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Risk Management Analysis in Road Pavement Work in West Sumatra with the Flanagan and Norman Approach (1993)

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ABSTRACT
Recurrent pavement failures in West Sumatra highlight the urgent need for integrated risk management in road projects. This study aims to identify significant risks, examine barriers to the implementation of mitigation strategies, and formulate an effective risk management approach based on the framework of Flanagan and Norman (1993). The research employed a literature review and in-depth interviews with 15 experts from academia, consultancy, and industry, combined with qualitative analysis using NVivo software and risk priority scoring. The findings indicate that economic risk (R4) ranks as the highest due to fluctuations in material prices, land acquisition challenges, and logistical constraints. The risk mapping suggests that a combination of risk reduction, risk transfer, risk retention, and risk avoidance strategies is required, depending on the characteristics of the risks. Barriers to implementation include delayed payments, weak stakeholder coordination, limited human resources, social resistance, logistical problems, and low compliance with occupational health and safety regulations. The analysis further demonstrates that the success of mitigation strategies is strongly influenced by the clarity of contractual clauses, financial discipline, institutional coordination, and consistency in field implementation. These findings are expected to contribute to the development of sustainable transportation policies and serve as a reference for all stakeholders involved in planning more resilient road projects.

INTRODUCTION

Damage to road infrastructure is an almost inevitable risk and often occurs at various stages of a construction project (Rezapouraghdam et al. 2019). According to Maharani et al. (2022), road infrastructure has a high probability of being damaged due to technical and environmental factors.

Savitri et al. (2023), Suryani et al. (2021), and Udiana et al. (2014) add that factors such as inappropriate construction implementation, low material quality, planning errors, and extreme weather conditions can affect the time, cost, and quality of road construction.

To anticipate and manage the risks that arise during construction projects, the concept of risk management is essential. Pamilangan et al. (2021) state that risk management is an inseparable part of efforts to maintain the sustainability of infrastructure projects. Lestari et al. (2022) define risk management as the process of identifying, analyzing, and responding to risks to ensure that project objectives can be achieved effectively.

Asrorudin (2025) describes various sources of risk that affect the project process—such as political, environmental, planning, economic, financial, natural, project-related, technical, human, criminal, and safety risks—which need to be identified and managed to ensure project success. Flanagan and Norman (1993) classify risk management strategies into four approaches, namely: Risk Retention, Risk Reduction, Risk Transfer, and Risk Avoidance.

Unfortunately, studies on the application of these strategies in road pavement work are still limited, especially in regions such as West Sumatra, which face complex geographical and climatic challenges. The novelty of this research lies in its specific application of the Flanagan and Norman (1993) risk management framework to road pavement projects in West Sumatra's unique context, which combines challenging topography, high rainfall intensity, and specific socio-cultural dynamics. Unlike previous studies that often focus on generic risk identification, this research provides a comprehensive mapping of eleven risk categories to the four Flanagan and Norman strategies, validated through expert interviews and qualitative analysis using NVivo software. Therefore, this study aims to identify in depth the most significant risks, evaluate challenges in implementing mitigation strategies, and develop effective risk management approaches to reduce recurrent damage before the planned service life is reached.

The research aims to identify significant risks in road pavement work in West Sumatra using the Flanagan and Norman Approach (1993), which includes identification, analysis, evaluation, and grouping of risk ownership based on the four risk management strategies defined by Flanagan and Norman (1993). Identify obstacles that arise in the implementation of risk management in road pavement work in West Sumatra. Formulate an integrated risk management implementation to prevent repeated road pavement repairs, as a basis for planning to support sustainable transportation policies.

The benefits of this research are expected to provide both theoretical and practical contributions. Theoretically, this study enriches the literature on construction risk management by demonstrating the application of the Flanagan and Norman framework in a specific regional context. Practically, the findings can serve as a guideline for contractors, project managers, and policymakers in West Sumatra to develop more effective risk mitigation strategies, improve project planning, optimize budget allocation, and enhance the longevity and quality of road infrastructure. Ultimately, this research supports the development of sustainable transportation policies and contributes to more resilient infrastructure development in regions with similar geographical and socio-cultural characteristics.

MATERIALS AND METHOD

This study employed a qualitative approach as explained by Pahleviannur (2022), emphasizing intensive and thorough investigation of field phenomena through the analysis of documents, journals, videos, images, and other supporting evidence. The method was selected to examine causative factors and obstacles in mitigation and risk management strategies so that road pavement maintenance could run effectively and minimize repeated damage.

