AHP for Road Maintenance

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Prioritization Of Road Management In District Ogan Komering Ulu Selatan Based On Analytical Hierarchy Process Method

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Abstract: Planning of district road management in District Ogan Komering Ulu Selatan has been based on village level board convention called "musrenbang", ofwhich only a few were accomplished. Government tends to plan road management based on decision making policy, prioritising road management based on intervention policy. The objective of this research was to determine the better prioritization of road management by using analytical hierarchy process method, based on the perceptions of peoplecompetent in road planning, using 5 (five) criteria i.e. road condition, traffic volume, accessibility, policy, and land use. The result of AHP evaluation showed the value of each criteria, with highest value was of road condition criterion(42.4%) subsequently followed by traffic volume criterion (21.4%), accessibility criterion (12.4%), policy criterion (13.3%) and land use criterion (10.4%). It is concluded that, in the prioritization of road management, there should be a standard of various criteria so that the available budget can be allocated precisely and on target.

Index Terms: Analytical Hierarchy Process, Road Management Priority, Ogan Komering Ulu Selatan

1 Introduction

Road is one of important infrastructure in supporting human and goods transportation. Good road infrastructure is able to support economics development in the surrounding area. In the regulation ofUndang-Undang No 38 year 2004, it was mentioned that road plays important role in economics, socio-culture, environment, politic, defence and security, and is maximally used for people prosperity. Therefore, it can be concluded that a road is the arteryof an area development. District OKU Selatan was founded on 18 December 2003, based on UU No. 37, year 2003 concerning the establishment of District Ogan Komering Ulu Selatan, Ogan Komering Ulu Timur, and District Ogan Ilir in South Sumatra Province. Based on Decision Letter of the Regent of Ogan Komering Ulu Selatan No : 600/58/KPTS/PU/2016 concerning the status of road segments and bridges in District Ogan Komering Ulu Selatan, there were 83 district-road segments with total length of 708.129 Km scattered in 19 sub-district. Data on road length released by Central Bureau of Statistics Ogan Komering Ulu Selatan year 2017, there were 262.76 km of good district-road, 291.57 kmof fairly good, 80.15 km of slightly broken, and 73,65 km of heavily broken in the district. With such conditions, there was a need of having appropriate criteria and method so that the policy taken could be more efficient reliable. Previous research had been conducted by Dian (2011) on the evaluation of road conditions and their management prioritization (Case study in Sub-district Kepanjen District Malang).

In the research, road management prioritization was conducted using 5 factors and was concluded that the first priority was emergency factor (29.45%) and subsequently followed by policy factor (28.12%), technical factor 923.18%), land use factor (9.90%), and inter connection with other roads (9.35%). Similar research has also been conducted by Jatmiko (2016) entitled "the Prioritization of District-Road Management in Office Building Areas of TanjungRedeb, District Berau" using 4 criteria, of which the first criterion was road condition (0.4213) and subsequently followed by financial condition (0.3923), traffic volume (0.1043), and area development (0.0820). Both researches showed appropriation in prioritization of road management. In this research, we used 5 criteria i.e. road condition criterion, traffic volume criterion, accessibility criterion, policy criterion, and land use criterion, All criteria were adjusted to the characteristics of the area concerned and the problems faced in the area. The objective of the research was to determine the better prioritization of road management based on AHP method in DistrictOgan Komering Ulu Selatan.

2 Location and Research Methodology

2.1 Research Location

The research was conducted in road segments under authority of District Ogan Komering Ulu Selatan, the map of the location can be seen in Figure 1 below.

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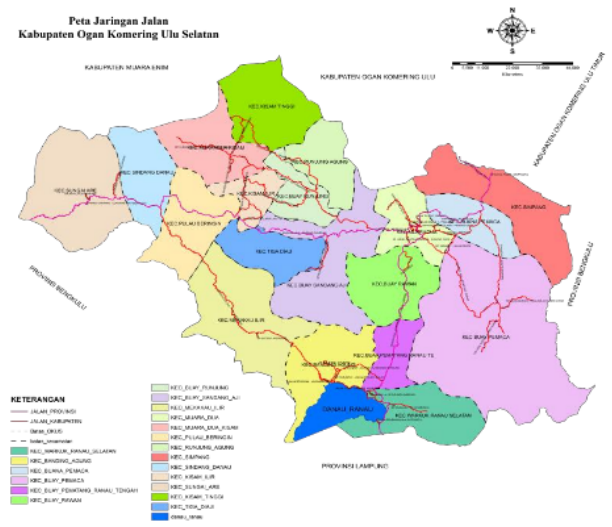

Figur 1. *Map of Road System in District OKUS*

2.2 Analitycal Hierarchy Process (AHP)

According to Saaty (1986), Analytical Hierarchy Process (AHP) in decision making is a simple and flexible method which gather creativities in solving problem. This method solves problems in the form of hierarchy and considers various suggestions to result in relative priority hierarchy. According to Saaty (1986), in the problem solving using AHP method, there were some basic principles of Analyses Hierarchy Process as follow.

