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# The Evaluation of Screening Process and Local Bureaucracy in Determining the Priority of Urban Roads Maintenance and Rehabilitation

**Andri Hendhratmoyo<sup>1</sup>, Syafi'i<sup>2</sup>, and FlorentinaPungky Pramesti<sup>2</sup>**

<sup>1</sup>Student of master program of Civil Engineering, UniversitasSebelasMaret, Jl. Ir. Sutami 36AKentinganJebres Surakarta 57126, INDONESIA

<sup>2</sup>Lecturer of master program of Civil Engineering, UniversitasSebelasMaret, Jl. Ir. Sutami 36A KentinganJebres Surakarta 57126, INDONESIA

Email: [andri.hmoyo80@gmail.com](mailto:andri.hmoyo80@gmail.com)

**Abstract.** Due to the limited budget of urban roads maintenance and rehabilitation, its prioritization is inevitable. Many models have been developed to solve these problems. That is the reason why the purpose of this study was to evaluate the screening process in the decision making of the urban roads maintenance and rehabilitation priority. The prioritization that have to be taken into account on the effect of important criteria are road condition, traffic volume, budget processing and land use. 30 stakeholders were asked to fill in the questionnaires. The object of this case study are 188 urban roads sections at *Ponorogo* in order to examine the priorities. The researchers collected the data from Surface Distress Index (SDI), traffic volume, budget processing and land use of these road sections. Based on analysis, the weights of the criteria were: road condition ( $W_1$ ) = 0,411; traffic volume ( $W_2$ ) = 0,122; budget processing ( $W_3$ ) = 0,363 and land use ( $W_4$ ) = 0,105. The result of this study by the comparison of the index values of the alternatives priorities, *Nyi Ageng Serang* Street, was revealed to have the highest priority over the other streets regarding of maintenance and rehabilitation activities.

## 1. Introduction

In accordance with its characteristics, roads have a tendency to have a declining condition indicated by the occurrence of roads damage. It is necessary to conduct both routine and periodic maintenance in order to maintain the proper conditions of roads. Because of the local government's budget limitation, it is necessary to formulate the policy from relevant stakeholders in determining the roads maintenance and rehabilitation priority with an analytical approach that can integrate with various criteria.

Up to now, many models have been developed to solve various issues related to the decision making, for example by using the methods of Analytical Hierarchy Process (AHP), Fuzzy Logic, VIKOR, and others. [1 - 3] are using the (AHP) method in prioritizing the road maintenance and rehabilitation. [4 - 6] are using fuzzy logic in the priority of road maintenance and rehabilitation. [7] and [8] have first developed research using the fuzzy logic method in determining the priority.

The Fuzzy Logic method, as the prominent component of soft computing builder, has proven to have excellent performance to solve problems that contain uncertainty. Since its introduction by Lotfi Zadeh in 1965, the fuzzy logic sets have an increasing demand by researchers both for the application in certain fields of science, and for developing the concepts given [9].



The budget for road maintenance in *Ponorogo* regency is still much devalued, so it needs various criteria in determining the priority of road maintenance and rehabilitation to reach the right target. Therefore, a screening process is required to decide whether or not a road segment is given the priority of maintenance and rehabilitation. So far the decision on maintenance and rehabilitation of roads still use a random choice system. The impact of the maintenance and rehabilitation of roads, especially in urban areas, becomes improperly targeted.

In this study, the assessment of road conditions uses the Surface Distress Index (SDI) method issued by the Directorate General of Highways Ministry of Public Works [10]. [11] In his research using SDI to determine pavement condition. The value of SDI is used as the basis of screening whether or not the roads get priority, while Fuzzy Logic Method is used to analyze the determining of priority of road maintenance and rehabilitation.

Based on the above description, the right system is necessary so that the activities of urban road maintenance and rehabilitation in *Ponorogo* regency can run well. The purpose of this research was to evaluate the priority of road maintenance and rehabilitation in *Ponorogo* Regency based on the screening process using Surface Distress Index (SDI) method and to evaluate the decision-making system by the policy maker (local bureaucracy).

## 2. Review of AHP and Fuzzy Logic Method

### 2.1. Analytical Hierarchy Process (AHP) Method

The assessment of the criteria and sub criteria uses AHP method. The weight calculation starts from sub criteria, criteria, to priority weight of roads maintenance and rehabilitation. This weighting is required to calculate the total weight of the priority of roads maintenance. The researcher used multicriteria methods to weight, by using the appraisal of pairwise comparison matrix based on Analytical Hierarchy Process (AHP) method. [12] The setting of the quantitative scale of 1 (one) to 9 (nine) is to assess the importance comparison of an element to the others as it is shown in Table 1.

