



Effect of Infrastructure Management Practices on Performance of Rural Bridge Construction Project in Rwanda. A Case Study of Mushepari Bridge Construction Project, Rubavu District (2020-2023)

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Abstract: The study was about the effect of infrastructure management practices on the performance of rural bridge construction projects in Rwanda. The study focused on the Mushepari bridge construction project in the Rubavu district. The study population target was 238 project staff, and the sample size was the same as the 238 respondents. Descriptive statistics, including frequency tables, percentages, means, and standard deviations, deviations, were used to summarize the data. Researchers conducted inferential analysis using Pearson correlation and multiple regression models. The findings revealed that accessibility, social infrastructure contribution, and institutional degree had a notable impact on project performance. Regression analysis indicated that accessibility ($p = 0.000$), social infrastructure contribution ($p = 0.001$), and institutionalization degree ($p = 0.031$) were statistically significant predictors of project performance. According to the inferential results, the correlations between accessibility, social infrastructure contribution, and institutionalization degree were 0.965, 0.936, and 0.871, respectively. This indicates that there was a significant relationship between the effects of infrastructure management practices and the performance of rural bridge construction projects in Rwanda. A case study of the Mushepari bridge project in Rubavu District demonstrated that 93.5% of the variation in project performance could be explained by infrastructure management practices, while the remaining 6.5% was attributed to other external factors not covered in the study. It is recommended that the Ministry of Infrastructure (MINIFRA) implement comprehensive training programs aimed at equipping project managers and construction teams with best practices in infrastructure management.

Keywords: Infrastructure Management Practices, Performance, Bridge Construction Project, Accessibility, Social Infrastructure, Institutionalization Degree

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1. Introduction

In Rwanda, a non-governmental organization called Bridge to Property (B2P) found that some areas are hard to reach due to natural disasters or being in different

districts, making it difficult for people on motorcycles to travel. This has made it tough for communities to connect, and many rural people still struggle to access markets, jobs, schools, clinics, and hospitals because of poor connectivity, which leads to poverty and isolation in their lives. The impact reflected on the pedestrians as

it was difficult for communities to be connected. The impact continues to be felt in other areas of the study, where rural people are still struggling to access markets, jobs, schools, clinics, and hospitals due to a lack of connectivity, which causes poverty and rural isolation within their communities. It is in this regard the researcher thought to address the gap by establishing the study on the impact of infrastructure (trail bridge) on the performance of rural bridge construction projects in Rwanda. A case study of the Mushepari bridge construction project, Rubavu district, Rwanda, as a developing country to promote with commitment to addressing the problem of separated places, in partnership with districts, public institutions, and private organizations, B2P, which specializes in the design and construction of pedestrian footbridges, has constructed over 95 bridges across Rwanda, with an additional 100 set to be completed (Prosperity, 2019).

The general objective of the study is to examine the role of Effect of infrastructure management practices on performance of rural bridge construction project in Rwanda. A Case study of Mushepari bridge construction project, Rubavu district

Specific Objectives:

1. To evaluate the effect of accessibility of trail bridge on performance of rural Mushepari bridge construction project in Rubavu district,
2. To determine the effect of social infrastructure contribution of trial bridges on performance of rural Mushepari bridge construction project in Rubavu district,
3. To assess the influence of institutionalization degree of Trial bridges on performance of rural Mushepari bridge construction project in Rubavu district

The study tested the following hypothesis:

H₀₁: There is no significant effect of accessibility of trail bridge on performance of rural Mushepari bridge construction project in Rubavu district,

H₀₂: There is no significant effect of social infrastructure contribution of trial bridges on performance of rural Mushepari bridge construction project in Rubavu district,

H₀₃: There is no significance influence of institutionalization degree of trial bridges on performance of rural Mushepari bridge construction project in Rubavu district.

2. Literature Review

2.1 Theoretical Literature

The theoretical framework for effect of infrastructure management practices on performance of rural bridge construction project in Rwanda.

