

Risk Analysis and Mitigation Strategies for Bridge Construction Projects in Hulu Sungai Tengah Regency

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ABSTRACT

Bridge construction projects are critical for regional connectivity but are inherently complex and vulnerable to significant risks, particularly in developing regions with unique geographical and social dynamics. This study aims to identify, analyze, and formulate effective mitigation strategies for the dominant risks encountered in bridge construction projects in Hulu Sungai Tengah Regency, Indonesia. A mixed-method approach was employed, with primary data collected through a structured questionnaire administered to 50 key stakeholders, including government officials, contractors, and consultants. Data were analyzed using the Severity Index (SI) method and a Probability Impact Matrix (PIM) to classify risk levels. The analysis identified 15 dominant risks, comprising 4 classified as high-risk and 11 as medium-risk. The most critical risks include material price fluctuation, unexpected costs from illegal levies, extreme weather conditions, and delays in material fabrication. The primary contribution of this research is the development of a practical, validated, role-based mitigation framework. This framework assigns specific responsibilities to the project owner, consultant, and contractor for each mitigation action, thereby enhancing its practical applicability and promoting collaborative risk management.

Keywords: Bridge construction, risk management, risk analysis, mitigation strategy, severity index.

INTRODUCTION

Infrastructure development projects, particularly bridge construction, have significant impacts on the social lives of communities. Bridges are one of the most important transportation networks, planning and designing of bridges is part art and part compromise, the most significant aspect of structural engineering [14]. This role is especially high bridge construction promoted accessibility convergence and economic integration, reducing regional disparities The intricate nature of bridge engineering research is a multidisciplinary field that encompasses a wide range of activities aimed at improving the safety, durability, and functionality of bridges. Each stage plays a crucial role in ensuring a successful project, from initial feasibility studies to final inspections and long-term maintenance plan. Without such diligent oversight, infrastructure failures in system development may at first sound inappropriate since infrastructure design practices focus on achieving an optimum functional capacity by balancing system cost and performance through technical models.

In Indonesia, regions like Hulu Sungai Tengah Regency in South Kalimantan rely heavily on this infrastructure to connect vital economic hubs. These bridges facilitate

traffic access between neighboring regencies such as Hulu Sungai Selatan, Hulu Sungai Utara, and Balangan, thereby enhancing the distribution of goods and services essential for supporting the local community's economic growth. The strategic placement of these structures is intended to create a more integrated and efficient regional economy, reducing transportation times and costs for local producers and consumers alike. This improved connectivity is not just an economic imperative but also a social one, linking remote communities to essential services like healthcare and education. Therefore, bridge construction play a crucial role in supporting regional connectivity, facilitating mobility, and driving local economic growth. If some bridge construction projects were delayed, damaging the economy and country development, because road users waste time and expenses in the travels, leading to cost increasing and other effects.

However, the high environmental impact of bridge construction causes numerous dilemmas in decision making related to the choice of the best material and technological solutions and their consequences in subsequent phases. Large-scale complex public projects face greater, more uncertain, and more diverse risks due to their particular characteristics of large size, long duration, and complexity, which bring both opportunities and challenges for construction enterprise. As stated by Anwar (2014), large infrastructure projects suffer from significant undermanagement of risk in practically all stages of the value chain and throughout the life cycle of a project. These risks are multifaceted, spanning technical, financial, environmental, and social domains, and can be further classified based on their nature, such as pure versus speculative risks [12]. One of the fundamental causes of project failure in such contexts remains the inadequate management of scale and complexity. The literature widely acknowledges that project complexity acts as a major player in project failure.

As the changes occurring to construction projects greatly influence cost overruns, schedule delays and quality degradation, they have close relationships with risk. Project histories in the region provide concrete evidence of these risks materializing; for instance, the Alat Bridge project suffered major delays directly attributable to issues in material fabrication. Such Prolonged delays not only lead to inflated costs and missed opportunities but also divert much-needed resources away from other critical initiatives. Furthermore, Deferred maintenance can lead to exponential cost increases and safety risks over time [4]. Workers should be trained in the safe operation of equipment and tools, recognizing potential hazards, and understanding emergency procedures.

