e-ISSN: 3031-6391
p-ISSN: 3026-0140

Content lists available at Indonesia Academia Research Society

International Journal of Industrial Engineering, Technology & Operations Management

Journal homepage: ejournals.indoacademia-society.com/ijietom

Original Article

Check for updates

Effects of Risk Management and Operational Management on Road Maintenance Project Performance: Evidence from East Kutai Regency

Nurhalija Rusdi [a,*], Andi Indrawati [a] and Rina Masithoh Haryadi [a]

[a] Master of Management Program, Faculty of Economics and Business, Universitas 17 Agustus 1945 Samarinda, 75124 Kalimantan Timur, Indonesia.
* Correspondence: nurhalizarusdi@gmail.com (N.R.)

Article History
Received 5 September 2025
Revised 18 November 2025
Accepted 10 December 2025
Available Online 31 December 2025

Keywords:
Risk management
Operational management
Project performance
Road maintenance
Infrastructure projects

Abstract

This study examines the effects of risk management and operational management on the performance of road maintenance projects in East Kutai Regency, Indonesia, a region characterized by complex terrain, high rainfall, and logistical constraints that often challenge project implementation. The research addresses the persistent problem of inconsistent project outcomes in terms of time, cost, and quality, which are frequently associated with managerial and operational inefficiencies. The primary objective is to analyze the extent to which risk management and operational management contribute to improving project performance. A quantitative approach was employed using an explanatory research design, with data collected through structured questionnaires from 32 stakeholders directly involved in road maintenance projects. The data were analyzed using Structural Equation Modeling based on Partial Least Squares to evaluate the relationships among variables. The results indicate that both risk and operational management have positive, significant effects on project performance. However, operational management exerts a stronger influence, underscoring the critical roles of effective planning, coordination, resource allocation, and supervision in achieving project success. In contrast, the effect of risk management is moderate, suggesting that its impact depends on its integration into operational practices. The model explains a substantial proportion of the variance in project performance, indicating satisfactory predictive capability. In conclusion, enhancing operational management while strengthening the practical implementation of risk management is essential to improving the efficiency, quality, and sustainability of road maintenance projects in complex environments.

1. Introduction

Road infrastructure development plays a pivotal role in accelerating regional economic growth and promoting equitable development across geographic areas. Well-developed road networks enhance connectivity between regions, facilitate the efficient movement of goods and services, and strengthen socio-economic integration, thereby contributing significantly to regional competitiveness and sustainability. In many developing regions, including East Kutai Regency, Indonesia, the demand for reliable road infrastructure continues to increase in response to rapid growth in key sectors such as mining, plantations, industry, port activities, and residential expansion. These sectors rely heavily on efficient transportation systems to maintain productivity and ensure uninterrupted logistics flows. Consequently, the quality and performance of road maintenance projects become critical determinants of regional economic stability and long-term development outcomes.

The geographical and environmental characteristics of East Kutai Regency further complicate infrastructure maintenance. The region is characterized by extensive territory, heterogeneous topography, and high rainfall intensity, all of which contribute to increased vulnerability of road infrastructure to deterioration and damage. Studies have shown that environmental and technical risks, such as erosion, landslides, and pavement degradation, are major contributors to project delays and

cost overruns in road construction and maintenance projects. In addition, financial constraints, limited resources, and managerial inefficiencies often exacerbate these challenges, leading to inconsistencies in project performance across time, cost, and quality. These conditions highlight the need for systematic, data-driven planning to ensure road maintenance activities are executed effectively and in accordance with technical standards.

Risk management has emerged as a critical discipline in addressing uncertainties inherent in infrastructure projects. It involves systematically identifying, assessing, and mitigating risks that may affect project outcomes. Effective risk management enables project stakeholders to anticipate potential disruptions and implement proactive strategies to minimize their impact. Previous studies emphasize that integrating reliability-based and risk-based approaches can significantly enhance maintenance decision-making and improve overall system performance (Da Silva et al., 2023; Selvik & Aven, 2011). Furthermore, risk management frameworks in infrastructure projects, including public–private partnerships, have been shown to improve project performance by aligning risk mitigation strategies with project objectives and stakeholder expectations (Fatima et al., 2024; Jiang et al., 2022). However, despite its theoretical importance, empirical evidence on the direct impact of risk management on project performance remains inconclusive, particularly in complex and dynamic environments.

In parallel, operational management plays a fundamental role in ensuring the effective execution of project activities. It encompasses planning, organizing, coordinating resources, supervising implementation, and evaluating performance. Strong operational management practices contribute to improved efficiency, better resource utilization, and enhanced quality control. Empirical findings indicate that project planning and managerial competencies are significant predictors of project success, often exerting a stronger influence than other managerial factors (Irfan et al., 2021). Similarly, operational inefficiencies, such as poor coordination, inadequate supervision, and ineffective resource allocation, can lead to substantial performance degradation in infrastructure projects. The integration of operational management with risk management is therefore essential to ensure that projects are not only well-planned but also resilient to uncertainties.

