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## IDENTIFICATION AND MITIGATION OF RISK FACTORS IN THE IMPLEMENTATION OF THE PROBOLINGGO-BANYUWANGI TOLL ROAD PROJECT PACKAGE 2

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### ABSTRACT

This study focuses on identifying and mitigating risks associated with constructing the Probolinggo-Banyuwangi Toll Road Project Package 2, a vital segment of Indonesia's Trans-Java Toll Network. The background highlights the project's significance in enhancing regional connectivity and supporting economic growth alongside the challenges it faces from technical, managerial, financial, social, and environmental factors. This research aims to identify critical risks and develop effective mitigation strategies. The methodology involves data collection through interviews, surveys, and document analysis, prioritizing risks based on their probability and impact. Key findings reveal that delayed delivery, rising material prices, and lack of skilled labor are the most significant risks, demanding targeted mitigation strategies. The conclusion emphasizes the importance of implementing real-time risk monitoring systems, improving logistics coordination, and fostering stakeholder collaboration, particularly with government agencies. By prioritizing critical risks and developing comprehensive mitigation strategies, this research contributes valuable insights for managing complex infrastructure projects, ensuring project sustainability and success.

**Keywords:** risk management, toll road construction, probolinggo-banyuwangi, risk mitigation, infrastructure development, iso 31000, as/nzs 4360

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### INTRODUCTION

Toll road infrastructure development supports economic growth, improves regional connectivity, and accelerates logistics distribution in Indonesia. One of the strategic projects being implemented is the construction of the Probolinggo-Banyuwangi toll road, which is part of the Trans Java Toll Road network and is also the main link between the western and eastern regions of Java Island. Package 2 of this toll road construction has excellent challenges, ensuring its successful implementation without significant obstacles.

Every construction project, including the Probolinggo-Banyuwangi Package 2 toll road project, faces various risks that can affect its success. These risks include technical, managerial, financial, social, and environmental aspects (Kamiya et al., 2021). Risk identification is an essential first step in construction project risk management to minimize negative impacts on cost and quality of work (Urbanik, 2024).

The highest risks in implementing this project can be technical factors, such as differences in field conditions with design plans, or social risks, such as conflicts with local communities (Lin et al., 2021). Therefore, an in-depth understanding of these types of risks is essential to develop appropriate mitigation strategies (LISANANDA, 2021; Zekos, 2021). International standards-based approaches, such as AS/NZS 4360, can be a reference for managing risks systematically (Dewi, 2023; Xu et al., 2024).

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Risks such as extreme weather changes, delays in land acquisition, and scarcity of construction materials are often the main issues in the Probolinggo-Banyuwangi Package 2 toll road construction project (Dong et al., 2024). Identifying the highest risk factors will help anticipate problems and allocate resources more efficiently (Rumimper et al., 2015).

Risk mitigation is an equally important step after identification. Mitigation strategies include developing effective monitoring systems, applying the latest construction technologies, and intensive coordination with relevant parties, including the government and local communities (Yin et al., 2025). This approach aligns with that outlined by Aslam and Baffoe-Twum (2024), who emphasized the importance of risk analysis using the Analytic Network Process method to improve decision-making in construction projects.

The ISO 31000:2018-based risk management approach is also relevant in this context, as it provides structured guidance for identifying, analyzing, and evaluating risks (LISANANDA, 2021). With this approach, the risks faced can be managed more effectively so that the project can run according to the predetermined schedule and budget (Lokobal, 2014). Non-optimal risk management can result in enormous losses for the project in terms of time, cost, and reputation (Patriadi, 2021). For example, delays in land acquisition can trigger a domino effect in the form of delays in all other stages of work (Fathoni Rodli et al., 2019). Therefore, risk identification and mitigation must be prioritized at every stage of project implementation (Aslam & Baffoe-Twum, 2024). Implementing comprehensive risk management requires active participation from all stakeholders, including contractors, consultants, and funders (Rumimper et al., 2015). With good collaboration, the risks that arise can be better managed to achieve the project objectives without significant obstacles (Kumi et al., 2025).