The operating environment in Hulu Sungai Tengah presents a unique and challenging risk assessment serves as a fundamental tool for identifying vulnerabilities. The results underscore the need to promote the integration of formalized risk assessment protocols tailored to local conditions, as generic models may not be sufficient. These include logistical difficulties and inflated transportation costs stemming from adverse geographical conditions such as varied terrain, steep elevations, and unstable soil types. Quarantine measures, factory shutdowns, and transportation restrictions disrupted the production and delivery of essential construction materials and caused extended construction timelines, as contractors had to wait for the arrival of crucial materials before commencing or continuing work. Consequently, engaging local communities is essential for effective disaster risk management [16].

Moreover, the financial intricacies of a construction project can be complex and multi-layered, which can cause risks for construction projects, including lack of sales, problems with the economy, unexpected cost increases, and competition with other firms. Non-technical risks such as organized extortion (premanisme) can significantly disrupt project timelines and budgets, adding another layer of complexity to project

management in the region. It makes sense to disapprove of a system that could fail because of factors we do not understand, given that the consequences of the failure are severe. Managing these risks requires anticipation, understanding, and proactive strategies to safeguard national security, public safety, and economic stability. The failure to address these non-technical aspects can undermine even the most well-planned engineering projects.

While the field of construction risk management is well-established, with foundational frameworks provided by scholars, there is a discernible gap in research that applies these principles to the specific context of bridge construction in developing regions like Hulu Sungai Tengah. Risk management is an organized approach to detect potential risks and reduce undesirable events (Copper and Chapman, 1993). Foundational frameworks, such as those by Flanagan and Norman (1993), outline the core risks in construction, including design failures, unexpected site conditions, and price fluctuations. However, applying these general frameworks without local adaptation is unlikely to be effective and may overlook critical region-specific risks.

Previous local studies have examined risks in other types of infrastructure, such as incinerators [9], coastal defenses [1], other bridge projects in different regions [17], or railway lines [8]. Even risk analysis in different sectors, such as operational risk in manufacturing, has been explored [13]. However, the unique combination of technical, logistical, and social risks associated with bridge projects in this specific regency remains underexplored. This research is crucial for developing more effective and targeted risk management practices for future infrastructure development in the area.

This research aims to achieve two primary objectives, which are designed to be both academically rigorous and practically applicable for stakeholders. First, it seeks to identify and analyze the dominant risk factors that impact bridge construction projects

funded by the regional budget (APBD) in Hulu Sungai Tengah Regency between 2022 and 2023. This involves a systematic process of risk identification, classification, and prioritization to understand which threats pose the greatest danger to project success. This initial step is foundational for any effective risk management plan, as it clarifies the primary challenges that must be addressed. The focus on a specific timeframe and funding source ensures the relevance and specificity of the findings.

Second, based on this analysis, it aims to develop and validate a framework of effective, role-based mitigation strategies tailored to the identified risks. The ultimate goal is to provide a practical tool for stakeholders to enhance project performance and ensure the successful delivery of critical infrastructure. This aligns with the core benefits of risk management, which include stabilizing annual revenue streams and providing greater clarity for decision-makers [6]. By validating these strategies with industry experts, the research ensures their feasibility and applicability in the real world. This framework is intended to serve as a valuable resource for improving project outcomes in the region.

MATERIALS & METHODS

This study employed a mixed-method research design, integrating quantitative survey data with qualitative insights from expert interviews and validation to provide a comprehensive analysis of the risk landscape. This approach was deliberately chosen to leverage the strengths of both methodologies, allowing for a richer and more nuanced understanding of the research problem. The quantitative data provides statistical rigor and generalizability, while the qualitative data offers depth, context, and practical validation of the findings. This integration ensures that the statistical results are grounded in the practical experiences and perspectives of industry professionals. Such a holistic approach is essential for developing a truly effective and applicable risk management framework.

