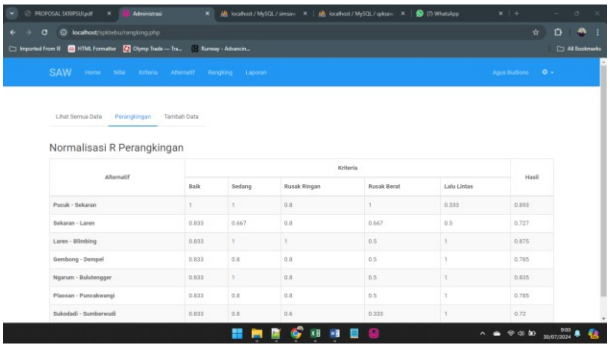

Figure 14. Calculation Page

The calculation page is implemented to display the results of normalization calculations to determine the best alternative based on the criteria and weights entered previously. This page features a normalization table containing data for all road segment alternatives, including criteria values and the final results using the SAW (Simple Additive Weighting) method.

B. System Functional Testing

In this research, black-box testing was used. This testing involved running the program according to requirements to determine whether it met the expected criteria or required revisions. The results of the black-box testing are as follows:

Table 1. Black-Box Test Results

No.	Level	Trials	Information	
			Appropriate	Not
1	User	*Login*	√	
		Displays the User Main Menu Page	√	
2	Preference Value	Displays the Preference Values Page	√	
		Displays Preference Value Data	√	
		Adding Preference Values	√	
		Editing Preference Values	√	
		Deleting Preference Values	√	
4	Criteria	Displays the Criteria Page	√	
		Display Criteria Data	√	
		Adding Criteria	√	
		Editing Criteria	√	
		Removing Criteria	√	
5	Alternative	Displaying Alternative Pages	√	
		Displaying Alternative Data	√	
		Adding Alternatives	√	
		Editing Alternatives	√	
		Removing Alternatives	√	
6	Rangking	Adding Ranking Data	√	
		Doing Ranking	√	
		Knowing the Ranking Results	√	
		Changing Ranking Data	√	
		Deleting Ranking Data	√	
7	*Logout*	Admin Logout Successfully	√	

Based on the testing in the table above, it is evident that the tests conducted on the menus within the developed application have met the researcher's expectations, and no errors were found.

C. SAW Method Calculation

The Decision Support System for Road Repair Prioritization using the SAW (Simple Additive Weighting) method is used to recommend road repairs for specific road segments that are considered as alternatives for priority testing. To perform calculations using the SAW method, criteria, weightings, and criterion types are required, as explained in the following table.

Table 2. Criteria Table

No	Criterion Name	Criteria Type	Criteria Weight
1	Good	cost	0.2
2	Light Damage	benefit	0.2
3	Moderately Damaged	benefit	0.2
4	Heavy Damaged	benefit	0.2
5	Traffic	cost	0.2

Based on the table above, it is the Alternative holds the data for each alternative road segment against all previously defined criteria. It also serves as a step for performing Normalization R, where it is checked whether the criteria fall under the benefit or cost category. The Normalization R phase can be described as follows:

$$r_{ij} = \begin{cases} \dfrac{x_{ij}}{Max_i\, x_{ij}} \\[2ex] \dfrac{Min_i\, x_{ij}}{x_{ij}} \end{cases}$$

Criteria Values Table. This table If j is a benefit attribute (benefit) If j is a cost attribute (cost). For the criterion "Good," where the unit of input is kilometers, and given the data (10, 30, 4, 5), the smallest value is 4. Therefore:

Table 3. Example of Normalization Calculation for Good Criteria

Road Section	Calculation	Results
Section A	4 / 10	0,4
Section B	4 / 30	0,133333333
Section C	4 / 4	1
Section D	4 / 5	0,8

Conversely, for criteria that fall under the benefit category, each element of the matrix is divided by the maximum value in the row of the matrix. This results in the Normalization R data, which is then used for ranking.

Table 4. R Normalization Table

Alternative	Criteria				
	Good (km)	Light Damage (km)	Moderately Damaged (km)	Heavy Damaged (km)	Traffic
Section A	0,4	0,4	0	0	0,909090909
Section B	0,133333333	1	0,2	0	0,909090909
Section C	1	0,8	0,6	1	1
Section D	0,8	1	1	0	0,877192982
Weight	0,2	0,2	0,2	0,2	0,2

The table above shows the results of all the Normalization R calculations performed previously. The last row of this table includes the weights for each criterion, referring to the criterion weights that were previously defined. These weights are used for ranking calculations and the subsequent ranking step. The final step is to perform summation by multiplying the criterion weights with each row of the normalized value matrix. For example, for the alternative Road Segment A, the calculation is as follows: (0,4 x 0,2) + (0,133333333 x 0,2) + (1 x 0,2) + (0,8 x 0,2) + (0,2 x 0,2) = 0,341818182 Thus, from all the calculations for the available alternatives and their corresponding criterion values, the ranking data is obtained.

Table 5. Final Score Table

Alternative	Criteria					Results
	Good (km)	Light Damage (km)	Moderately Damaged (km)	Heavy Damaged (km)	Traffic	
Section A	0,4	0,4	0	0	0,909090909	0,341818182
Section B	0,133333333	1	0,2	0	0,909090909	0,448484848
Section C	1	0,8	0,6	1	1	0,88
Section D	0,8	1	1	0	0,877192982	0,735438596

The table above represents the final step, where it contains the sum of the results from multiplying the Normalization R data by the criterion weights, resulting in the final values used for ranking. From these calculations, it can be determined that the most recommended road segment is Road Segment C with a total value of 0.88, followed by Road Segment D with 0.73, and so on.

IV. CONCLUSION

The conclusion of this research is that the system aims to provide an objective and data-driven solution for determining road repair priorities, ensuring that decisions are not solely based on subjective assessments. By using the SAW (Simple Additive Weighting) method, the system systematically considers various relevant criteria, making the evaluation and decision-making process more efficient and structured. This technology simplifies decision- making by providing tools that automatically compute and analyze data based on multiple criteria, reducing the time and effort required for the assessment process. The systematic use of the SAW method minimizes the likelihood of human errors often encountered in manual evaluations, resulting in more accurate and reliable outcomes. Recommendations for future researchers include further development of the application by adding additional features. It is also suggested that the Public Works Department of Lamongan Regency consider incorporating additional reference criteria that the author may not have fully addressed. Additionally, expanding the application to include more road segments is advised.

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