Data were obtained from literature and semi-structured interviews with experts consisting of academics, technical consultants, and field practitioners regarding significant risks in road pavement projects and their handling strategies based on the Flanagan and Norman (1993) risk management framework, which includes risk retention, risk reduction, risk transfer, and risk avoidance. Risk identification was conducted through literature review and in-depth interviews, followed by assessment of impact levels and likelihood to produce risk scores categorized as very high, medium-high, medium, or low.

The research involved 15 resource persons—four academics, five technical consultants, and six field practitioners—selected for their professionalism, background, experience, and ability to provide relevant information. Interview and literature data were processed using NVivo software through the stages of data reduction, presentation, axial coding, and thematic analysis. Axial coding connected key categories, including political, environmental, planning, economic, financial, natural, project-related, technical, human, criminal, and safety risks. Thematic analysis was then carried out to identify patterns, meanings, and linkages between risks, enabling the development of more targeted mitigation strategies for road pavement project management.

RESULTS AND DISCUSSION

Risk Management Strategy Analysis

The results of the identification of risk types and obstacles to the implementation of risk management based on the literature and field findings, as well as risk priority assessments from experts, show the existence of significant risk complexity in road pavement work. This complexity indicates that one type of risk cannot always be addressed with a single approach, but rather requires a diverse combination of strategies. Therefore, in this study, a risk management strategy framework according to Flanagan and Norman (1993) was used, which includes four main approaches: avoidance, transfer, reduction, and retention. These strategies are the basis for analyzing the most appropriate risk management alternatives according to the characteristics and priority level of each risk.

1. Handling Political Risk

From the results of the analysis, political risks in road construction projects are said to stem from unclear regulations, weaknesses in contract preparation, and potential conflicts of interest due to the absence of rules on the use of public space. Meanwhile, from the literature review, political risks are often emphasized on the intervention of project owners through changes in the scope of

work and design adjustments due to budget pressures. This indicates that political risks are contextual, where dominant factors can differ from one project to another, depending on regulatory conditions, contractual relationships, and budget policy dynamics.

The combination of the literature and findings shows the complexity of political risks that must be anticipated through strong regulation, detailed contract drafting, and transparent work change control mechanisms. If mapped into the framework of risk management methods according to Flanagan and Norman (1993), these measures fall into the category of Risk Reduction. This is because all proposed strategies function as preventive measures and control measures to suppress both the possibility and impact of political risks.

2. Environmental Risk Handling

From the results of the literature and findings, it can be understood that environmental risks have a great impact on the technical aspects of drainage management. Drainage dysfunction magnifies the negative impact of the environment because it has direct implications for the life of road services. In addition, environmental risks can also be caused by construction activities (noise and environmental pollution).

If mapped into risk management methods according to Flanagan and Norman (1993), these environmental risks are predominantly included in the Risk Reduction category. This is because most risk factors can be minimized through the implementation of preventive measures, such as improving drainage design and maintenance, waste control, using quality materials, and implementing environmental management and occupational safety standards. However, a small part of environmental risks remains in the Risk Retention category, especially in external aspects that are difficult to fully control, such as increased traffic loads. Thus, the environmental risk mitigation approach in road projects emphasizes more on risk reduction efforts through good design, management, and supervision, as well as internal adjustments in the event of conditions beyond the control of the field.

3. Planning Risk Handling

Estimation errors in planning risks can arise due to initial design that is not in accordance with field conditions, incorrect calculation of contract volume, and inadequate soil studies (Nugraha et al., 2015; Scott, 2021). The findings of the study show that poor project planning, inaccuracy of RAP estimates, and limitations of geological and hydrological surveys are the main causes of design incompatibility with existing conditions. This reinforces the literature assertion that negligence in the initial studies and contract calculations contributes greatly to the emergence of risks in the planning stages, both technically and managerially, being the main factor in the emergence of risks in construction projects.

Thus, all aspects of risk at the planning stage, both technical and managerial, are mapped into the Risk Reduction category. This is because weaknesses in planning can be minimized through better prevention and control, such as more accurate surveys, competent stakeholder selection, intensive coordination, mature work methods, and detailed PCM. In other words, the main strategy

in anticipating planning risks is to strengthen the quality of planning from the beginning so that the impact of risks in the construction stage can be minimized.