Despite the growing body of literature on project management, a critical gap remains in understanding the combined, context-specific effects of risk management and operational management on project performance, particularly in road maintenance projects in developing regions. Many existing studies examine these two aspects independently, without adequately exploring their interactions in shaping project outcomes. Moreover, limited research has focused on the unique challenges posed by environmental and logistical conditions in regions such as East Kutai Regency. This gap is further compounded by evidence suggesting that risk management practices are often not fully integrated into operational processes, thereby limiting their effectiveness in improving project performance (Damayanti, 2023; Rahi, 2019).

Additionally, recent studies highlight the importance of adopting integrated and adaptive management frameworks that combine technical, managerial, and environmental considerations to enhance infrastructure performance. For instance, risk-based maintenance approaches and resilience-oriented frameworks have been shown to improve the reliability and sustainability of infrastructure systems (Malik et al., 2024; Taherdoost, 2022). Similarly, the application of multi-criteria decision-making methods, such as the Analytical Hierarchy Process (AHP), provides a systematic approach for prioritizing risks and optimizing resource allocation in complex project environments (Syahrani & Diyanty, 2023; Sirait et al., 2023). These approaches underscore the need for a more holistic and integrated perspective in managing infrastructure projects.

Given these considerations, this study aims to examine the influence of risk management and operational management on the performance of road maintenance projects in East Kutai Regency. By focusing on the interplay between these two critical management dimensions, this research seeks to provide empirical evidence on their relative and combined contributions to project performance. The study also aims to address the persistent issue of inconsistent project outcomes by identifying key factors that influence efficiency, cost control, and quality achievement in road maintenance activities.

Ultimately, this research contributes to both theoretical and practical domains by proposing an integrated framework that links risk management and operational management to project performance. The findings are expected to provide policymakers, project managers, and infrastructure stakeholders with valuable insights for developing more effective, resilient, and context-sensitive management strategies. In doing so, the study supports the broader goal of enhancing the sustainability and reliability of road infrastructure systems, particularly in regions characterized by high environmental and operational complexity.

2. Literature Review

2.1. Risk Management in Infrastructure Projects

Risk management has evolved into a fundamental component of modern project management, particularly in infrastructure development where uncertainty, complexity, and long project lifecycles are prevalent. It is commonly defined as a systematic process of identifying, analyzing, evaluating, and responding to risks that may affect project objectives, including time, cost, and quality.

In infrastructure contexts, risk management is not only a protective mechanism but also a strategic tool that enhances decision-making and project resilience.

Early frameworks such as Reliability-Centered Maintenance (RCM) emphasized the importance of maintaining system functionality through reliability analysis. However, subsequent developments have extended this perspective by integrating risk considerations into maintenance planning. For instance, the concept of Reliability and Risk-Centered Maintenance (RRCM) highlights the need to simultaneously account for system reliability and potential risk impacts in maintenance decision-making, thereby improving asset performance and cost efficiency (Selvik & Aven, 2011; Da Silva et al., 2023). These approaches suggest that risk-informed maintenance strategies can lead to more robust and sustainable infrastructure systems.

In the context of large-scale infrastructure projects, particularly public–private partnerships, risk management frameworks have been shown to enhance project performance by aligning risk identification and mitigation strategies with project objectives and stakeholder expectations (Fatima et al., 2024; Jiang et al., 2022). These frameworks often incorporate multidimensional risk factors, including financial, environmental, technical, and institutional risks, and emphasize the importance of continuous monitoring and adaptive response mechanisms. Furthermore, empirical studies demonstrate that effective risk management enhances resilience and operational stability in infrastructure systems (Malik et al., 2024).

Despite these theoretical advancements, the practical effectiveness of risk management remains inconsistent. Several studies indicate that while risk management frameworks are widely adopted, their implementation is often fragmented and lacks integration with operational processes (Damayanti, 2023). Additionally, the impact of risk management on project performance is not always direct, as it may be mediated by other factors such as managerial capability, organizational culture, and environmental conditions (Rahi, 2019). This suggests that the relationship between risk management and project performance is complex and context-dependent, requiring further empirical investigation.

2.2. Operational Management and Project Performance

Operational management plays a critical role in translating project plans into tangible outcomes. It encompasses a range of activities, including planning, organizing, coordinating resources, supervising execution, and evaluating performance. In infrastructure projects, operational management ensures that resources are utilized efficiently, processes are executed effectively, and project objectives are achieved within the specified constraints.

The literature consistently identifies operational management as a key determinant of project success. For example, project planning and managerial competencies have been found to significantly influence project performance, with planning often emerging as the most critical factor (Irfan et al., 2021). Effective planning provides a structured framework for resource allocation, scheduling, and risk anticipation, thereby reducing uncertainties and enhancing project outcomes. Similarly, operational efficiency, reflected in coordination, supervision, and process control, directly affects the quality and timeliness of project delivery.