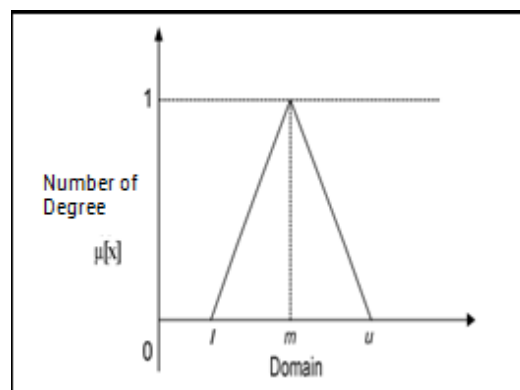
**Table 1.** The Rating Scale Comparison of AHP

Interest's Intensity	Description	Explanation
1	Both elements are equally important	Two elements have the equally large influence on the goal
3	One element is slightly more important than the other elements	Experience and judgment support one element more than the other
5	One element is more important than the other elements	Experience and judgment are very strong in favor of one element over the other
7	One element is more important than the other elements	One strong element is sustained and dominant in practice
9	One absolute element is more important than any other elements	The evidence that supports one element against another has the highest degree of affirmation that might be reinforcing
2,4,6,8	Values between two adjacent considerations	This value is given when there are two compromises between two options
Contrary	If i activity gets one score compared to j activity, then j has the opposite value compared to i	

Source: Saaty, 2008

## 2.2. Fuzzy Logic Method

The fuzzy logic method introduced by [8] uses Triangular Fuzzy Number (TFN). Triangular Fuzzy Number is a combination of two (linear) lines. Figure 1 describes the graph of Triangular Fuzzy Number (TFN) is illustrated in the form of a triangular curve.



**Figure 1.** Triangular Fuzzy Number  
Source: Chang, 1996

The fuzzy triangle scale defines the intensity value of AHP to divide each fuzzy set by two, except for the strength interest of one. Table 2 explains the triangular fuzzy scale [10].

**Table 2.** Fuzzy Triangle Scale

Intensity of Interest AHP	The Set of Linguistics	TFN	Reciprocity
1	Comparison of the same element (equal)	(1,1,1)	(1,1,1)
3	One element is more important than the other (weak)	(1, 3/2, 2)	(1/2, 2/3, 1)
5	One element is more important than that other (fairly strong)	(2, 5/2, 3)	(1/3, 2/5, 1/2)
7	One element is much more important than the others (very strong)	(3, 7/2, 4)	(1/4, 2/7, 1/3)
9	One absolute element is more important than the other (absolute)	(4, 9/2, 9/2)	(2/9, 2/9, 1/4)

The fuzzy logic completion steps according to [8] are as follows:

- Creates a hierarchical structure of the problem to be solved and determines the matrix comparison in pairs between the criteria and TFN scale. The geometric mean is calculated in each value.
- Defines the value of fuzzy synthetic extent (Si) with number I criterion as the following equation:

$$Si = \sum_{j=1}^m M_{gi}^j \otimes \left[ \sum_{i=1}^n \sum_{j=1}^m M_{gi}^j \right]^{-1} \quad (1)$$

In order to obtain the equation,  $\sum_{j=1}^m M_{gi}^j$ , the m value of the matrix in the equation below reveals the fuzzy sum operation. In the final calculation phase, values (1, m, u) are obtained and used for the next phase.

$$\sum_{j=1}^m M_{gi}^j = (\sum_{j=1}^m l_j, \sum_{j=1}^m m_j, \sum_{j=1}^m u_j) \quad (2)$$

1 is the lower limit value, m is the expected value and u is the limiting upper value. So that the equation  $\left[\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j\right]^{-1}$  a fuzzy sum operation is performed from the value  $M_{gi}^j$  ( $J = 1, 2, \dots, m$ ) to obtain the following equation:

$$\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j = (\sum_{i=1}^n l_i, \sum_{i=1}^n m_i, \sum_{i=1}^n u_i) \quad (3)$$

Then, it calculates the inverse of the vector in the above equation to get the equation below:

$$\left[\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j\right]^{-1} = \frac{1}{\sum_{i=1}^n u_i}, \frac{1}{\sum_{i=1}^n m_i}, \frac{1}{\sum_{i=1}^n l_i} \quad (4)$$

c. Calculates the degree of possibility

To obtain the degree of possibility,  $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$  is expressed in the equation below:

$$V(M_2 \geq M_1) = \sup [\min(\mu_{M_1}(x), \mu_{M_1}(y))] \quad (5)$$

And x and y are values on the axis of the membership function of each criteria. This equation can be defined as follows:

$$V(M_2 \geq M_1) = \begin{cases} 1 & , \text{ if } m_2 \geq m_1 \\ 0 & , \text{ if } l_2 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & , \text{ Otherwise} \end{cases} \quad (6)$$