The primary data were collected through a structured questionnaire administered to a purposively selected sample of 50 respondents, a method chosen for its ability to gather standardized data efficiently from a diverse group. This sample was carefully chosen to represent the key stakeholders in local bridge construction projects, thereby ensuring the credibility and relevance of the data for a comprehensive analysis. Purposive sampling was deemed the most appropriate technique as it allowed for the deliberate selection of individuals with specific expertise and direct experience in the subject matter. This targeted approach is essential for capturing nuanced insights that might be missed by random sampling methods. The inclusion of government officials, contractors, and consultants ensures that the data reflects a 360-degree view of the risk environment.

The respondent pool comprised 12 government officials (24%) from the Public Works and Spatial Planning Agency (Dinas PUPR), 11 contractors (22%), and 27 consultants (54%). The significant professional experience within this group is evidenced by the demographic data, which shows that 72% of respondents were over the age of 30, bringing a depth of practical knowledge to their assessments. This distribution was designed to capture a balanced perspective from the three primary entities involved in public construction projects: the owner, the executor, and the supervisor. The high percentage of experienced professionals lends significant weight to the survey responses, as their judgments are informed by years of direct involvement in similar projects. This demographic characteristic strengthens the validity of the study's conclusions.

The questionnaire was designed to evaluate 18 pre-identified risk variables, which were categorized under six principal factors: Political, Economic and Financial, Natural and Environmental, Technical, Human, and Safety and Security. For each risk variable, respondents used a five-point Likert scale to rate its perceived frequency of occurrence

(probability) and its potential severity of impact (consequence) on project objectives. This dual-rating system is critical for a comprehensive risk assessment, as a risk's overall significance is a function of both how often it occurs and how damaging it is when it does. The use of a standardized Likert scale facilitates quantitative analysis and comparison across different risk factors. The pre-identification of variables was based on a thorough literature review and preliminary interviews.

To ensure the academic rigor of the instrument, statistical tests were performed to confirm its validity and reliability before the main data analysis. Validity indicates the degree to which an instrument measures what it is intended to measure [2][3]. All questionnaire items were confirmed as valid through Spearman correlation analysis, with all significance values being less than 0.05. Furthermore, the scales demonstrated high internal consistency and reliability, a measure of an instrument's stability and consistency [15], with Cronbach's Alpha coefficients exceeding 0.80 for all variables. These robust statistical results provide confidence that the questionnaire is a trustworthy and consistent tool for data collection.

The data analysis process was systematic and multi-staged, designed to move from raw data to actionable insights in a logical progression. This followed established principles of risk analysis, which involve both the identification and assessment of risks [16]. First, the ordinal data from the Likert scales were converted into a quantitative index using the Severity Index (SI) method, which provides a weighted average of the responses. This was calculated with the formula:

$$SI = \frac{\sum_{i=0}^4 a_i \cdot x_i}{4 \sum_{i=0}^4 x_i} \times 100$$

Where 'ai' is the constant weight for each response and 'xi' is the frequency of the response. This calculation produced separate SI scores for the probability (P) and impact (I) of each risk.

Subsequently, a final Risk Index (RI) was calculated for each variable by multiplying these separate probability and impact scores ($RI=P \times I$), a standard practice in risk analysis. This RI value provides a single, composite measure of the overall significance of each risk, combining its likelihood and consequence into one score. This value was then used to classify each risk into one of three categories (Low, Medium, or High) by mapping it onto a standard 5x5 Probability Impact Matrix (PIM). This classification is a crucial step, as it allows for the prioritization of risks, enabling project managers to focus their attention and resources on the most critical threats, a core principle of qualitative risk analysis [10].

The final stage of the methodology involved the formulation and validation of mitigation strategies, a critical step to ensure the practical utility of the research. Based on the risk analysis, a set of potential strategies was developed to address the identified dominant risks. These proposed strategies were then subjected to an expert validation process through structured interviews with senior-level practitioners representing project owners, consultants, and contractors. This crucial step not only confirmed the feasibility and applicability of the strategies but also enabled the assignment of clear roles and responsibilities for their implementation. This process transforms a generic list of recommendations into a concrete, actionable, and collaborative framework for all project stakeholders.