In the context of road infrastructure, operational management becomes even more crucial given the environment's dynamic, uncertain nature. Studies on road maintenance projects highlight that factors such as resource availability, stakeholder coordination, and technical execution significantly influence project performance (Ghanbari & Hasani, 2024; Murugi & Nyang'au, 2023). Moreover, integrating advanced management tools and data-driven approaches has been shown to improve operational efficiency and decision-making in infrastructure projects (Taherdoost, 2022).

However, operational management is not without challenges. Inefficiencies in coordination, lack of supervision, and poor resource management can lead to delays, cost overruns, and quality issues. These challenges are particularly pronounced in developing regions where institutional capacity and technological resources may be limited. Therefore, strengthening operational management practices is essential for improving project performance and ensuring the sustainability of infrastructure systems.

2.3. Integration of Risk and Operational Management

While risk management and operational management have been extensively studied as separate domains, there is a growing recognition of the need to integrate these two aspects to enhance project performance. Infrastructure projects are inherently complex systems where risks and operations are interdependent. Effective risk management requires a deep understanding of operational processes, while operational efficiency depends on the ability to anticipate and mitigate risks.

Recent studies suggest that integrating risk management with operational management can lead to more resilient and adaptive project systems. For instance, risk-based maintenance and asset management models emphasize aligning risk assessment with operational decision-making to optimize resource allocation and minimize system vulnerabilities (Alshboul et al., 2023; Alkhawaja & Varouqa, 2023). Similarly, the use of multi-criteria decision-making methods, such as the Analytical Hierarchy Process (AHP), enables prioritizing risks based

on their impact on operational performance, thereby facilitating more informed decision-making (Syahrani & Diyanty, 2023; Sirait et al., 2023).

Moreover, empirical evidence indicates that risk management effectiveness is often contingent on the quality of operational management. For example, financial risk management has been shown to significantly improve safety outcomes in road construction projects when supported by a conducive project environment and strong operational practices (Kirui et al., 2025). This highlights the interdependent relationship between risk and operational management, where the effectiveness of one is influenced by the other.

Despite these insights, the integration of risk and operational management remains underexplored in the literature. Many studies continue to treat these domains independently, without adequately examining their interaction and combined impact on project performance. This limitation is particularly evident in road maintenance projects, where the dynamic interplay between environmental risks and operational processes is critical to project success.

The existing literature reveals several critical gaps that warrant further investigation. Although risk management and operational management are widely recognized as key determinants of project performance, prior studies have predominantly examined these factors in isolation, with limited empirical evidence on their interactions and combined influence on project outcomes, particularly in infrastructure maintenance contexts. Moreover, the effectiveness of risk management in enhancing project performance remains inconclusive. While some studies report a positive relationship, others suggest that its impact may be indirect or highly context-dependent, underscoring the need for deeper empirical exploration across diverse project environments.

In addition, there is a notable lack of context-specific research that captures the unique challenges faced by road maintenance projects in regions characterized by complex environmental and logistical conditions, such as East Kutai Regency. High rainfall intensity, diverse topography, and infrastructure limitations create a dynamic, uncertain operational setting that necessitates a more integrated, adaptive management approach. Although recent literature highlights a shift toward holistic frameworks that integrate technical, operational, and risk management dimensions, empirical validation of such approaches remains limited, particularly in developing regions.

In response to these gaps, this study adopts an integrative perspective to examine the influence of risk management and operational management on the performance of road maintenance projects. By emphasizing their combined and context-specific effects, this research seeks to provide a more comprehensive understanding of the factors driving project success. Ultimately, the study contributes to both theory and practice by offering insights that support the development of more effective, resilient, and context-sensitive infrastructure management strategies.

3. Materials and Methods

This study adopts a quantitative, descriptive-verifiable approach to obtain objective, measurable evidence on the effectiveness of risk and operational management in road maintenance projects. The quantitative approach enables systematic measurement of operational phenomena, while the descriptive component provides a comprehensive depiction of existing conditions related to risk management, operational management, and project performance. The verifiability aspect allows empirical testing of relationships among variables, thereby ensuring the scientific rigor of the findings. The research design is explanatory, examining causal relationships among risk management and operational management as independent variables and project performance as the dependent variable.

Data were collected through a structured survey targeting stakeholders directly involved in road maintenance projects in East Kutai Regency. Respondents included technical implementing officials, contractors, supervisory consultants, and field personnel responsible for planning, execution, and control of maintenance activities. This approach ensures that the data reflect practical insights from experienced practitioners within the project environment. The study focuses on three main variables. Risk management (X_1) is a systematic process that involves risk identification, probability assessment, impact analysis, mitigation planning, and control evaluation. Operational management (X_2) involves planning, coordinating, allocating resources, supervising, and monitoring project performance. Project performance (Y) is measured based on the achievement of key project indicators, including time efficiency, cost effectiveness, quality compliance, and output performance.

