Priority Recommendations for Residential Road Improvement Using the SMART Analysis Method

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***Abstract*— Roads are infrastructure for organizing transportation, which are places for traffic to flow both for people and goods to reach destinations safely, securely, comfortably, quickly, smoothly, orderly, and efficiently, especially roads in residential areas. Setting priorities for the road improvement program is the responsibility of the Public Housing, Settlement Areas, and Land Affairs Office, which handles technical planning, development, arrangement, supervision, and control of development in residential areas. Recommendations for road proposals for the currently running improvement program, based on an assessment of their physical condition, are carried out by experts. This prioritization certainly takes a long time because experts have to compare the physical conditions of the roads one by one to make a decision. A decision support system is specifically designed for the decision-making process that can be applied in various aspects of the decision-making field. Recommendations for alternative roads in the road improvement program were analyzed using the SMART method to find alternatives with the highest preference value and the advantage that they can be used for all weighting techniques. Accuracy testing shows that the priority recommendation output presented by the application has an accuracy rate of 80%. This value is obtained by comparing the results of recommendations from experts.**
Keywords*— *Priorities, SMART, Decision Support Systems, Road.

***Abstrak*— Jalan menjadi prasarana untuk penyelenggaraan transportasi, yang menjadi tempat arus lalu lintas baik angkutan orang maupun barang untuk mencapai tujuan dengan selamat, aman, nyaman, cepat, lancar, tertib dan teratur secara efisien, terutama jalan pada lingkungan permukiman penduduk. Penentuan prioritas pada program peningkatan jalan menjadi tanggung jawab Dinas Perumahan Rakyat, Kawasan Permukiman dan Pertanahan, yang bertugas menangani perencanaan teknis, pembangunan, penataan, pengawasan, dan pengendalian pembangunan di kawasan permukiman. Rekomendasi usulan jalan untuk program perbaikan yang sedang berjalan saat ini, dengan menyeleksi jalan berdasarkan penilaian kondisi fisiknya, dilakukan oleh ahli, penentuan prioritas ini tentunya membutuhkan waktu yang lama, karena ahli harus membandingkan satu persatu kondisi fisik jalan, guna menentukan keputusannya. Sistem pendukung keputusan merupakan suatu sistem yang dirancang khususnya untuk proses pengambilan keputusan yang dapat diterapkan diberbagai aspek bidang pengambilan keputusan. Rekomendasi alternatif jalan pada program peningkatan jalan dianalisis menggunakan metode SMART, untuk mencari alternatif yang memiliki nilai prefensi tertinggi dan memiliki kelebihan yaitu dapat digunakan untuk semua jenis teknik pemberian bobot. Pengujian akurasi menunjukkan bahwa output rekomendasi prioritas yang disajikan aplikasi memliki tingkat akurasi 80%, nilai ini diperoleh dengan membandingkan hasil rekomendasi yang bersumber dari ahli.**
Kata Kunci*— *Prioritas, SMART, Sistem Pendukung Keputusan, Jalan.

I. INTRODUCTION

The public facility is the most widely used transportation infrastructure by the community for carrying out their daily mobility, so the volume of vehicles passing through a road will affect its capacity and carrying capacity. The strength and durability of road pavement construction are largely determined by the load that the road receives, the characteristics of the bearing capacity of the subgrade, and the quality of the pavement's raw materials [1]. The good transportation operations, roads must serve the flow of traffic for people and goods to reach destinations safely, securely, comfortably, quickly, smoothly, orderly, and efficiently, especially roads in residential areas. The function of the road network is differentiated based on the nature and movement of traffic and road transport, which is divided into arterial, collector, local and environmental.

Setting priorities for the road improvement program is the responsibility of the Public Housing, Settlement Areas, and Land Affairs Office, which handles technical planning, construction, arrangement, supervision, and control of development in residential areas. Technical planning for development in residential areas for priority determination of roads to be repaired/constructed, through direct observation in the field by experts, by assessing the feasibility of the road development plan by considering several factors/criteria that determine the selection of the location of the recommended road to be the priority for proposed improvements road. The criteria for determining priority for road repairs in residential areas include; road damage level, population, public facilities, road length, and road age [2][3]. Recommendations for road proposals for the currently running improvement program, by selecting roads based on an assessment of their physical condition, are carried out by experts. This prioritization certainly takes a long time because experts have to compare the

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physical conditions of the roads individually to make a decision.