In general, this research focuses on two main things. First, identify the highest risk factors in implementing the Probolinggo-Banyuwangi Package 2 toll road construction project. Second, mitigation strategies can be developed to reduce the impact of these risks. This is done with a theory-based approach and empirical studies that have been done before (Cuadros & Ramirez, 2024; Park et al., 2024). The formulation of this research problem includes questions regarding the highest risk factors encountered during project implementation and mitigation measures that can be taken to ensure project success. Thus, the focus of this research is directed at identifying risks as well as mitigation strategies that can be effectively implemented.

This study presents a novel approach to risk management in constructing the Probolinggo-Banyuwangi Toll Road Project Package 2 by integrating international standards and advanced analytical methods. Unlike previous works, which often focus on isolated risk factors, this research offers a comprehensive framework that systematically identifies and mitigates risks by leveraging qualitative and quantitative data analysis. The primary objectives of this study are twofold: first, to identify the most critical risk factors affecting the successful implementation of the Probolinggo-Banyuwangi toll road construction project, and second, to develop effective mitigation strategies that address these identified

risks. These objectives align with the challenges faced in construction projects, ensuring their relevance to the issues.

## **METHOD**

### **Research Design**

Research design is a framework used to direct the course of research. In this research, the research design applied is a descriptive method with qualitative and quantitative approaches. This approach aims to understand the risk phenomenon in the Probolinggo - Banyuwangi toll road construction project and evaluate the level of possibility and impact. The descriptive method allows researchers to describe the conditions in the field based on the data obtained from the research subjects. This research also uses a quantitative approach to analyze data obtained through surveys and interviews. This analysis aims to provide a numerical description of the level of risk and mitigation strategies taken. Thus, the research results can make a meaningful contribution to risk management in construction projects. This combination of approaches provides flexibility in exploring the phenomenon in depth and objectively.

In addition, this research design includes validating the data collected through interviews and questionnaires. Validation was conducted to ensure that the data used in the research had a high level of reliability. This process involves reviewing the data by the respondents and testing for accuracy using triangulation methods. In this way, the researcher can ensure that the resulting conclusions genuinely reflect reality. This research was conducted in stages, from literature review to field data collection. These stages were designed to ensure that all aspects of the research were well managed. Each stage was designed to contribute to a better understanding of the research problem and develop relevant solutions. As a final step, the research also included an evaluation of the results to ensure that the recommendations were effectively implemented. This evaluation included discussions with contractors and risk management experts to obtain feedback on implementing the proposed solutions. In this way, the research produced theoretical findings and tangible practical benefits.

### **Subjects and Objects of Research**

The research subject is an important element in a study because it is the primary data source. In this study, the subjects are the contractors implementing the Probolinggo - Banyuwangi toll road construction project. These subjects were chosen because they have direct experience in managing risks during the project. They include project managers, field implementers, and administrative staff involved in the project. Research subjects include people or groups who provide data to researchers. In this case, the research subjects could provide accurate and relevant information related to the risks faced during the project. The researcher attempted to obtain data from various roles in the project to ensure the research results reflected various perspectives. The research object in this study is the risks that arise during the implementation of the Probolinggo - Banyuwangi toll road construction project.

These risks cover various aspects, such as technical, safety, and environmental. The focus of the research is to identify the principal risks, analyze their impacts, and evaluate the mitigation strategies that have been implemented.

In this research, the object includes not only risks that have been identified but also potential risks that may arise in the future. Researchers used primary and secondary data to identify and analyze the object of this research. Primary data is obtained from interviews and surveys, while secondary data comes from project documents and related literature. By exploring the subject and object of this research, the researcher hopes to make a meaningful contribution to construction project risk management. The research results are expected to be the basis for better decision-making in the future.

### **Location and Time of Research**

The research location is where data is collected to answer research questions. This research was conducted at the Probolinggo—Banyuwangi toll road construction project. This location was chosen because it relates to the research focus: risk in large-scale construction projects. This project is one of the national strategic projects involving various parties, thus providing much relevant data to analyze.

