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Research paper



Determination of Priority Scale Provincial Road Handling in Purwakarta District, West Java

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Abstract

The provincial roads maintenance and repair are often constrained by limited budgets, so that the road management priority is generally determined by policy factors, which often cause roads treatment disparity. The purpose of this study was to determine the criteria and sub-criteria, the weights of criteria and sub-criteria, as well as develop a mathematical equation in order to determine to roads handling priority in the area of Purwakarta, West Java. The Delphi and Cut Off Point methods were applied to determine the criteria, which result in three criteria selected i.e. road condition, traffic volume and economic factors respectively. Afterward, the Analytical Hierarchy Process was used to determine the weighting factors for the criteria and sub-criteria. The results for the criteria weights were as follows: the roads conditions had a weighting factor of 67.7%, the traffic volume of 18.3% and the economy of 13.0%. Based on the criteria and sub-criteria weight, a mathematical equation was developed to define the handling priority of roads in Purwakarta.

Keywords: *provincial road; handling priority; Cut Off Point; AHP.*

1. Introduction

Purwakarta City is one of the regencies located in West Java Province - Indonesia. Provincial roads in Purwakarta Regency are damaged due to several factors including road construction, road load factors that exceed capacity, and road construction costs. Regarding the provincial road budget, the Rp. 1 trillion budget stipulated in the 2015 [4] APBD (regional income and expenditure budget) still feels inadequate. Because the allocated budget must also be reduced by the workers' salary budget. The APBD allocates more than 10% for road infrastructure improvements, and it is still not comparable with the length of roads in West Java.

The budget limitation caused the priority in handling the road network to be more dominated by policy factors that were more based on political aspects. This condition often causes inequality in handling roads. In connection with this matter, a study of priority scale for handling provincial roads in Purwakarta Regency needs to be conducted with the right method to help policy makers in determining priorities according to their needs and benefits that involve all stakeholders.

The purpose of this study was to select the appropriate criteria and sub criteria using a combination of Delphi method with the Cut off Point method, determine the criteria and sub criteria weighting using the Analytical Hierarchy Process (AHP) method, and create mathematical equations to determine the priority order of handling roads on the provincial road network in Purwakarta Regency.

2. Literature Review

2.1. Road Classification Based on Status

Road grouping is intended to realize road certainty based on road development authority. According to Government Regulation of the Republic of Indonesia No.26 of 1985 [2, 5] concerning Roads, road grouping is as follows:

a. National Roads are roads that connect between provincial capitals, which have strategic interests in national interests under the guidance of ministers or appointed officials.
b. Provincial roads are roads under the guidance of the province or designated institutions, among which are primary collector roads that connect the provincial capital to the regency / municipality capital.
c. Regency roads are roads under the guidance of districts or designated agencies.
d. Municipal roads are roads under municipal coaching, including city and secondary roads in the city.
e. Village Road is a road under village development, namely a secondary road in the village.
f. Special roads are roads under the guidance of designated officials or agencies namely roads that are specifically built by agencies or groups.

2.2. Road Handling

Road handling according to Government Regulation of The Republic of Indonesia No. 34 of 2006 concerning Roads is an activity that is part of the implementation of road construction which includes the determination of the plan for the level of performance to be achieved and the estimated costs required. In the Elucidation of Government Regulation of the Republic of Indonesia No. 34 of 2006 [3] concerning Roads, it is stated that the road network handling program includes road maintenance programs, road improvement programs, and new road construction programs. Road management focuses more on periodic maintenance and betterment. Road handling reviewed in this study is a road maintenance and road improvement program, not including a new road construction program.

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3. Methodology

3.1. Method of Collecting Data

In this study, there are 3 stages of data collection namely:

a. Data Collection Phase 1 aims to select criteria and sub criteria. Data collection was carried out by interviewing respondents who understood the problem of handling provincial roads and the criteria under study.
b. Data Collection Phase 2 aims to choose the model criteria. Data collection in the form of primary data by conducting questionnaires to expert respondents who are considered to understand the problem of handling provincial roads and the criteria examined.
c. Data Collection Phase 3 aims to determine the criteria and sub criteria weight by using the AHP method. Data collection was in the form of primary data by conducting a questionnaire on expert respondents

3.2. Data Processing Method

The method used to process data in this study is a combination of Delphi method with Cut Off Point method, and AHP method.