4. Economic Risk Management

Based on the results of the research, the problem of land acquisition is quite dominant, characterized by building speculation by the community, the existence of land brokers, and disputes over inherited land ownership. In addition, findings such as; Aspects of exchange rate changes, delays in the distribution of goods and logistics losses, as well as fluctuations in material prices are influenced by increases in material prices, taxes, difficult location access, and the accumulation of goods by distributors. These findings are consistent with the literature that states that economic risks in construction projects are generally triggered by supply chain or logistics disruptions, increased material costs, and limited supporting infrastructure.

If mapped into risk management methods according to Flanagan and Norman (1993), economic risks in road projects do not only require a single strategy, but a combination of several risk management methods depending on the risk aspects faced such as;

1) Risk Avoidance → be used on the risk of land acquisition which is very problematic (contractors should choose not to enter).
2) Risk Transfer → dominant for land acquisition issues and material price fluctuations (transferred to the owner/third party through contract).
3) Risk Reduction → used on logistics risk (distribution delays) and price fluctuation control, for example with more mature supply chain planning, selection of local suppliers, and arrangement of escalation price contracts to mitigate the impact of material price spikes.
4) Risk Retention → arise in external factors such as exchange rates and material price increases that are not entirely avoidable, so this risk is borne by the contractor through budget adjustments.

5. Financial Risk Handling

The results of the literature and field findings show that the financial risks that occur have a similar consistency, where contractors face cash flow uncertainty due to late terms, dependence on down payments, and weak reserve fund planning. Thus, both the literature and the findings of the study emphasize that weaknesses in the aspect of liquidity and uncertainty of the availability of funds are the dominant factors causing financial risks in construction projects.

If mapped into risk management methods according to Flanagan and Norman (1993), financial risk management emphasizes more on cash flow control and financial discipline, while preparing contractual mechanisms and reserve funds to maintain the sustainability of the project. So that financial risks in road projects require strategies that are in accordance with the amount of risk impacts that will be faced such as;

1) Risk Transfer → used to transfer to the project owner through contractual clauses, such as late payment fines or bank guarantee schemes.
2) Risk Reduction → be used to minimize the risk of using funds outside the budget by tightly controlling budgets, internal audits, and discipline of project cost plans, and improving financial management capacity, providing experts, and better time management.
3) Risk Retention → for external conditions that cannot be avoided, for example, the contractor still has to bear part of the liquidity burden by preparing a reserve fund or initial capital.

6. Natural Risk Management

Natural risks have been shown to greatly affect project productivity, especially during heavy rains, unstable soil conditions, floods, extreme weather, and rainy season disruptions that hamper pavement work. This factor is an external risk that is difficult for the contractor to control, so it requires adaptation strategies such as accelerating work methods, shifting schedules, or the use of special weather-resistant equipment. Without alternative planning, natural risks can lead to significant delays, cost overruns, and a decrease in the quality of work. Therefore, it is important to have risk management based on weather and environmental conditions from the early stages of the project to minimize the impact caused.

Based on the description of the natural risk problem above, road projects cannot be completely avoided. However, if framed into the treatment method according to Flanagan and Norman (1993), the risk can be mapped into several strategies;

1) Risk Reduction is the main approach through technical mitigation efforts and adaptive planning. Examples are adjusting work schedules according to the season, using acceleration methods when the weather is supportive, implementing temporary drainage systems, and utilizing equipment that is resistant to extreme weather conditions.
2) Risk Retention, where part of the risk must still be borne by the contractor, especially when facing unpredictable extreme weather, which requires reserve funds and schedule flexibility.
3) Risk Transfer at certain risks, for example by diverting potential losses due to flooding or equipment damage through a project insurance scheme (force majeure insurance).
4) Risk avoidance in extreme conditions where the project site has a very high disaster vulnerability can be considered, namely by not carrying out work in a location that is not technically or financially feasible.

7. Project Risk Handling

Based on a comparison of the literature and field findings, it can be understood that the risk of a road project is not only influenced by technical factors as described in the literature. But it is also influenced by social, logistical, managerial, and human resource aspects that arise from conditions in the field. Therefore, the risk of road projects should be mitigated technically and socially so that the project can be carried out effectively, efficiently, and sustainably. So that road project risks are mapped into a combination of several handling strategies;

1) Risk Reduction, predominantly used for social, logistics, managerial, and human resources aspects (controlling community disturbances with socialization, improving coordination between stakeholders, traffic management, improving human resource competencies with workforce training, quality and safety supervision).
2) Risk Avoidance, used in cases of land rejection or high social conflict, where the project is not feasible to proceed at the site.
3) Risk Transfer, for land acquisition (transferred to the owner/government) or road damage due to circumstances beyond his control, can carry out responsibilities that are transferred through contract clauses or agreements with local governments for maintenance.

