Project Delay Analysis Using Fault Tree Analysis (FTA) Method And Failure Mode And Effect Analysis (FMEA) Method (Case Study of the Karian Rangkasbitung Dam Development Project)

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ABSTRACT

The Karian Dam Project is one of a total of 48 dam construction strategic projects in Indonesia that have experienced delays. Based on Addendum 6, the Karian Dam Project is targeted for completion in March 2021. However, the Karian Dam Project experienced delays in several works. This study discusses the factors of delay, the location of the risk of delay, and the work item assistance that causes delays in the Karian Dam Project. The research method used in this study is a quantitativ. Data collection was carried out using questionnaires and interviews. The obtained data is then analyzed using the Fault Tree Analysis (FTA) method to find the source of risk that is the cause of the delay. The subsequent analysis uses the Failure Mode and Effect Analysis (FMEA) method to assess the risks that have been identified using the FTA method for risk capture. According to the findings, there are 47 potential sources of delay in the FTA method. After calculating the probability index, it is found that activity A9-1 (planning and implementation) has the highest probability index value of 4. The FMEA method obtains the highest value of the highest Risk Priority Number (RPN) there is R-42 (planning change) with an RPN value of 64, and on arrest risk using the search risk matrix, as many as 9 risks are at high risk (high risk).

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1. INTRODUCTION

The development of dam infrastructure in Indonesia is a form of a government effort to provide raw water, flood control, irrigation water needs, and the development of water tourism destinations. In fact, the construction of dams in Indonesia is still very slow and lagging compared to neighboring countries. Seeing this condition, the Indonesian government is currently actively trying to accelerate infrastructure development, especially dams, to improve people's welfare.
In the Presidential Regulation of the Republic of Indonesia (Perpres RI) Number 109 of 2020, out of a

total of 201 PSNs, 48 are in the dam construction sector. One of them is the Karian Dam, which is located in Rangkasbitung District, Lebak Regency, Banten [1]. The construction of the Karian Dam aims to develop the water tourism sector, provide additional irrigation for the Ciujung area, supply raw water for cities and industries in Tangerang City, Tangerang Regency, Serang City, Serang Regency, Cilegon City, DKI Jakarta, and Mini Hydro Power Plant (PLTM)[2].
Based on Addendum 6 planning, the Karian Dam project is expected to be completed in March 2021 [3]. However, in fact, according to the construction progress data as of December 13, 2021, the construction of the Karian Dam has only reached 93.43%, in other words, the Karian Dam development project has experienced delays since the last contract addendum [4].
According to Leonda (2008), delays in construction projects refer to the time the project is reworked after it has been approved in the contract and is underway. Completion of work that is not on time is a sign of decreased productivity and wasteful obstacles in terms of project financing, both in the form of long-term loans and other investments.

2. METHODS

2.1 Research Stages

Figure 1 shows the stages of the research.