We need the values of  $V(M_2 \geq M_1)$  dan  $V(M_1 \geq M_2)$  to compare  $M_1$  and  $M_2$ .

d. Compares the degree of possibility among the criteria

The comparison between degrees of possibility between  $M_i$  ( $i = 1, 2, 3, 4, 5, \dots, k$ ) can be defined by:  $V(M \geq M_1, M_2, \dots, M_k) = V[(M \geq M_1), (M \geq M_2), \dots, (M \geq M_k)]$  and  $\min V(M \geq M_i)$ , ( $i=1,2,3,\dots,k$ ).

Assume that the equation (7) is:

$$d'(A_i) = \min V(S_i \geq S_k) \quad (7)$$

for  $k = 1, 2, 3, 4, 5, \dots, n$ ;  $k \neq i$ . Then the weight vector is given by (8) as follows:

$$W' = (d'(A_1), d'(A_2), \dots, d'(A_n))^T \quad (8)$$

Where  $A_i$  ( $i=1,2,3,4,5,\dots,n$ ) is  $n$  element.

e. Normalization

Normalization of vector weight is given by the following equation:

$$W = (d(A_1), d(A_2), \dots, d(A_n))^T \quad (9)$$

Where W is a non-fuzzy number of the weight vector.

f. Calculates the global weight

Weighting the criterion and sub criterion vectors reveals the result, and the multiplication of criterion weight with its sub criterion result in the global weight calculation.

### 3. Research Method

The study was in *Ponorogo* Regency on urban roads district covering 4 (four) sub districts of *Ponorogo* Regency: *Ponorogo* District, *Jenangan* District, *Siman* District and *Babadan* District.

In this study, the assessment of interests between the criteria and sub criteria determines the basis for the priority of roads maintenance and rehabilitation. In order to get interest assessment, 30 respondents, who are the policy makers of the road maintenance and rehabilitation in *Ponorogo* regency, filled in the questionnaires.

The obtained data are in the form of value/ weight of the degree of importance between the criteria and sub criteria that affect the decision making of the priority of roads maintenance and rehabilitation. The criteria include: road condition, traffic volume, budget processing, and land use.

The researchers used purposive sampling method to determine the respondents and the selected respondents have the knowledge and competence in the field of roads maintenance and rehabilitation. The data of the road segment that became the object of research is 188 road segments. The 188 road segments are ranked based on the Surface Distress Index (SDI), that was SDI values  $> 50$  (above 50) received the priority of roads maintenance and rehabilitation and SDI values  $< 50$  (below 50) did not receive the priority of roads maintenance and rehabilitation, as the roads were categorized in good condition.

After knowing the weights (W) criterion, the next step is to analyze each alternative road segment to get the priority total weight of roads maintenance and rehabilitation from the highest to the lowest. The ranking priority of roads maintenance and rehabilitation used the value of total weight. The calculation of alternative weight starts from the criteria of road conditions on each road segment. Alternative weight assessment determines the sub criteria of road conditions that are total area of cracks, average crack widths, the total number of potholes and the average depth of wheel rutting [9]. Tables 3, 4, 5 and 6 explain the further detailed information.

**Table 3.** The Assessment of Alternative Weight on Total Area of Cracks

No.	Percentage total area of cracks	Weight Assessment
1	None	1
2	Percentage of cracks: $< 10\%$	2
3	Percentage of cracks: $10 - 30\%$	3
4	Percentage of cracks: $> 30\%$	4

**Table 4.** The Assessment of Alternative Weight on Average Crack Widths

No.	Average Crack Width	Weight Assessment
1	None	1
2	Average Crack Width: FINE $< 1\text{ MM}$	2
3	Average Crack Width: MED $1 - 3\text{ MM}$	3
4	Average Crack Width: WIDE $> 3\text{ MM}$	4

**Table 5.** The Assessment of Alternative Weight on Total Number of Potholes

No.	Total Number of Potholes	Weight Assessment
1	None	1
2	The number of potholes: $< 10 / \text{KM}$	2
3	The number of potholes: $10 - 50 / \text{KM}$	3
4	The number of potholes: $> 50 / \text{KM}$	4

**Table 6.** The Assessment of Alternative Weight on Average of Depth Wheel Rutting

No.	Average of Depth Wheel Rutting	Weight Assessment
1	None	1
2	Depth of Rutting: $< 1\text{ CM}$	2
3	Depth of Rutting: $1 - 3\text{ CM}$	3
4	Depth of Rutting: $> 3\text{ CM}$	4

The next alternative weight assessment is on traffic volume criteria. Table 7 shows the detailed interval division of traffic volume.