4. Data Processing and Analysis

4.1. Selection of Criteria and Sub Criteria

The selection of criteria and sub-criteria begins with interviewing round 1 and round 2 interviews with 8 (eight) expert respondents from government elements namely from the Department of Highways of West Java Province as many as 2 respondents, the Office of Highways and Irrigation of Purwakarta Regency as many as 2 respondents, West Java Provincial Bappeda (Development Planning Agency at Sub-National Level) were 2 respondents, and Purwakarta District Bappeda were 2 respondents. Next, two rounds of interviews and discussions were conducted, then a summary of the opinions of all respondents was prepared as shown in Table 1.

Table 1: Criteria and Sub Criteria

No.	Criteria	Sub Criteria	No.	Criteria	Sub Criteria
1.	Road Conditions	Hole-hole, Slope / Slate, Cracks, Used Wheel Grooves, Road Slope, Drainage	4.	Population Density	High Density, Medium Density, Low Density
2.	Traffic Volume	6 Axle Trucks, 5 Axle Trucks, 4 Axle Trucks, 3 Axle Trucks, Buses, Passenger Cars, Motorcycle	5.	Economy	Benefits, Estimated Project Costs
3.	Land Use	Industrial Estate, Agricultural Area, Tourism Area, Service and Settlement Area, Protected Area	6.	Executive Policy	- District Musrenbang - Provincial Musrenbang - Additional Cost Budget

4.2. Selection of Criteria and Model Sub Criteria

According to [6], that the method for determining the importance of criteria is to use the Cut off method. This stage begins with the distribution of questionnaires to 12 respondents namely from the Department of Highways of West Java Province as many as 4 respondents, the Office of Highways and Irrigation of Purwakarta Regency as many as 2 respondents, Bappeda of West Java Province as many as 4 respondents, and Bappeda of Purwakarta District as much as 2 respondents. Recapitulation of respondents' answers to the criteria is shown in Table 2.

Table 2: Recapitulation of Respondents' Answers to Criteria

Criteria	Not Important (a)	Important (b)	Very Important (c)	Total Score (d)	Total Questionnaire (e)	Average Score (f)	Inf. (g)
Road Conditions	2	0	10	32	12	2.667	Max. Value
Traffic Volume	1	2	9	32	12	2.667	
Land Use	7	5	0	17	12	1.417	Min. Value
Population Density	6	6	0	18	12	1.500	
Economic	3	4	5	26	12	2.167	
Executive Policy	7	4	1	18	12	1.500	

Calculation of Total Score (d) using in (1).

Total Score (d) = {(ax1)+(bx2)+(cx3)} (1)

Example calculation for Criteria for Road Conditions:

a. Total Score (d):

(d) = (2 x 1) + (0 x 2) + (10 x 3) = 32

b. Average Score (f) = $\frac{d}{e} = \frac{32}{12}$ = 2,667

Cut Off Point Value = $\frac{\text{Maximum Value+Minimum Value}}{2}$ (2)

Then,

Cut Off Point Value = $\frac{(2,667+1,417)}{2}$ = 2,042

Based on the above Cut Off Point values, the Criteria for Land Use, Population Density, and Executive Policy must be excluded from the model criteria because the average value is less than 2.042 and is considered the three criteria are less important in determining the priority of handling provincial roads in Purwakarta Regency. Thus, the model criteria that will be used are road conditions, traffic volume factors and economic factors.

4.3. Assessment Criteria Weight

The weight of each criterion is analyzed by the AHP method with the following steps:

Step 1: Initial Matrix Calculation

Beginning with analyzing the answers to questionnaires from 45 respondents with the reverse calculation in accordance with the pairwise comparison matrix. The complete data is shown in Table 3.

Table 3: Comparison Scale of Criteria Assessment

Resp.	Scoring Scale			Resp.	Scoring Scale			Resp.	Scoring Scale		
	A : B	A : C	B : C		A : B	A : C	B : C		A : B	A : C	B : C
1	9,000	9,000	9,000	16	6,000	6,000	3,000	31	5,000	3,000	2,000
2	5,000	3,000	2,000	17	1,000	2,000	0,500	32	5,000	5,000	1,000
3	5,000	3,000	2,000	18	0,500	1,000	3,000	33	5,000	5,000	0,250
4	7,000	0,333	0,333	19	5,000	3,000	2,000	34	1,000	7,000	7,000