Decision Support System (DSS) application technology can be used to assist in recommending priority alternatives for determining roads to be repaired. A decision support system is specifically designed for the decision-making process that can be applied in various aspects of the decision-making field [4]. DSS is a computer-based interactive system that presents and processes information [5], which enables decision-making to be more productive, dynamic, and innovative [6]. The decision support system can be used to determine the right priority for road improvement which is analyzed using the VIKOR method [7], DSS for determining road repair priorities is a process for generating alternative decisions that have been obtained from processing decision-making models using the AHP-SAW-TOPSIS method [2]. Alternative recommendations use the Simple Multi-Attribute Rating Technique (SMART) method by looking for alternatives that have the highest preference value [8], so that the recommendations obtained are accurate based on the specified criterion values [9]. The advantage of this method is that it is simple and can be used for all types of weighting techniques [10], so it can help make decisions in application areas in environmental, construction, logistics transportation, military, manufacturing, and assembly issues [11]. One of the roles of a decision support system is that it can assist decision-makers in obtaining alternatives that are by the objectives of multi-criteria decision-making [12], where each alternative has criteria and has value and weight to facilitate decision-making with special cases [13]. Determination of building material suppliers uses the SMART method as an analytical model that presents information on the feasibility of the selected supplier as an alternative solution [14]. DSS is a decision-making tool for imposing a lockdown during the Covid-19 pandemic [15]. Its application is also used to determine a government program and feasibility analysis using the AHP method [16].

II. LITERATURE REVIEW

A. Road Function

According to their designation based on Law No. 38 of 2004 concerning Roads, roads consist of public and special roads. Public roads are further grouped according to system, function, status, and road class [17]. Environmental road network management programs include road maintenance and improvement programs and new road construction programs [18]. Road handling consists of routine maintenance, periodic maintenance, rehabilitation, and reconstruction.

1. Routine maintenance includes road shoulder maintenance; filling surface gaps/cracks; asphalt paving; and hole patching.
2. Periodic maintenance activities include road shoulder repairs; filling surface gaps/cracks; hole patching; wave repair; non-structural resurfacing; and thin asphalt coating.
3. Rehabilitation activities include road shoulder repair, asphalt paving, and structural resurfacing.

B. Decision Support System

DSS allows decision makers to produce decisions in a faster time-saving analysis time [15], due to system support that can process large amounts of data [19] quickly and can produce decisions that are by the objectives [20].

C. Stages Analysis Use the SMART method

The Simple Multi-Attribute Rating Technique (SMART) method was developed for decision-making with many criteria and theoretical basis alternatives and had a weight [21]. The basis of the theory can be seen in how important the value of the weight is compared to other criteria [22]. The stages of analysis using this method are described as follows [11][23]:

1. Determine the criteria, determine the criteria used to solve problems or cases, with discussions with experts, to obtain information on the criteria used in the decision-making system.
2. Determine the weight of the criteria by giving weight to each criterion using a certain rating scale, taking into account the importance of each criterion.
3. Normalization weight of the criteria normalization is done by changing the value of the numeric column in the data set to use a common scale without distorting the differences in the range of values or losing information. Normalization is also required for some algorithms to model the data properly. The following equation is used to normalize weights [14]:

$$w_i' = \frac{W_i}{\sum_{j=1}^{n} w_j} \quad (1)$$

Description :
W_i': weight of normalized criteria for criterion i
W_i: weight criteria i-th
W_j: weight criteria jth _
j : 1,2,3, ... , n amount criteria

4. Provide parameter values for each criterion, assigning criteria values for each alternative using quantitative data (numbers) or qualitative data. If the criterion value is used in qualitative form, we need to convert it into quantitative data by making value parameters use a certain scale.
5. Determining the value of utility is done by assigning an importance value based on the usefulness of the criteria, which depends on the nature of the value.
   (a) Cost criteria have a value in a currency, such as costs to be incurred (e.g., price criteria). This type of criterion is calculated using the following equation [24]:

$$u_i(a_i) = \frac{C_{max} - C_{out}}{C_{max} - C_{min}} \quad (2)$$

Description :
$u_i(a_i)$: utility criterion value i for the alternative -i
c_{max}: maximum criterion value
c_{min}: minimum criterion value

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c_{out}: output criterion value

(b) Criteria for benefits (benefit criteria) are criteria that can be an advantage (e.g., criteria for size or quality and others) and are calculated by equation (2).