RESULT AND DISCUSSION

The analysis of data collected from the 50 stakeholders provided a detailed profile of the risk landscape for bridge construction projects in Hulu Sungai Tengah. The findings reveal a set of dominant risks that require strategic management and offer insights into their underlying causes and interconnections. This comprehensive picture is essential for developing targeted and effective mitigation strategies that go beyond generic advice. The results serve as a critical diagnostic tool for project managers, government agencies, and

contractors operating in the region. By understanding the specific nature of these risks, stakeholders are better equipped to anticipate challenges and proactively manage them. This section delves into the specifics of these findings and their practical implications for project management.

Identification and Analysis of Dominant Risk Factors

From the 18 potential risk variables evaluated, the analysis identified 15 as dominant, meaning they were classified as either Medium or High risk and thus warrant significant management attention. This finding indicates that a vast majority of the pre-identified risks are indeed relevant and pressing concerns in the context of bridge construction in this regency. The high number of dominant risks underscores the complexity and challenging nature of these projects. It suggests that project managers must adopt a comprehensive and vigilant approach to risk management, as threats are numerous and varied. This initial classification is the first step toward prioritizing resources and developing a focused management plan.

Of these dominant risks, 4 were categorized as High Risk and 11 as Medium Risk, a distribution that provides important strategic insights. This distribution suggests that while a small number of critical risks pose the most severe threats, a broader set of moderate risks combines to create a consistently challenging project environment. This finding points towards the need for a dual-focused management approach that is both targeted and systematic. Such an approach would involve intensive, priority-driven action for the high-risk factors and systematic, procedural management for the more numerous medium-risk ones. This ensures that both the most severe and the most frequent challenges are adequately addressed.

This necessitates a dual-focused management approach: intensive, priority-driven action for the high-risk factors and systematic, procedural management for the medium-risk ones. The high-risk items demand immediate

and robust mitigation plans, often requiring direct oversight from senior management. In contrast, the medium-risk items can typically be managed through established project management processes and standard operating procedures. This differentiation allows for a more efficient allocation of limited management resources, ensuring that attention is directed where it is most needed. The complete classification of these dominant risks is presented in Table 1, which serves as a clear roadmap for risk management efforts.

The data in Table 1 clearly show that the high-risk factors are concentrated in the economic, environmental, and technical domains, providing a clear focus for mitigation efforts. These specific areas are where the most significant vulnerabilities lie for bridge projects in the region. The identified high-risk factors include fluctuation in material prices, unexpected costs from illegal levies, extreme weather

conditions, and delays in material fabrication. These are not abstract possibilities but concrete challenges that frequently disrupt project progress. Understanding this concentration of risk is vital for developing effective, targeted interventions that address the root causes of project failure.

These are risks that occur frequently and have a major impact on project cost, schedule, and quality, requiring the most urgent management attention. Their high probability and high impact scores mean they have the greatest potential to derail a project if left unmanaged. For example, a sudden spike in steel prices can single-handedly render a project budget unviable, while a delay in the fabrication of critical components can bring all on-site work to a halt. The high-risk classification of these items signals that they should be the top priority for all stakeholders involved in the project. Proactive and aggressive management of these four factors is non-negotiable for project success.

Table 1. Dominant Risk Factors and Classification

Risk Variable	Category	Probability (P)	Impact (I)	Risk Index (RI)	Classification
Fluctuation in material prices	Economic & Financial	4	4	16	High Risk
Unexpected costs (illegal levies)	Economic & Financial	4	4	16	High Risk
Extreme weather conditions	Natural & Environmental	4	4	16	High Risk
Delays in material fabrication	Technical	4	4	16	High Risk
Political intervention	Political	3	4	12	Medium Risk
Changes in government budget priorities	Political	3	4	12	Medium Risk
Delayed payments from client	Economic & Financial	3	4	12	Medium Risk
Challenging existing site conditions	Natural & Environmental	3	4	12	Medium Risk
Soil erosion and sedimentation	Natural & Environmental	3	4	12	Medium Risk
Inadequate construction equipment	Technical	3	4	12	Medium Risk
Errors in planning and design	Technical	3	4	12	Medium Risk
Incompetence of field supervisors	Human	3	4	12	Medium Risk
Ineffective communication	Human	3	4	12	Medium Risk
Poor work culture of laborers	Human	3	4	12	Medium Risk
Changes in government policy	Political	2	4	8	Medium Risk