Primary data were collected using a closed-ended questionnaire with a five-point Likert scale, widely recognized for its reliability and ease of use in capturing respondents' perceptions and attitudes (Taherdoost, 2022). The data collection process involved distributing questionnaires to all relevant project personnel. The study employed saturated sampling, in which all members of the defined population were included as respondents, yielding a total sample of 32 participants. This approach ensures comprehensive representation of the project stakeholders and enhances the validity of the findings.

Data analysis was conducted using Structural Equation Modeling based on Partial Least Squares (SEM-PLS) with SmartPLS software. The analysis followed a two-stage procedure. The first stage involved evaluating the measurement model to ensure the validity and

reliability of the constructs. Convergent validity was assessed using outer loading values with a threshold of 0.70, while discriminant validity was evaluated using the Average Variance Extracted (AVE) with a minimum criterion of 0.50. Reliability was confirmed through Cronbach's Alpha and Composite Reliability values exceeding 0.70. The second stage involved assessment of the structural model to test the hypothesized relationships among variables. The model's predictive power was evaluated using the coefficient of determination (R^2), and hypothesis testing was conducted using path coefficients and bootstrapping to assess statistical significance. Both partial (t-test) and simultaneous (F-test) analyses were applied to examine the individual and combined effects of risk management and operational management on project performance.

The study was conducted in the North Sangatta District of East Kutai Regency, specifically focusing on culvert repair works along Jalan Soekarno Hatta. This location was selected due to its high-risk characteristics, including ongoing traffic activity, open excavations, varying soil conditions, and high rainfall intensity, all of which contribute to increased project complexity. These conditions provide a relevant context for examining the effectiveness of risk and operational management practices in real-world infrastructure maintenance projects.

4. Results and Discussions

4.1. Demography Profile of Respondent

This study involved 32 respondents who were directly engaged in road maintenance projects in East Kutai Regency. Respondents were selected using a purposive sampling technique based on possessing relevant knowledge and involvement in risk management processes and project operational management. The respondents' profiles are described by gender, age group, work unit or institution, and length of work experience on the project. An analysis of these characteristics is essential to ensure that the data were obtained from competent sources and to better understand the context of potential variations in respondents' perspectives.

Table 1. Result of Demography Profile of Respondents

Demographic	Category	Frequency	Percentage
Gender	Male	28	87.5
	Female	4	12.5
Age	< 30 years	13	40.63
	30–40 years	11	34.38
	41–50 years	8	25
Work Unit / OPD	Public Works and Spatial Planning Office	12	37.5
	Perkim Service	1	3.13
	Consultant	11	34.38
	Private Company (CV/PT)	8	25
Length of Work on Project	< 1 year	2	6.25
	1–3 years	8	25
	3–5 years	7	21.88
	> 5 years	15	46.88

Table 1 presents the demographic profile of respondents involved in road maintenance projects in East Kutai Regency. The distribution of respondents provides important insights into the composition, experience, and institutional representation of the sample, which are critical for ensuring the reliability and relevance of the study findings.

In terms of gender, the sample is predominantly male, comprising 28 respondents (87.5%), while female respondents account for only 4 individuals (12.5%). This distribution reflects the typical gender composition within the construction and infrastructure sectors, where male participation remains dominant, particularly in field-based and technical roles.

Regarding age, the respondents are relatively young and within the productive working age groups. The largest proportion falls into the 30 years or younger category, with 13 respondents (40.63%), followed by those aged 30–40 years, with 11 respondents (34.38%). Meanwhile, respondents aged 41–50 years represent 8 individuals (25%). This distribution indicates that most participants are in their early to mid-career stages, suggesting a workforce that is both active and adaptable to project demands, while still supported by a proportion of more experienced personnel.

From the perspective of institutional affiliation (Work Unit/OPD), the respondents are drawn from diverse organizational backgrounds. The largest group comes from the Public Works and Spatial Planning Office, with 12 respondents (37.5%), reflecting the central role of government agencies in managing and supervising road maintenance projects. Consultants represent 11 respondents (34.38%), indicating strong involvement of professional expertise in project planning and supervision. Private companies (CV/PT) contributed 8 respondents (25%), highlighting contractors' participation in project execution. Meanwhile, the Perkim Service is minimally represented with only 1 respondent (3.13%), suggesting a more limited role in this specific project context.

Regarding work experience on the project, the data indicate a relatively experienced respondent pool. Most respondents have more than 5 years of experience, totaling 15 individuals (46.88%), indicating a strong presence of seasoned professionals who are likely to possess in-depth knowledge of project operations and risk management practices. Respondents with 1–3 years of experience account for 8 individuals (25%), while

those with 3–5 years of experience account for 7 individuals (21.88%). Only 2 respondents (6.25%) have less than 1 year of experience. This distribution suggests the sample is dominated by experienced personnel, thereby enhancing the credibility and validity of the collected data.