6. Calculating the final value, analyzing alternative values based on each criterion using the following equation [21]:

$$u_i(a_i) = \sum_{j=1}^{n} w_j * u_j(a_i) \quad (3)$$

Description :
$u_i(a_i)$: total value for alternative i
w_j: mark weight criteria to -j already normalized
$u_j(a_i)$: utility criterion value to -j for alternative i-

7. The alternative ranking is the sorting of alternative solutions, which are the analysis results from the largest to the smallest value. The alternative with the highest final value shows the best alternative.

III. RESEARCH METHODS

The development of a decision support system aims to recommend priority alternative roads to be repaired in residential areas, and the application presents alternative roads with priority values indicated by ranking. The results of the recommendations presented can be used by the local government, more specifically for the Public Housing, Settlement Areas, and Land Affairs Office of Merauke Regency. The stages of research activities for developing the application are shown in the research flowchart.

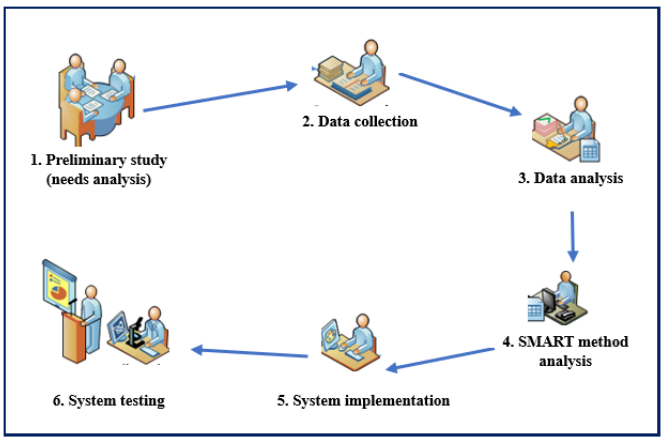

Fig. 1. Stages of research activities

The stages of analysis using the SMART method in a decision support system to recommend alternative roads as priority road improvement programs are shown in Figure 1, with the stages of activities described as follows:

1. Needs Analysis is an activity carried out to find information about system requirements (input/output) and analysis of user needs so that the resulting information can meet the needs of system users. The results of this activity are the data needed by system management and information needs for users.
2. Data collection is an activity to obtain information needed to achieve research objectives. The data related to the research are; road data, road improvement criteria data, and road physical condition assessment data through field survey activities. The data used is a sample of ten damaged road data in the Merauke District which is the result of an environmental road survey by the Public Housing, Settlement Areas and Land Affairs Office.
3. Data analysis is the stage for modeling the problem by determining the priority of the road improvement program, such as determining the weight for each criterion and calculating the criteria to determine the recommended alternative solutions. This activity was done through joint discussions with government authorities, namely the Public Housing, Settlement Areas, and Land Affairs Office employees.
4. SMART method analysis is an analysis of the results of assessing the physical condition of the road with the stages of the SMART algorithm to find information on alternative solutions as a result of recommendations presented to decision-makers through the application. At this stage, it will rank all alternative street name solutions recommended as priority road improvement programs.
5. System implementation is the stage of implementing analysis into a decision support system to determine whether the results/output presented by the system are by the information needs of decision-makers.
6. System testing is an activity to measure the truth of alternative solutions the system recommends, compared to alternative recommendations from experts. This activity will produce an accuracy value for the accuracy of the recommendation output.