8. Technical Risk Handling

Technical risks in flex road projects are not only related to the use of substandard materials, improper construction methods, and limited tools as explained in the literature (Agnasari, 2015; Simanjuntak et al., 2022; Nugraha, 2015), but it is also strengthened by field findings regarding weak procurement planning, communication with suppliers, quality inspections, and technical documentation. These conditions magnify the potential for technical failures and confirm that suboptimal procurement management and quality control are important factors in creating risks. Therefore, the necessary mitigation includes the implementation of a stricter quality management system, careful procurement planning with backup suppliers, and increased the capacity of technical personnel so that risks can be minimized from the initial stage to the implementation of the project.

Thus, if mapped into risk management by Flanagan and Norman (1999), the technical risks in the dominant road project are mapped inwards;

1) Risk Reduction, because almost all factors (materials, methods, tools, procurement, quality) can be minimized through better prevention, control, and quality control.
2) Risk Retention is still necessary, especially for tool breakdowns that cannot be fully predicted.
3) Risk Transfer is relevant to the risk of material supply, which can be transferred to the supplier through contracts.

9. Human Risk Handling

Field findings reveal that human risk in construction projects is not only related to low discipline, skills, and productivity of the workforce, but is also influenced by psychological factors, social interventions in the form of incompetent entrusted workers, conflicts between local and internal contractors, and weak performance management systems. This expands the literature by adding local social and cultural dimensions that are rarely highlighted, where community dynamics and the role of local figures also influence the effectiveness of work. Thus, the quality of human resources is a significant source of risk that needs to be mitigated through communication, mediation, clear work rules, and transparent division of roles.

So that human risk can be mapped into Risk Reduction, because most problems can be reduced through;

1) Discipline & low competence are reduced through training, strict supervision, implementation of SOPs, and certification of workers.
2) The mental readiness of contractors/practitioners is mitigated with stress management, balanced workload sharing, and management support.
3) Low local labor productivity can be minimized with short training, mentoring, and a combination of local labor and skilled labor.
4) Social interventions are mitigated by providing basic briefings or placing them in simple jobs so as not to degrade quality.
5) Internal social conflicts (local vs. internal contractors) are mitigated through communication, mediation, clear work rules, and transparent division of roles.
6) Ineffective labor performance can be minimized by building a performance management system, routine evaluation, and the implementation of quality standards.
7) Risk avoidance is also relevant, especially for social intervention cases in the form of entrusted labor that is completely not technically feasible.

10. Criminal Risk Handling

Field findings stated that projects in the field face various real threats, including theft and loss of project assets (work tools, materials, to intimidation from outsiders/NGOs), sabotage of heavy equipment (batteries, fuel, spare parts), deliberate material damage by local parties, social disorder such as thuggery and threats from community groups, and serious security disturbances that have the potential to temporarily halt the project's run. Thus, these findings enrich the literature by showing that criminal risk in construction projects in the local context cannot be understood as an individual event (theft/extortion), but rather as part of a system of social risk involving conflicts of interest, social instability, and intimidation practices. Criminal risks in construction projects have various forms of criminality (ranging from theft, intimidation, thuggery, to sabotage of tools and materials) that have direct implications for the smooth and sustainable of the project. Therefore, criminal risks in construction projects cannot be completely avoided (limited avoidance) can only be done in the context of initial prevention (e.g. avoiding conflict areas or storing materials safely).

The dominant handling management strategy is Risk Reduction, namely by increasing security, building good social relations with the community, and involving law enforcement. In addition, Risk Transfer is important, for example through insurance for heavy equipment & materials, contract guarantees in the event of significant equipment/material damage, or government intervention in the event of social insecurity that hinders project activities. However, there are also conditions where the contractor must still carry out Risk Retention for minor losses or indirect costs due to criminal disturbances, such as; Small loss of material in the field, additional costs for internal security, or minor delays due to intimidation, the project continues, despite a 1–2 day delay due to negotiations with outside parties.

11. Handling Safety Risks

Field findings show that safety risks in road pavement projects are not only influenced by the technical aspects of K3, but also by work culture, social conditions, traffic, planning, and environmental factors. These risks include internal worker factors (discipline, PPE compliance), technical factors (unmarked tools, absence of safety facilities, signs, and work zones), and external factors (traffic, surrounding communities, natural conditions). Thus, safety management requires an integrated approach that goes beyond formal standards, encompassing technical, managerial, social, and environmental aspects.