The demographic profile indicates that the respondents are largely experienced practitioners with diverse institutional backgrounds and predominantly technical roles. The combination of substantial work experience and involvement from key stakeholders, including government agencies, consultants, and private contractors, provides a strong foundation for capturing reliable perceptions of risk management, operational management, and project performance in road maintenance projects. This diversity and experience level strengthen the robustness of the subsequent analysis and support the generalizability of the study findings within similar infrastructure contexts.

4.2. Measurement Model Evaluation

4.2.1. Construct Validity and Reliability

Table 2 presents the results of the measurement model evaluation, including indicator loadings, internal consistency reliability (Cronbach's alpha and composite reliability), and convergent validity assessed through the Average Variance Extracted (AVE). These metrics are essential to ensure that the constructs used in this study are both valid and reliable for further structural model analysis.

Table 2. Result of Construct Validity and Reliability

Construct(s)	Indicator(S)	Loadings	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
Risk Management	X1.1	0.766	0.865	0.869	0.649
	X1.2	0.846			
	X1.3	0.803			
	X1.4	0.848			
	X1.5	0.762			
Operational Management	X2.1	0.730	0.835	0.848	0.605
	X2.2	0.716			
	X2.3	0.812			
	X2.4	0.832			
	X2.5	0.835			
Project Performance	Y1	0.878	0.919	0.922	0.714
	Y2	0.850			
	Y3	0.863			
	Y4	0.864			
	Y5	0.830			
	Y6	0.780			

The outer loading values for all indicators across the three constructs, namely Risk Management, Operational Management, and Project Performance, exceed the recommended threshold of 0.70. Specifically, the loadings for the Risk Management construct range from 0.762 to 0.848, indicating that all five indicators (X1.1–X1.5) have strong contributions in explaining the latent construct. Similarly, the Operational Management construct shows loadings between 0.716 and 0.835, while the Project Performance construct shows even higher loadings, ranging from 0.780 to 0.878. These results confirm that all indicators have satisfactory indicator reliability and are appropriate for representing their respective constructs.

The reliability of each construct was evaluated using Cronbach's alpha and composite reliability. The results indicate that all constructs meet the recommended minimum threshold of 0.70, demonstrating high internal consistency. The Risk Management construct shows a Cronbach's alpha value of 0.865 and a composite reliability of 0.869, indicating strong reliability. The Operational Management construct also exhibits acceptable reliability, with Cronbach's alpha of 0.835 and composite reliability of 0.848. Meanwhile, the Project Performance construct demonstrates the highest level of reliability, with Cronbach's alpha of 0.919 and composite reliability of 0.922. These findings suggest that the measurement items within each construct are consistent in capturing the underlying theoretical concepts.

Convergent validity was assessed using the Average Variance Extracted (AVE), with a recommended threshold of 0.50. All constructs exceed this threshold, indicating that a substantial proportion of variance in the indicators is explained by their respective latent variables. The AVE values are 0.649 for Risk Management, 0.605 for Operational Management, and 0.714 for Project Performance. The relatively high AVEs, particularly for Project Performance, indicate strong convergent validity and that the constructs are well represented by their indicators.

The results of the measurement model evaluation confirm that all constructs meet the criteria for indicator reliability, internal consistency, and convergent validity.

No indicators needed to be removed, as all loading values exceeded the acceptable threshold. The robustness of these results indicates that the measurement model is well-specified and suitable for further analysis of the structural relationships between risk management, operational management, and project performance.

4.3. Structural Model Evaluation

4.3.1. Coefficient Determination

The evaluation of the structural model begins with assessing the coefficient of determination (R^2), which indicates the model's predictive accuracy and the extent to which the independent variables explain the variance of the dependent variable.

Table 3. Result of Coefficient Determination (R-Square)

Variable	R-Square	R-Square Adjusted
Project Performance	0.532	0.522

Note: Independent variables: Risk Management (X1) and Operational Management (X2)

Table 3 presents the R-square and adjusted R-square values for the Project Performance variable. The results show that the R-square value is 0.532, indicating that Risk Management (X1) and Operational Management (X2) collectively explain 53.2% of the variance in project performance. This level of explanatory power is moderate, suggesting that the model has a meaningful ability to predict project performance outcomes in the context of road maintenance projects. The adjusted R-square of 0.522 further confirms the model's robustness, given the number of predictors included. The relatively small difference between the R-square and adjusted R-square values indicates that the model is stable and not overfitted, suggesting that the independent variables contribute effectively without inflating the explanatory power.

These findings imply that more than half of the variation in project performance is influenced by the combined effects of risk management and operational management. However, the remaining 46.8% of the variance is explained by other factors not included in this model, such as environmental conditions, organizational capacity, technological adoption, and external uncertainties. Therefore, while the model demonstrates satisfactory predictive capability, it also suggests opportunities for future research to incorporate additional variables to enhance explanatory power. The results of the coefficient of determination confirm that the proposed model adequately explains project performance and provides a solid foundation for further hypothesis testing and structural relationship analysis.