IV. RESULT AND DISCUSSION

A. *Modeling of Road Improvement Priority Recommendation System*

The flow of data and information from users of decision support systems to recommend roads, which are priority road improvement programs, is shown in the flowchart in Figure 2. User involvement is explained as follows:

1. Admin has access to add system user data, add and update criteria/sub-criteria data, add and update road data, add and update road condition assessments sourced from field survey results, obtain information on the results of the SMART method analysis in the form of alternative rankings recommended roads for the road improvement program.
2. Tim Survei has access to add road condition assessment data from the survey results that have been conducted and can obtain information related to the list of road data.
3. Pimpinan, have access to obtain information on the list of road data, the results of alternative j

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recommendations, which are a priority for the road improvement program, are proven accurately based on the results of an analysis with rankings.

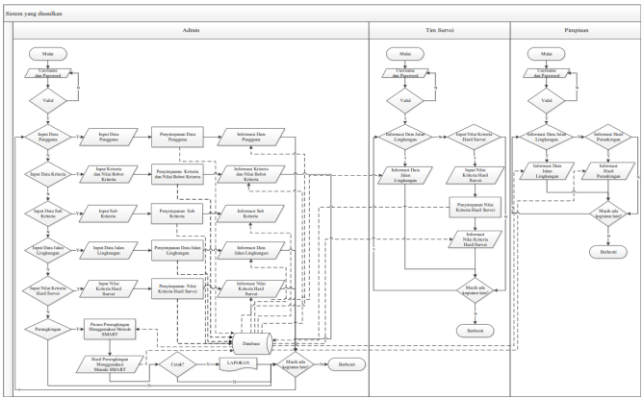

Fig. 2. Flowchart System for recommending priority for road improvement

The context diagram of the decision support system for determining the priority of environmental roads can be seen in Figure 3, which shows three external entities related to the system, namely admin, survey team, and leader.

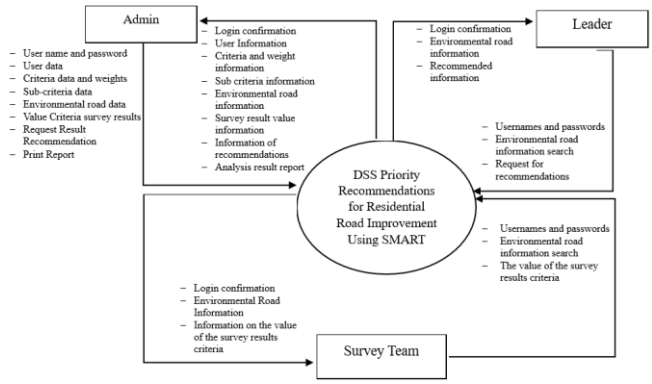

Fig. 3. Context Diagram of System for recommending priority for road improvement

The Data Flow Diagram represents the system built graphically and shows the various processes, data flows, and information shown in Figure 4. The processing of data into information is explained as follows:

1. Process 1.0 is a login process where the admin, survey team, and leadership must enter a username and password to gain access rights to the system.
2. Process 2.0 is a data management process where the admin can view, add, edit, or delete master data.
3. Process 3.0 is a ranking process where the admin can carry out an analysis of environmental road priorities. The system uses criteria weights and sub-criteria, along with survey results criteria values using the SMART method; the results of the analysis are in the form of a ranking of recommended alternative solutions. Admin and leaders can access ranking result data.
4. Process 4.0 is the process of making a report through a printed facility. The results of alternative recommendations for the road improvement program, the admin can be accessed.

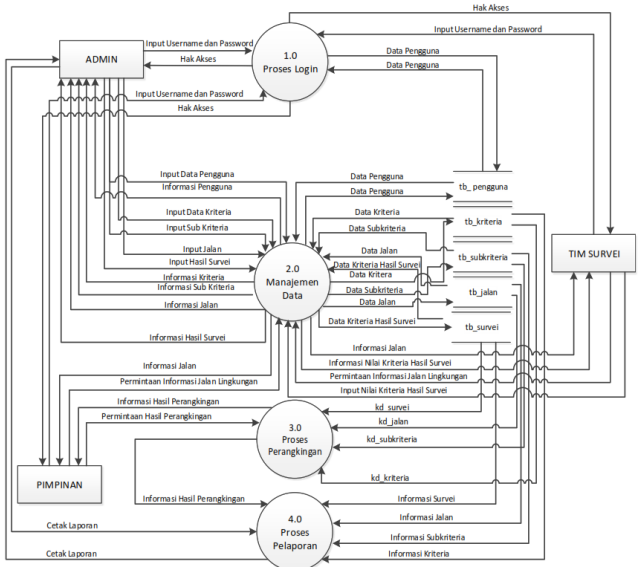

Fig. 4. Data flow diagram of the priority recommendation system for road improvement

