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Risk Analysis of Surabaya – Bojonegoro Highway Improvement Project Based on Fuzzy Logic

Nova Nevila Rodhi[1]

[1]*Faculty of Faculty of Science and Engineering, Universitas Bojonegoro.*
Email : [1]*nova.nevila@gmail.com* .

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A B S T R A C T

Infrastructure development is one of the efforts to improve the welfare of the community, but in its implementation, road construction projects have risks that can have an impact on the project as well as on the external side of the project. This research is a case study on the road widening project of Bojonegoro – Surabaya KM 107. The purpose of this research is to analyze the risks in the project using fuzzy logic. Based on the results of the analysis, it can be concluded that the Bojonegoro - Surabaya highway widening project has 10 risk factors, namely noise, air pollution, heavy equipment vibration, traffic accidents, congestion, reduced parking space, increased fuel consumption of road users, decreased income of people in surrounding locations, conflict between road users, covid 19. The results of the analysis using a risk matrix, all risk factors are at a moderate level, but the results of the analysis using fuzzy, there are 2 risks that are at a high level, namely traffic congestion and a decrease in people's income in surrounding locations.

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1. Introduction

The implementation of infrastructure development projects is being intensively carried out by the Bojonegoro district government, one of which is the Surabaya - Bojonegoro KM 107 highway improvement project. Roads are one of the infrastructures that can support the local community's economy, this is in line with the objectives of the Ministry of Public Works Restra in 2010 which states that the construction of road and bridge infrastructure aims to support the distribution of goods and human traffic and to form a regional spatial structure. [1] [2]. Road construction projects have risks that impact the surroundings [3] [4] [5]. The road construction project process has risks that have an impact on the environment [1]. Risk is generally defined as the probability of an unexpected event occurring [6] [7], While the notion of project risk in risk management is the cumulative effect of uncertain event opportunities, which affect project goals and objectives [8]. Risk plays an important role in every decision making and can affect project performance [9] [10]. To minimize project risk, a risk management system can be implemented as stated in the risk management concept [11] [12], in risk management only has 4 (four) stages, namely, risk identification, risk quantification, risk response and risk monitoring and control where planning in these stages can be carried out together [13], [14]

Different risk patterns from one project to another require the concept of handling with different methods, one way to analyze risk is to convert qualitative data into quantitative data. [15]. For risk analysis, generally the data used is based on the respondent's expert judgment, so that the data is allegedly ambiguous. For data processing with ambiguous elements, the results of the study recommend the fuzzy logic method for effective risk data analysis [16] [17] [18]. The fuzzy method is suitable for risk analysis of road improvement [19]. The results of the Mamdani fuzzy analysis are considered to be able to provide a more feasible solution. As explained by Khalifa dkk 2015 [21] and Rodhi (2021) [20], that the fuzzy method is very suitable for cases that have a high risk, but minimal data.

The purpose of the study was to analyze the risk of the Surabaya - Bojonegoro Highway Improvement Project based on Fuzzy Logic. The results of this study can be used as a reference to solve problems related to the failure of road widening projects, especially in terms of efforts to implement early warning so as to minimize and overcome the risks of road widening projects.

2. Research Method

This study uses an observation method with a quantitative approach. Primary data collection in this study was carried out by distributing questionnaires to respondents. The population in this study is a road contractor company working on a highway project in Bojonegoro Regency. As for the sample, 10 contractors were selected using a purposive sampling method from contractor companies to be respondents. The 10 respondents with the criteria of contractors who have experience working on highway projects for at least 10 years with a nominal project cost of at least Rp. 500,000,000 (five hundred million rupiah).

Table 1. Risk variables of the Bojonegoro – Surabaya highway widening project

No	Risk Factor
1	Noise
2	Air pollution
3	Heavy equipment vibration
4	Traffic accident
5	Congestion
6	Less parking space
7	Increased fuel consumption of road users
8	Decrease in people's income in surrounding locations
9	Conflict between road users
10	Covid 19

Source: Identification results, (2021)

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The instrument used for the assessment of risk variables in this study was carried out by assessing the probability and impact through distributing questionnaires to respondents. As for the measurement criteria used, it was obtained based on a literature review which was then adjusted to the measurement patterns commonly used in highway construction projects.

