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Application of the Promethee II Method for Determining Road Improvement Priorities

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ABSTRACT

The road is an infrastructure that is often passed by the community. If there is damage, it will significantly disrupt community activities; for example, road conditions become jammed. This is necessary for the Public Works and Spatial Planning Office of the City of Cirebon to handle the road repairs, but in carrying out repair planning, there are obstacles, one of which is the difficulty in determining priority for road repairs with limited funds from the center. This research decision support system using the Promethee II method aims to find accurate results that are useful in determining priority road repairs that will be selected for repair. The criteria used in this study are Section Length, Road Width, Damage Condition, Traffic Volume (LHR), and Road Access. The results of this study selected Jalan A1 as an alternative that had the highest rating level of 0.613333333, and this indicated that this road was a road that had to be prioritized for repair. The test results show that the Promethee II method can produce priority recommendations for road improvements based on the required criteria.

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1. INTRODUCTION

The development of science and technology, especially information technology, has a significant role in various aspects of life [1], [2]. As is the case in government institutions, especially in the Public Works and Spatial Planning Office, information technology plays an essential role in improving the performance of every activity carried out related to data and information management, such as in recording survey data, as well as processing survey data for making decisions and as well as for data presentation [3]–[6].

The Public Works and Spatial Planning Office handles infrastructure such as roads, bridges, culverts, sidewalks, and street lighting related to daily community activities [7]. If the facility is damaged and repaired too late, it will affect the community's performance. For example, the road condition becomes jammed, many accidents occur, and traffic

disturbances occur. It is a challenging task for the Public Works and Spatial Planning Office to be able to manage data from all damaged roads. However, the handling of road repairs is often not on target due to errors in determining the priority for handling these road repairs. Determining the priority for handling road repairs is very important to make the handling actions carried out more appropriately and follow interests.

As road operators, the government and local governments are obliged to prioritize road maintenance and inspection in stages to maintain the level of road service according to the specified minimum service standards [8]. The government is also responsible for financing the construction of public roads and bridges. In carrying out these duties, the role of the community is also considered. The role of the community can be through direct complaints or their contribution in holding the annual Development Planning Meeting as a reference for the government to select road repairs, which is then conducted a survey (survey) to the location to obtain road damage data which the government will then discuss as a follow-up to road repair work.

The main problem arising from the regional government's authority to manage roads is its limited budget. In addition, the increasing number of roads managed by local governments, the increasing number of damaged roads, and the limited funds and bureaucratic complications faced by the government itself. Then, there is no budget for road sections that have exceeded the planned age limit for repairs. Because there are roads that are damaged in parts, limited funds for management, and many reports in the form of public complaints about damaged road conditions, the local government must prioritize which roads must be repaired immediately. The limited budget is the main obstacle that causes the dominance of policy factors based on the political aspects owned by each stakeholder (stakeholder). This often causes inequality. If the amount of data being managed is getting bigger, it will affect the storage space, search time, and the method of managing the data, especially if the data stored is still in the form of physical data or sheets of paper. Therefore, it is necessary to make efforts to improve the road.

To overcome problems like the one above, a system should be needed that can be used to assist in the process of making decisions on priority road repairs in a more accurate, fast, and objective manner to make it easier for the government to carry out road maintenance. Determining priority for road repairs usually takes a long time because the agency must first check and select the damage criteria by comparing directly using printed documents containing data on priority determination criteria obtained from the survey process, where comparisons are made by comparing the existing road conditions. Heavily damaged status first, then supported by analyzing several other criteria.

A Decision Support System (DSS) is created to solve a problem related to several problems that cannot be solved without using certain assistance, such as structured and unstructured problems [8]. DSS aims to provide interactive tools that enable decision-makers to analyze using available solution models [9]. DSS functions, for several things, among others, as a comprehensive understanding of the problem, providing a systematic framework for thinking, can guide the application of decision-making techniques, and improving the quality of a decision [10]. In the DSS, to determine the weighting and ranking, the Promethee II method can be used [11].