B. *Analysis Stages Using the SMART Method*

Determining priority recommendations for road improvement programs using the SMART method begins with determining the criteria used to solve problems or cases, with discussions with experts at the Public Housing, Settlement Areas, and Land Affairs Office to obtain information on the criteria used in the decision-making system. SMART analysis stages are described as follows:

1. Determination of the criteria used consists of the physical condition of road damage, population, number of public facilities such as places of worship, health facilities, educational facilities, road length, and age. Each criterion has different unit values and sub-criteria, shown in Table 1.

TABLE 1. PRIORITY CRITERIA FOR ROAD IMPROVEMENT

No	*Criteria*	*Unit*	*Sub Criteria / Value*
1	Condition physique damaged road	condition state	• Damaged lightweight (1) • Damaged medium (2) • Damaged weight (3)
2	Amount Resident	Person	• <40 people (1) • 40 to 60 people (2) • 70 to 100 people (3) • > 100 people (4)
3	Amount facility general	units	• No There are facilities (1) • One Facility (2) • Two facilities (3) • >2 facilities (4)
4	Long road	Meters	• <100m (1) • 100 to 300 m (2) • 301 to 600 m (3) • 601 to 1000m (4) • > 1000m (5)

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No	Criteria	Unit	Sub Criteria / Value
5	Age road	Year	• < 1 year (1) • 1 to 3 years (2) • 4 to 5 years (3) • >5 years (4)

2. The weighting of the criteria, taking into account the value of the importance of the criteria, with the results of the weighting is shown in Table 2.

TABLE II. THE WEIGHTING OF ROAD IMPROVEMENT PRIORITY CRITERIA

Code	Criteria	Weight	Type
Kr_1	The physical condition of road damage	30%	Benefit
Kr_2	Number of inhabitants	25%	Benefit
Kr_3	Public facilities	20%	Benefit
Kr_4	Road length	15%	Cost
Kr_5	Road age	10%	Benefit

3. Normalizing the criteria weight values by applying equation 1, which is explained as follows:

The physical condition of road damage $= \frac{30}{100} = 0{,}3$

Number of inhabitants $= \frac{25}{100} = 0{,}25$

Public facilities $= \frac{25}{100} = 0{,}25$

Road length $= \frac{15}{100} = 0{,}15$

Road age $= \frac{10}{100} = 0{,}1$

4. Assessment of criteria for alternatives using quantitative data. The examples of cases used for the analysis of the SMART method are shown in Table 3 below:

TABLE III. ROAD IMPROVEMENT RECOMMENDATION CASE

Case	Street Name	Code				
		Kr_1	Kr_2	Kr_3	Kr_4	Kr_5
X_1	Jln Pisang	3	3	2	2	3
X_2	Jln Gambit	2	2	1	2	2
X_3	Jln Kanguru	1	1	1	2	2
X_4	Jln Arafura	3	3	2	2	4
X_5	Jln Cikombong	2	1	1	4	2

5. Calculate the utility value of each criterion using equation 2, which is explained as follows:
(a) Road damage utility value (Kr_1)

$$X_{11} = \frac{3-1}{3-1} = 1 \qquad X_{12} = \frac{2-1}{3-1} = 0{,}5$$

$$X_{13} = \frac{1-1}{3-1} = 0 \qquad X_{14} = \frac{3-1}{3-1} = 1$$

(b) The utility value of the number of inhabitants (Kr_2)

$$X_{21} = \frac{3-1}{4-1} = 0{,}67 \qquad X_{22} = \frac{2-1}{4-1} = 0{,}33$$

$$X_{23} = \frac{1-1}{4-1} = 0 \qquad X_{24} = \frac{3-1}{4-1} = 0{,}67$$

This stage is done for all alternatives based on each criterion.