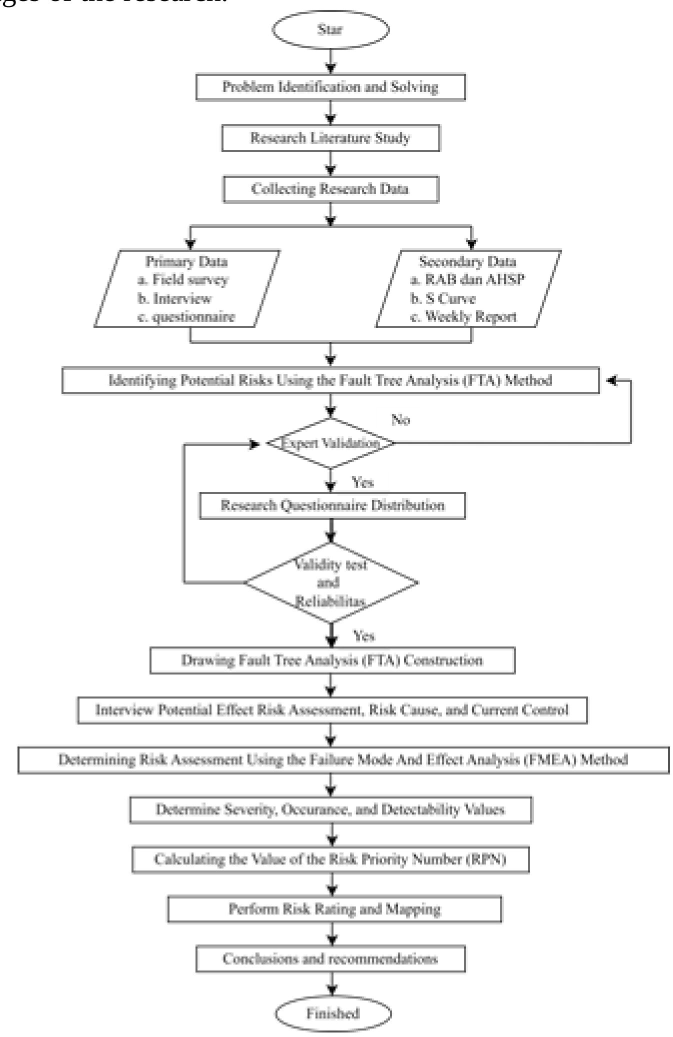


Figure 1. Research Flow Chart

The expert validation test uses the Aikenns v content validation test, with the formula

$$V = \frac{\sum s}{n\ (c - 1)} \quad (1)$$

2.2 Types and Data Sources

There are two types of data used in this study, primary data and secondary data.

a. Primary Data
   Primary data is information that has been collected from research sources such as interviews, group or individual opinions, and observations of an object.
b. Secondary Data
   Secondary data is information derived from project documents, such as the budget plan document, the time schedule document, and the Karian Dam Project weekly report document.

2.3 Method of Collecting Data

The self-administered survey method is a data collection technique by giving questionnaires to respondents and asking respondents to fill out the questionnaire and explaining the purpose of the questions in the questionnaire if the respondent asks at the beginning of the questionnaire so that the respondent understands. There are two types of ways of collecting data, namely:

a. Through the household drop-off survey, respondents were asked to fill out the questionnaire given, and the completed questionnaire was returned to the author by the deadline given.
b. Via email, respondents will be given a questionnaire via email and the author will remind the respondent until the questionnaire is filled out and sent back to the author. Primary data is

2.4. Method of Data Analysis

The method used to identify possible risks is the Fault Tree Analysis (FTA) method. Fault Tree Analysis is presented in the graphical form that contains several event symbols. After creating a Fault Tree Analysis diagram, the overall probability calculation of the previously identified delay risks and calculating the impact (severity) arising from these risks uses the Failure Mode and Effect Analysis (FMEA) method. The identified risks are then subjected to a risk assessment. This analysis phase begins by determining the potential effect, risk cause, and current control. The severity of the impact that will be caused can be identified through the potential effect identification indicator. Meanwhile, to assess how often the risk occurs (occurance) can be identified through the risk cause (detectability) a risk can be detected and can be measured through identification through current control then the value of the Risk Priority Number (RPN) can be calculated.

After the Risk Priority Number (RPN) is calculated, carry out a risk classification to determine the priority and risk rating according to the calculation. Then the risk mapping used two assessments, namely severity and occurrence. The risk level used for risk mapping consists of low risk, medium risk, and high risk. Risk mapping can show the level of each identified risk based on two risk factors, namely consequence (severity) and probability (occurrence). The matrix used is in the form of 5x5 with a combination of severity and frequency scores to provide an overview of each level of risk. risk) is shown in red. The image of the risk mapping matrix according to the consequences (severity) and likelihood (occurance) can be seen in the graphic below:

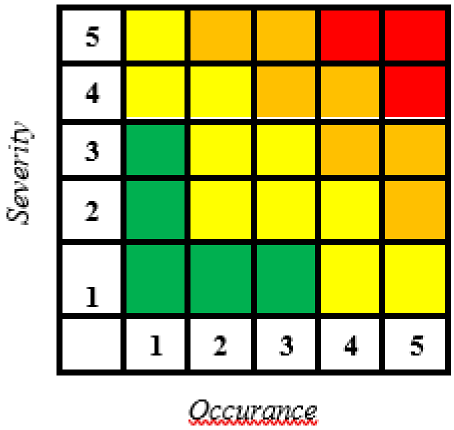


Figure 2. Risk Mapping Matrix

3. RESULTS AND DISCUSSION

In this study, there are 2 types of validity that are used for different purposes, namely expert validation tests and content validity tests. expert validation test is used to obtain expert agreement to find out whether the instrument indicators are appropriate and relevant to be used as research indicators. while the validity test is used to assess the results, how good and by the existing theory, and also other measures of similar concepts.