Building a better Decision Support System (DSS) requires the proper method to achieve quality decisions and have a high level of accuracy. The proper method that can be used is the PROMETHEE II method. The PROMETHEE II method ranks relatively simple in concept and application compared to other multi-criteria analysis methods. This method will later make decisions with several conflicting criteria and alternatives and produce the most significant value, which will be selected as the best alternative. Brans and Vincke [12] developed the Promethee method (preference ranking organization method for enrichment evaluation) in 1985. The PROMETHEE I method can provide a partial cut of the decision alternatives, while the PROMETHEE II method can obtain an overall ranking of the alternatives [9]. Based on the research that has been done, the Promethee method shows good effectiveness in solving multi-criteria decision support problems [13]–[16].

2. METHOD

In this study, the authors used a qualitative descriptive method. The method finds a phenomenon's elements, characteristics, and properties [17]. The steps are determining the research topic and identifying problems to be discussed next, interviews with those who understand the process of determining road repair priorities at the PUPR City Cirebon Service, knowledge acquisition, exploring theories related to decision support systems, using the Promethee II method, and priority road improvements from the internet, books, journals, collection of research data following the selection of the data needed, studying the process of assessing road repair priorities currently implemented, processing data calculations using the Promethee II method obtaining suggestions on priority road repair decisions, analysis, and evaluation of data calculation results, and conclude.

Data collection is done by observation technique. Observation is a crucial way to get specific information about people because what people say is not necessarily the same as what they do [18], [19]. In this case, the researcher made observations at the Public Works and Spatial Planning Office of the City of Cirebon to obtain information for research materials. The second technique is carried out with interviews. In this case, the researcher conducts a question and answer with the head of the Highways Division and the Highways Field Employees to obtain the information and data needed in the research.

The last one is Literature studies. Literature studies are related to theoretical studies and other references related to values, culture, and norms that develop in the social situation under study [20], [21]; literature studies are critical in researching because this research will not be separated from the scientific literature. Data is obtained from relevant data to the problem to be examined by conducting other literature studies such as books, journals, articles, and previous research.

3. RESULTS AND DISCUSSION

PROMETHEE is one of the Multi-Criteria Decision Making (MCDM) methods, which means determining or sorting in a multi-criteria analysis [22]–[24]. Before carrying out the calculation process, it is necessary to determine the criteria, weight, and type of each criterion as follows:

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1. Determine alternatives, following alternative sample data used

Table 1. Code and Alternative Ways

Code	Alternative
A1	Jl. Cangkring 1
A2	Jl. Cangkring Tengah
A3	Jl. Tuparev
A4	Jl. Wahidin
A5	Jl. Kebon Blimbing
A6	Jl. Langen Sari

2. Determine the criteria that will be used as a reference in decision making

Table 2. Criteria Weighting

Criteria	Description	Weight
C1	Section Length	20%
C2	The width of the road	15%
C3	Damage Condition	35%
C4	LHR	25%
C5	Road Access	5%

Table 2 above shows W = (0.2, 0.15, 0.35, 0.25, 0.05).

3. Determine the variable assessment on each criterion
   a. Road Length Criteria

Table 3. Segment Length Sub Criteria

Section Length sub-criteria	Value
> 5 Km	50
< 3 Km	40
< 1 Km	30
< 50 m	20
< 100 m	10

   b. Road Width Criteria

Table 4. Road Width Sub Criteria

Road Width sub-criteria	Value
<= 10 m	50
< 9 m	40
< 8 m	30
< 7 m	20
< 5 m	10

   c. Damage Condition Criteria

Table 5. Sub Criteria for Conditions of Damage

Damage Condition Sub Criteria	Value
Very ugly	50
Bad	40
Currently	30
Good	20
Very good	10

d. LHR criteria

Tabel 6. Sub Criteria LHR

LHR Sub Criteria	Value
2000 – 5000	50
500 – 2000	40
200 – 500	30
50 – 200	20
20 – 50	10

e. Road Access Criteria

Table 7. Road Access Sub Criteria

Sub Kriteria Akses Jalan	Value
Country	50
Province	40
City	30
Regency	20
Village	10

After classifying the criteria, the next step is to match each alternative criteria that have been compiled. The following is the table.