5	5,000	3,000	2,000	20	6,000	5,000	2,000	35	1,000	1,000	1,000
6	5,000	4,000	2,000	21	5,000	3,000	2,000	36	7,000	1,000	0,143
7	7,000	7,000	2,000	22	8,000	5,000	3,000	37	3,000	9,000	0,333
8	6,000	5,000	2,000	23	4,000	2,000	2,000	38	7,000	3,000	0,333
9	0,143	0,143	0,143	24	7,000	6,000	2,000	39	7,000	4,000	2,000
10	5,000	6,000	5,000	25	4,000	4,000	2,000	40	6,000	7,000	2,000
11	9,000	7,000	0,143	26	5,000	0,333	0,333	41	6,000	0,200	0,250
12	7,000	5,000	1,000	27	7,000	0,333	5,000	42	7,000	1,000	2,000
13	6,000	5,000	2,000	28	4,000	6,000	6,000	43	5,000	4,000	2,000
14	1,000	0,333	0,200	29	5,000	0,143	0,143	44	7,000	5,000	2,000
15	7,000	7,000	0,143	30	5,000	3,000	2,000	45	3,000	7,000	0,333
								ΣR	231,643	173,818	87,580
								ΣR/45	5,148	3,863	1,946

Information:
ΣR = cumulative number of comparison scoring scales.
ΣR / 45 = Average comparison score by dividing R against 45 respondents

Furthermore, the value used is the cumulative average value. The size of each matrix is:
Matrix A: B = 5,148
Matrix A: C = 3,863
Matrix B: C = 1,946

Whereas,
The B: A matrix is the opposite of matrix A: B = 1 / ((A: B)) = 1 / ((5,148)) = 0.194

The C: A matrix is the opposite of matrix A: C = 1 / ((A: C)) = 1 / ((3,863)) = 0,259

The C: B matrix is the opposite of matrix B: C = 1 / ((B: C)) = 1 / ((1,946)) = 1,514

The initial criteria matrix data are shown in Table 4.

Table 4: Initial Criteria Matrix A B C

	A	B	C
A	1,000	5,148	3,863
B	0,194	1,000	1,946
C	0,259	0,514	1,000
Σ	1,453	6,661	6,809

Step 2: Calculation of Vector Eigenvalues
Number of lines A = Matriks AA x Matriks AB x Matriks AC
= 1,000 x 5,148 x 3,863 = 19,883

Number of lines B = Matriks BA x Matriks BB x Matriks BC
= 0.194 x1,000 x 1,946 = 0,378

Number of lines C = Matriks CA x Matriks CB x Matriks CC
= 0,259 x 0,514 x 1,000 = 0,133

Determine the amount of wi:
wi = $\sqrt[n]{\text{Number of lines}}$ where n = 3

So that:
wi line A = $\sqrt[3]{19,883}$ = 2,709

Then, Eigen Vector (Xi) = $\frac{wi}{\sum Wi}$ = = $\frac{2,709}{3,943}$ = 0,687

Vector Eigen value data for the criteria priority determination scale are shown in Table 5.

Table 5: Vector Eigenvalues for Priority Determination Criteria

	A	B	C	Amount	Wi	E-Vector
A	1,000	5,148	3,863	19,883	2,709	0,687
B	0,194	1,000	1,946	0,378	0,723	0,183
C	0,259	0,514	1,000	0,133	0,510	0,130
Σ	1,453	6,661	6,809	20,394	3,943	1,000

Step 3: Calculation of Maximum Eigenvalues

Maximum Eigenvalues are obtained from the Initial Matrix multiplied by the E-Vector of each matrix and then the multiplication results are summed. This is shown in Figure 1.

	A	B	C		E-Vector		Λ
A	1,000	5,148	3,863	x	0,687	=	2,131
B	0,194	1,000	1,946		0,183		0,580
C	0,259	0,514	1,000		0,130		0,404
					λmax	=	3,114

Fig. 1: Maximum Criteria for Eigen Value Matrix

Then, the Maximum Eigen value (λmax) = 3.114

Step 4: Control the Consistency Index
Consistency Index (CI) = $\frac{(\lambda maks-n)}{(n-1)}$; where n =3
CI = $\frac{(3,114-3)}{(3-1)}$ = 0,057
Consistency Ratio (CR) = $\frac{CI}{RI}$, to n = 3 then RI = 0,58

Random Index Value (RI) for each matrix order shown in Table 6.

Table 6: Random Index Value (RI)

Matrix Sequence	1	2	3	4	5	6	7	8	9
RI	0,00	0,00	0,58	0,90	1,12	1,32	1,41	1,45	1,49

CR = $\frac{0,057}{0,58}$ = 0,098

The Consistency Ratio (CR) value is smaller than 0.1, so the value is in accordance with the terms of consistency which must be smaller than 0.1 or 10%.