1) Decomposition. After defining a problem, it is necessary to decompose the problem, i.e. to breakdown a whole problem into its smallest elements. .
2) Comparative Judgment. This principle means making evaluation on the relative importance of two elements in certain level in connection to element in the immediate higher level. This evaluation is the core of AHP because it will affect the priority of each element.
3) Synthesis of Priority. From each matrix of pairwise comparison, its eigenvector obtain was identified as local priority, because pairwise comparison occurred in each level, and to make global synthesis needs synthesis between local priorities. Procedure of synthesis differs according to the hierarchical form.
4) Logical Consistency. Consistency has two meanings. First, the resemble objects can be grouped according to their variances and relevancies. Second, levels of relations among the objects based on certain criteria.

2.3 Mathematical Model

Mathematical model is a mathematic equation system used to solve a problem, so that the problem solution is simpler. Based on the valuation of criteria from the respondents, priority hierarchy is calculated using mathematical equation system according to Brodjonegoro (1991) as follow:

Y = A (a1 x value a1 + …. + a5 x value a5 + …. + D (d1 x value d1 + …. + d5 x value d5)

where:

Y = Priority hierarchy
A s/d D = alternativevalue level 2 (based on respondent analysis)
a1, a2,… =alternative value level 3 (based on data analysis)

3 Results and Discussion

3.1Calculation of Respondents' Perception

The AHP method was begun with questionnaire distribution to respondents, in this case was distributed to 20 respondents. The data collected from respondents were primary data , the results of interview guided by questionnaire. The perception of 20 respondents on criteria and sub-criteria are presented in the following table.

Table 1. *Perception of Respondents on criteria in the questionnaire*

Responden	Persepsi Responden									
	A : B	A : C	A : D	A : E	B : C	B : D	B : E	C : D	C : E	D : E
R1	3	1	1	1	1	5	3	1	1	1
R2	3	5	1	1	1	3	1	3	1	3
R3	3	3	3	1	3	1	1	1	3	1
R4	3	1	3	5	1	1	3	1	3	1
R5	8	3	3	7	5	5	1	1	1	7
R6	1	1	7	7	5	5	3	1	1	1
R7	7	7	7	7	3	3	3	1	3	1
R8	3	3	3	3	5	3	1	1	1	5
R9	5	5	3	3	1	3	5	1	1	1
R10	3	3	1	1	3	1	3	1	1	5
R11	5	5	5	3	3	1	1	1	1	1
R12	5	3	3	3	3	5	3	1	1	1
R13	1	1	3	3	3	1	3	1	1	1
R14	5	3	2	1	3	4	5	3	3	1
R15	3	1	1	5	3	3	3	2	3	1
R16	1	5	1	1	1	3	3	1	1	3
R17	1	1	3	1	5	3	1	1	3	1
R18	3	1	1	3	3	5	1	3	1	3
R19	5	3	5	1	3	3	3	1	1	3
R20	7	7	1	5	1	7	5	3	1	1

Source: *Analysis Result, 2018*

Notes:
A. Road condition
B. Traffic Volume
C. Accessibility
D. Policy Factor
E. Land Use

Table 2. *Perception of Respondents on Road Condition Sub-criteria*

Responden	Persepsi Responden									
	a1 : a2	a1 : a3	a1 : a4	a1 : a5	a2 : a3	a2 : a4	a2 : a5	a3 : a4	a3 : a5	a4 : a5
R1	1	3	3	3	1	1	1	3	3	1
R2	3	3	5	5	1	1	1	3	1	1
R3	3	3	3	3	1	1	1	3	3	1
R4	5	5	7	5	3	1	1	3	3	1
R5	5	7	7	1	1	1	1	1	1	1
R6	3	1	3	3	1	1	1	1	5	1
R7	3	1	3	7	3	1	1	1	1	1
R8	9	1	7	7	1	1	1	1	1	1
R9	3	3	3	3	1	3	1	1	1	1
R10	1	1	1	1	1	1	1	1	1	1
R11	5	5	3	5	1	1	1	1	1	1
R12	3	1	3	5	3	1	1	3	1	1
R13	3	3	3	3	1	1	1	1	1	1
R14	3	7	5	1	1	1	1	1	1	1
R15	5	5	3	3	1	1	1	3	1	1
R16	3	5	3	5	4	1	1	3	3	1
R17	1	3	5	5	3	1	1	1	3	3
R18	1	1	3	3	1	1	3	3	3	1
R19	3	3	3	5	1	1	3	1	3	1
R20	9	7	9	1	1	1	7	7	5	1

