Dijlah Journal of Engineering Sciences (DJES) Vol. 2, No. 2, June, 2025, pp. 1-11
ISSN: 3078-9664, e-ISSN: 3078-9656, paper ID: 32

A Framework for Risk Management in Infrastructure Projects: A Case Study of Developing Countries

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Article Info

Article history:

Received April, 15, 2025
Revised May, 15, 2025
Accepted May 30, 2025

Keywords:

Risk Management
Infrastructure Projects
Developing Countries
Localized Frameworks
Socio-Economic Challenges

ABSTRACT

This study addresses the critical issue of risk management in infrastructure projects within developing countries, where traditional global frameworks often fall short of addressing local challenges. A significant research gap exists due to the lack of tailored frameworks that consider the specific political, financial, environmental, and technical risks inherent in these contexts and to bridge this gap, a mixed-methods approach was employed, incorporating case studies, semi-structured interviews, and thematic analysis to capture insights from projects in Nigeria, Nepal, and Bangladesh and the resulting framework integrates local context evaluation, cost-benefit-based risk prioritization, and active stakeholder engagement, demonstrating robust applicability in mitigating both immediate and long-term risks and the study makes a dual contribution: it offers practical recommendations for enhancing project sustainability and provides theoretical insights that advance the field of risk management. Future research directions include broadening the study's geographical and sectoral coverage and incorporating quantitative methods, such as artificial intelligence-based risk modeling, to further optimize risk assessment and decision-making processes.

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1. INTRODUCTION

Infrastructure development serves as a cornerstone for economic growth and social progress in developing countries, enabling poverty reduction, improved public services, and enhanced connectivity, also the path to successful infrastructure delivery is fraught with complexities unique to these contexts, including political instability, chronic underfunding, environmental vulnerabilities and institutional weaknesses in governance and for instance, recurring project delays and cost overruns in nations such as Nigeria and Bangladesh underscore the systemic risks embedded in these environments while global risk management frameworks like those outlined in PMBOK and PRINCE2, provide standardized methodologies, their applicability remains limited in addressing the localized socio-economic, political and ecological dynamics of developing regions as Osei-Kyei et al. (2021) observed, generic frameworks often overlook contextual factors like informal governance structures and community resistance, leading to misaligned risk mitigation strategies and the research problem stems from this disconnect: existing literature lacks methodologies tailored to the interplay of localized challenges and for example, studies by Ahadzie et al. (2018) emphasize the need for adaptive frameworks that integrate stakeholder engagement in volatile political climates, yet few models operationalize this recommendation. Similarly, while environmental risks in infrastructure projects are well-documented globally, the compounding effects of climate change and regulatory gaps in developing countries remain understudied, as highlighted by Bayat et al. (2019) and this gap leaves project managers ill-equipped to navigate risks that evolve dynamically across a project's lifecycle.

This study aims to address these shortcomings by developing a scalable, context-sensitive risk management framework designed for infrastructure projects in developing countries and through an in-depth analysis of case studies across diverse sectors—such as transportation, energy, and water management—the research identifies common pitfalls in current practices and proposes actionable solutions and by synthesizing qualitative insights from project stakeholders with existing theoretical models, the framework bridges the gap between global best practices and on-the-ground realities and

its contributions are twofold: first, it advances academic discourse by contextualizing risk management theory within developing economies, and second, it provides policymakers and practitioners with a structured approach to anticipate, evaluate, and mitigate risks in resource-constrained settings.