2.1.1 Agency theory

Jensen and Meckling (1976) developed Agency Theory, identifying two main types of agency conflicts. The first arises between shareholders and managers, while the second exists between equity holders and debt holders. The conflict between shareholders and managers occurs because managers do not possess full ownership stakes in the firm, meaning they cannot fully benefit from value-maximizing activities. As a result, they may not always act in the best interests of shareholders. The second type of conflict stems from the differing incentives between debt holders and equity holders. Equity holders may be encouraged to invest in high-risk projects that benefit them disproportionately, potentially to the detriment of debt holders (Mandell, 2008).

According to the theory, project managers, when left to act independently, are expected to prioritize the interests of those who appointed or elected them. This implies that projects should be executed in a manner that maximizes benefits for the owners (Lan, 2010).

Bonazzi (2007) adds that Agency Theory outlines mechanisms aimed at minimizing losses and maximizing wealth for the principal. Therefore, managers are expected to act in the best interests of the beneficiaries at all times. This theory plays a crucial role in project management, emphasizing the importance of stakeholder interests in all managerial decisions related to the project.

Agency Theory is particularly relevant to this study as it supports the role of project managers in ensuring the efficient use of resources—such as time, finances, human capital, and materials—in alignment with the interests of stakeholders. The researcher adopted this theory to provide a strong conceptual framework for examining the effects of infrastructure, specifically the Trial Bridge, on the performance of rural bridge construction projects in Rwanda. The case study focuses on the Mushepari Bridge construction project in Rubavu District.

2.1.2 Theory of Change

The Theory of Change explains how specific interventions are expected to lead to desired development outcomes, grounded in a causal analysis supported by available evidence (De Silva, 2014). For engineering projects, a robust Theory of Change must be informed by data, stakeholder consultations, and insights from past experiences, ensuring that strategies are context-sensitive and based on what works (De Silva, 2014).

This approach helps identify effective solutions by addressing the root causes of challenges and guiding decisions based on comparative advantages, feasibility, and potential risks. It also highlights underlying assumptions and uncertainties that need to be

continuously revisited to ensure the strategy remains aligned with the intended outcomes (De Silva, 2014).

According to Taplin (2013), the Theory of Change offers a comprehensive framework for understanding how and why a specific change is expected to occur within a given context. It focuses on bridging the gap between project activities and long-term goals by mapping out all the intermediate outcomes required to achieve those goals. These causal links are illustrated in an Outcomes Framework, which serves as a guide for designing interventions and monitoring their impact.

In the context of trail bridge construction, the Outcomes Framework clarifies the connection between project activities and long-term community development objectives (Rengarajan & Sivasubramaniyan, 2020; Taplin, 2013). This leads to improved planning and resource allocation, as decisions are based on a clear understanding of how change unfolds. It also enhances evaluation by enabling the measurement of progress beyond immediate outputs, focusing on sustained impact.

The use of a Theory of Change in this study is essential for several reasons. First, it supports continuous learning across project cycles (Davies, 2018). By articulating the development challenge, making assumptions explicit, and testing them against evidence, it ensures that strategies are logically sound. If an approach fails or risks emerge, the Theory of Change provides a basis for making timely adjustments. Lessons from monitoring and evaluation inform ongoing refinements to improve effectiveness (Rengarajan & Sivasubramaniyan, 2020).

Additionally, the Theory of Change facilitates partnership development. By aligning stakeholders on shared goals and assumptions, it builds consensus and strengthens collaboration among planners, donors, program staff, and beneficiaries. This participatory approach can foster new or improved partnerships, enhancing coordination and complementarity (Davies, 2018).

Finally, the Theory of Change adopted by Bridges to Prosperity suggests that rural communities are often isolated by flooding, and that trail bridges effectively eliminate this isolation (Davies, 2018). Evidence indicates that bridge use is not significantly affected by rainfall, suggesting a preference for trail bridges over traditional crossings. However, further research is needed to determine whether seasonal factors, such as harvests or extreme weather events, influence usage patterns (Davies, 2018).

2.2 Empirical Review

A study by Rachid (2019) examining delays and cost overruns in Ugandan public-sector construction found key causes: scope changes or altered material specs; high inflation, insurance, and interest rates; inadequate monitoring (due to unreliable supervision); late payments to contractors, subcontractors, or suppliers; and fuel shortages.

