

Risk Management Analysis in the Implementation of High-Rise Building Construction Projects in Banjarmasin City, South Kalimantan

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Abstract : High-rise building projects in swampy areas, such as in Banjarmasin City, South Kalimantan, face various technical and non-technical risks that can hinder project implementation, particularly those related to cost and time efficiency. This study aims to identify key risk factors that emerge during the implementation phase and formulate mitigation strategies suited to local project characteristics. This research method uses a quantitative approach with purposive sampling through the distribution of structured questionnaires and semi-structured interviews with stakeholders, including contractors, consultants, and PBG officials. Data analysis was conducted using a severity index and a probability-impact matrix to determine risk levels and prioritize their management. The study findings indicate eight significant risk factors, such as material damage or loss, weather delays, and logistical inefficiencies. Recommended mitigation strategies include improving material security, scheduling work according to weather conditions, and more organized material management. This research contributes to construction risk management practices, particularly for high-rise building projects in areas with unstable geographical conditions.

Keywords: Risk Management, High-Rise Buildings, Construction Projects, Severity Index, Swamp Land, Mitigation Strategy.

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I. INTRODUCTION

High-rise building projects inherently face various threats, both technical and non-technical, that have the potential to hinder the achievement of project objectives related to time, cost, and quality (Harahap et al., 2010; Soeharto, 2008). These risk complications increase in large-scale projects built on land with specific characteristics, such as peatland in Banjarmasin City, South Kalimantan. One example illustrating this situation is the construction of the Adaro Office, which faced significant challenges due to environmental conditions and time constraints.

Frequent problems include disruptions due to extreme weather, heavy equipment damage, lack of material storage space, and design changes during construction. These threats can lead to schedule delays, increased costs, and even project failure, as seen in the 2022 building collapse in Banjarmasin. Although several previous studies (Yuliana & Hidayat, 2017; Saputri, 2019; Joshua, 2023) have discussed the main risk

factors in construction projects, few studies have examined mitigation strategies based on specific geographic conditions.

This study aims to identify and analyze the main risk factors influencing the implementation of a high-rise building project on swampy land in Banjarmasin, as well as to formulate mitigation strategies appropriate to the conditions in the area. Using a quantitative approach through the application of severity indices and probability-impact map analysis, this study is expected to fill a gap in the risk management literature and provide practical guidance for construction operators in similar areas.

II. MATERIALS & METHODS

This study applies a descriptive quantitative method with a survey to assess and identify various risks encountered in the implementation of a high-rise building project in Banjarmasin, Indonesia. The main focus of this study is to systematically identify the various risks that arise, determine

their likelihood and impact, and develop the most effective mitigation strategies to improve project outcomes.

This research focuses on a multi-story building project built on soft soil or swampy land in Banjarmasin, with two case studies as the focus: the Amanah Hospital project and the Barito Perkasa Maritime Office. The subjects studied involved parties directly involved in the project, including IV. contractors, supervising consultants, and project owners. A purposive sampling method was applied to select 30 professional respondents with extensive knowledge and experience in construction project management.

The data collection process was carried out by distributing a Likert-scale questionnaire, conducting structured interviews, and reviewing project documentation. The collected data was analyzed quantitatively using the risk

level formula (Risk Level = Likelihood × Impact), then grouped using a risk matrix. The findings from this analysis were used to prioritize risks and plan appropriate mitigation strategies based on the latest construction risk management practices.

III. RESULTS

Based on a risk analysis conducted for the Barito Perkasa Maritime Office development project in Banjarmasin, 34 risk factors were identified. These risks are divided into eight main categories: natural disaster risks, design and technology-related risks, contractual risks, material and equipment risks, labor-related risks, management risks, implementation risks, and environmental/social risks.