Source: *Analysis Result, 2018*

Notes:
A1 = Holes
A2 = Cavities
A3 = Cracks
A4 = Tire furrow
A5 = Roadside

Table 3. *Perception of Respondents on Traffic Volume Sub-criteria*

Responden	Persepsi Responden						
	b1 : b2	b1 : b3	b1 : b4	b2 : b3	b2 : b4	b3 : b4	
R1	1		5	1		3	3	1
R2	3		3	3		1	3	1
R3	1		3	1		1	1	1
R4		3	4	1		1	3	1
R5	1	1		1		3	1	1
R6	1	1		1		3	1	1
R7		5	5		3	1	1	1
R8	1		3		3	1	1	1
R9	1	1		1		5	3	1
R10	1		5		5	5	1	1
R11	1	1		1		1	1	1
R12	1		3		3	1	1	1
R13	1	1		1		1	1	1
R14	1	1		1		1	1	1
R15	1	3			3	1	5	1
R16		3	1	1		3	1	1
R17	1	1			5	1	5	1
R18		3	3	3		3	1	1
R19	3		1	1		1	5	1
R20	1		7	5		7	3	1

Source: *Analyses Results, 2018*

Notes:
B1 = Light truck
B2 = Bus
B3 = Mini Bus / Passenger vehicle
B4 = Motor cycle

Table 4. *Perception of Respondents on Accessibility Sub-criteria*

Responden	Persepsi Responden
	c1 : c2
R1	1
R2	5
R3	5
R4	7
R5	5
R6	7
R7	2
R8	1
R9	1
R10	5
R11	5
R12	1
R13	5
R14	1
R15	5
R16	5
R17	3
R18	1
R19	3
R20	9

Source: *Analysis result, 2018*

Notes:
C1 = Acess to province Road
C2 = District Road Access

Table 5. *Perception of Respondenton Policy Sub-criteria*

Responden	Persepsi Responden
	d1 : d2
R1	1
R2	1
R3	5
R4	1
R5	7
R6	1
R7	1
R8	9
R9	9
R10	1
R11	7
R12	1
R13	5
R14	1
R15	3
R16	3
R17	7
R18	3
R19	3
R20	7

Source: *Analysis Result, 2018*

Notes:
D1 = Sub-district Convention (Sub-district Musrenbang)
D2 = District Convention (District Musrenbang)

Table 6. *Perception of Respondenton Land Use*

Responden	Persepsi Responden					
	e1 : e2	e1 : e3	e1 : e4	e2 : e3	e2 : e4	e3 : e4
R1	3	1	1	3	3	1
R2	3	1	1	1	5	1
R3	3	1	1	5	3	1
R4	3	5	1	1	1	1
R5	9	5	1	9	9	1
R6	1	1	1	1	1	1
R7	1	1	1	1	1	1
R8	5	1	1	7	7	1
R9	7	1	1	1	3	1
R10	5	3	2	5	5	1
R11	5	1	1	5	5	1
R12	3	3	1	1	3	1
R13	3	3	1	1	3	1
R14	3	1	1	5	1	1
R15	5	1	1	5	1	1
R16	5	5	1	3	1	1
R17	1	3	3	1	5	1
R18	3	3	5	1	3	1
R19	1	1	5	3	3	1
R20	1	1	1	1	1	1

Source : *Analysis Result, 2018*

Notes:
E1 = Agriculture Sector
E2 = Education Sector
E3 = Socio-Culture Sector
E4 = Trade and Service Sector

After values of each criteria were obtained, the next step was doing further analysis by using pair comparison between criteria presented in comparison matrix, and then Eigenvector value (Xi), number of rows, and Wi vale were obtained as presented in the following table.

Table 7. *Eigenvector Value of Criteria*

	A	B	C	D	E	JB	wi	Xi
A	1,000	3,750	3,100	2,642	2,860	87,829	2,448	0,42425
B	0,267	1,000	2,667	2,370	1,720	2,899	1,237	0,21446
C	0,323	0,375	1,000	1,050	1,467	0,186	0,715	0,12386
D	0,379	0,422	0,952	1,000	1,757	0,267	0,768	0,13313
E	0,350	0,581	0,682	0,569	1,000	0,079	0,602	0,1043
				∑			5,769	1,000

Source : *Analysis Result, 2018*

Table 8 . *Eigenvector Value of Road Condition Sub-criteria*

	a1	a2	a3	a4	a5	JB	wi	Xi
a1	1,000	3,600	3,400	4,100	3,700	185,681	2,843	0,475
a2	0,278	1,000	1,096	1,100	1,157	0,387	0,827	0,138
a3	0,294	0,913	1,000	2,100	2,100	1,184	1,034	0,173
a4	0,244	0,909	0,476	1,000	1,100	0,116	0,650	0,109
a5	0,270	0,864	0,476	0,909	1,000	0,101	0,632	0,106
				∑			5,987	1,000