In Rwanda, Bridges to Prosperity's Theory of Change argues that rural communities face dangerous isolation during floods, and trail bridges alleviate this risk (Davies, 2018). Their analysis suggests bridge usage is consistent regardless of rainfall, indicating a community preference for these crossings. However, further study is needed to assess seasonal variation—whether usage spikes during harvest or extreme weather events (Davies, 2018).

Research in Pakistan by Timilsina (2020) identifies natural disasters (floods, earthquakes) as leading causes of construction delays, along with financial and payment issues, poor planning, inadequate site management, lack of experience, and material or equipment shortages (Thakur, 2021). Similarly, Al-Hazim (2019) reports that terrain and weather are primary drivers of delays and overruns in Jordan's infrastructure projects.

Ghosh and Gupta (2021) underscore the importance of accounting for environmental "dynamic loads" such as strong winds and seismic activity in bridge design. Karunakaran (2019) adds that poor planning, design changes, hidden utilities, material shortages, and communication breakdowns significantly delay projects. In Nepal, Bista and Dahal (2018) found low bidding driven by unrealistic norms, ambiguous contracts, and social acceptance issues to be a major delay factor. Suwal and Shrestha (2021) further highlight inadequate planning, clearance delays, poor site management, low bids, and labor issues in trail-bridge projects.

In Saudi Arabia, studies by Zidane & Andersen (2018) and Durdyev & Hosseini (2019) identify delayed payments, corruption, technical staff qualifications, and bureaucracy as prominent causes of delay. Further research (Durdyev & Hosseini, 2019; Sanni-Anibire, 2022) reiterates that contractor cash-flow problems, design changes, subcontractor conflicts, and slow decision-making by owners compound delays.

Amoatey (2021) finds that in Nigeria, the most significant delay drivers are financing and payment issues, poor contract management, material shortages, and inadequate planning. Yap & Skitmore (2018) show that in Malaysia only 21% of public and 33% of private construction projects met their deadlines, citing design issues, financial resource management, contract

administration, site management, and limited ICT adoption.

In Ghana, Durdyev & Hosseini (2019) and Abbasi (2020) report that 75% of groundwater projects overran their schedules, mainly due to payment delays, contract mismanagement, material procurement issues, inflation, and contractor financial strains. In Morocco, Kassem (2020) finds that budget estimation errors, frequent design modifications, site hazards, stakeholder failures, and insufficient feasibility studies were the top five delay contributors.

3. Methodology

This section outlines the research methodology employed in the study, detailing the research design, instruments, population, sample size, data analysis techniques, and ethical considerations.

3.1 Research Design

This study adopted a descriptive research design to interpret and analyze data. The descriptive design is appropriate for generating information after events have occurred. The research utilized a quantitative approach, relying on descriptive statistics and correlation analysis to examine relationships between variables.

3.2 Study Population and Sample Size

The target population consisted of 238 respondents, including 58 project staff and 180 members of the local community. Given the relatively small population size, a census survey was conducted, involving the entire population rather than selecting a sample. This approach is recommended when the target population is below 400, as it helps achieve a desirable level of precision.

3.3 Research Instruments

Structured questionnaires were distributed to respondents, who included infrastructure personnel and staff from other relevant departments. The questionnaire allowed respondents to choose from predetermined options and express their views on the subject matter. This method facilitated rapport between the researcher and participants, enabling clarification of the study's purpose and addressing any ambiguities.

Additionally, document analysis was used, drawing on both published and unpublished sources. This helped enhance the study's depth and credibility, especially in examining the impact of infrastructure (specifically trail bridges) on the performance of rural bridge construction projects in Rwanda.

3.4 Data Analysis

Both descriptive and inferential statistical methods were employed to analyze the data collected. Data were processed using the Statistical Package for Social Sciences (SPSS), version 25.0. Descriptive statistics such as frequency tables, percentages, and means were used to present key characteristics of the dataset.