Table 1. Research Variables

CODE	Risk Variables
	Force Majeure Risk
A1	Unpredictable weather conditions (Rain)
A2	Natural disasters (earthquakes, floods, etc.)
	Design and Technology Risks
A3	Changes in the design and technical aspects of the work due to adjustments to field conditions
A4	Incomplete drawings and technical specifications
A5	Safety regulations that are not implemented in the field
A6	Mismatch between the plan drawings and the actual conditions at the project location
A7	Changes in work items that cause delays in work execution
A8	Materials and concrete quality that do not meet specifications
	Contractual Risk
A9	Difficulty in licensing arrangements
A10	Late payment by owner
	Material and Equipment Risks
A11	Lack of material storage space
A12	Lack of waste/material disposal sites
A13	Delay in material delivery
A14	Increase in material prices
A15	Damage/loss of material
A16	Damage/loss of equipment
A17	Availability of materials
A18	The materials used do not meet specifications
	Labor Risk
A19	Lack of competent workforce (do not have competency certificates)
A20	Labor shortage
A21	Potential senior worker transfer
A22	Low labor productivity
	Risk Management
A23	Late design preparation and approval
A24	Use of inappropriate implementation methods
A25	Mismatch between the volume of work in the BOQ and conditions in the field
A26	The work was not accepted by the owner
	Implementation Risk
A27	Changes to the work schedule
A28	Security disturbances at the project site
A29	Difficult site location conditions
A30	Difficulty in installing formwork and scaffolding at certain heights
	Environmental/Community Impact
A31	Air pollution during project implementation

A32	Damage to private property owned by communities around the project
A33	Noise that occurs during work execution
A34	The emergence of traffic jams around the work location on the project

A. Validity Test

The questionnaire was distributed and supplemented with interviews involving various parties, including the owner, construction management consultant, contractor, planner, supervisor, and the Building Approval (PBG) team. The validation process of the measuring instrument is a crucial step in this study to ensure that the instrument can accurately measure the variables studied. Specifically, the purpose of this validation is to assess the extent to which the instrument can identify the influence of dominant risk factors in the implementation of high-rise building construction. A valid measuring instrument ensures that each element and indicator in the questionnaire accurately reflects the research construct, thereby increasing the reliability of the data used in further analysis. The results of this study also have the potential to become a reference for subsequent studies, particularly in examining the dominant risks that may arise in high-rise building construction in Banjarmasin City, both at local and national levels. To evaluate the internal validity of this measuring instrument, a correlation analysis was conducted between the scores of each item and the total score using the Spearman Rank method.

B. Reliability Test

Reliability testing is conducted to evaluate the extent to which a questionnaire acts as a reliable and consistent tool, producing stable data when applied repeatedly under the same conditions. This assessment applies statistical methods to assess the tool's internal consistency. According to Noor (2020), a reliability value below 0.6 is considered inadequate, while a value of 0.7 or higher indicates a high-quality and reliable tool. Therefore, reliability testing plays a crucial role in ensuring that the tool can produce consistent results in a research context.

C. Results of Calculation of Probability, Cost Impact and Time Impact Using Severity Index

The results of the risk probability analysis using the Severity Index (SI) are presented as a basis for determining the level or measure of risk. This analysis is conducted based on information obtained from a questionnaire regarding the likelihood of risk occurrence, as seen in Tables 2, 3, and 4. The Severity Index is calculated using formula 2.1 developed by Suseno et al. (2015) and supported by the method proposed by Zulfa (2017).

Table 2. Risk Probability Assessment Results

Risk Code	Variables	SI (%)	Scale	Category
Force Majeure Risk				
A1	Unpredictable weather conditions (Rain)	65.3%	4	High
A2	Natural disasters (earthquakes, floods, etc.)	65.3%	4	High
Design and Technology Risks				
A3	Changes in the design and technical aspects of the work due to adjustments to field conditions	62.0%	4	High
A4	Incomplete drawings and technical specifications	58.7%	3	Medium
A5	Safety regulations that are not implemented in the field	54.7%	3	Medium
A6	Mismatch between the plan drawings and the actual conditions at the project location	65.3%	4	High
A7	Changes in work items that cause delays in work execution	61.3%	4	High
A8	Materials and concrete quality that do not meet specifications	53.3%	3	Medium
Contractual Risk				
A9	Difficulty in licensing arrangements	57.3%	3	Medium
A10	Late payment by owner	58.7%	3	Medium
Material and Equipment Risks				
A11	Lack of material storage space	60.0%	3	Medium
A12	Lack of waste/material disposal sites	59.3%	3	Medium
A13	Delay in material delivery	61.3%	4	High
A14	Increase in material prices	61.3%	4	High
A15	Damage/loss of material	65.3%	4	High
A16	Damage/loss of equipment	66.7%	4	High
A17	Availability of materials	61.3%	4	High
A18	The materials used do not meet specifications	54.7%	3	Medium
Labor Risk				