3.1 Expert Validation Test

Before carrying out the distribution of the research questionnaire, a validation test was carried out on experts. This expert validation test entails three competent experts determining whether the research instrument was able to measure what was measured. This expert validation test uses the aikenns v content validation test. Table 1 shows the results of expert validation.

Table 1. Expert Validation Test Results

No	∑S	V	Validity	No	∑S	V	Validity
1	7	0,58	Medium	29	5	0,42	Medium
2	5	0,42	Medium	30	7	0,58	Medium
3	3	0,25	Low	31	9	0,75	Medium
4	4	0,33	Low	32	5	0,42	Medium
5	5	0,42	Medium	33	6	0,5	Medium
6	5	0,42	Medium	34	6	0,5	Medium
7	3	0,25	Low	35	6	0,5	Medium
8	7	0,58	Medium	36	7	0,58	Medium
9	3	0,25	Low	37	5	0,42	Medium
10	4	0,33	Low	38	5	0,42	Medium
11	5	0,42	Medium	39	3	0,25	Low
12	3	0,25	Low	40	4	0,33	Low
13	5	0,42	Medium	41	5	0,42	Medium
14	7	0,58	Medium	42	6	0,5	Medium
15	3	0,25	Low	43	7	0,58	Medium
16	5	0,42	Medium	44	6	0,5	Medium
17	5	0,42	Medium	45	5	0,42	Medium
18	7	0,58	Medium	46	6	0,5	Medium
19	3	0,25	Low	47	8	0,67	Medium
20	6	0,5	Medium	48	9	0,75	Medium

21	7	0,58	Medium	49	6	0,5	Medium
22	7	0,58	Medium	50	10	0,83	High
23	9	0,75	Medium	51	11	0,92	High
24	5	0,42	Medium	52	8	0,67	Medium
25	5	0,42	Medium	53	7	0,58	Medium
26	7	0,58	Medium	54	8	0,67	Medium
27	5	0,42	Medium	55	8	0,67	Medium
28	5	0,42	Medium	56	11	0,92	High

The results of the expert validation test table show that the instrument is declared valid if the Aiken V value is > 0,4. For instruments that were distributed as many as 56 and obtained valid results as many as 47 and invalid there were 9 instruments. In this study, the instruments that will be used are 47 instruments that have been validated by the expert agreement.

3.2 Validity Test

The purpose of the validity test is a way to find out how good the measuring instrument is and can measure what is to be measured. The validity test used was the Aikens Index v. The assessment was carried out by giving questionnaires to respondents with a Likert score of 1 to 5. This validity test was carried out with the help of Microsoft Excel software and was carried out on 7 respondents.

Table 2. Validity Test Results

No	∑S	V	Validity	No	∑S	V	Validity
1	8	0,7	Medium	25	19	1,6	High
2	8	0,7	Medium	26	10	0,8	High
3	8	0,7	Medium	27	14	1,2	High
4	12	1	High	28	12	1	High
5	20	1,7	High	29	17	1,4	High
6	8	0,7	Medium	30	12	1	High
7	10	0,8	High	31	12	1	High
8	12	1	High	32	16	1,3	High
9	12	1	High	33	9	0,8	Medium
10	20	1,7	High	34	11	0,9	High
11	6	0,5	Medium	35	8	0,7	Medium
12	11	0,9	High	36	11	0,9	High
13	20	1,7	High	37	16	1,3	High
14	10	0,8	High	38	18	1,5	High
15	8	0,7	Medium	39	12	1	High
16	17	1,4	High	40	9	0,8	Medium
17	12	1	High	41	8	0,7	Medium
18	13	1,1	High	42	20	1,7	High
19	9	0,8	Medium	43	19	1,6	High
20	12	1	High	44	19	1,6	High
21	12	1	High	45	13	1,1	High
22	18	1,5	High	46	15	1,3	High
23	8	0,7	Medium	47	21	1,8	High
24	10	0,8	High				

The results of the second stage of the questionnaire tabulation table indicate that the instrument is declared valid if the value of Aiken's V > 0,4. For the instruments that were distributed as many as 47 and obtained very good results as many as 47, it can be concluded that the instruments used in this study can be used as a research measurement tool.