Inferential statistics were applied to examine relationships among variables. Pearson correlation tests and multiple regression analysis were conducted to assess the connection between independent variables and the dependent variable project performance. Regression analysis is a statistical method used to identify the linear relationship between variables for purposes of prediction and causal inference.

The regression model used in this study is as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon$$

Where:

- Y = Project performance
- β_0 = Constant
- $\beta_1, \beta_2, \beta_3$ = Regression coefficients
- X_1 = Accessibility
- X_2 = Social infrastructure contribution
- X_3 = Degree of institutionalization
- ε = Error term

3.5 Ethical Considerations

Given the involvement of human participants, ethical considerations were paramount. Participants' privacy and anonymity were protected, and personal information was handled with care. All participants were fully informed about the study's objectives and gave their consent before participating. The researcher clearly explained the purpose of the study and its potential implications, ensuring that participants understood their role and how their responses would be used.

4. Results and Discussion

This section highlights the rigorous data collection and analysis processes undertaken to examine the impact of infrastructure management practices on the performance of rural bridge construction projects in Rwanda. The application of both descriptive and inferential statistical methods provided a comprehensive understanding of the data, yielding meaningful insights that emphasize the critical role of effective management in ensuring successful project outcomes. A total of 238 questionnaires were distributed, all of which were

completed and returned resulting in an exceptional 100% response rate. This high level of participation not only enhances the credibility and reliability of the study's findings but also underscores the value of community engagement in infrastructure projects. Overall, this section establishes a solid foundation for the conclusions and recommendations presented in the following section.

4.1 Inferential Statistics

This section presents the findings from inferential statistical test including correlation coefficient and multiple linear regression analysis between independent variable and dependent variables in this research study.

Table: 1 Correlation

		Accessibility	Social Infrastructure Contribution	Institutionalization Degree	Project Performance
Accessibility	Pearson Correlation	1	.951**	.921**	.965**
	Sig. (2-tailed)		.000	.000	.000
	N	238	238	238	238
Social Infrastructure Contribution	Pearson Correlation	.951**	1	.862**	.936**
	Sig. (2-tailed)	.000		.000	.000
	N	238	238	238	238
Institutionalization Degree	Pearson Correlation	.921**	.862**	1	.871**
	Sig. (2-tailed)	.000	.000		.000
	N	238	238	238	238
Project Performance	Pearson Correlation	.965**	.936**	.871**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	238	238	238	238

** . Correlation is significant at the 0.01 level (2-tailed).

Source: Primary, 2024

The results demonstrate the relationship between infrastructure management practices and the performance of rural bridge construction projects in Rwanda, using the Mushepari Bridge construction project in Rubavu District as a case study. The analysis focused on key factors of infrastructure management, namely Accessibility, Social Infrastructure Contribution, and Degree of Institutionalization. To determine the strength and direction of these relationships, the Statistical Package for Social Sciences (SPSS) software, version 25.0, was used to compute Pearson correlation coefficients.

The Pearson correlation coefficient ranges from -1 to 1. A value between -1 and 0 indicates a negative correlation (with -1 to -0.5 considered a strong negative correlation, and -0.5 to 0 a weak negative correlation), while a value between 0 and 1 indicates a positive correlation (with 0 to 0.5 considered weak and 0.5 to 1 considered strong).

Research in Pakistan by Timilsina (2020) identifies natural disasters (floods, earthquakes) as leading causes of construction delays, along with financial and payment issues, poor planning, inadequate site management, lack of experience, and material or equipment shortages (Thakur, 2021).

The results revealed strong positive correlations between the independent variables and project performance: Accessibility ($r = 0.965$), Social Infrastructure Contribution ($r = 0.936$), and Degree of Institutionalization ($r = 0.871$). Similarly, Al-Hazim (2019) reports that terrain and weather are primary drivers of delays and overruns in Jordan's infrastructure projects. These findings indicate a significant and strong relationship between infrastructure management practices and the successful performance of rural bridge construction projects in Rwanda, as evidenced by the Mushepari Bridge case study.