A19	Lack of competent workers (do not have competency certificates)	59.3%	3	Medium
A20	Labor shortage	59.3%	3	Medium
A21	Potential senior worker transfer	59.3%	3	Medium
A22	Low labor productivity	61.3%	4	High
Risk Management				
A23	Late design preparation and approval	56.3%	3	Medium
A24	Use of inappropriate implementation methods	54.7%	3	Medium
A25	The discrepancy between the volume of work in the BOQ and conditions in the field	62.7%	4	High
A26	The work was not accepted by the owner	62.7%	4	High
Implementation Risk				
A27	Changes to the work schedule	62.7%	4	High
A28	Security disturbances at the project site	65.3%	4	High
A29	Difficult site location conditions	59.3%	3	Medium
A30	Difficulty in installing formwork and scaffolding at certain heights	59.3%	3	Medium
Environmental/Community Impact Risk				
A31	Air pollution during project implementation	61.3%	4	High
A32	Damage to private property owned by communities around the project	63.3%	4	High
A33	Noise that occurs during work execution	69.3%	4	High
A34	The emergence of traffic jams around the project location	61.3%	4	High

Table 3. Results of the Impact Assessment on the Risk Cost Aspect

Risk Code	Variables	SI (%)	Scale	Category
Force Majeure Risk				
A1	Unpredictable weather conditions (Rain)	53.3%	3	Medium
A2	Natural disasters (earthquakes, floods, etc.)	53.3%	3	Medium
Design and Technology Risks				
A3	Changes in the design and technical aspects of the work due to adjustments to field conditions	55.3%	3	Medium
A4	Incomplete drawings and technical specifications	58.7%	3	Medium
A5	Safety regulations that are not implemented in the field	60.0%	3	Medium
A6	Mismatch between the plan drawings and the actual conditions at the project location	58.0%	3	Medium
A7	Changes in work items that cause delays in work execution	59.3%	3	Medium
A8	Materials and concrete quality that do not meet specifications	58.7%	3	Medium
Contractual Risk				
A9	Difficulty in licensing arrangements	62.0%	4	High
A10	Late payment by owner	59.3%	3	Medium
Material and Equipment Risks				
A11	Lack of material storage space	60.0%	3	Medium
A12	Lack of waste/material disposal sites	66.0%	4	High
A13	Delay in material delivery	57.3%	3	Medium
A14	Increase in material prices	67.3%	4	High
A15	Damage/loss of material	71.3%	4	High
A16	Damage/loss of equipment	68.7%	4	High
A17	Availability of materials	58.0%	3	Medium
A18	The materials used do not meet specifications	60.7%	4	High
Labor Risk				
A19	Lack of competent workers (do not have competency certificates)	66.0%	4	High

A20	Labor shortage	59.3%	3	Medium
A21	Potential senior worker transfer	65.3%	4	High
A22	Low labor productivity	58.7%	3	Medium
Risk Management				
A23	Late design preparation and approval	58.0%	3	Medium
A24	Use of inappropriate implementation methods	60.7%	4	High
A25	The discrepancy between the volume of work in the BOQ and conditions in the field	59.3%	3	Medium
A26	The work was not accepted by the owner	60.0%	3	Medium
Implementation Risk				
A27	Changes to the work schedule	58.0%	3	Medium
A28	Security disturbances at the project site	55.3%	3	Medium
A29	Difficult site location conditions	55.3%	3	Medium
A30	Difficulty in installing formwork and scaffolding at certain heights	55.3%	3	Medium
Environmental/Community Impact Risk				
A31	Air pollution during project implementation	58.7%	3	Medium
A32	Damage to private property owned by communities around the project	60.0%	3	Medium
A33	Noise that occurs during work execution	58.7%	3	Medium
A34	The emergence of traffic jams around the project location	59.3%	3	Medium