A deeper analysis of these risks, informed by qualitative interviews with experienced practitioners, reveals critical causal relationships that are not apparent from the quantitative data alone. A significant financial-logistical risk nexus exists, where a failure in one area triggers a cascade of consequences across other project domains. This interconnectedness means that risks cannot be managed in isolation; a holistic approach is required to understand and address these complex chains of events. The interviews provided rich, contextual details that helped to map out these intricate relationships. This qualitative insight is invaluable for developing mitigation strategies that address root causes rather than just symptoms.

For example, the medium-risk factor of "Delayed payments from client" directly weakens a contractor's cash flow, creating immediate financial pressure. This financial constraint, in turn, prevents them from procuring materials in advance or in bulk, which is a key strategy for managing price volatility. This condition makes them highly vulnerable to the high-risk factor of "Fluctuation in material prices," as they are forced to buy materials on the spot market at prevailing rates. This vulnerability is exacerbated because they cannot take advantage of lower prices or lock in costs early in the project timeline.

This vulnerability is further compounded because they cannot take advantage of lower prices or lock in costs early. Simultaneously, this lack of working capital can hinder their ability to provide upfront payments to suppliers, which is often a prerequisite for initiating production. This directly leads to the high-risk outcome of "Delays in material fabrication," as suppliers will not begin work without financial assurance. This clear chain of events demonstrates how a single administrative or financial process failure, such as a delayed payment, can precipitate severe logistical and budgetary crises down the line. It highlights the critical importance of timely payments from the project owner.

Simultaneously, this lack of working capital can hinder their ability to provide upfront payments to suppliers, leading directly to the high-risk outcome of "Delays in material fabrication." This demonstrates how a single administrative or financial process failure can precipitate severe logistical and budgetary crises. This chain reaction illustrates the fragile interdependencies within the project ecosystem, where a problem in one area quickly metastasizes to others. Understanding these causal links is essential for developing effective mitigation strategies that target the initial trigger points. For instance, ensuring a smooth and timely payment process can proactively mitigate both price fluctuation and fabrication delay risks.

Furthermore, the analysis of the high-risk factor "Unexpected costs (illegal levies)" or *pungli* reveals its systemic socio-economic nature, which requires a nuanced management approach. Its high-risk rating, contrasted with the low-risk classification of general "Security Incidents," suggests that stakeholders do not perceive *pungli* as a random criminal act. Instead, it is viewed as a predictable, almost institutionalized, form of extortion that frequently and directly impacts the project budget. This perception is a critical finding, as it shapes how the risk should be managed. It is not a matter of enhancing security patrols, but of navigating a complex local power structure.

Instead, it is viewed as a predictable, almost institutionalized, form of extortion that frequently and directly impacts the project budget. This distinguishes it as a persistent operational cost to be managed, rather than a stochastic security threat to be avoided (Maulidzha, 2024). This understanding implies that mitigation cannot solely rely on reactive measures but must involve proactive engagement with local communities and authorities. The risk is so embedded in the local context that it functions more like an unofficial tax, requiring careful negotiation and relationship management. This insight, derived from the combination of quantitative ratings and qualitative interviews, is crucial

for developing a realistic and effective mitigation plan.

A Validated Framework for Collaborative Risk Mitigation

Moving beyond risk identification, this study's most significant contribution is the development of a practical and validated framework for risk mitigation. This framework is designed to be actionable and relevant to the local context, providing a clear path forward for project stakeholders. The emphasis on practicality ensures that the research output is not merely an academic exercise but a useful tool for industry practitioners. This focus on application is what sets this research apart from many theoretical studies on risk management. The goal was to create a resource that could be immediately implemented to improve project outcomes.