6. Analyze the alternative final values based on each criterion by multiplying the weight of the criteria using Equation 3.
(a) Calculate the final value of road damage (Kr_1)

$X_{11} = 1 * 0{,}3 = 0{,}3$ $\qquad$ $X_{12} = 0{,}5 * 0{,}3 = 0{,}15$

$X_{13} = 0 * 0{,}3 = 0$ $\qquad$ $X_{14} = 1 * 0{,}3 = 0{,}3$

(b) Calculate the final value of the number of inhabitants (Kr_2)

$X_{21} = 0{,}67 * 0{,}25 = 0{,}17$ $\qquad$ $X_{22} = 0{,}33 * 0{,}25 = 0{,}08$

$X_{23} = 0 * 0{,}25 = 0$ $\qquad$ $X_{24} = 0{,}67 * 0{,}25 = 0{,}17$

Analysis of the final results by adding up the value of each criterion is exemplified as follows:
Calculating the analysis results of Jln Pisang (X_1)
$X_1 = 0.3 + 0.17 + 0.07 + 0.11 + 0.07 = 0.71$

7. Ranking of alternative solutions is sorting the results of the calculation of stage 6 from the highest value to the minimum.

TABLE IV. ALTERNATIVE RATING RESULTS

Ranking	Street Name	Preference results
1	Jln Arafura	0,75
2	Jln Pisang	0.71
3	Jln Gambit	0,38
4	Jln Cikombong	0,22
5	Jln Kanguru	0,15

C. *Results of SMART Implementation for Analysis of Alternative Solutions*

Determination of sub-criteria is carried out to scale the criteria unit to a certain value. In contrast, the results of the preparation of the sub-criteria used are shown in Figure 5.

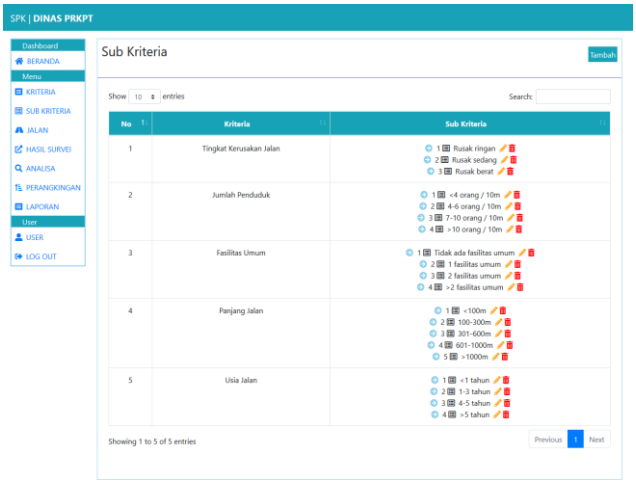

Fig. 5. Sub-criteria for road improvement recommendation system

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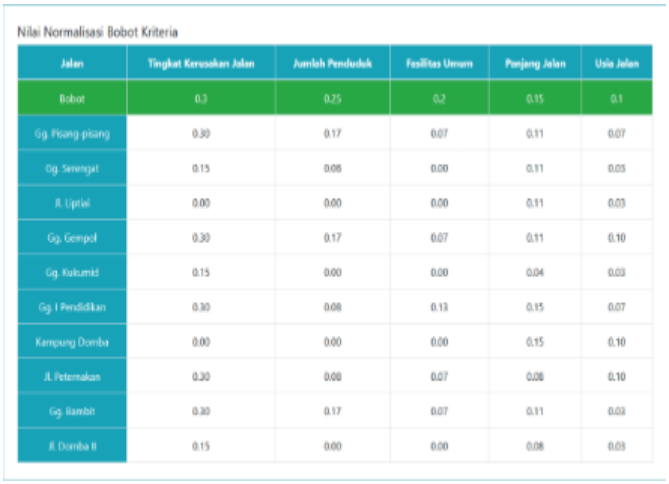
The results of normalizing the criterion weights use equation 1, shown in Figure 6. The weight values use a scale of 0 to 100.