Table 4. Results of the Impact Assessment on the Time Aspect of Risk

Risk Code	Variables	SI (%)	Scale	Category
Force Majeure Risk				
A1	Unpredictable weather conditions (Rain)	66.0%	4	High
A2	Natural disasters (earthquakes, floods, etc.)	66.0%	4	High
Design and Technology Risks				
A3	Changes in the design and technical aspects of the work due to adjustments to field conditions	56.7%	3	Medium
A4	Incomplete drawings and technical specifications	58.0%	3	Medium
A5	Safety regulations that are not implemented in the field	64.7%	4	High
A6	Mismatch between the plan drawings and the actual conditions at the project location	58.0%	3	Medium
A7	Changes in work items that cause delays in work execution	63.3%	4	High
A8	Materials and concrete quality that do not meet specifications	60.0%	3	Medium
Contractual Risk				
A9	Difficulty in licensing arrangements	55.3%	3	Medium
A10	Late payment by owner	60.7%	4	High
Material and Equipment Risks				
A11	Lack of material storage space	59.3%	3	Medium
A12	Lack of waste/material disposal sites	62.7%	4	High
A13	Delay in material delivery	63.3%	4	High
A14	Increase in material prices	59.3%	3	Medium
A15	Damage/loss of material	59.3%	3	Medium
A16	Damage/loss of equipment	56.7%	3	Medium
A17	Availability of materials	59.3%	3	Medium
A18	The materials used do not meet specifications	63.3%	4	High
Labor Risk				
A19	Lack of competent workers (do not have competency certificates)	65.3%	4	High
A20	Labor shortage	56.0%	3	Medium

A21	Potential senior worker transfer	62.7%	4	High
A22	Low labor productivity	60.7%	4	High
Risk Management				
A23	Late design preparation and approval	62.7%	4	High
A24	Use of inappropriate implementation methods	61.3%	4	High
A25	The discrepancy between the volume of work in the BOQ and conditions in the field	59.3%	3	Medium
A26	The work was not accepted by the owner	58.7%	3	Medium
Implementation Risk				
A27	Changes to the work schedule	57.3%	3	Medium
A28	Security disturbances at the project site	58.7%	3	Medium
A29	Difficult site location conditions	61.3%	4	High
A30	Difficulty in installing formwork and scaffolding at certain heights	60.7%	4	High
Environmental/Community Impact Risk				
A31	Air pollution during project implementation	58.7%	3	Medium
A32	Damage to private property owned by communities around the project	60.0%	3	Medium
A33	Noise that occurs during work execution	58.7%	3	Medium
A34	The emergence of traffic jams around the project location	58.7%	3	Medium

D. Risk Analysis of Cost and Time Aspects

Risk analysis related to cost and time is performed by multiplying the values of probability (P) and impact (I), which indicate the likelihood of the risk occurring and the magnitude of the impact it can cause. After this calculation, the results are mapped on a Probability Impact Matrix (PIM) to illustrate and categorize the risk level in a structured

manner. This matrix serves as a tool in setting mitigation priorities and assists the decision-making process to reduce the impact of risks on the smooth running of the project. After obtaining an assessment scale for the probability and impact of each risk, calculations are performed using the $P \times I$ matrix to determine the risk level and appropriate handling strategy

Table 5. Impact of Risk on Cost Aspects

Variables	P	I	P x I	Risk Level
Force Majeure Risk				
A1	4	3	12	Medium
A2	4	3	12	Medium
Design and Technology Risks				
A3	4	3	12	Medium
A4	3	3	9	Medium
A5	3	3	9	Medium
A6	4	3	12	Medium
A7	4	3	12	Medium
A8	3	3	9	Medium
Contractual Risk				
A9	3	4	12	Medium
A10	3	3	9	Medium
Material and Equipment Risks				
A11	3	3	9	Medium
A12	3	4	12	Medium
A13	4	3	12	Medium
A14	4	4	16	High
A15	4	4	16	High
A16	4	4	16	High
A17	4	3	12	Medium
A18	3	4	12	Medium

Labor Risk				
A19	3	4	12	Medium
A20	3	3	9	Medium
A21	3	4	12	Medium
A22	4	3	12	Medium
Risk Management				
A23	3	3	9	Medium
A24	3	4	12	Medium
A25	4	3	12	Medium
A26	4	3	12	Medium
Implementation Risk				
A27	4	3	12	Medium
A28	4	3	12	Medium
A29	3	3	9	Medium
A30	3	3	9	Medium
Environmental/Community Impact Risk				
A31	4	3	12	Medium
A32	4	3	12	Medium
A33	4	3	12	Medium
A34	4	3	12	Medium

Based on the analysis in Table 5, it is known that, based on the calculation of risk levels based on probability and impact on costs, 31 risk variables fall into the Medium

Risk category and 3 variables fall into the High Risk category. There are no variables in the Low Risk category.