Table 2. Likert Scale Used to Determine the Level of Risk

Scale	Impact	Description	Probability
1	Insignificant	Minimal impact	Never
2	Minor	Short-term impact	Unlikely
3	Moderate	Significant impact	Possible
4	Major	Major Short-term impact	Likely
5	Catastrophic	Major Long-term impact	Always

Source: Rodhi, 2015 [3]

Risk		Probability				
		1	2	3	4	5
Impact	1	L	L	L	L	L
	2	L	L	L	M	M
	3	L	L	M	M	H
	4	L	M	M	H	H
	5	M	M	H	H	H

Source: PMI (2013) [14]

Figure 1. Risk Matrix in Research

Figure 1 explains that there are 3 levels of risk, namely low (L) in green, medium (M) in yellow and high (H) in red. From the results of matrix-based risk analysis, further analysis is carried out using fuzzy logic.

The application of the fuzzy logic method in this study, the selected function is a triangular function. The input membership degrees are built based on the risk categories that have been used in infrastructure projects, namely low, medium and high. As for the degree of membership, the output is built based on the categories proposed by Rodhi 2021 [20].

Table 3. Input Values in Fuzzy

No	Fuzzy Variables	Fuzy Numbers of Probability	Fuzy Numbers of Impact
1	Low	(1 ; 2 ; 3)	(1 ; 2 ; 3)
2	Medium	(2 ; 3 ; 4)	(2 ; 3 ; 4)
3	High	(3 ; 4 ; 5)	(3 ; 4 ; 5)

Source: Rodhi, (2021) [20]

Table 4. Output Value in Fuzzy

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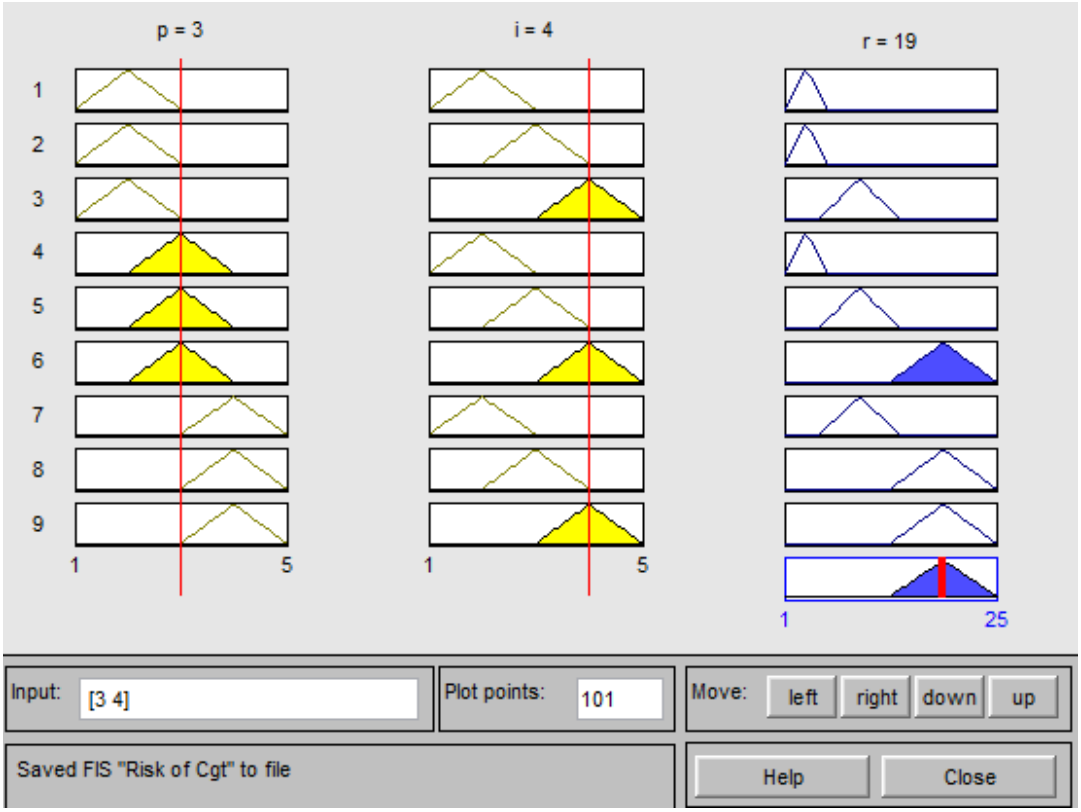
No	Fuzzy Variables	Fuzy Numbers	Fuzy Numbers (Normalization)
1	No	0	(1; 2; 3)
2	Negligible	0.1	(2; 3; 4; 5; 6; 7; 8)
3	Low	0.3	(7; 8; 9; 10; 11; 12; 13)
4	Medium	0.5	(12; 13; 14;15; 16;17 ; 18)
5	High	0.7	(17; 18; 19; 20; 21; 22 ; 23)
6	Very High	0.9	(22; 23; 24)
7	Full	1	(23; 24; 25)

Source: Rodhi, (2021) [20]

4. Results and Discussions

Data analysis was carried out by calculating the probability and impact values, then the analysis was carried out using the fuzzy logic method. The results of the analysis are presented in Figure 2 and Table 5 below:



Source: Analysis results, (2021).