3.3 Reliability Test

The reliability test was carried out on the questionnaire statement items, which were considered valid by experts. The instrument reliability coefficient is used to assess how consistently respondents respond to the statement items in the questionnaire. Decision-making on the reliability test is based on the Cronbach's Alpha value > 0,60 if the Cronbach's Alpha value is < 0,60 then it is declared unreliable. Figure 1 shows the results of the reliability test.

Reliability Statistics

Cronbach's Alpha	N of Items
.726	47

Figure 3. Reliability Test Results

The result of the reliability coefficient of the instrument is 0.726 indicating that the Cronbach's Alpha value is 0.726> 0.600. So on the results of reliability testing, it can be said that all statements on the questionnaire variables are reliable.

3.4 Fault Tree Analysis (FTA) Risk Identification Results

The identification results of the Fault Tree Analysis (FTA) are used to determine possible delays that may occur during the Karian Dam construction project. The fault tree model below shows each risk of delay in the Karian Dam Development Project.

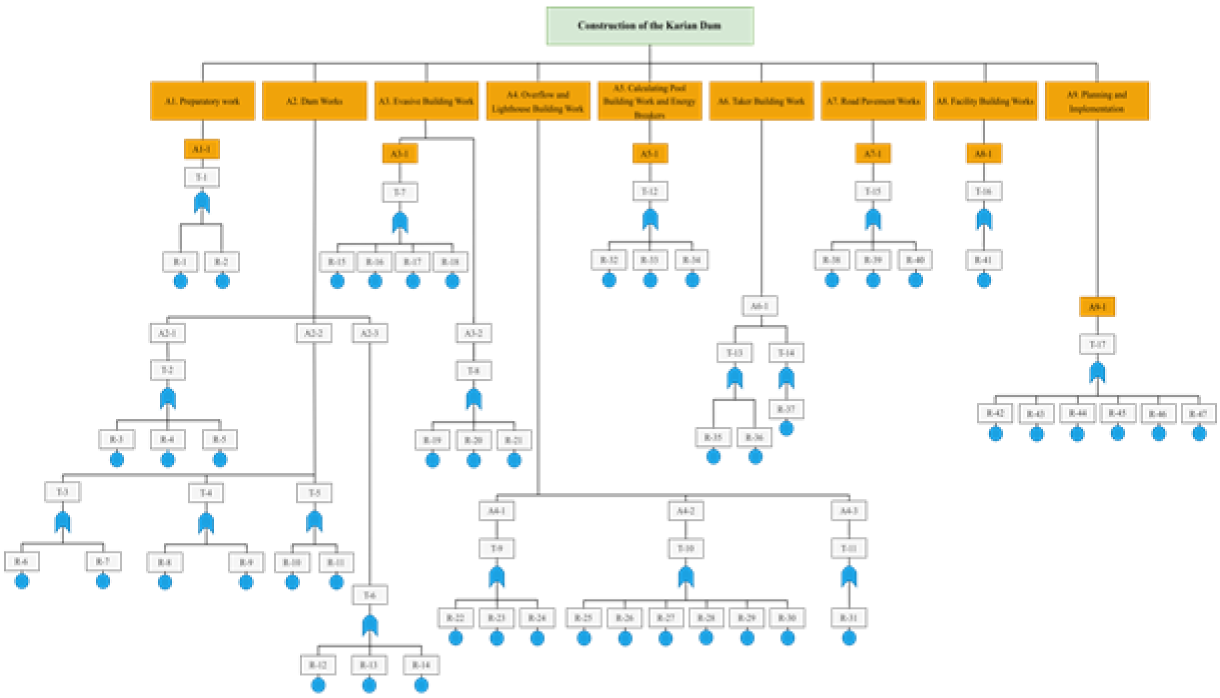


Figure 4. Reliability Test Results

3.5 Assessment of Severity, Occurance, and Detectability

The second stage of the questionnaire data that have been tabulated is then calculated using Microsoft Excel software to obtain the severity, occurrence, and detectability values. The results of data processing and assessment using Microsoft Excel software for each criterion for severity, occurrence, and detectability values are shown in the following Table 3.