**Table 7.** The Alternative Weight Assessment of traffic volume

<b>Traffic Volume</b>	<b>Weight Assessment</b>
< 2000	1
2000 - 4000	2
4000 - 6000	3
> 6000	4

The following alternative weight assessment is on the criteria of the budget processing. The alternative weight assessment for each road segment can be made as follows:

- Getting a priority proposal at the District Community Consultations on Development Planning is given a value of 4. If there is no priority proposal the given value is 1.
- Getting a priority proposal at the Local Government Work Departments Forum is given a value of 4. If it does not get a priority proposal, the value is 1.
- Getting a priority proposal in the Regency Community Consultations on Development Planning is given a value of 4. If there is no priority proposal, the given value is 1.
- Listed or entered in the Local Government Budget is given a value of 4. If it is not listed or entered, the given value is 1.
- Listed or entered in the Revised Local Government Budget is given a value of 4. If it is not listed or entered, the given value is 1.

The last assessment of the alternative weight is on the land use criteria. The amount of value is adjusted to the land or space utilization with the following scoring system:

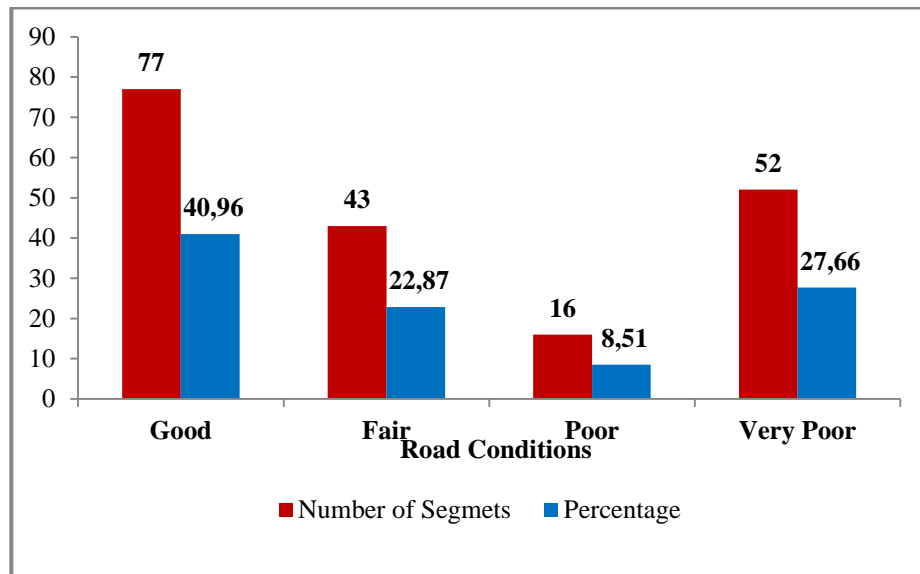
- If the road segment can support the social cultural activities, the given value is 4. If it cannot support the activities, the given value is 1.
- If the road segment can support the trade and industry activities, the given value is 4. If it cannot support the activities, the given value is 1.
- If the road segment can support the agricultural and plantation activities, the given value is 4. If it cannot support the activities, the given value is 1.
- If the road segment can support settlement activities, the given value is 4. If it cannot support the activities, the given value is 1.

#### 4. Result and Discussion

Based on the survey of road conditions and the value of Surface Distress Index [10] on 188 urban road segments, the assessment results of road condition ranks are 111 road segments received priority maintenance and rehabilitation (Fair Condition, Poor Condition, and Very Poor Condition). The graph of road conditions as it shown in figure 2.

From the analysis result using the Fuzzy Logic method, the weight for each criterion is as follows: road condition criteria is  $(W1) = 0.411$ , traffic volume criteria is  $(W2) = 0.122$ , budget processing criteria is  $(W3) = 0.363$  and the land use criteria is  $(W4) = 0.105$ . While the priority sequence in roads maintenance and rehabilitation is *Nyi Ageng Serang Street*, the second priority up to the tenth in a row *MT. Haryono Gg. VI Street, Delima Street, Barito Street, Ukel Street, Larasati Street, Truntum Street, MT. Haryono Gg. V Street, Subali Street and Jenar Street*. Figure 3 and 4 shows detailed weight of criterion and sub criteria.