Nilai Normalisasi Bobot Kriteria

Jalan	Tingkat Kerusakan Jalan	Jumlah Penduduk	Fasilitas Umum	Panjang Jalan	Usia Jalan
Bobot	0.3	0.25	0.2	0.15	0.1
Gg. Pisang-pisang	0.30	0.17	0.07	0.11	0.07
Gg. Serengat	0.15	0.08	0.00	0.11	0.03
Jl. Liptial	0.00	0.00	0.00	0.11	0.03
Gg. Gempol	0.30	0.17	0.07	0.11	0.10
Gg. Kukumid	0.15	0.00	0.00	0.04	0.03
Gg. I Pendidikan	0.30	0.08	0.13	0.15	0.07
Kampung Domba	0.00	0.00	0.00	0.15	0.10
Jl. Peternakan	0.30	0.08	0.07	0.08	0.10
Gg. Bambit	0.30	0.17	0.07	0.11	0.03
Jl. Domba II	0.15	0.00	0.00	0.08	0.03

Fig. 6. Results of the normalization of the criterion weights

Assessment of road conditions based on survey results is used to add data to each alternative's criteria value, namely the name of the road. The implementation of adding alternative data is shown in Figure 7.

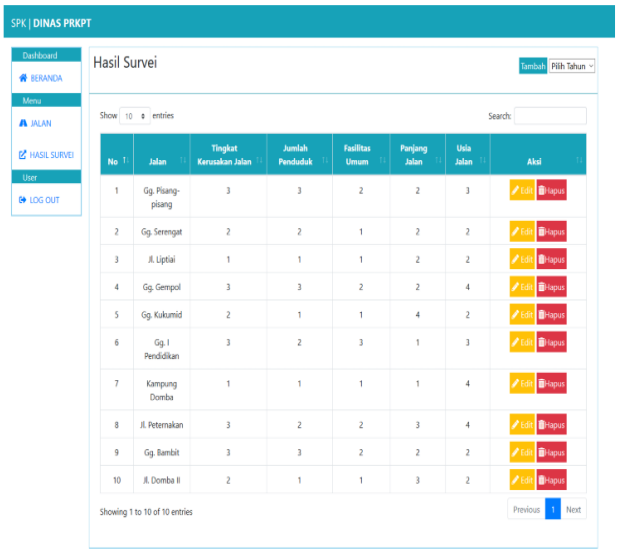
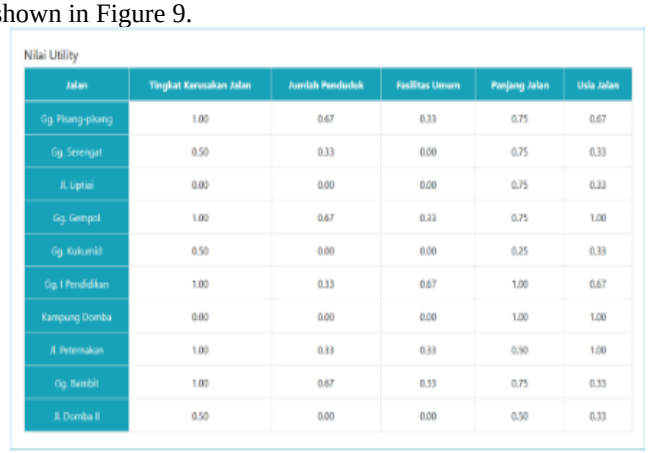


Fig. 7. Facility to add alternatives

The SMART method analysis begins by providing the criterion values for each alternative/case, as shown in Figure 8.

Fig. 8. Facilities for assessing criteria for each alternative

The system facility for presenting information on the results of calculating the utility value of each criterion uses equation 2, shown in Figure 9.