Table 3. Assessment of Severity, Occurance, and Detectability Results

Risk Code	Severity	Occurance	Detectability	Risk Code	Severity	Occurance	Detectability
R - 1	2	2	2	R - 25	4	4	3
R - 2	2	2	2	R - 26	2	2	2
R - 3	2	2	2	R - 27	3	3	3
R - 4	2	2	3	R - 28	3	3	3
R - 5	4	3	4	R - 29	3	3	3
R - 6	2	2	2	R - 30	2	3	3
R - 7	2	2	3	R - 31	3	2	3
R - 8	2	3	2	R - 32	3	3	3
R - 9	2	3	3	R - 33	2	2	2
R - 10	4	4	3	R - 34	2	3	2
R - 11	2	2	2	R - 35	2	2	2
R - 12	2	2	2	R - 36	3	3	2
R - 13	3	4	3	R - 37	3	3	3
R - 14	2	2	2	R - 38	3	3	3
R - 15	2	2	2	R - 39	2	2	3
R - 16	3	4	3	R - 40	2	3	2
R - 17	2	3	3	R - 41	3	2	2
R - 18	3	3	2	R - 42	4	4	4
R - 19	2	2	2	R - 43	4	4	3
R - 20	3	2	2	R - 44	4	3	4
R - 21	2	2	2	R - 45	2	3	3
R - 22	3	3	4	R - 46	3	3	3
R - 23	1	2	2	R - 47	3	4	4
R - 24	2	2	2				

After obtaining the severity, occurrence, and detectability values, the severity, occurrence, and detectability recapitulation values are obtained for the risk of delays in the Karian Dam Development project. Figure 4 is a graph of the results of the severity recapitulation value.

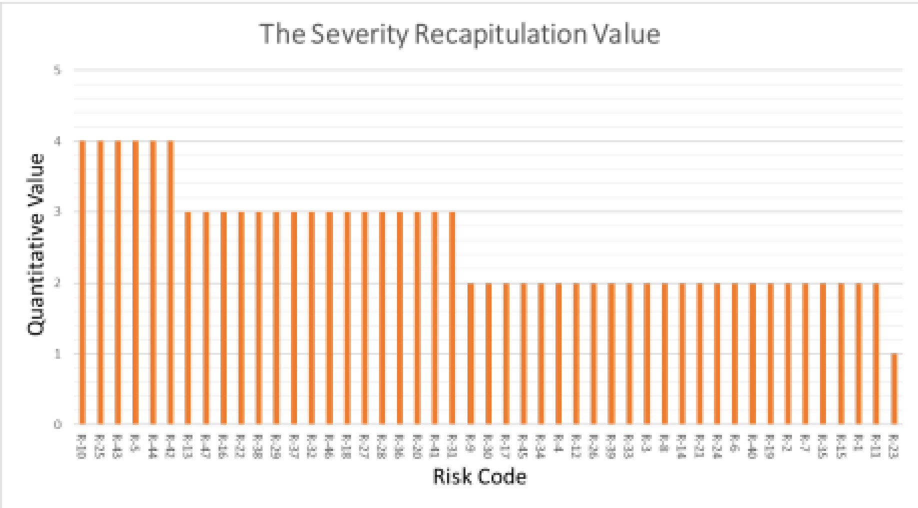


Figure 5. The Severity Recapitulation Value

From the recapitulation of the severity values of all risks that have been identified, it shows that 6 risks have the highest level of severity, which is worth 4, including R-10, R-25 (erratic weather), R-43 (changes in working drawings), R-5 (uncertain weather), R-44 (revision of planners), and R-42 (changes in planning).