The selection of research sites was also based on accessibility and data availability. The researcher directly accessed the project site and the actors involved, enabling effective primary data collection. In addition, this location provided sufficient supporting documents to complement the secondary data. The research was conducted over six months, starting from January to June. The time covered various stages of the research, from data collection to analysis and reporting. The first stage involved a literature review and document study to understand the research problem.

The second stage involved collecting primary data through interviews and questionnaires. Data collection was conducted in stages to ensure that every aspect of the research was well covered. Researchers also conducted field visits during this process to get a first-hand picture of the project conditions. The final stage was data analysis and reporting of the research results. The analysis used quantitative and qualitative methods to provide a comprehensive picture of the risks. The research results were then summarized in a report presented to relevant parties.

### **Data Collection Procedure**

Data collection procedures are systematic steps taken to obtain the necessary information. In this study, data was collected through two main types of sources, namely primary data and secondary data. Primary data was obtained directly from the research subjects, while secondary data came from related documents and literature. Primary data collection was conducted using interviews and questionnaires. Interviews were conducted with project implementation contractors to obtain in-depth information about the risks they face. Questionnaires were used to collect quantitative data on the likelihood and impact of risks.

Secondary data was obtained from project documents and literature studies. Project documents include technical reports, risk management records, and other operational data. Literature studies were conducted to complete the understanding of concepts and theories relevant to the object of research. Data collection procedures were carried out by considering research ethics. The researcher ensured that all respondents provided information voluntarily and were aware of the research objectives. In addition, the data collected was kept confidential to protect the privacy of respondents. After the data was collected, the next step was validation to ensure the reliability and accuracy of the data. Validation was conducted using the triangulation method, which involves comparing data from multiple sources to ensure consistency.

### **Data Analysis Method**

The data analysis method is a technique used to process and understand the data that has been collected. In this study, data analysis was conducted using quantitative and qualitative approaches. Quantitative approaches are used to analyze numerical data, such as the likelihood and impact of risks. This analysis was conducted using statistical software to produce objective results. The qualitative approach was used to understand the context and meaning of the data obtained. Qualitative analysis identified themes and patterns that emerged from interview data and documents. This approach allows researchers to delve into complex phenomena and gain deeper insights.

The first stage of analysis involves grouping the data by risk category. The data was then analyzed to identify key risks that significantly impacted the project. This step was followed by an evaluation of the mitigation strategies that had been implemented. The next stage is the interpretation of the results of the analysis to answer the research questions. This interpretation was done by referring to the relevant theoretical framework and the validated data. Researchers also compared the results with previous findings to identify similarities and differences. As a final step, the analysis results are presented as a report that includes the main findings and recommendations. This report is expected to serve as a guide for risk management in other construction projects. Thus, this research makes a meaningful contribution to developing science and practice in risk management.

## **RESULTS AND DISCUSSION**

### **Results**

This study identifies the highest risk factors in the Probolinggo - Banyuwangi Toll Road Package 2 construction project using data from the risk assessment by key respondents. Based on the analysis, risks with the highest probability and impact are categorized as critical. Probability and impact are measured on a scale of 1 to 5, where the total risk score is calculated by multiplying the probability value by the impact. Risks with the highest scores were prioritized for mitigation. The analysis results show that delayed material delivery (A3) is the highest risk, with a risk score of 25, based on a probability score of 5 and an impact of 5 from several respondents in Table 1. This indicates that this risk is almost certain to occur

and significantly impact the project schedule. Causes of delay include logistical constraints, difficult project site access, and lack of coordination between contractors and suppliers. Another risk is material price increase (A1) with a risk score of 20, which is influenced by high probability (4) and significant impact (5). Fluctuations in market prices, transportation costs, and taxes drive this factor. Material price increases lead to unexpected increases in project costs, affecting budget allocations for other project items.