Nilai Utility

Jalan	Tingkat Kerusakan Jalan	Jumlah Penduduk	Fasilitas Umum	Panjang Jalan	Usia Jalan
Gg. Pisang-pisang	1.00	0.67	0.33	0.75	0.67
Gg. Serengat	0.50	0.33	0.00	0.75	0.33
Jl. Liptial	0.00	0.00	0.00	0.75	0.33
Gg. Gempol	1.00	0.67	0.33	0.75	1.00
Gg. Kukumid	0.50	0.00	0.00	0.25	0.33
Gg. I Pendidikan	1.00	0.33	0.67	1.00	0.67
Kampung Domba	0.00	0.00	0.00	1.00	1.00
Jl. Peternakan	1.00	0.33	0.33	0.50	1.00
Gg. Bambit	1.00	0.67	0.33	0.75	0.33
Jl. Domba II	0.50	0.00	0.00	0.50	0.33

Fig. 9. Calculation results of the utility value

The final stage of the analysis uses the SMART method, namely ranking the alternatives from the highest to the smallest preference value. The ranking results show the priority order of alternatives for road improvement program recommendations for decision-makers. The ranking page on the recommendation system can be seen in Figure 10.

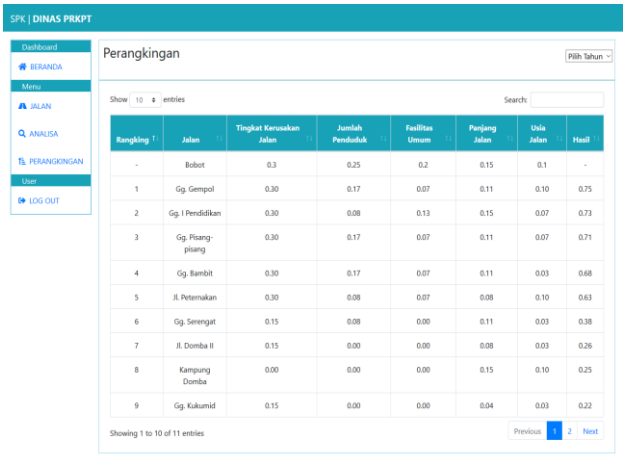


Fig. 10. SMART method analysis results

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D. Testing the Accuracy of the Results of System Recommendations

The accuracy level analysis technique is carried out by comparing the results of recommendations from the system and the results of the selection independently by experts. The cases used to determine the accuracy value are shown in the following table:

TABLE V. COMPARISON OF EXPERT RECOMMENDATION RESULTS AND SYSTEM

No	*Street Name*	*Criteria Value*					*S*	*A*
		Kr1	*Kr2*	*Kr3*	*Kr4*	*Kr5*		
1	Gg. Pisang	Damaged weight	135	1	150	4	3	3
2	Gg. Serengat	Damaged medium	123	0	238	2	6	6
3	Jl Liptiai	Damaged lightweight	25	0	118,5	3	10	10
4	Gg. Gempol	Damaged weight	120	1	150	6	1	1
5	Gg. Kukumid	Damaged medium	275	0	1000	3	9	9
6	Gg. Pendidikan	Damaged weight	18	2	30	5	2	2
7	Kampung Domba	Damaged lightweight	23	0	80	6	8	7
8	Jl. Peternakan	Damaged weight	201	1	345	3	5	5
9	Gg. Bambit	Damaged weight	140	1	200	3	4	4
10	Jl Domba 2	Damaged medium	137	0	245	3	7	8

Description:
S : System output ranking/priority
A : Ranking / priority of experts

The measurement of the accuracy value is based on the results of the ranking in Table 5, which shows that there are differences in the output recommendations sourced from the system and experts in cases number 7 and 10, so the accuracy value is obtained using the following equation [25]:

$$pr = \frac{test\ data\ is\ correct}{Total\ of\ sample\ data} * 100\% \quad (4)$$

Based on equation 4, the system accuracy value is 80%, which is explained as follows:

$$pr = \frac{8}{10} * 100\% = 80\%$$

V. CONCLUSION

The road improvement recommendation system can be used as a tool for decision-makers in considering options. Alternative recommendations use the SMART analysis method to find alternatives with the highest preference value so that the recommendations obtained are appropriate based on the importance value of the specified criteria. The advantage of this method is that it can be used for all types of weighting techniques to help decision-makers in application areas such as; construction, transportation, logistics, and others.

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