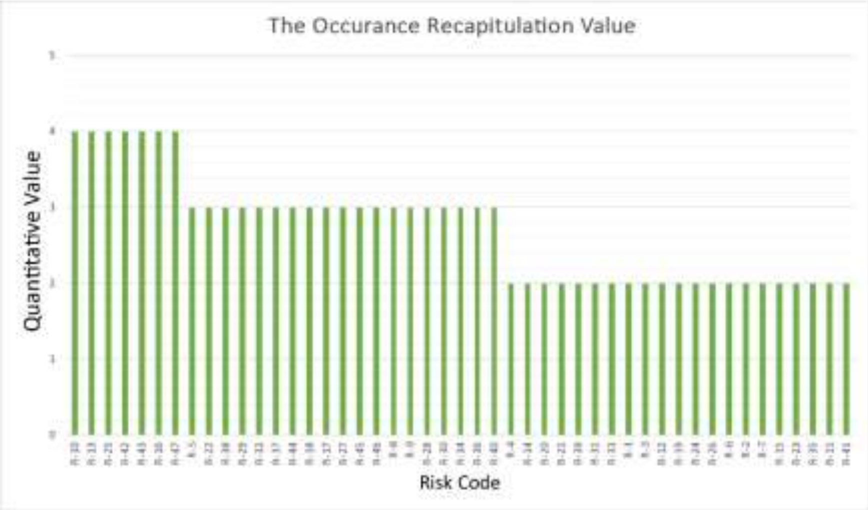


Figure 6. The Occurance Recapitulation Value

From the results of the recapitulation of the Occurance value of all risks that have been identified, it shows that 7 risks have the highest level of possible risk, which is worth 4. These risks include R-10 (uncertain weather), R-25 (uncertain weather), R -13 (Uncertain weather), R-43 (Changes in working drawings), R-42 (Changes in planning), R-16 (seepage of springs in the circumvention tunnel) and R-47 (Pandemic Covid19).

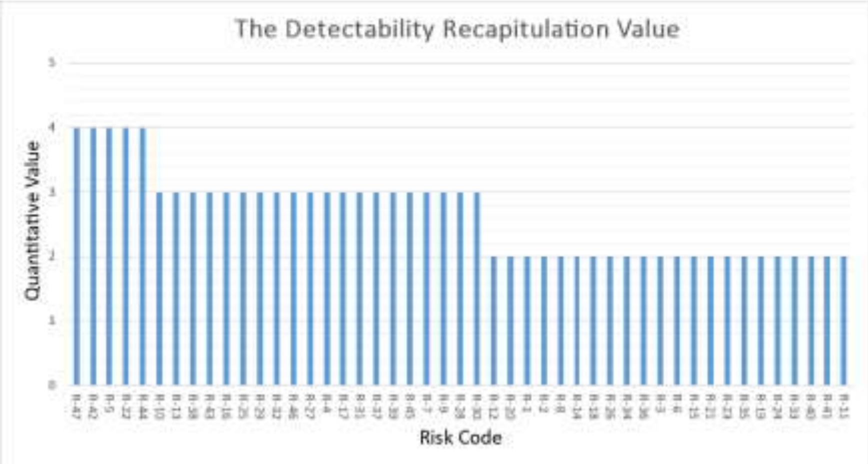


Figure 7. The DetectabilityRecapitulation Value

From the results of the recapitulation of the Detectability values of all risks that have been identified, it shows that 5 risks have the highest possible level of a risk occurring, namely a value of 4, including R-47 (Pandemic Covid-19), R-42 (Changes in planning), R- 5 (Uncertain weather), R-22 (Unstable soil), R-44 (Revised by planners).

3.6 Calculation of RPN (Risk Priority Number) Value

Distribution of questionnaires to 7 people who are experienced and experts in their fields was carried out to determine the severity, occurrence, and detectability values. The results of data processing and assessment on Microsoft Excel software for each of the criteria for severity, occurrence, and detectability can be seen in Table 4.

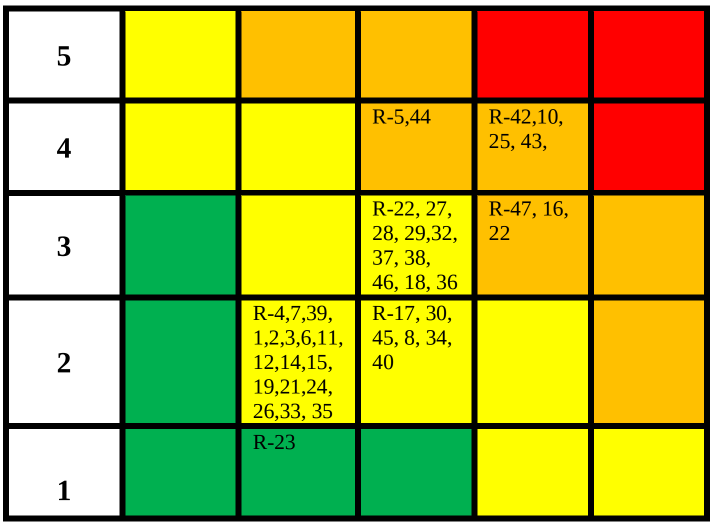
Table 4. Rating Results of Risk Priority Number (RPN) Value