Table 8. Conformity Rating of Each Alternative on Each Criterion

Alternative	Criteria				
	C1	C2	C3	C4	C5
A1	50	50	40	30	50
A2	30	20	30	20	10
A3	40	50	40	10	40
A4	10	20	20	30	50
A5	20	10	30	30	30
A6	10	20	20	10	20
Max	50	50	40	30	50
Min	10	10	20	10	10

The Decision Matrix formed from the match table is as follows:

$$x = \begin{bmatrix} 50 & 50 & 40 & 30 & 50 \\ 30 & 20 & 30 & 20 & 10 \\ 40 & 50 & 40 & 10 & 40 \\ 10 & 20 & 20 & 30 & 50 \\ 20 & 10 & 30 & 30 & 30 \\ 10 & 20 & 20 & 10 & 20 \end{bmatrix}$$

After going through the value search stage for each alternative for priority road improvements in Cirebon, the results search process will be carried out using the Promethee II method. The stages of the search process are as follows.

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a. Normalizing the decision matrix with equations

$$R_{ij} = \frac{[X_{ij} - \min(X_{ij})]}{[\max(X_{ij}) - \min(X_{ij})]} \quad 1)$$

so obtained

$$R_{11} = \frac{50-10}{50-10} = 1 \qquad R_{14} = \frac{10-10}{50-10} = 0$$

$$R_{12} = \frac{30-10}{50-10} = 0.5 \qquad R_{15} = \frac{20-10}{50-10} = 0.25$$

$$R_{13} = \frac{40-10}{50-10} = 0.75 \qquad R_{16} = \frac{1-1}{5-1} = 0$$

Thus, the normalized decision matrix made from the above normalization results is as follows:

Table 8. Decision Matrix Normalization

Alternativ	Criteria				
	C1	C2	C3	C4	C5
A1	1	1	1	1	1
A2	0.5	0.25	0.5	0.5	0
A3	0.75	1	1	0	0.75
A4	0	0.25	0	1	1
A5	0.25	0	0.5	1	0.5
A6	0	0.25	0	0	0.25

b. Compute the preference Function

P_{12}: $1 \leq 0.5 = 1 - 0.5 = 0.5$

$1 \leq 0.25 = 1 - 0.25 = 0.75$

$1 \leq 0.5 = 1 - 0.5 = 0.5$

$1 \leq 0.5 = 1 - 0.5 = 0.25$

$1 \leq 0 = 1 - 0 = 1$

P_{13}: $1 \leq 0.75 = 1 - 0.75 = 0.25$

$1 \leq 1 = 0$

$1 \leq 1 = 0$

$1 \leq 0 = 1 - 0 = 1$

$1 \leq 0.75 = 1 - 0.75 = 0.25$

P_{14}: $1 \leq 0 = 1 - 0 = 1$

$1 \leq 0.25 = 1 - 0.25 = 0.75$

$1 \leq 0 = 1 - 0 = 1$

$1 \leq 1 = 0$

$1 \leq 1 = 0$

P_{15}: $1 \leq 0.25 = 1 - 0.25 = 0.75$

$1 \leq 0 = 1 - 0 = 1$

$1 \leq 0.5 = 1 - 0.5 = 0.5$

$1 \leq 1 = 0$

$1 \leq 0.5 = 1 - 0.5 = 0.5$

P_{16}: $1 \leq 0 = 1 - 0 = 1$

$1 \leq 0.25 = 1 - 0.25 = 0.75$

$1 \leq 0 = 1 - 0 = 1$

$1 \leq 0 = 1 - 0 = 1$

$1 \leq 0.25 = 1 - 0.25 = 0.75$

The calculation above can use the same formula to find other preference function values.

Table 9. Preference Functions for All Alternative Pairs

Alternatives	Criteria				
	C1	**C2**	**C3**	**C4**	**C5**
P12	0.5	0.75	0.5	0.5	1
P13	0.25	0	0	1	0.25
P14	1	0.75	1	0	0
P15	0.75	1	0.5	0	0.5
P16	1	0.75	1	1	0.75
P21	0	0	0	0	0
P23	0	0	0	0.5	0
P24	0.5	0	0.5	0	0
P25	0.25	0.25	0	0	0
P26	0.5	0	0.5	0.5	0
P31	0	0	0	0	0
P32	0.25	0.75	0.5	0	0.75
P34	0.75	0.75	1	0	0