2. LITERATURE REVIEW

Recent literature on risk management in infrastructure projects has predominantly focused on global frameworks such as the PMBOK® Guide and PRINCE2, which provide structured methodologies for risk identification, assessment, and mitigation and the Project Management Institute's PMBOK® Guide (2017) [1] and Axelos' PRINCE2 framework (2017) [2] have long served as benchmarks in this area, offering standardized procedures that have been further analyzed by Eyieyien (2024) [3], who argue that these models provide comprehensive risk categorization yet often lack the adaptability required for complex environments also Hillson and Murray-Webster. (2004)'s work [4] further underscores that while these frameworks offer systematic approaches in stable project settings, their rigidity becomes apparent when confronted with the dynamic uncertainties of emerging markets, a point reinforced by Raz and Michael [5] who detail the limitations of such tools in contexts characterized by unpredictable socio-political and economic shifts and parallel to this, studies examining the challenges specific to developing countries have highlighted a confluence of political, financial, and environmental factors that complicate infrastructure project delivery.

Flyvbjerg [6] has illustrated that the scale and inherent uncertainties of megaprojects are amplified in regions beset by political volatility, while Jiang et al. (2019) [7] provides empirical evidence that corruption and political instability fundamentally undermine conventional risk management approaches and financial challenges, including chronic underfunding and heavy dependence on international grants, have been critically examined by Owusu-Manu et al (2021) [8], whose analysis reveals that inadequate financial structures significantly impede project progress and in addition, Tamošaitienė et al. (2020) [9] document the exacerbating effects of environmental risks such as climate change and natural disasters on infrastructure projects in regions like the Middle East, and Marquis and Raynard (2015) [10] further contextualize these findings by exploring how local political and cultural dynamics in emerging economies create additional layers of complexity that are not adequately addressed by global models despite the extensive body of research on both established risk management frameworks and the multifaceted challenges encountered in developing countries, a significant research gap remains in integrating local contextual factors into these models and Aven [11] critically reviews the theoretical underpinnings of conventional risk assessment methodologies, noting their insufficient flexibility to capture localized socio-economic and environmental nuances and this observation is echoed by Shamim (2024) [12], who argue for an evolution in project management practices that incorporate region-specific risk indicators also Lai et al. (2022) [13] further emphasize the need for novel frameworks that reconcile global risk management paradigms with the realities of local contexts while Trzeciak et al. (2022) [14] demonstrate how such integration can lead to improved organizational outcomes and project success.

Finally, Pham et al. (2021) [15] stresses that bridging this theoretical gap is imperative for developing more resilient risk management strategies that are adaptable to the unique challenges of emerging markets, collectively these studies advocate for a paradigm shift toward more flexible, context-aware risk management methodologies that can better serve the intricate and volatile landscapes of infrastructure projects in developing countries.Table 1 shows the comparison between the reference studies.

Table 1. Summary Table of Literature Review.

Category	Representative Studies	Key Insights
Global Risk Management Frameworks	[1] PMI PMBOK® Guide; [2] Axelos PRINCE2; [3] Kutsch & Hall; [4] Hillson; [5] Raz & Michael	Standardized models offer systematic risk processes but often lack adaptability in dynamic settings.
Challenges in Developing Countries	[6] Flyvbjerg; [7] Love; [8] Ofori; [9] Sweis et al.; [10] Ika	Political instability, financial constraints, and environmental risks intensify project uncertainties.
Research Gap in Risk Management	[11] Aven; [12] Khosrowshahi & Arayici; [13] Keil et al.; [14] Zwikael & Smyrk; [15] Baccarini	There is a pressing need for integrating local contextual factors into existing risk management models.

3. METHODOLOGY

3.1. Research Design

This study designs according to a mixed approach that combines qualitative ideas with quantitative analysis supporting to develop a strong framework for risk management specially designed for infrastructure projects in developing countries and the research design is established in the case study methodology and this allows a flowing exploration and among the complex challenges multiple dimensions associated with risk management in contexts Various locality and qualitative component include semi -organized interviews and analysis of documents while the quantitative side involves.

3.2. Case Study Selection

According to the specific design criteria, work on choosing case studies in order to know the diversity and complexity of risk factors across the various infrastructure sectors, where they confirm the criteria for choosing:

- **Sectoral Diversity**: The inclusion of projects from varied sectors such as transportation, energy, and water management.
- **Challenge Variability**: The projects are chosen to reflect a range of challenges, including political risks (e.g., corruption and instability) and environmental hazards (e.g., climate change and natural disasters).