**Table 1. Ranking of Major Risks in the Project**

Risk	Probability	Impact	Risk Score
Delay in material delivery (A3)	5	5	25
Increase in material prices (A1)	4	5	20
Poor material quality (A4)	4	4	16

Furthermore, the risk of poor material quality (A4) is also a significant concern, with a total risk score of 16. This often occurs due to non-optimal supervision during material procurement. Materials that do not meet specifications can reduce the quality of construction and require additional work to repair, ultimately increasing the cost and time of project implementation.

**Table 2. Risk Rating**

	Risk Event	Risk Value	Rating
Materials	Increase in material prices	9	2
	Scarcity of materials	9	3
	Delay in material delivery	12	1
	Poor material quality	6	14
	Inappropriate material volume and type	6	15
	Excess material usage (waste material)	9	4
	Changes in material specifications	4	26
	Material theft	9	5
Equipment	Incomplete equipment	6	16
	Equipment that is no longer suitable	4	27
	Equipment delivery delays	6	17
	Equipment misplacement	6	18
	Loss of Equipment	6	19
Labor	Lack of labor availability	9	6
	Lack of labor capability/skills	9	7
	Arriving/starting work late, leaving early	4	28
Contract	Change order	4	29
	Contract Clauses	4	30
Financial	Payment method that is not on time	9	8

	Cost estimation inaccuracy	6	20
	Fluctuations (uncertainty) in bank lending rates	4	31
	Cash flow bottlenecks	4	32
	Not paying attention to unexpected costs	6	21
Physical Conditions on site	Hard-to-reach location conditions	9	9
	Poor <i>site</i> and location conditions	4	33
	Difficult land acquisition conditions	4	34
Natural Conditions	Poor weather conditions	9	10
	Natural disasters	2	44
Social Conditions	Demonstration, project site picketing	4	35
	Riots	2	45
	Cultural conditions and customs of the communities around the site that hinder the project	4	36
	Work Strike	4	37
Contractor Management	Lack of proxy manager experience	4	38
	Lack of communication and coordination between parties involved in the project	4	39
	Lack of supervision of contractors and suppliers	4	40
	Lack of control over work implementation schedule	4	41
Policy/Legalization Government	Changes in government political policy that made it difficult to complete the project	4	42
	Monetary instability	2	46
	Bureaucratic bottleneck in licensing process	4	43
Construction Methods and Technology	Change in construction method	9	11
	Incorrect or incomplete design	9	12
	Inappropriate selection of construction method	6	22
	Difficulty applying new/specialized technology	9	13
Occupational Health and Safety	Accidents occur due to human error	6	23
	Accidents occur due to equipment failure	6	24
	Poor Occupational Health and Safety (OHS) procedures	6	25

The top three risks are delays in material delivery, rising material prices, and poor material quality, and the material aspect significantly contributes to project constraints. Other factors, such as the lack of skilled labor (A15), with an average risk score of 12, also added to the complexity of project implementation. These figures provide the basis for the mitigation priorities described in the next section.

## Discussion

### Highest Risk Factors in Probolinggo - Banyuwangi Toll Road Construction Project Package 2

The highest risk factors in the Probolinggo - Banyuwangi Toll Road Package 2 construction project were determined based on the risk assessment results by the respondents involved, including the project manager, OHS expert, and field implementers. The risk analysis using probability and impact parameters found several risks with the highest scores, one of which was the delay in material delivery (A3). Based on the risk assessment table, late material delivery has the highest score, with an average probability of 4.3 and an impact of 4.7, resulting in an average risk score of 20.21. This risk is almost certain to occur and significantly impact the smooth running of the project schedule, mainly due to logistical constraints in hard-to-reach locations and less than-optimal coordination with suppliers.

In addition to material delivery delays, material price increases (A1) became another significant risk with an average risk score of 19.5. Market price fluctuations, increased transportation costs, and changes in government policies regarding construction materials trigger this factor. These price spikes not only affected the project's total cost but also forced contractors to look for alternative materials that could offset the increased budget. Meanwhile, poor material quality (A4) is also a concern, with an average risk score of 16.6. This risk arises due to a lack of supervision in the material procurement process, so materials that do not meet specifications are often accepted and reduce the quality of construction.