The true novelty of this framework lies not in the strategies themselves, many of which are standard practices in construction management, but in the final step of expert validation. This step systematically assigned specific roles and responsibilities to the key project participants: the Project Owner (government agency), the Consultant, and the Contractor. This process is crucial for successful implementation because it eliminates ambiguity about who is accountable for each mitigation action. Without this clarity, even the best strategies can fail due to a lack of ownership and coordination among the different parties involved.

This process is crucial for successful implementation because it eliminates ambiguity and fosters a sense of shared ownership among the stakeholders. This assignment of roles transforms a generic list of strategies into a collaborative and accountable operational plan, which is far more likely to be effective in practice. It addresses not just what should be done, but also clarifies who is responsible for each action, from initiation to completion. This

level of detail is essential for translating strategic intent into concrete results on the ground. It creates a clear chain of command and responsibility for risk management activities.

This is a critical step often missing in theoretical risk literature, which frequently stops at recommending strategies without detailing the mechanics of their implementation. This assignment of roles transforms a generic list of strategies into a collaborative and accountable operational plan. By explicitly defining responsibilities, the framework prevents the common problem of "buck-passing," where each party assumes another is handling a particular risk. This clarity is essential for creating a proactive and coordinated response to potential threats. The framework thus serves as a practical blueprint for collaborative risk management [7][11].

It addresses not just what should be done, but clarifying who is responsible for each action. This is a critical step often missing in theoretical risk literature. This focus on accountability is a key differentiator of this research and is central to its practical value. The framework ensures that every critical mitigation task has a designated owner, which significantly increases the likelihood of its successful execution. This approach moves risk management from a theoretical concept to a structured, operational process embedded within the project's management system.

To provide an actionable guide for practitioners, the framework focuses on the four highest-rated risks, as they represent the most urgent threats to project success. By concentrating on these critical few, the framework ensures that management attention and resources are directed where they can have the greatest impact. This prioritization is essential, as attempting to address all risks with equal intensity is often impractical and inefficient. The validated mitigation framework for these high-priority factors is detailed in Table 2, offering a clear and concise guide for immediate action.

Table 2. Validated Mitigation Framework for High-Risk Factors

High-Risk Factor	Validated Mitigation Strategy	Project Owner's Responsibility	Consultant's Responsibility	Contractor's Responsibility
Fluctuation in Material Prices	Implement contracts with price adjustment clauses based on a standard price index (SHS) and conduct regular market analysis.	Provide the budget and legal framework for price adjustments. Approve claims based on SHS.	Verify the contractor's claims for price adjustments against market data and contract terms.	Monitor market prices, manage procurement efficiently, and submit justified adjustment requests with supporting evidence.
Unexpected Costs (Illegal Levies)	Foster transparent relationships with local authorities and communities. Enforce strict compliance with official procedures and maintain a zero-tolerance policy.	Establish formal communication channels with local government and law enforcement. Ensure all administrative processes are transparent and official.	Monitor administrative processes for compliance. Report any indications of unofficial payment requests to the owner.	Adhere strictly to official procedures. Refuse and immediately report any demands for illegal payments to the owner and consultant.
Extreme Weather Conditions	Develop a weather-responsive work schedule. Implement physical protection for materials and equipment. Ensure worker safety protocols are in place.	Approve a flexible work schedule that accounts for seasonal weather patterns. Provide budget for protective measures.	Monitor weather forecasts and advise on necessary adjustments to the work plan. Inspect the implementation of protective measures.	Plan and execute work activities to avoid peak adverse weather. Secure materials and equipment. Provide protective gear and shelter for workers.
Delays in Material Fabrication	Conduct rigorous pre-qualification of suppliers. Establish clear and realistic fabrication and delivery schedules. Perform regular monitoring of supplier progress.	Set clear supplier qualification criteria in tender documents. Approve the master project schedule, including fabrication timelines.	Review and approve the contractor's choice of suppliers. Monitor fabrication progress through inspections or reports.	Select reliable suppliers with proven capacity. Coordinate closely with suppliers to ensure adherence to the schedule. Provide regular progress updates.