4.4. Hypothesis Testing

The next stage of the structural model evaluation involves testing the proposed hypotheses using path coefficient analysis via bootstrapping. This analysis examines the significance and strength of the relationships between the independent variables, including Risk Management (X1) and Operational Management (X2), and the dependent variable, Project Performance (Y).

Table 4. Result of Hypothesis Testing

Path Analysis	Original sample (O)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	Decision
Risk Management -> Project Performance	0.222	0.122	1.813	0.040	Supported
Operational Management -> Project Performance	0.550	0.101	5.453	0.000	Supported

Note: Directional Hypotheses use One-Tailed

The results presented in Table 4 indicate that both hypothesized relationships are statistically significant and positively influence project performance. First, the relationship between Risk Management and Project Performance shows a path coefficient of 0.222, indicating a positive effect. The t-statistic value of 1.813 exceeds the critical threshold for one-tailed testing, and the p-value of 0.040 is below the significance level of 0.05. These results confirm that Risk Management has a statistically significant, albeit relatively moderate, effect on project performance. This suggests that effective identification, assessment, and mitigation of risks contribute to improved project outcomes, although the magnitude of the effect is not as strong as that of other factors.

Second, Operational Management demonstrates a stronger and more substantial influence on Project Performance, with a path coefficient of 0.550. The t-statistic of 5.453 is well above the required threshold, and the p-value of 0.000 indicates a highly significant relationship. This finding highlights that operational management practices—such as planning, coordination, resource allocation, and supervision—play a dominant role in determining the success of road maintenance projects. The strength of this relationship suggests that improvements in operational processes can lead to significant enhancements in project efficiency, quality, and timeliness.

Thus, the two proposed hypotheses are supported, confirming that Risk Management and Operational

Management significantly affect Project Performance. However, the comparative results reveal that Operational Management has a more pronounced impact than Risk Management. This indicates that while risk management is important, the effectiveness of day-to-day operational execution is a more critical driver of project success in road maintenance projects. These findings reinforce the importance of integrating both management dimensions, with particular emphasis on strengthening operational capabilities to achieve optimal project performance.

5. Discussion

This study aims to examine the influence of risk management and operational management on the performance of road maintenance projects in East Kutai Regency. The findings reveal that both variables have a positive and significant effect on project performance; however, their magnitude and practical implications differ. The results provide important insights into how managerial practices shape infrastructure project outcomes, particularly in complex and high-risk environments.

5.1. Role of Risk Management in Project Performance

The results indicate that risk management has a positive, statistically significant effect on project performance, although its influence is relatively moderate compared to operational management. This finding supports the theoretical perspective that risk management serves as a critical mechanism for identifying, assessing, and mitigating uncertainties that may disrupt project execution. In line with reliability- and risk-centered maintenance theories, integrating risk considerations into project planning enhances system stability and supports better decision-making (Selvik & Aven, 2011; Da Silva et al., 2023).

Furthermore, the findings are consistent with prior studies that emphasize the importance of structured risk management frameworks for improving infrastructure performance (Fatima et al., 2024; Jiang et al., 2022). Effective risk management allows project stakeholders to anticipate potential disruptions such as environmental hazards, financial uncertainties, and technical constraints, which are particularly relevant in East Kutai, where high rainfall and varied topography increase project vulnerability.

However, the relatively modest effect size suggests that risk management alone is insufficient to significantly improve project performance. This aligns with previous research indicating that the impact of risk management is often indirect or contingent on other organizational and operational factors (Damayanti, 2023; Rahi, 2019). In practice, risk management frameworks may be implemented formally but not fully integrated into daily project operations, thereby limiting their effectiveness. This highlights the need for a more embedded and operationally aligned risk management approach.

5.2. Dominant Role of Operational Management

In contrast, operational management demonstrates a strong and highly significant effect on project performance, making it the most influential factor in this study. This finding reinforces the central role of operational processes in translating project plans into successful outcomes. Operational management encompasses key activities such as planning, coordination, resource allocation, and supervision, all of which directly influence project efficiency, quality, and timeliness.

The results are consistent with the existing literature, which identifies project planning and managerial competencies as critical determinants of project success (Irfan et al., 2021). Effective operational management ensures that project activities are executed systematically, resources are utilized optimally, and potential issues are addressed promptly. In the context of road maintenance projects, where field conditions are dynamic and unpredictable, strong operational control becomes even more essential.

Additionally, studies on infrastructure management highlight that operational efficiency significantly contributes to improved project outcomes, particularly in environments with limited resources and high uncertainty (Ghanbari & Hasani, 2024; Murugi & Nyang'au, 2023). The strong effect observed in this study suggests that operational management is the primary driver of performance, as it directly governs the project's execution phase. This finding implies that even well-designed risk management strategies may not yield optimal results without effective operational implementation.