On the other hand, labor factors such as the lack of skilled labor (A15) are a big challenge, especially in project locations far from the city center. This risk has an average risk score of 14.4. This condition hinders work productivity, especially at critical stages that require specialized skills. In addition, project management factors, such as lack of communication and coordination between parties involved (A34), also significantly impacted project efficiency with an average risk score of 12.8. These risks are generally interrelated and have a cumulative impact that affects the project's success.

The results of this assessment show that the dominant risks are related to materials, logistics, and labor. These three categories require special attention to minimize their impact on project schedule, cost, and quality. Other factors, such as hard-to-reach site conditions and natural constraints, also contribute to the project's complexity despite having lower risk scores. Therefore, adequate mitigation measures must be implemented immediately to address these risks.

### Risk Mitigation in Probolinggo - Banyuwangi Toll Road Construction Project Package 2

Mitigation strategies are designed to reduce the impact of the identified key risks. For the risk of material delivery delays (A3), the proposed strategy involves improving the logistics system through real-time digital monitoring. This technology allows contractors to monitor material delivery from suppliers to the project site so that potential delays can be

anticipated. In addition, establishing long-term contracts with key suppliers is also important to ensure consistent material availability. This step has proven effective in similar projects to reduce dependence on unreliable suppliers.

Mitigating the risk of rising material prices (A1) involves purchasing materials in bulk at the beginning of the project to reduce exposure to market price fluctuations. Another strategy that can be implemented is using fixed-price contracts with suppliers to lock in prices for a certain period. In addition, utilizing local materials that are more economical but still meet the project's technical specifications is also a solution worth considering. This reduces transportation costs and supports sustainability by utilizing local resources.

To reduce the risk of poor material quality (A4), regular material inspections should be conducted before the materials are used at the project site. Involving a technical consultant or a team of experts in the procurement process can improve the quality control of the materials received. Building strong relationships with reputable suppliers can also minimize this risk. Using an integrated documentation system to track material specifications can also improve efficiency and accuracy in procurement.

Labor risks such as a lack of skills (A15) can be addressed by conducting periodic training for workers in the field. This training improves workers' technical competencies, enabling them to better cope with job challenges. In addition, incentives for workers willing to work in remote locations can attract more qualified workers. Collaboration with local training institutions to produce new workers ready to enter the field can also be a long-term solution.

Implementing a digital-based project management system that allows all parties to share information in real time mitigates project management risks such as lack of communication and coordination (A34). In addition, regular coordination meetings among the project team should be increased to ensure all parties understand each other's objectives and responsibilities. To achieve optimal results, these mitigation strategies require close cooperation from all parties, including contractors, suppliers, and consultants.

## CONCLUSION

The Probolinggo-Banyuwangi Package 2 toll road construction project faces significant risks, including design changes, material delivery delays, financial instability, and difficult site access during rainy seasons. These factors can adversely affect time and cost efficiency, with logistical issues often leading to project delays. Several strategies have been proposed to mitigate these risks: establishing a clear delivery schedule with suppliers, building a new access road to the work site, and enhancing coordination among stakeholders to address design changes and financial problems. Recommendations for effective risk management include adhering to international standards like ISO 31000, fostering collaboration among contractors, government agencies, suppliers, and local communities, and improving communication through regular meetings. The government should facilitate licensing processes and support addressing external challenges, such as adverse weather.

Additionally, contractors are encouraged to invest in advanced construction technologies and real-time monitoring systems to streamline logistics and track material deliveries. Addressing workforce challenges involves implementing technical training programs and incentive systems to attract skilled labor, particularly in remote areas while collaborating with vocational institutions for long-term solutions. Further research should focus on developing context-specific risk management strategies for similar infrastructure projects, exploring innovative approaches like predictive analytics for risk forecasting and sustainable practices to minimize environmental impact. By adopting these recommendations, the Probolinggo-Banyuwangi toll road project can effectively manage risks and serve as a benchmark for large-scale infrastructure development.

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