Step 5: Weighting Criteria
Element weight is obtained from the E-Vector value expressed in Percentages as shown in Table 4.7.

Table 7: Weighting Priority Scale Criteria for Handling Provincial Roads

Criteria	Weight (%)
Road Condition Factors	68,7
Traffic Volume Factors	18,3
Economic Factors	13,0

Based on data in Table 7, it can be seen that road conditions are the main criteria in determining the priority of handling provincial roads in Purwakarta Regency with a weight of 68.7%. The selection of road conditions criteria as the main criteria according to the demands of the people who always want a good road, and is expected to be able to serve the movement of people and goods from the place of origin to the destination safely and comfortably. Besides this, good road conditions must also be attempted to prevent traffic accidents.
Criteria for traffic volume ranks second with a weight of 18.3%; and finally the economic criteria with a weight of 13.0%. The traffic volume factor has a more important priority when compared to economic factors because the traffic volume in several

provincial roads in Purwakarta Regency is quite dense especially at the time of entering or returning to work. In addition, trucks with large tonnages also often pass to transport industrial goods to and from industrial areas in Purwakarta Regency.
In the same way this is done with sub criteria, so that when summarized in its entirety, it will look like in Figure 2.

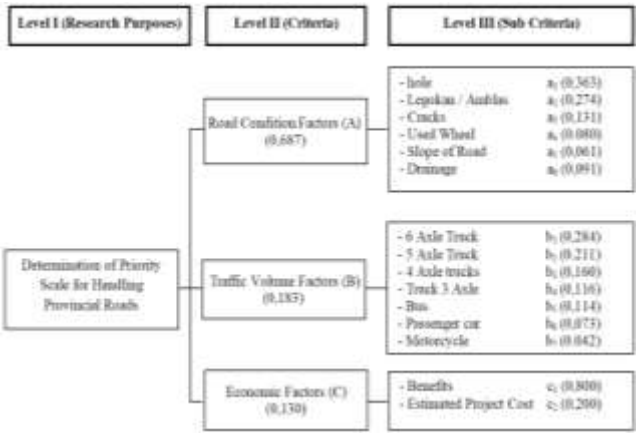

Fig. 2: Structure of Provincial Road Hierarchy Level Management

4.4. Calculation of Priority Order for Handling Provincial Roads

Calculation of Priority Order for Handling Provincial Roads Determination of the priority sequence for handling road links using a mathematical model according to [1] namely:

$Y = A\ (a_1 \times X_1 + ... + a_6 \times X_6) + B\ (b_1 \times X_7 + ... b_7 \times X_{13}) + C\ (c_1 \times X_{14} + c_2 \times X_{15})$

By:
Y = Road Handling Priority Scale
A to C = Weight of Level 2 criteria (based on the analysis of respondents)
a_1, a2, a_3 ... c_2 = Alternative weight level 3 (based on the analysis of respondents)
X_1, X_2, ..., X_{15} = Alternative weight level 3 (based on secondary data analysis)

From the results of calculations with a mathematical model to determine the priority order of handling road links in the provincial road network in Purwakarta regency obtained the following equation:

$Y = 0{,}687\ \{(0{,}363 \times X_1) + (0{,}274 \times X_2) + (0{,}131 \times X_3) + (0{,}080 \times X_4) + (0{,}061 \times X_5) + (0{,}091 \times X_6)\} + 0{,}183\ \{(0{,}284 \times X_7) + (0{,}211 \times X_8) + (0{,}160 \times X_9) + (0{,}116 \times X_{10}) + (0{,}114 \times X_{11}) + (0{,}073 \times X_{12}) + (0{,}042 \times X_{13})\} + 0{,}130\ \{(0{,}800 \times X_{14}) + (0{,}200 \times X_{15})\}$

The mathematical model equation above can then be applied to the implementation of determining the priority sequence for handling road links in the provincial road network using road conditions, traffic volume and economic data. Examples of data recapitulation from the calculation of the weighted sub-criteria of secondary data based on simulation data are shown in Table 8.