5.3. Interplay between Risk Management and Operational Management

The combined findings of this study highlight the complementary relationship between risk management and operational management. While risk management provides a strategic framework for anticipating and mitigating uncertainties, operational management ensures that these strategies are effectively implemented in practice. The moderate contribution of risk management, compared to the stronger influence of operational management, suggests that its effectiveness is largely dependent on how well it is integrated into operational processes.

This observation is supported by studies emphasizing the importance of aligning risk assessment with operational decision-making to enhance project resilience and efficiency (Alshboul et al., 2023; Alkhawaja & Varouqa, 2023). Moreover, the use of decision-support tools such as the Analytical Hierarchy Process (AHP) has been shown to improve risk prioritization and facilitate better resource allocation, thereby strengthening the link between risk and

operational management (Syahrani & Diyanty, 2023; Sirait et al., 2023).

In the specific context of East Kutai Regency, the interaction between these two management dimensions becomes even more critical due to environmental and logistical complexities. High rainfall, unstable soil conditions, and ongoing traffic activities require continuous monitoring, adaptive planning, and rapid response mechanisms. Therefore, an integrated management approach that combines proactive risk identification with effective operational execution is essential to ensure project success.

6. Conclusions

This study investigated the influence of risk management and operational management on the performance of road maintenance projects in East Kutai Regency, Indonesia. The findings demonstrate that both variables have a positive, statistically significant effect on project performance, with operational management as the dominant determinant. Specifically, effective planning, coordination, resource allocation, and supervision were found to play a critical role in ensuring timely completion, cost efficiency, and quality compliance.

While risk management also contributes to performance improvement, its effect is comparatively moderate, suggesting that its effectiveness depends on the extent to which it is integrated into daily operational practices. The study contributes to the literature by providing empirical evidence on the combined, context-specific effects of risk and operational management in infrastructure maintenance projects, particularly under complex environmental conditions. It highlights the importance of adopting an integrated management approach that aligns proactive risk mitigation with strong operational execution to achieve optimal project outcomes.

From a practical perspective, the findings suggest that project stakeholders should prioritize strengthening operational management systems while enhancing the implementation of risk management strategies in real project settings. Improving coordination among stakeholders, optimizing resource utilization, and ensuring continuous monitoring and evaluation are essential to improving project performance in challenging environments such as East Kutai Regency.

Despite its contributions, this study has several limitations. The sample size is relatively small and limited to a specific geographic location, which may affect the generalizability of the findings. Additionally, the study focuses on two key variables, while other potentially influential factors, such as technological adoption, organizational culture, and external environmental conditions were not included in the model.

Future research is recommended to expand the scope by incorporating additional variables and applying the model in different regions or infrastructure sectors to enhance generalizability. Further studies may also explore the mediating or moderating roles of contextual factors to better understand the complex dynamics between risk management, operational management, and project performance.

Author Contributions: Conceptualization, N.R. and A.I.; methodology, N.R.; software, N.R.; validation, A.I. and R.M.H.; formal analysis, N.R.; investigation, N.R. and A.I.; resources, N.R.; data curation, A.I. and R.M.H.; writing—original draft preparation, N.R. and A.I.; writing—review and editing, N.R., A.I. and R.M.H.; visualization, N.R.; project administration, N.R.; funding acquisition, N.R. All authors have read and agreed to the published version of the manuscript.

Author Initials:
N.R.: Nurhalija Rusdi
A.I.: Andi Indrawati
R.M.H.: Rina Masithoh Haryadi

Funding: This research received no external funding.

Institutional Review Board Statement: This study was conducted in accordance with ethical research standards. As the research involved minimal risk and collected non-sensitive data through voluntary questionnaires, formal Institutional Review Board approval was not required. Nevertheless, all procedures adhered to ethical principles, including informed consent, confidentiality, and the protection of participants' rights throughout the research process.

Informed Consent Statement: Informed consent was obtained from all participants involved in this study. Prior to data collection, respondents were informed of the research's purpose, the voluntary nature of their participation, and their right to withdraw at any time without consequences. All participants agreed to participate voluntarily, and their responses were kept strictly confidential and used solely for academic research.

Data Availability Statement: The data used in this study are available from the corresponding author upon reasonable request. Due to respondents' confidentiality and privacy considerations, the data are not publicly available.

Acknowledgments: The authors would like to thank Universitas 17 Agustus 1945 Samarinda, Indonesia, for its support of this research and publication. We also thank the reviewers for their constructive comments and suggestions.

Conflicts of Interest: The authors declare no conflict of interest.

References

Afefy, I. H., Mohib, A., El-Kamash, A. M., & Mahmoud, M. A. (2019). A new framework of reliability centered maintenance. *Jordan Journal of Mechanical and Industrial Engineering, 13*(3), 175–190.

Alkhawaja, A. A. S. D. I., & Varouqa, I. F. (2023). Risk management of infrastructure line services and their impact on the financial costs of road projects in Jordan. *Measurement: Sensors, 25*, 100647.

Alshboul, O., Shehadeh, A., & Hamedat, O. (2023). Development of integrated asset management model for highway facilities based on risk evaluation. *International Journal of Construction Management, 23*(8), 1355–1364.