Therefore, safety risks in dominant road projects are mapped into the Risk Reduction category, as most of them can be minimized through the implementation of strict K3, supervision, and provision of safety facilities. Risk Transfer is also relevant, especially through labor insurance to protect against serious accidents. Risk Retention is necessary for external risks that are difficult to predict.

Discussion: Evaluation of Risk Mitigation Strategies

The results of the risk classification based on the literature and field findings, mapped into the framework of Flanagan & Norman (1993) in subchapter 4.4, show that risk management in flexible road pavement projects is complex and multi-strategy. There is no single type of risk that can only be addressed with a single approach, but requires a combination of strategies that are tailored to the risk source, level of impact, and socio-technical context of the project.

Therefore, it is necessary to evaluate the strategy to align the literature recommendations with the real conditions of the project, so that the chosen strategy is not only conceptual, but also applicable and adaptive to social, technical, and institutional dynamics at the work site to be more effective and sustainable.

This evaluation is based on the results of the level of risk in table 4.4 and the diagram in figure 4.2 is then associated with the implementation barriers outlined in table 4.9. Furthermore, the effectiveness of the strategy is analyzed by taking relevance to the literature and practice, so that conclusions are drawn about the most appropriate mitigation strategy and in accordance with the characteristics of each type of risk.

1. Very High Risk Category

Economic risk occupies the highest level of risk value (20.5) for road pavement work in West Sumatra, so it is included in the category of very high risk that has the potential to hinder the sustainability of the project. The dominant factors that trigger this risk are problematic land acquisitions, fluctuations in material prices, difficult site access and delays in logistics distribution. The mitigation strategies mapped refer to a combination of risk avoidance (preferably avoiding highly problematic land acquisition), transfer (through the application of price escalation clauses in contracts transferred to project owners), reduction (more mature supply chain planning, selection of local suppliers, and arrangement of escalation price contracts to reduce the impact of material

price spikes) and retention (external factors such as exchange rates and unsustainable material price increases). completely avoidable).

However, the effectiveness of this strategy faces challenges in the field, especially related to delays in the disbursement of term funds which cause contractors to have difficulty maintaining cash flow. This shows that the existing strategy has not been able to fully reduce the impact of economic risks. Therefore, this study emphasizes the importance of a combination of mitigation strategies, namely by adding a contingency fund and setting up a more flexible progressive payment system. This evaluation is in line with the literature (Labombang 2011; Sholeh 2025) which emphasizes the need for management to avoid loss of cost, quality, and time by adhering to clear contractual clauses regarding the rights and obligations of each party. As for maintaining cash flow, contractors need to understand the basic principles and laws in doing business, reinvest profits into the business, keep all records of company transactions, and separate company accounts from personal accounts (Abdullah, 2021).

2. Medium – High Risk Category

Environmental Risk (15.1), Natural Risk (16.4), Technical Risk (16.8) and Safety Risk (17.6) occupy the Medium-High category in the Level of Risk assessment for road pavement work in West Sumatra. Therefore, this risk is a category of risk that requires an active and sustainable mitigation strategy, because it can have a significant impact even though it can still be controlled. The dominant factor that triggers the environment is the technical aspect of drainage management, in addition to unstable soil, the use of heavy equipment causes environmental disturbances and pollution. Meanwhile, the dominant factors that affect safety risks are not only influenced by the technical aspects of K3, but also by work culture, social conditions, traffic, planning, and environmental factors.

a. Environmental Risk Assessment

Based on the results of field findings and risk mapping according to the risk management method of Flanagan and Norman (1993), environmental risk mitigation in road pavement projects emphasizes more on impact reduction through technical design, integrated environmental management, and continuous monitoring and evaluation systems. In its implementation, the environmental risk mitigation strategy still faces a number of obstacles. Public rejection sometimes persists even after a deliberation process has been carried out, which shows the need for a more effective social communication approach. In addition, not all projects carry out a thorough baseline study, so some potential environmental problems are only identified as the project progresses. Another obstacle arises from difficulties in coordination with the Natural Resources Conservation Agency (BKSDA) in several locations, which results in the inhibition of impact control on protected areas.