Table 8: Recapitulation of Calculation Results of Simulation Data Sub Criteria

Name Street	Sub Criteria Weight (Simulation Data)														
	Road Conditions(a)						Traffic Volume (b)							Economic (c)	
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}
A	0,250	0,250	0,500	0,500	0,500	0,250	0,037	0,078	0,178	0,168	0,274	1,000	0,106	0,796	0,794
B	0,500	0,500	0,250	0,500	0,250	0,500	0,034	0,047	0,112	0,100	0,209	0,941	0,072	0,557	0,474
C	0,250	0,250	0,500	0,250	0,500	0,250	0,019	0,037	0,150	0,140	0,162	0,925	0,090	1,000	1,000

Information:
Holes (X_1), Legokan / Amblas (X_2), Cracks (X_3), Used Wheel Grooves (X_4), Road Slope (X_5), Drainage (X_6), 6 Axle Trucks (X_7), 5 Axle Trucks (X_8), 4 Axle Trucks (X_9), 3 Axle Trucks (X_{10}), Buses (X_{11}), Mbl Passengers (X_{12}), Motorbikes (X_{13}), Benefits (X_{14}) Project Cost Estimates (X_{15})

Then, Determination of Priority Scale for Provincial Road Handling with AHP Method is:
1. Road Section A

$Y_A = 0{,}687\{(0{,}363 \times 0{,}250) + (0{,}274 \times 0{,}250) + (0{,}131 \times 0{,}500) + (0{,}080 \times 0{,}500) + (0{,}061 \times 0{,}500) + (0{,}091 \times 0{,}250)\} + 0{,}183\{(0{,}284 \times 0{,}037) + (0{,}211 \times 0{,}078) + (0{,}160 \times 0{,}178) + (0{,}116 \times 0{,}168) + (0{,}114 \times 0{,}274) + (0{,}073 \times 1{,}000) + (0{,}042 \times 0{,}106)\} + 0{,}130\{(0{,}800 \times 0{,}796) + (0{,}200 \times 0{,}794)\}$
$Y_A = 0{,}339$

Furthermore, in the same way we obtained the weights:

2. Road Section B
$Y_B = 0.474$

3. Section C
$Y_C = 0.378$

So, the priority order for handling provincial roads is that road B occupies the first priority, then road segment C, and the last priority is road segment A.

5. Conclusion

Based on the results of the analysis, the following conclusions can be drawn:

1. The results of the analysis using a combination of Delphi method with Cut Off Point method is known that the criteria to be used in determining the priority of handling provincial roads are factors of road conditions, traffic volume factors, and economic factors. Population density factors, land use factors and executive policy factors are considered less influential in determining the priority of handling provincial roads in Purwakarta Regency.
2. The results of the criteria analysis using the AHP method, shows that the highest criteria weight is the factor of road conditions with a weight of 68.7%; followed by a traffic volume factor of 18.3%; while the lowest is an economic factor of 13.0%.
3. Sub factors of road condition factors show that the perforated road gives the largest rating weight of 36.3%. Subsequent contributions were provided by legokan / collapsed roads with a weight of 27.4%; cracked with a weight of 13.1%; drainage with a weight of 9.1%; wheel rails with a weight of 8.0%; and finally the slope of the road with a weight of 6.1%.
4. Sub criteria for traffic volume show that the road traversed by 6 Axle Truck has the most important influence, namely by weighing 28.4%; then followed by a 5 Axle Truck with a weight of 21.1%; 4 Axle Truck with a weight of 16%; 3 Axle Truck with a weight of 11.6%; Bus with a weight of 11.4%; next Passenger Cars weighing 7.3%; and lastly a motorcycle with a weight of 4.2%.
5. Sub-economic criteria show that the benefit factor gives the largest contribution in determining the priority of road handling,

with a weight of 80.0% compared to the cost of project activities with a weight of 20.0%.

6. A mathematical equation model is obtained to determine the priority sequence of road handling in the provincial road network in Purwakarta Regency based on the AHP method namely:

$$Y = 0{,}687\ \{(0{,}363 \times X_1) + (0{,}274 \times X_2) + (0{,}131 \times X_3) + (0{,}080 \times X_4) + (0{,}061 \times X_5) + (0{,}091 \times X_6)\} + 0{,}183\ \{(0{,}284 \times X_7) + (0{,}211 \times X_8) + (0{,}160 \times X_9) + (0{,}116 \times X_{10}) + (0{,}114 \times X_{11}) + (0{,}073 \times X_{12}) + (0{,}042 \times X_{13})\} + 0{,}130\ \{(0{,}800 \times X_{14}) + (0{,}200 \times X_{15})\}$$

From the results of the research and discussion that has been obtained, it can be given several suggestions related to the determination of priority handling of provincial roads, as follows:

a. Need to do research with a wider study location covering all provincial roads in West Java Province.
b. Calculations for determining the priority sequence for handling provincial roads should use fact data from the field survey results.

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