Figure 2. Risk analysis using fuzzy logic

Figure 2 above is an example of a risk analysis process using fuzzy which is applied to the congestion variable, where the probability value is 3 and the impact value is 4 which then produces a risk value of 19. The same process is carried out one by one on the other 9 variables whose results are listed in table 5 below:

Table 5. Results of risk analysis of the Bojonegoro - Surabaya highway widening project

No	**Risk Factors**	**P**	**I**	***Probability Impact Matrix***	***Fuzzy***

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				Risk	Level	Risk	Level
1	Noise	3	3	**9**	**S**	**15.0**	**M**
2	Air pollution	2	3	**6**	**S**	**12.5**	**M**
3	Heavy equipment vibration	3	3	**9**	**S**	**15.0**	**M**
4	Traffic accident	3	2	**6**	**S**	**12.5**	**M**
5	Congestion	4	3	**12**	**S**	**19**	**H**
6	Less parking space	3	3	**9**	**S**	**15.0**	**M**
7	Increased fuel consumption of road users	3	3	**9**	**S**	**15.0**	**M**
8	Decrease in people's income in surrounding locations	3	4	**12**	**S**	**19**	**H**
9	Conflict between road users	3	3	**9**	**S**	**15.0**	**M**
10	Covid 19	3	3	**9**	**S**	**15.0**	**M**

Source: Analysis Results, (2022)

From table 5 it can be explained that the noise risk factor in a probability impact matrix has a risk value of 9 with a moderate risk level. Meanwhile, with the fuzzy method, the risk factor is also at a moderate (M) level with a value of 15. The risk factor for air pollution by probability impact matrix has a risk value of 6 with a moderate (M) risk level. Meanwhile, with the fuzzy method, the risk factor is also at a moderate level with a value of 12.5.

The risk factor for heavy equipment vibration in a probability impact matrix has a risk value of 9 with a moderate (M) risk level. Meanwhile, with the fuzzy method, the risk factor is also at a moderate level with a value of 15. The risk factor for traffic accidents in a probability impact matrix has a risk value of 6 with a moderate risk level. Meanwhile, with the fuzzy method, the risk factor is also at a moderate (M) level with a value of 12.5.

The risk factor for congestion in the probability impact matrix has a risk value of 12 with a moderate (M) risk level. However, with the fuzzy method, the risk factor is at a high (H) level with a value of 19. The risk factor for reducing parking space by probability impact matrix has a risk value of 9 with a moderate (M) risk level. Meanwhile, with the fuzzy method, the risk factor is also at a moderate level with a value of 15.

Risk factors the increase in fuel consumption of road users by probability impact matrix has a risk value of 9 with a moderate (M) risk level. Meanwhile, with the fuzzy method, the risk factor is also at a moderate level with a value of 15. The risk factor for decreasing people's income in the surrounding location by means of a probability impact matrix has a risk value of 12 with a moderate (M) risk level. However, with the fuzzy method the risk factor is at a high (H) level with a value of 19.

The risk factor for conflict between road users in a probability impact matrix has a risk value of 9 with a moderate (M) risk level. Meanwhile, with the fuzzy method, the risk factor is also at a moderate (M) level with a value of 15. The risk factor for covid 19 in a probability impact matrix has a risk value of 9 with a moderate (M) risk level. Meanwhile, with the fuzzy method, the risk factor is also at a moderate (M) level with a value of 15. The results of the matrix-based analysis are different from the fuzzy results. To assess the risk, it certainly has a very significant effect.

5. Conclusion and Suggestion

5.1 Conclusion

Based on the results of the analysis, it can be concluded that the Bojonegoro - Surabaya highway widening project has 10 risk factors, namely noise, air pollution, heavy equipment

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vibration, traffic accidents, congestion, reduced parking space, increased fuel consumption of road users, decreased income of people in surrounding locations, conflict between road users, covid 19. The results of the analysis using a risk matrix, all risk factors are at a moderate level, but the results of the analysis using fuzzy, there are 2 risks that are at a high level, namely traffic congestion and a decrease in people's income in surrounding locations

5.1 Suggestion

It is necessary to develop research related to the use of fuzzy logic for risk analysis, in addition to using the Mamdani fuzzy method, the Tsukamoto fuzzy method can also be used, so that comparisons can be made regarding the effectiveness of the fuzzy method for risk analysis.

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