This evaluation is also in line with the literature (Asrorudin, 2025) which states that the importance of managing risks in an integrated and collaborative manner to support projects, with recommendations for mitigation strategies including; a) more careful implementation of surveys,

b) quality monitoring to avoid repetitive work, c) preparation of emergency response plans to deal with natural disasters, d) emphasizing the need to implement safe work protocols in sensitive areas. In addition, Lestari (2022) also supports utilizing sophisticated and latest measurement tools to support survey data, as well as approaching residents and emphasizing that if the project is completed, it will have a positive impact on residents.

b. Natural Risk Evaluation

Natural risks such as heavy rains, unstable soil, flooding, and extreme weather have a major impact on project productivity because they are difficult for contractors to control. Based on the description of the problem, natural risks in road projects cannot be completely avoided, but can be handled with strategies according to the method of Flanagan and Norman (1993), namely risk reduction through technical mitigation and adaptive planning such as schedule adjustments, acceleration of work methods, temporary drainage, and weatherproof equipment; risk retention by bearing part of the risk through reserve funds and schedule flexibility; risk transfer through the project's insurance scheme against losses due to flooding or equipment damage; and risk avoidance by not carrying out work in locations with very high disaster vulnerability.

However, the implementation of the strategy still faces obstacles, such as adjustments to work methods that are not optimal, projects that are still forced despite extreme weather conditions, and geotechnical surveys that are rarely carried out in depth. These barriers indicate that adaptation and mitigation strategies need to be strengthened with more realistic alternative plans, such as schedule shifting, the use of specialized equipment, and improving the quality of technical surveys.

The proper use of measuring instruments in the field of construction and civil engineering is a very important skill for the relevance of construction data such as land surveys and mapping. If possible, the coverage of technology in surveys for planning can be utilized by other measurement tools such as Total Station and GPS to generate a more comprehensive understanding of modern survey technology (Hasrul et al., 2024).

c. Technical Risk Evaluation

Technical risks in flex road projects are not only related to the use of substandard materials, improper construction methods, and limited tools as explained in the literature (Agnasari, 2015; Simanjuntak et al., 2022; Nugraha, 2015), but it is also strengthened by field findings regarding weak procurement planning, communication with suppliers, quality inspections, and technical documentation. Obstacles that often arise include delays in tools and materials due to weak logistics, difficulties in preparing sudden material alternatives, and the inability of suppliers to fulfill contracts on time.

The findings in the field map technical risks into risk management according to the Flanagan and Norman (1999) method, predominantly managed through Risk Reduction, because almost all factors (materials, methods, tools, procurement, quality) can be minimized through prevention, control, and quality control; Risk Retention, especially in equipment malfunctions that cannot be fully predicted; and Risk Transfer, which is relevant to the risk of material supply by transferring responsibility to the supplier through contractual clauses. In other words, the mitigation needed includes the implementation of a stricter quality management system, careful procurement planning

with backup suppliers, strengthening logistics, and increasing the capacity of technical personnel so that risks can be minimized from the initial stage to the implementation of the project.

Rahmadila (2025) with her research "Evaluation of the Quality Management System of Paving Work by Testing Ac-BC Samples" is also in line with the evaluation, the quality of AC-BC asphalt samples in Mamuju Regency has met technical standards and has the potential to support the construction of quality roads, but the success of its implementation is greatly influenced by a strict quality management system and continuous supervision. Therefore, good scheduling planning, the use of quality materials, and the use of adequate heavy equipment are needed. Rahmadila suggested strengthening the logistics aspect so that the distribution of materials runs smoothly with periodic monitoring, and the need to improve contractor coordination with local governments, as well as increasing the capacity of technical personnel through training related to spreading and compaction methods. These efforts are expected to minimize technical risks, ensure smooth project implementation, and ensure the resilience of the pavement layer to traffic loads and extreme environmental conditions.

Moi and Purnawita (2021) conducted a risk assessment on the Waebetu-Tarawaj Road Construction Project. The high risk category consists of; The residents' rejection of land acquisition and damage to equipment (heavy equipment) resulted in delays being borne by contractors because these risks occurred at the stage before and during the development project. In addition, the medium risk category consists of; Schedule delays affect project costs, unpredictable weather resulting in work interruptions, labor incompetence affects quality, and soil geological conditions (non-standard soil hardness) are risks borne by PU (owners) to ensure that heavy equipment operators must have a certificate of expertise and an operating permit. Then, the contractor must make an estimate of the project schedule and make an alternative to accelerate the project work, make weather reports based on the situation in the field equipped with BMKG data and find solutions with the owner to overcome existing problems.