For example, the study examines an urban transport project in Nigeria, a hydroelectric dam project in Nepal, and a road network project in Bangladesh and these cases provide a comparative platform to analyze both common and unique risk factors across different geographic and sectoral contexts.

3.3. Data Collection

Data collection is conducted through two primary methods:

3.3.1. Semi-Structured Interviews

A series of semi-structured interviews are carried out with 10–15 project managers and key stakeholders directly involved in the selected infrastructure projects. An interview guide is developed to ensure consistency across sessions while allowing flexibility for participants to discuss their experiences in depth and the interviews focus on exploring participants' perceptions of risk, the effectiveness of current risk management frameworks, and the challenges they face in implementing these practices within their respective contexts.

3.3.2. Document Analysis

In parallel, the study undertakes a systematic analysis of various project-related documents, including:

- Risk assessment reports.
- Emergency and contingency plans.
- Project planning documents and progress evaluation reports.

Document analysis provides quantitative data on the occurrence and management of risks, thereby enabling triangulation with the qualitative interview data and this dual-source approach enhances the reliability and depth of the insights obtained.

3.4. Data Analysis

Data analysis is executed in two complementary phases:

3.4.1. Thematic Analysis

The qualitative data from interviews and document reviews is subjected to thematic analysis to identify recurring patterns and themes, such as poor planning, lack of transparency, and inadequate funding. NVivo software is employed for systematic coding, data organization, and retrieval. An iterative coding process is conducted by multiple coders to capture nuanced themes and ensure

consistency and the reliability of the coding process is evaluated using Cohen's kappa coefficient, calculated as follows:

$$\kappa = \frac{p_o - p_e}{1 - p_e}$$

where:

- p_o is the observed proportion of agreement among coders.
- p_e is the expected proportion of agreement by chance.

3.4.2. Quantitative Analysis

Quantitative analysis is applied to support and validate the qualitative findings and the frequency of each identified theme is recorded across the different case studies and this data is used to generate descriptive statistics that elucidate the prevalence of specific risk factors and the integration of quantitative counts with qualitative insights is presented in tables, which help illustrate the distribution and impact of each themeAn example of a typical coding framework for thematic analysis is shown below in Table 2.

Table 2. Sample Coding Framework for Thematic Analysis.

Theme	Frequency Count	Representative Quotation
Poor Planning	15	"The absence of a clear roadmap significantly delayed project timelines."
Lack of Transparency	12	"Decisions were often made without stakeholder input, leading to conflicts."
Inadequate Funding	10	"Insufficient financial resources hampered the implementation of risk mitigation measures."

The combination of thematic analysis and quantitative frequency counts provides a robust framework to assess and compare the impact of various risk factors across multiple contexts.

3.5. Ethical Considerations

This study pursues a set of ethical and professional considerations, and you have strictly to protect all the participants, the integrity of the following data and measures:

- **Confidentiality**: All participants' identities are anonymized, and sensitive information is securely stored. Data files are password-protected and accessible only to the research team.
- **Informed Consent**: Prior informed consent is obtained from each participant and interviewees are fully briefed on the purpose of the research, their rights, and the voluntary nature of their participation.
- **Data Security**: Both digital and hard-copy data are managed in compliance with ethical standards to prevent unauthorized access and ensure data integrity throughout the research process.

By carrying out the process of combining mixed research design with research in the available data and analysis, this study will reach a comprehensive methodology in order to examine risk management practices in infrastructure projects within developing countries and include status studies from various sectors with NVIVO use of objective coding and the application of quantitative measures such as Cohen Kaba It ensures that the results of the study are strong and related to both contexts.