Source: *Analysis Result, 2018*

Table 9. *Eigenvector Value of Traffic Volume Sub-criteria*

	b1	b2	b3	b4	JB	wi	Xi
b1	1,000	1,060	0,866	0,947	0,869	0,966	0,240
b2	0,943	1,000	0,844	0,713	0,568	0,868	0,216
b3	1,154	1,185	1,000	1,000	1,368	1,081	0,269
b4	1,056	1,402	1,000	1,000	1,481	1,103	0,275
			∑			5,018	1,000

Source : *Analysis Result, 2018*

Table 10. *Eigenvector Value of Accessibility Sub-criteria*

	c1	c2	JB	wi	Xi
c1	1,000	3,610	3,610	1,900	0,783
c2	0,277	1,000	0,277	0,526	0,217
		∑		2,426	1,000

Source : *Analysis result, 2018*

Table 11. *Eigenvector Value of Policy Sub-criteria*

	d1	d2	JB	wi	Xi
d1	1,000	0,793	0,793	0,891	0,442
d2	1,261	1,000	1,261	1,123	0,558
		∑		2,013	1,000

Sourcer: *Analysis Result, 2018*

Table 12. *Eigenvector of Land Use Sub-criteria*

	e1	e2	e3	e4	JB	wi	Xi
e1	1,000	0,579	2,100	1,550	1,886	1,172	0,261
e2	1,726	1,000	3,000	3,200	16,570	2,018	0,449
e3	0,476	0,333	1,000	1,000	0,159	0,631	0,141
e4	0,645	0,313	1,000	1,000	0,202	0,670	0,149
			∑			5,491	1,000

Source: *Analysis Result, 2018*

3.2 Calculation of Maximum Eigen Value

Maximum Eigen value was derived from the result of multiplication of original matrix by Eigenvector value of each matrix as the following example.

	A	B	C	D	E		Xi		
A	1,000	3,750	3,100	2,642	2,860		0,424		2,262
B	0,267	1,000	2,667	2,370	1,720	x	0,214	=	1,153
C	0,323	0,375	1,000	1,050	1,467		0,124		0,634
D	0,379	0,422	0,952	1,000	1,757		0,133		0,685
E	0,350	0,581	0,682	0,569	1,000		0,104		0,538
							Jumlah =		5,272

Eigen Maximum (λ maks) = ∑aij . Xi = 5,272

Maximum Eigen value was calculated for each of all sub-criteria.

3.2 Consistency Indeks (CI) Control Value

Consistency Indeks (CI) value was derived from the following equation:

Consistency Index (CI) = (λ max – n)/(n-i), where n is matrix size 5 x 5
= (5.272 – 5)/(5 – 1)
= 0,068

Continued with the following equation to obtain Consistency Ratio (CR) value.

Consistency Ratio (CR) = CI/RI, if n = 5, RI = 1.12
= 0.068/1.12
= 0.061 < 0.1, **consistent**!

Consistency Ratio could be accepted because its value was less than 0,1 or 10%.

3.2 Calculation of Priority Hierarchy

After being determined the value of each element (x1 to x17), to formulate the priority hierarchy of district road management with Analytical Hierarchy Process (AHP) method, then be calculated using mathematical model of Brojonegoro (1991). For example, the calculation of Priority Hierarchy of rad segment K.027 Jagaraga – Pemkab, this road segment categorized as fairly good condition and grouped into type of periodically maintained road with a condition of 100% steady. Below is the mathematical calculation of the example road segment.

Y = 0,424(0,475*3+0,138*1+0,173*2+0,109*1+0,106*3)+
0,214(0,248*0,46+0,252*0,03+0,244*1,99+0,256*7,48)+
0,124(0,783*1+0,17*1)+ 0,133 (0,442*0+0,558*0)+
0,104(0,261*1+0,449*0+0,141*1+0,149*1)
= 3,334

The calculation of other road segments was done in the same way and the result was coded as Y. The Y values of all road segments were then sequentially organized from the highest to the lowest.

4 Conclusion

The result of the research using Analytical Hierarcy Process (AHP) in the determination of road management priority hierarchy showed that the first priority in the road management was for road segment K.027 Jagakarsa – Pemkab, followed by road segment K.018 (Simpang Perkantoran - Perkantoran), road segment K.041 (Banding Agung – Pulau Beringin) and so on. The research used 5 criteria i.e. road condition, traffic volume, accessibility, policy and land use. It is suggested that road management in District OganKomering Ulu Selatan to use several criteria as the basic of road management prioritization.

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