Da Silva, R. F., Melani, A. H. de A., Michalski, M. A. de C., & de Souza, G. F. M. (2023). Reliability and risk centered maintenance: A novel method for supporting maintenance management. *Applied Sciences, 13*(19), 10605. https://doi.org/10.3390/app131910605

Damayanti, E. S. (2023). Risk management: An overview of literature review. *Formosa Journal of Science and Technology, 2*(4), 1115–1122. https://doi.org/10.55927/fjst.v2i4.3837

Fatima, A., Mubin, S., & Masood, R. (2024). Risk-based integrated performance assessment framework for public-private partnership infrastructure projects. *Organization, Technology and Management in Construction, 16*(1), 251–274. https://doi.org/10.2478/otmcj-2024-0018

Ghanbari, M., & Hasani, Z. K. (2024). Key success factors in road maintenance management projects: A case study of Maysan Province, Iraq. *IIUM Engineering Journal, 25*(1), 102–114.

Gichohi, P. P., Iravo, M., & Muchelule, Y. (2024). Project risk management on the performance of road construction projects in Kenya. *International Journal of Management and Business Research, 6*(1), 108–130.

Heizer, J., Render, B., & Munson, C. (2020). *Operations management: Sustainability and supply chain management* (13th ed.). Pearson.

Irfan, M., Khan, S. Z., Hassan, N., Hassan, M., Habib, M., Khan, S., & Khan, H. H. (2021). Role of project planning and project manager competencies on public sector project success. *Sustainability, 13*(3), 1421. https://doi.org/10.3390/su13031421

Jiang, W., Yang, Q., Jiang, J., Martek, I., & Gao, F. (2022). Operational risk management of public–private partnership infrastructure projects: A bibliometric literature review. *Buildings, 12*(11), 1905. https://doi.org/10.3390/buildings12111905

Kirui, N. K., Rambo, C. M., & Luketero, S. W. (2025). Moderating effects of project environment on financial risk management and safety of road construction projects in Kenya. *International Journal of Project Organisation and Management, 17*(3), 327–352.

Malik, R., Safutra, N. I., Fole, A., & Pangestu, F. A. (2024). Improving resilience in water distribution systems: An application of the House of Risk method at PDAM Gowa Unit Tompobulu. *Jurnal Sistem Teknik Industri, 26*(2), 199–209. https://doi.org/10.32734/jsti.v26i2.16171

Mohajeri Borje Ghaleh, R., Pourrostam, T., Mansour Sharifloo, N., Majrouhi Sardroud, J., & Safa, E. (2021). Delays in road construction projects from risk management perspective. *Infrastructures, 6*(9), 135. https://doi.org/10.3390/infrastructures6090135

Murugi, S. K., & Nyang'au, S. P. (2023). Project planning and performance of maintenance projects on trunk roads in Kenya. *International Journal of Social Sciences Management and Entrepreneurship, 7*(2), 394–407.

Rahi, K. (2019). Project resilience: A conceptual framework. *International Journal of Information Systems and Project Management, 7*(1), 69–83. https://doi.org/10.12821/ijispm070104

Selvik, J. T., & Aven, T. (2011). A framework for reliability and risk centered maintenance. *Reliability Engineering & System Safety, 96*(2), 324–331.

Sirait, E., Manurung, E. H., Mubarok, A., & Suripto, S. (2023). Faktor-faktor yang mempengaruhi tingkat risiko pada proyek konstruksi infrastruktur. *Jurnal Rekayasa Konstruksi Mekanika Sipil (JRKMS), 6*(1), 41–47. https://doi.org/10.54367/jrkms.v6i1.2556

Syahrani, S. A., & Diyanty, V. (2023). Evaluasi manajemen risiko proyek konstruksi terhadap biaya operasional proyek menggunakan metode AHP. *Jurnal Akademi Akuntansi, 6*(2), 215–224. https://doi.org/10.22219/jaa.v6i2.26571

Taherdoost, H. (2022). Designing a questionnaire for a research paper: A comprehensive guide to design and develop an effective questionnaire. *Asian Journal of Managerial Science, 11*(1), 8–16. https://doi.org/10.51983/ajms-2022.11.1.3087

Taherdoost, H. (2022). What are different research approaches? Comprehensive review of qualitative, quantitative, and mixed method research, their applications, types, and limitations. *Journal of Management Science & Engineering Research, 5*(1), 53–63.

Usman, H., Tuhari, I. S., & Cheumar, M. (2026). Enterprise risk management in Islamic bank: A systematic literature review. *International Journal of Research and Innovation in Social Science (IJRISS), 9*(12), 3930–3941.

Yustiarini, D., Soemardi, B. W., & Pribadi, K. S. (2025). Integrating multi-stakeholder governance and engineering approaches for sustainable regional road maintenance. *Indonesian Journal of Science and Technology, 10*(2), 367–398.