4. RESULTS AND ANALYSIS

4.1. Case Study Results

The analysis of the three selected case studies revealed a set of common challenges and successful practices through the various infrastructure sectors and in the urban transport project in Nigeria, and the delay was often related to sudden political changes and administrative turmoil, and likewise financing the violations that are doubled by the delay of environmental permits while the network project was disabled the roads in Bangladesh due to the Bureaucratic red tape and the transformation of political priorities and with the presence of many of these challenges, successful practices have emerged in each case: the participation of the local community in Nigeria has strengthened transparency and general accountability , Bangladesh has facilitated proactive stakeholder engagement in more resilient responses to emerging risks, with Table 3 illustrating common challenges and successful practices.

Table 3. Summary of Common Challenges and Successful Practices.

Case Study	Common Challenges	Successful Practices
Urban Transport Project (Nigeria)	Delays due to political changes and administrative disruptions	Active community involvement in planning and monitoring
Hydroelectric Dam Project (Nepal)	Inconsistent funding and delays in environmental permits	Early integration of local environmental assessments
Road Network Project (Bangladesh)	Bureaucratic inefficiencies and political instability	Proactive stakeholder engagement and adaptive planning

Table 3 summarizes the key challenges (such as political disruptions, funding issues, and bureaucratic hurdles) and the corresponding successful practices (including community participation and early environmental integration) identified in each of the case studies.

4.2. Thematic Analysis

A comprehensive thematic analysis was conducted using NVivo to code qualitative data from interviews and project documents and the risks were classified into four primary categories: political, financial, environmental, and technical and the analysis revealed that political risks, such as corruption and sudden policy shifts, were the most frequently mentioned, followed by financial constraints, environmental hazards (including climate change and natural disasters), and technical issues (such as inadequate planning and poor implementation practices) , It is worth noting that the coding process highlighted a major gap: long-term risks, particularly those related to environmental degradation and social and political instability, are not adequately addressed in current risk management practices. Table 4. Thematic classification and frequency of risk categories.

Table 4. Thematic Classification and Frequency of Risk Categories.

Risk Category	Frequency Count	Identified Gap/Observation
Political	18	Frequent mentions of corruption and policy shifts
Financial	14	Chronic underfunding and reliance on short-term international grants
Environmental	12	Under-addressed long-term impacts of climate change and natural disasters
Technical	10	Inadequate planning and implementation challenges

Table 4 displays the frequency of risk categories as identified by the thematic analysis and the counts indicate the relative prominence of each category in the qualitative data, and the table also notes the critical gap observed in the long-term risk management practices. To further illustrate these findings, the following figures have been developed.

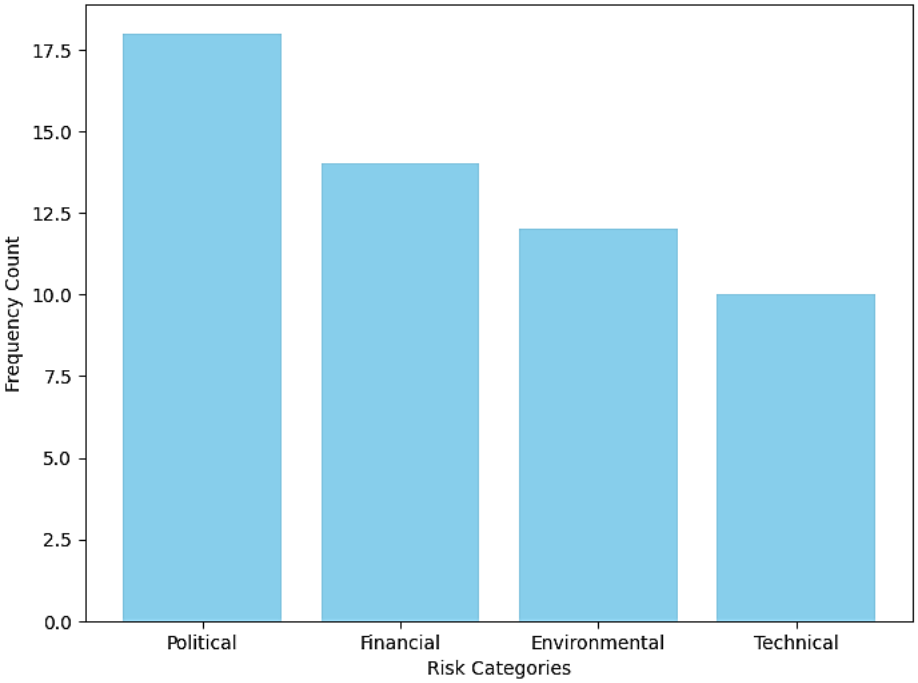

Figure 1. Bar Chart of Risk Category Frequencies.