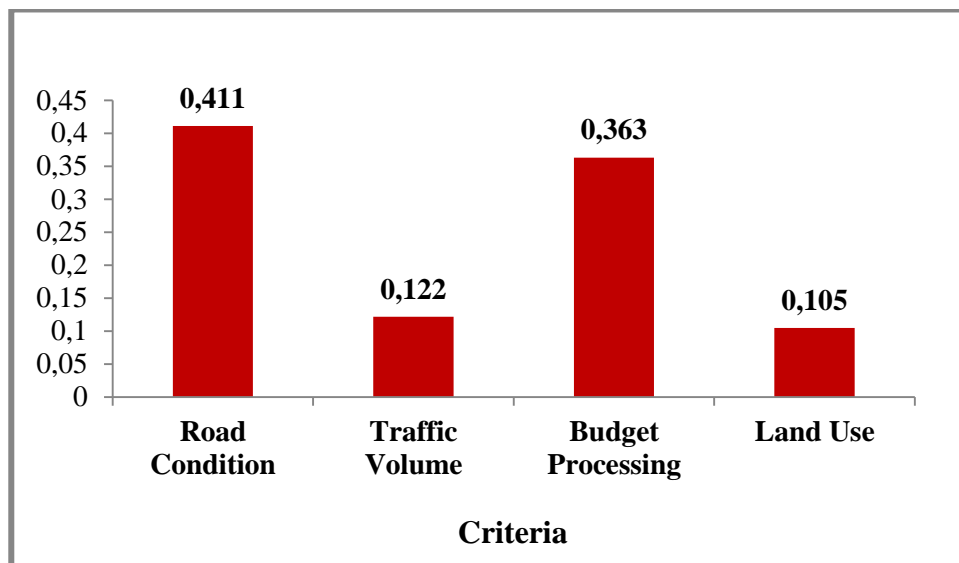


**Figure 2.** The Graph of Road Conditions

Weight	
Criteria	Sub Criteria
<b>Road Condition</b> (W1=0,411)	Total Area of Cracks (0,266)
	Average Cracks Widths (0,197)
	Number of Potholes (0,298)
	Depth Wheel Rutting (0,239)
<b>Traffic Volume</b> (W2=0,122)	Heavy Vehicle (0,284)
	Bus (0,284)
	Light Vehicle (0,216)
	Car (0,141)
	Motorcycle (0,075)
<b>Budget Processing</b> (W3=0,363)	District Community Consultations on Development Planning (0,254)
	Local Government Work Department Forum (0,088)
	Regency Community Consultations on Development Planning (0,218)
	Local Government Budget (0,270)
	Revised Local Government Budget (0,169)
<b>Land Use</b> (W4=0,105)	Social Cultural Activities (0,197)
	Trade and Industry Activities (0,271)
	Agricultural and Plantation Activities (0,274)
	Settlement Activites (0,258)

**Figure 3.**The Weight of Criteria and Sub Criteria Roads Maintenance and Rehabilitation





**Figure 4.** The Graph of Criteria

The important matters based on the result of the study are:

1. Based on the rank of the Surface Distress Index value, from the total 188 road segments, there are 111 road segments that get the priority of maintenance and rehabilitation. It means that 77 road segments do not get the priority (good condition). 111 road segments which get the priority are ranked from a fair condition, poor condition and very poor condition. In this study, Surface Distress Index method is an effective method in the screening process of road condition assessment.
2. The criterion of road condition are the most important criteria of inter interests assessment according to the respondents (policy maker). The next criterion is Budget Processing, and continues to the traffic volume and the land use criteria.
3. Budget Processing criterion become a keyfactor in prioritizing the road maintenance and rehabilitation. The road condition criteria is  $(W1) = 0.411$  and the budget processing criteria is  $(W3) = 0.363$ . It shows that the local bureaucracy influence is highly visible in determining the priority of maintenance and road rehabilitation.
4. Budget Processing criterion becomes the most important criterion after the Road Condition. It is because of the most respondents comes from the bureaucracies who understand that the priority of roads maintenance and rehabilitation must go through the correct budget processing and by the applicable of rules.

## 5. Conclusion

Based on the analysis using the fuzzy logic method, the weight for each criterion is as follows: the road condition criterion is  $(W1) = 0.411$ , the traffic volume criterion is  $(W2) = 0.122$ , the budget processing criterion is  $(W3) = 0.363$  and the land use criterion is  $(W4) = 0.105$ .

Based on the analysis, budget Processing becomes the second most important criterion after the road condition. It shows that the role of local bureaucracy is very important in the process of decision-making of road maintenance and rehabilitation. While the priority order of the roads maintenance and rehabilitation is *Nyi Ageng Serang* Street.

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