d. Safety Risk Evaluation

Based on subchapter 4.5.11, occupational safety risks in road projects are predominantly included in the Risk Reduction category, as most of the causes can be minimized through the implementation of a strict K3 system, routine supervision, provision of safety facilities, and compliance with the use of PPE. Risk Transfer strategies through labor insurance are also relevant for financial protection, while Risk Retention remains necessary on external risks that are difficult to predict, such as traffic conditions and social changes around the project. However, the implementation of safety risk mitigation has not run optimally because there are still obstacles in the field such as; some work equipment is not always marked or re-checked periodically so that it has the potential to cause accidents, (SOP) safety is also not enforced with discipline, both by management and workers, while another obstacle that is quite dominant is the use of incomplete PPE. Based on these obstacles, the effectiveness of the strategy will only be effective if it is supported by a strong commitment from all relevant parties, both in the enforcement of K3, improving safety culture, as well as cross-agency coordination and community participation.

This evaluation is in line with the latest literature such as; Simarmata and Setiawannie (2021) stated that administrative action is needed related to worker compliance with the use of Personal Protective Equipment (PPE). Workers who do not use complete PPE in accordance with K3 regulations need to be given sanctions/punishments to foster awareness and prevent the recurrence of mistakes and other violations. On the other hand, workers who consistently comply with K3 rules by using complete PPE while working need to be rewarded. The implementation of this reward can increase awareness and concern for the importance of using PPE and motivate workers to avoid unsafe actions and conditions (unsafe actions and unsafe conditions).

3. Medium Risk Category

Medium-priority risks consist of; Planning Risk (13.1), Financial Risk (13.4), Project Risk (13), and Human Risk (10.7) are risks with categories that still need to be addressed because their impact and possibility cannot be ignored.

a) Planning Risk Evaluation

Planning risks arising from negligence in initial studies and contract calculations contribute greatly to the emergence of risks in the planning stages, both technically and managerially, being the main factors in the emergence of risks in construction projects. So that all aspects of risk at the planning stage, both technical and managerial, are mapped into the Risk Reduction category. This is because weaknesses in planning can be minimized through better prevention and control, such as more accurate surveys, competent stakeholder selection, intensive coordination, mature work methods, and detailed PCM. In other words, the main strategy in anticipating planning risks is to strengthen the quality of planning from the beginning so that the impact of risks in the construction stage can be minimized.

The evaluation can be supported by verifying the design and comprehensive field data, as well as recording changes officially to ensure that the quality of the project is maintained (Martanto, 2025).

b) Financial Risk Evaluation

Weakness in the aspect of liquidity and uncertainty of the availability of funds are the dominant factors causing financial risks in construction projects. If mapped into the risk management method according to the method of Flanagan and Norman (1993), the handling strategy can be carried out through risk transfer by shifting the burden to the project owner through contract clauses such as late payment fines or bank guarantees, risk reduction by minimizing the potential for misuse of funds through strict budget control, internal audit, cost discipline, financial management capacity building, the provision of experts, as well as good time management, and risk retention to deal with the inevitable external conditions, where the contractor still bears part of the liquidity burden by preparing reserve funds or initial capital. So, in simple terms, financial risk management emphasizes more on controlling cash flow and financial discipline of contractors, while preparing contractual mechanisms and reserve funds to maintain the sustainability of the project.

Financial analysis needs to be a concern for contractors, because the dominant risk cause in construction projects today is still influenced by contractual, design, technology and others that will affect the completion of the work both timeliness and cost savings. Therefore, special attention is needed to these risks for contractors to prepare reserve budgets and cost mitigation strategies in order to take into account the details of losses or profits (Nugroho and Hayati, 2024).

c) Project Risk Evaluation

Based on a comparison of the literature and field findings, it can be understood that the risk of a road project is not only influenced by technical factors, but also by the social, logistical, managerial, and human resource aspects that emerge in the field. Obstacles that often occur include socialization to the community that is still not effective, the dependence of project schedules on political decisions instead of technical considerations, and weak coordination between parties such as villages and local officials. Protek Risk Management based on findings can be mapped into a combination of strategies; (1) Risk Reduction, predominantly used for social, logistical, managerial, and human resource aspects; (2) Risk Avoidance, used in cases of land rejection or high social conflict where the project is not feasible to proceed at the site; and (3) Risk Transfer, for example for land acquisition transferred to the owner/government or road damage due to circumstances beyond his control that can be regulated through contract clauses or agreements with local governments related to maintenance.