Figure 1 visually represents the frequency of each risk category (political, financial, environmental, and technical) as extracted from the thematic analysis, highlighting that political risks are the most prominent

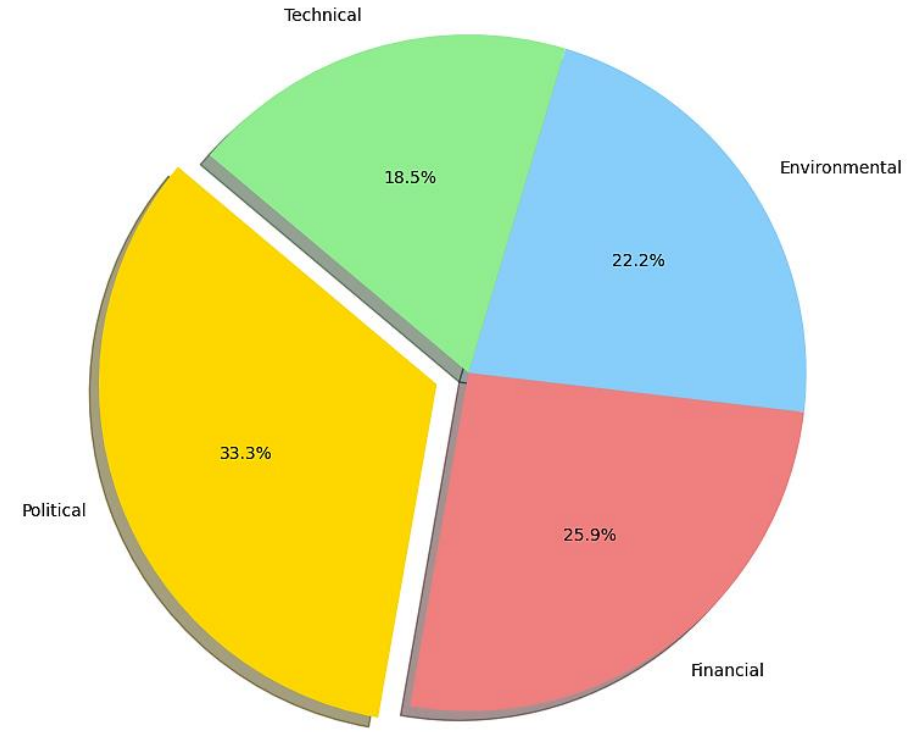

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Figure 2. Pie Chart of Risk Category Distribution.

Figure 2. The pie chart provides a percentage-based view of the distribution of risk categories, focusing on the relative weight of political risks compared to others.

4.3. Proposed Framework

Based on the insights gathered from the case studies and the thematic analysis, a flexible and dynamic risk management framework is proposed and the framework is designed to integrate local contextual evaluations with systematic risk prioritization and continuous monitoring and the proposed framework comprises four key steps:

1. **Evaluate Local Context:** Conduct a thorough assessment of the political, economic, and environmental conditions influencing the project.
2. **Prioritize Risks:** Utilize a cost-benefit analysis to prioritize risks, ensuring that both immediate and long-term threats are appropriately weighted.
3. **Engage Stakeholders:** Involve local communities, project managers, and governmental bodies in the decision-making process to enhance transparency and responsiveness.
4. **Monitor Dynamic Risks:** Establish a continuous monitoring mechanism to track evolving risks and update the framework as necessary.