This framework underscores the importance of proactive management, with many of the most effective strategies being implemented during the pre-construction phase. This represents a crucial shift from a reactive, crisis-management mindset to a proactive, risk-prevention approach. By addressing potential problems before they materialize, stakeholders can avoid costly delays and disruptions during the construction phase. This emphasis on front-end planning is a key theme that emerges from the analysis. It highlights that prevention is almost always more effective and less expensive than cure. For example, using contracts with price adjustment clauses, conducting thorough site

investigations to mitigate risks from existing conditions, and rigorously pre-qualifying suppliers are all front-end actions. These measures are designed to build resilience into the project plan from the very beginning. A price adjustment clause protects the contractor from unforeseen market volatility, while a thorough site investigation can prevent costly surprises related to soil conditions or other environmental factors. Similarly, ensuring that suppliers are reliable and capable before signing a contract is a fundamental step in preventing fabrication delays.

These actions directly address the root causes of many problems that emerge later in the

project lifecycle. This reinforces the conclusion that many on-site problems are merely symptoms of inadequate planning, design, and procurement processes. By focusing on these upstream activities, project teams can prevent a host of downstream issues from ever occurring. This proactive stance is the hallmark of mature project management and is essential for navigating the complex risk environment of bridge construction. It requires a long-term perspective that values thorough preparation over rushed execution [5].

By embedding these collaborative and proactive measures into the project lifecycle, stakeholders can significantly reduce the likelihood and impact of the most critical risks. This integrated approach ensures that risk management is not a separate, siloed activity but an integral part of how the project is planned and executed. It fosters a culture of risk awareness and shared responsibility among all team members. This cultural shift is just as important as the specific strategies themselves, as it creates an environment where potential problems are identified and addressed early.

This approach not only enhances the predictability of project outcomes but also fosters a culture of shared accountability and continuous risk management among all involved parties. When all stakeholders understand their roles and are committed to proactive risk management, the project is far more resilient to unexpected challenges. This collaborative environment can lead to more innovative and effective solutions to problems as they arise. Ultimately, the adoption of such a framework can lead to more resilient and efficient construction practices, ensuring that investments in public infrastructure deliver maximum value to the community [14].

CONCLUSION

This study successfully identified and analyzed the dominant risks affecting bridge construction projects in Hulu Sungai Tengah Regency, providing a clear and detailed picture of the challenges faced by

stakeholders in this specific context. The research concludes that the risk landscape is defined by 15 dominant factors, with four of these being classified as high-risk: fluctuation in material prices, unexpected costs from illegal levies, extreme weather conditions, and delays in material fabrication. These critical risks, which stem from a combination of economic, social, environmental, and technical sources, represent the most significant and immediate threats to project success in terms of cost, time, and quality.

The principal contribution of this research is the development of a practical, validated, and role-based mitigation framework, which moves the study from diagnosis to prescription. By moving beyond mere identification to assign specific, actionable responsibilities to the project owner, consultant, and contractor for each high-risk factor, this framework promotes a proactive and collaborative approach to risk management. It transforms theoretical strategies into an executable plan, thereby enhancing accountability and ensuring that mitigation efforts are integrated throughout the project lifecycle. This is particularly important in the critical pre-construction phase, where many risks can be most effectively addressed.

The implications of these findings are significant for public infrastructure development in the region and potentially beyond. The systematic and collaborative risk management model presented offers a valuable template for the Hulu Sungai Tengah government, its Public Works agency, and local construction firms to improve project efficiency, reduce costly delays, and ultimately increase the probability of successful project outcomes. It is strongly recommended that this validated framework be adopted as a standard practice for all future bridge construction projects to build institutional capacity for risk management. Moreover, this model can be adapted for similar infrastructure initiatives in other developing regions that face comparable geographical, economic, and

social challenges, thus offering broader value beyond its immediate context.

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