Table 6. Impact of Risk on Cost Aspects

Variables	P	I	P x I	Risk Level
Force Majeure Risk				
A1	4	4	16	High
A2	4	4	16	High
Design and Technology Risks				
A3	4	3	12	Medium
A4	3	3	9	Medium
A5	3	4	12	Medium
A6	4	3	12	Medium
A7	4	4	16	High
A8	3	4	12	Medium
A9	3	3	9	Medium
A10	3	4	12	Medium
Material and Equipment Risks				
A11	3	3	9	Medium
A12	3	4	12	Medium
A13	4	4	16	High
A14	4	3	12	Medium
A15	4	3	12	Medium
A16	4	3	12	Medium
A17	4	3	12	Medium
A18	3	4	12	Medium
Labor Risk				
A19	3	4	12	Medium
A20	3	3	9	Medium

A21	3	4	12	Medium
A22	4	4	16	High
Risk Management				
A23	3	4	12	Medium
A24	3	4	12	Medium
A25	4	3	12	Medium
A26	4	3	12	Medium
Implementation Risk				
A27	4	3	12	Medium
A28	4	3	12	Medium
A29	3	4	12	Medium
A30	3	4	12	Medium
Environmental/Community Impact Risk				
A31	4	3	12	Medium
A32	4	3	12	Medium
A33	4	3	12	Medium
A34	4	3	12	Medium

The study results, presented in Table 6, show that, in terms of temporal impact, 29 risk elements fall into the Medium Risk category, and 5 risk elements are identified as High Risk. These findings indicate that the majority of risks can significantly impact the project schedule and material provision. However, the presence of several risks with a high level of impact indicates the need for a more in-depth management and mitigation approach to avoid serious project delays.

Risk management focuses on elements categorized as High Risk, determined based on the maximum risk index value for each aspect of the analysis. These risks are prioritized in the control process because they have the potential to significantly impact project success. Management methods are implemented with a measured and adaptive approach to reduce the likelihood of negative consequences. Once key risks are identified, the next step is to develop recommendations containing response actions and efficient risk management strategies to control the identified key risk factors (Flanagan & Norman, 1993).

E. Validation of Strategy Recommendations and Risk Responses

Table 7. Recommended Strategy and Risk Response for Cost Aspects

Code	Risk	Risk Response	Risk Strategy
A14	Increase in material prices	Risk Reduction	Make contracts/lock prices with suppliers, and monitor prices with market conditions periodically.
priceA15	Damage/loss of material	Risk Reduction	Tighten security, store materials in safe locations, and provide training to all relevant parties to understand effective material handling procedures.
A16	Damage/loss of equipment	Risk Reduction	Routine and periodic maintenance of equipment and increasing project safety by involving local communities in supervision

Table 8. Recommended Strategy and Risk Response for Time Aspect

Code	Risk	Risk Response	Risk Strategy
A1	Unpredictable weather conditions	Risk Reduction	Installation of temporary shelters to protect the work from rain and strong winds, preparation of action plans that include adjustments to work schedules, and regular weather monitoring so that the project can run more efficiently.
A2	The occurrence of natural disasters	Risk Avoidance And Risk Reduction	through a location feasibility study to identify potential vulnerabilities such as floods, earthquakes or landslides
A7	Changes in work items that cause delays in work execution	Risk Reduction	Identifying risks early on and creating a more flexible project schedule, including allocating additional time to accommodate unexpected changes.

A13	Delay in material delivery	Risk Reduction	Ordering materials in advance, monitoring delivery schedules regularly, and preparing alternative materials so that work can continue without interruption.
A22	Low Labor Productivity	Risk Reduction	Providing regular training and guidance to improve skills and work efficiency, providing performance-based incentives as a form of motivation

IV. CONCLUSION

The evaluation results of this study identified eight major risk factors that significantly impact project cost and duration. Three key risk factors that significantly impact costs include material price increases, material damage or loss, and equipment damage or loss. Meanwhile, the five risk factors that most significantly impact project duration are weather uncertainty, natural disasters, changes in work resulting in delays, delays in material delivery, and low labor efficiency.

To manage and mitigate the effects of these risks, a number of proactive approaches are implemented, including: seeking alternative suppliers, providing training to workers, conducting regular equipment maintenance, formulating action plans, monitoring weather conditions, designing contingency plans, developing adaptable schedules, providing backup materials, and planning realistic work hours. By implementing these approaches, risks can be effectively minimized so that project objectives can be achieved according to the established plan.

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