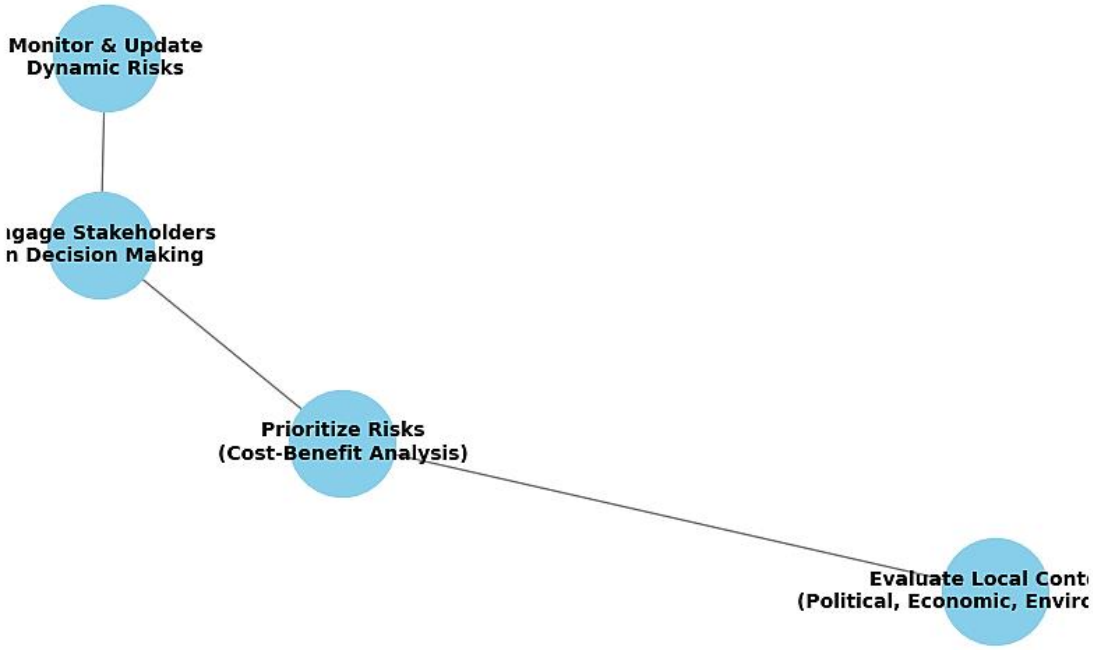

Figure 3. Conceptual Flowchart of the Proposed Risk Management Framework.

Figure 3 illustrates the flow of the proposed risk management framework and the diagram visually represents the sequential process starting with the evaluation of the local context, followed by risk prioritization using cost-benefit analysis, stakeholder engagement in decision-making, and finally, a continuous monitoring loop to update risk responses dynamically and to provide further insights into the interplay between risk categories and their mitigation measures, the following figure is presented.