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Alternatives	Criteria				
	C1	C2	C3	C4	C5
P35	0.5	1	0.5	0	0.25
P36	0.75	0.75	1	0	0.5
P41	0	0	0	0	0
P42	0	0	0	0.5	1
P43	0	0	0	1	0.25
P45	0	0.25	0	0	0.5
P46	0	0	0	1	0.75
P51	0	0	0	0	0
P52	0	0	0	0.5	0.5
P53	0	0	0	1	0
P54	0.25	0	0.5	0	0
P56	0.25	0	0.5	1	0.25
P61	0	0	0	0	0
P62	0	0	0	0	0.25
P63	0	0	0	0	0
P64	0	0	0	0	0
P65	0	0.25	0	0	0

c. Computes the aggregate preference function

Table 10. Results of the Aggregate Preference Function

Alternativ	Criteria				
	C1	C2	C3	C4	C5
P12	0.1	0.1125	0.175	0.125	0.05
P13	0.05	0	0	0.25	0.0125
P14	0.2	0.1125	0.35	0	0
P15	0.15	0.15	0.175	0	0.025
P16	0.2	0.1125	0.35	0.25	0.0375
P21	0	0	0	0	0
P23	0	0	0	0.125	0
P24	0.1	0	0.175	0	0
P25	0.05	0.0375	0	0	0
P26	0.1	0	0.175	0.125	0
P31	0	0	0	0	0
P32	0.05	0.1125	0.175	0	0.0375
P34	0.15	0.1125	0.35	0	0
P35	0.1	0.15	0.175	0	0.0125
P36	0.15	0.1125	0.35	0	0.025
P41	0	0	0	0	0
P42	0	0	0	0.125	0.05
P43	0	0	0	0.35	0.0125

Alternativ	Criteria				
	C1	C2	C3	C4	C5
P45	0	0.0375	0	0	0.025
P46	0	0	0	0.25	0.0375
P51	0	0	0	0	0
P52	0	0	0	0.125	0.025
P53	0	0	0	0.25	0
P54	0.05	0	0.175	0	0
P56	0.05	0	0.175	0.25	0.0125
P61	0	0	0	0	0
P62	0	0	0	0	0.0125
P63	0	0	0	0	0
P64	0	0	0	0	0
P65	0	0.0375	0	0	0

Table 11. Combined Preference Functions

Alternatives	A1	A2	A3	A4	A5	A6	Total
A1	-	0.5625	0.3125	0.6625	0.5	0.95	2.9875
A2	0	-	0.125	0.275	0.0875	0.4	0.8875
A3	0	0.375	-	0.6125	0.4375	0.6375	2.0625
A4	0	0.75	0.2625	-	0.0625	0.2875	0.7875
A5	0	0.15	0.25	0.225	-	0.4875	1.1125
A6	0	0.0125	0	0	0.0375	-	0.05
Total	0	1.275	0.95	1.775	1.125	2.7625	

d. Determine outflow and outranking flows

Table 12. Results of Outflow and Outranking Flow

Alternativ	Leaving Flow	Entering Flow
A1	0.5975	0
A2	0.1775	0.255
A3	0.4125	0.19
A4	0.1575	0.355
A5	0.2225	0.225
A6	0.01	0.5525

e. Compute the net outranking of each alternative

Table 13. Net Outranking Results for Each Alternative

Alternatives	Net Flow	Ranking
A1	0,5975	1
A2	-0,0775	4
A3	0,2225	2
A4	-0,1975	5
A5	-0,0025	3
A6	-0,5425	6

Based on calculations using the Promethee II method, it results that A1, Jl. Cangkring 1 is a priority for road repair.

From table 8, it can be seen that A1 has criteria for segment length > 5 km, Road width <= 10m, condition of damage "bad," Criteria LHR 200-500, and Road Criteria "country." compared to the A4 (net flow is -0,1975), even though the status is the same as country roads, the condition of damage is still in "good" condition, and the segment length is only less than 100m. So it is natural that A1 is a priority road that must be repaired.

4. CONCLUSION

After carrying out the analysis, design, implementation, and testing that has been carried out, conclusions can be obtained regarding the system for determining road repair priorities; namely, the system built can speed up the process of determining road repair priorities. Besides that, the system built can make it easier for the selection team to determine road repair priorities. Furthermore, lastly, the Promethee II Method can be applied to determine road improvement priorities so that the system that has been built can be according to the expected procedure.

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