Evaluation of the obstacles that occur is recommended by approaching, negotiating, and providing explanations to certain parties and convincing the community that the construction of road projects will not disrupt the community order, and emphasizing projects that will have a positive impact on helping to support residents' activities later (Lestari, 2022).

d) Human Risk Evaluation

Human risk in construction projects is not only related to discipline, skills, and labor productivity, but is also influenced by social interventions in the form of incompetent entrusted labor, limited local human resources that are difficult to train in a short time, and weak certification requirements from some service providers. This condition confirms that the quality of human resources is a significant source of risk that needs to be mitigated, especially through Risk Reduction, such as training, strict supervision, implementation of SOPs, worker certification, communication, mediation, and performance management systems. Meanwhile, Risk Avoidance is also relevant for cases of social intervention involving entrusted labor that is completely not technically feasible, so that the quality of work is maintained (risk management mapping according to the Flanagan and Norman 1993 method).

The evaluation is supported by research by Darsa et al (2023) who conducted a SWOT analysis to provide recommendations for strategies for improving human resources in road construction projects, mentioning the importance of strengthening internal factors such as; fair experience and compensation, human resource management, employee motivation, discipline and conducive work environment, and improved work ability. In addition, the company must carry out continuous development by collaborating with trusted and competent partners.

4. Low Risk Category

From the results of the interpretation, the Level of Political Risk (R1) 7.6 and Criminal Risk (R10) 7.5 are low-priority risks because the possibility of these risks is certain in a project location, although these two risks still need to be noted in project management.

a) Political Risk Assessment

Political risks in road construction projects arise from unclear regulations, weaknesses in contracts that often do not contain detailed policy change clauses, lack of national regulations related to new policy compensation, and stakeholder coordination that has not been maximized. This condition confirms that political risks are contextual and can differ between projects depending on regulations, contractuals, and budget policy dynamics. Therefore, the handling strategy according to the risk management method of Flanagan and Norman (1993) is mapped in Risk Reduction, through the preparation of more detailed contracts, strengthening regulations, and transparent work change control mechanisms as preventive and control measures to reduce the possibility and impact of political risks.

The results of the evaluation are supported by research by Helda (2023) which states that it is necessary for parties in the construction services industry to pay attention to the contractual position and applicable legal provisions in the implementation of construction services, because they are closely related to the rights and obligations, as well as the interests of the parties to be carried out in a construction work. This form of contractual position can be done through balanced risk allocation in construction contracts and the use of dispute avoidance methods by using third parties as mediators.

b) Criminal Risk Assessment

Criminal risks in road construction projects include asset theft, sabotage of heavy equipment, deliberate material damage, to intimidation and thuggery, which have a direct impact on the smooth running of the project. Field obstacles show that the involvement of security forces is uneven, the practice of thuggery still occurs despite the presence of the authorities, and the cost of securing third parties is relatively expensive and often not budgeted. Therefore, the dominant handling strategies are mapped in Risk Reduction through increased security and strengthening of social relations with the community, Risk Transfer through insurance schemes, contract guarantees, or government intervention in social disorder, and Risk Retention to bear small losses or additional costs that cannot be completely avoided.

The evaluation is relevant to the results of Aggraini and Husain's (2025) research which summarizes several expert opinions for handling criminal risks through increasing security and strengthening social relationships, by;

a. Hidayat and Noegroho (2021) emphasized that collaboration between the government, traditional leaders, religious leaders, and civil society is crucial in conflict-prone areas.
b. The importance of social integration through a balance between consensus and conflict approaches (Haris et al. 2023). Multi-party mediation is able to resolve a number of disputes quickly through consensus, while cases that do not find agreement are proceeded to formal legal proceedings as a form of structured conflict approach.

CONCLUSION

The risk analysis of road pavement work in West Sumatra, conducted with 15 experts using a qualitative approach, NVivo analysis, and mapping based on the Flanagan & Norman (1993) framework, revealed that planning, project, technical, human, and safety risks were predominantly addressed through risk reduction strategies, while political, environmental, economic, financial, and natural risks required a mix of risk transfer, retention, and avoidance. Economic risks emerged as the highest priority due to price fluctuations, land issues, and logistical delays, followed by environmental, natural, technical, and safety risks in the medium-high category. Effective mitigation was linked not only to appropriate strategy selection but also to consistent implementation, institutional support, stakeholder coordination, and K3 compliance, with obstacles stemming from regulatory constraints, limited human resources, social resistance, logistics weaknesses, and contractor financial discipline. Future research should investigate quantitative validation of these qualitative findings, explore integrated digital monitoring systems for real-time risk control, and assess long-term impacts of institutional and stakeholder coordination on sustaining road infrastructure quality.

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