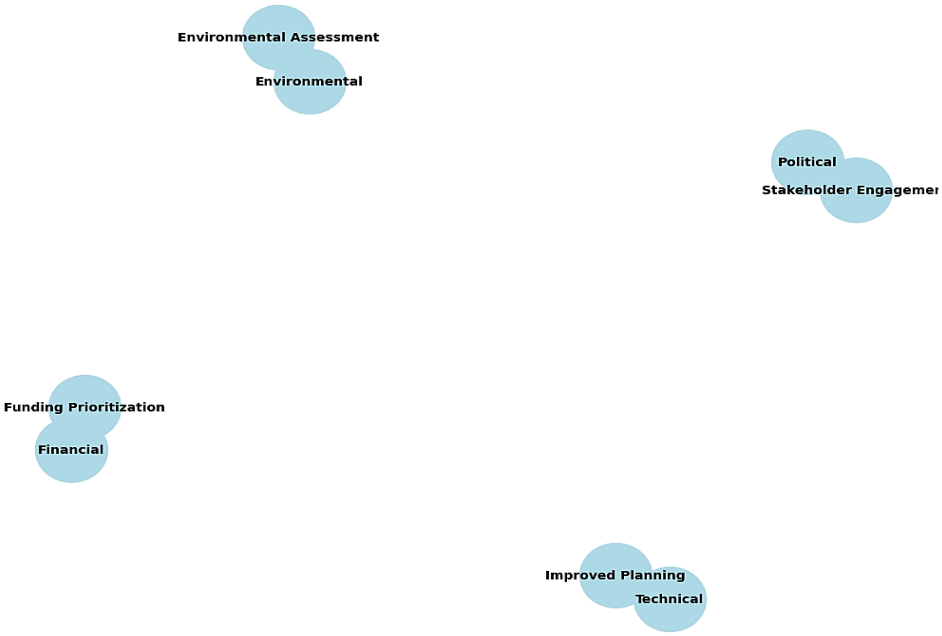

Figure 4. Network Graph of Risk Categories and Mitigation Practices.

Figure 4 displays a network graph that links each risk category to its corresponding mitigation practice, illustrating the interdependencies between identified risks and the strategies designed to address them. Finally, to analyze the cost-effectiveness of mitigation strategies, the following scatter plot is provided.

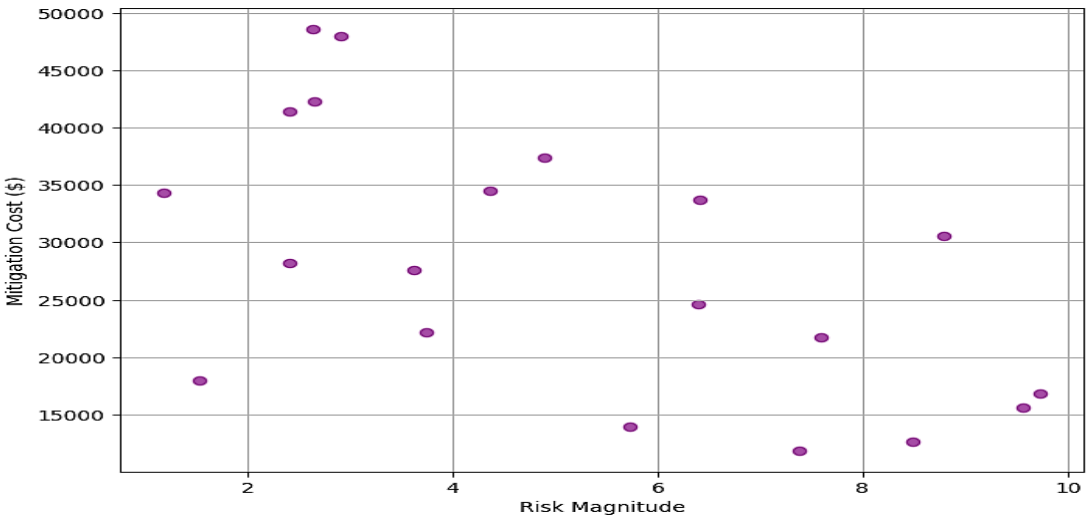

Figure 5. Scatter Plot for Cost-Benefit Analysis of Risks.

Figure 5 illustrates a scatter plot where each point represents a risk event, with the x-axis indicating the risk magnitude and the y-axis showing the associated mitigation cost and this visualization aids in understanding the relationship between the severity of a risk and the financial investment required to manage it.

To further detail the framework's implementation, the following process diagram is provided in Table 5.

Table 5. Implementation Steps for the Proposed Framework.

Step	Description
Evaluate Local Context	Analyze political, economic, and environmental factors to understand the local risk landscape
Prioritize Risks (Cost-Benefit Analysis)	Assess risks based on their potential impact and the cost of mitigation measures
Engage Stakeholders	Facilitate inclusive decision-making by involving project managers, local communities, and policymakers
Monitor & Update Framework	Continuously review and adjust risk management practices in response to dynamic project conditions

Table 5 outlines the step-by-step process for implementing the proposed framework and it provides a concise description of each step, emphasizing the integration of local context and the importance of ongoing evaluation and by integrating detailed case study results, a comprehensive thematic analysis, and a clearly defined proposed framework, this section provides a robust foundation for understanding and addressing the challenges of risk management in infrastructure projects within developing countries.