Risk Code	RPN	Risk Code	RPN
R - 1	8	R - 25	48
R - 2	8	R - 26	8
R - 3	8	R - 27	27
R - 4	12	R - 28	27
R - 5	48	R - 29	27
R - 6	8	R - 30	18
R - 7	12	R - 31	18
R - 8	12	R - 32	27
R - 9	18	R - 33	8
R - 10	48	R - 34	12
R - 11	8	R - 35	8
R - 12	8	R - 36	18
R - 13	36	R - 37	27
R - 14	8	R - 38	27
R - 15	8	R - 39	12
R - 16	36	R - 40	12
R - 17	18	R - 41	12
R - 18	18	R - 42	64
R - 19	8	R - 43	48
R - 20	12	R - 44	48
R - 21	8	R - 45	18
R - 22	36	R - 46	27
R - 23	4	R - 47	48
R - 24	8		

3.7 Risk Mapping

Delay risk mapping can be done after obtaining the Severity, Occurance, Detectability values and obtaining the RPN (Risk Priority Number) value. There is a division of 5 regions in conducting risk mapping which refers to two assessment criteria, namely Severity and Occurance. Risk mapping to determine the risk level of each delay risk that occurs. The risk level consists of low risk (low risk) shown in green, medium risk (medium risk) shown in yellow, high risk (high risk) shown in orange, and very high risk (extreme risk) shown in red.

The results of the risk mapping below are based on risk numbers and can be seen in Figure 7.



	1	2	3	4	5

The severity of the risk of delay *(Severity)*

The level of probable risk of delays occurring *(occurance)*

Figure 8. Risk Mapping Results

From the results of the calculation of the Risk Priority Number (RPN) and risk mapping in Figure 7, there are 3 types of risk levels for delays in the Karian Dam Development project, namely high risk, medium risk, and low-risk levels. Recapitulation of the level of risk of delays that occurred in the Karian Dam construction project can be seen in Figure 8.

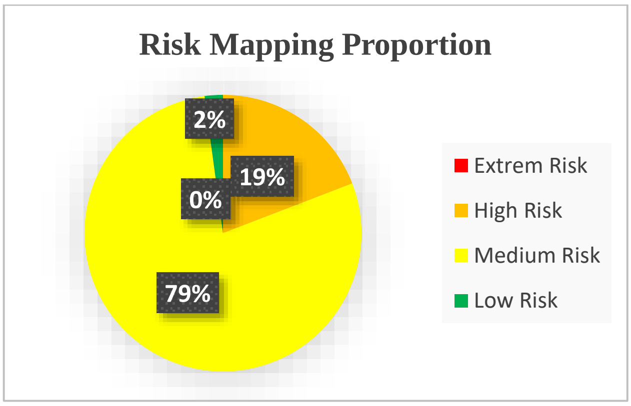


Figure 8. Result of Risk Mapping Proportion

The results in Figure 8 explain the proportion of risk mapping in this study through the recapitulation of the risk levels for the construction of the Karian Dam which is experiencing delays. It can be concluded that 79% of the risk of delays occurs at the high-risk level, 19% is at the medium risk level, 2% occurs at the low-risk level. , and at the extreme risk level, there is no risk of 0% delay. By using risk mapping, contractors can prioritize what risks need to be handled so as not to cause losses or minimize losses that occur according to company conditions.

4. CONCLUSION

Based on the objectives and results of research on project delays using the Fault Tree Analysis (FTA) method and the Failure Mode And Effect Analysis (FMEA) method, the following conclusions are obtained from work items that cause delays with probability index value indicators using Fault Tree Analysis include planning and implementation work (A9-1) with a probability index value of 4 and A4 work (overflow and crest building work) with a total index value of 3. Risk analysis using the fault tree analysis method obtained a delay risk of 47 risks out of 56 risks that had been tested for instrument validation by experts and tested for the reliability of all activities involved in the Karian Dam Development project. Furthermore, the probability index calculation was carried out and the results of activities A9-1 and A-42, namely the planning and construction activities of the overflow building, had the highest basic event probability values of 4 and 3. Based on the calculation results of the risk priority number (RPN) using the failure mode and effect analysis method by distributing questionnaires to obtain severity, occurrence, and detectability values through potential effect, risk cause, and current control indicators, the value of the risk priority number (RPN) is obtained. the highest, namely R-42 (change in planning) of 64, and is included in the high risk that will impact delays until additional contracts occur.

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