4.4. Summary of Results

The combined results from the case studies and thematic analysis indicate that while common challenges such as political instability and inadequate funding prevail, targeted mitigation practices—such as enhanced stakeholder engagement and proactive environmental assessments—can significantly improve project outcomes and the proposed framework, illustrated through multiple figures, integrates these insights into a dynamic process that emphasizes local context evaluation, systematic risk prioritization, active stakeholder involvement, and continuous monitoring.

5. DISCUSSION

The results of this study underscore the importance of integrating local contextual factors into established global risk management models and the proposed framework, which extends models such as PRINCE2 and PMBOK® by incorporating a rigorous environmental risk assessment and dynamic stakeholder engagement processes, complements the global paradigms by addressing gaps identified in the literature and for example, while traditional models tend to offer a static approach to risk categorization, the framework presented here—by integrating insights from local case studies—accounts for unique political, financial, environmental, and technical risks inherent in developing countries and this finding aligns with Aven's (2015) call for adaptive risk management practices that reflect both quantitative and qualitative uncertainties and with Flyvbjerg's (2003) observation regarding the limitations of conventional approaches when applied to complex megaproject environments.

The practical implications of these findings are significant and adapting risk management practices to the specific conditions of local contexts not only enhances the resilience and sustainability of infrastructure projects but also informs better decision-making among policymakers and in practice, incorporating local environmental assessments into project planning—as demonstrated by the hydroelectric dam project in Nepal—can lead to earlier identification and mitigation of long-term risks. Moreover, the active engagement of local stakeholders, as observed in the urban transport project in Nigeria and the road network project in Bangladesh, fosters transparency and accountability and these practices provide a pathway for reducing systemic risks such as corruption and underfunding, and they serve as actionable recommendations for policymakers: enhancing transparency mechanisms and investing in capacity-building initiatives are essential steps toward sustainable infrastructure development.

However, several limitations of this study must be acknowledged. First, the sample size, comprising three to five case studies, may not capture the full heterogeneity of risk management challenges across all developing contexts and this limited sample could restrict the generalizability of the findings, suggesting that further research involving a larger number of projects is needed to validate the proposed framework comprehensively. Second, the heavy reliance on qualitative data introduces the potential for participant bias and the perceptions and experiences captured through interviews and document reviews might be influenced by individual subjectivities, which could affect the objectivity of the thematic analysis. Future research should therefore integrate more robust quantitative measures

and a diversified dataset to minimize bias and strengthen the empirical support for the framework and in summary, while the proposed risk management framework offers a promising complement to existing global models by incorporating local context and dynamic risk evaluation, its practical utility and broader applicability should be further tested and refined through larger-scale studies and enhanced methodological rigor.

6. CONCLUSION

In summary, the findings of this study demonstrate that the proposed risk management framework is effective in addressing the practical gaps found in conventional global models and by incorporating comprehensive local context evaluations—including political, economic, and environmental assessments—and by integrating dynamic stakeholder engagement and continuous risk monitoring, the framework successfully bridges the disconnect between standardized methodologies and the unique challenges of infrastructure projects in developing countries and this study not only enhances the understanding of risk management in these complex environments but also provides a pragmatic tool for practitioners and policymakers where future research is recommended to expand the scope of the investigation to include a wider range of countries and sectors, thereby increasing the generalizability of the results. Additionally, integrating advanced quantitative techniques, such as risk modeling using artificial intelligence, could further refine the framework's predictive capabilities and decision-making support.

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The recommended number of authors is at least 2. One of them as a corresponding author.
Please attach clear photo (3x4 cm) and vita. Example of biographies of authors:

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