Table 2: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.967 ^a	.935	.934	.92253

a. Predictors: (Constant), Institutionalization Degree, Social Infrastructure Contribution, Accessibility

Source: Primary data, 2024

The results include the Model Summary, which was used to examine the effect of infrastructure management practices on the performance of rural bridge construction projects in Rwanda, using the Mushepari Bridge construction project in Rubavu District as a case study. The correlation coefficient ($R = 0.967$) indicates a very strong positive relationship between infrastructure management practices and project performance. Kassem (2020) finds that budget estimation errors, frequent

design modifications, site hazards, stakeholder failures, and insufficient feasibility studies were the top five delay contributors.

Furthermore, the R Square value was 0.935, meaning that approximately 93.5% of the variation in project performance can be explained by the combined influence of the identified infrastructure management practices.

This high R Square value suggests that the model has strong explanatory power and highlights the critical role of effective infrastructure management in achieving

successful outcomes in rural bridge construction projects.

Table 3: ANOVA of effect of infrastructure management practices on performance of rural bridge construction project

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2878.702	3	959.567	1127.504	.000 ^b
	Residual	199.147	234	.851		
	Total	3077.849	237			

a. Dependent Variable: Project Performance

b. Predictors: (Constant), Institutionalization Degree , Social Infrastructure Contribution , Accessibility

Source: Primary data, 2024

The results of the ANOVA test indicate that the model is statistically significant, with an F-value of 1127.504 and a p-value of 0.000. This suggests that the regression model is a good fit for predicting the relationship between infrastructure management practices and the performance of rural bridge construction projects. The significance level ($p < 0.05$) confirms that the observed

relationships are not due to chance, and the model can reliably be used for predictive analysis in this context. Amoatey (2021) finds that in Nigeria, the most significant delay drivers are financing and payment issues, poor contract management, material shortages, and inadequate planning.

Table 4: Coefficients of effect of infrastructure management practices on performance of rural bridge construction project

Model		Unstandardized Coefficients		Standardized Coefficients		Sig.
		B	Std. Error	Beta	T	
1	(Constant)	8.153	.647		12.604	.000
	Accessibility	.931	.075	.881	12.481	.000
	Social infrastructure contribution	.208	.064	.178	3.275	.001
	Institutionalization degree	-.081	.037	-.093	-2.168	.031

a. Dependent Variable: Project Performance

Source: Primary data, 2024

The results present the constant and regression coefficients of the independent variables measuring the effect of infrastructure management practices on the performance of rural bridge construction projects in Rwanda. This analysis, centered on the Mushepari Bridge construction project in Rubavu District, confirmed statistical significance for all variables, as each recorded a p-value less than 0.05.

According to the SPSS output (as detailed in Table 4), the regression model used is:

$$Y = 8.153 + 0.931X_1 + 0.208X_2 - 0.081X_3 + \varepsilon$$

The equation suggests that, even in the absence of the three variables, the base level of project performance stands at 8.153. Each coefficient indicates the expected change in project performance for a one-unit change in the respective independent variable, holding all other variables constant. Accessibility has the highest positive impact (0.931), followed by Social Infrastructure Contribution (0.208). The Degree of Institutionalization has a small negative coefficient (-0.081), suggesting that if not properly managed, institutional processes might hinder performance. Ghosh and Gupta (2021) underscore the importance of accounting for environmental "dynamic loads" such as strong winds and seismic activity in bridge design

The SPSS analysis also provided t-statistics for each variable. The t-statistic for the constant was 12.604 (calculated as $B = 8.153$ divided by $SE = 0.647$). Accessibility had a t-statistic of 12.481 ($B = 0.931$, $SE = 0.075$), Social Infrastructure Contribution scored 3.275 ($B = 0.208$, $SE = 0.064$), and Degree of Institutionalization returned -2.168 ($B = -0.081$, $SE = 0.037$). All these results are statistically significant with p-values of 0.000, 0.001, and 0.031 respectively. Suwal and Shrestha (2021) further highlight inadequate planning, clearance delays, poor site management, low bids, and labor issues in trail-bridge projects.

These findings underscore the importance of infrastructure management practices in influencing construction project outcomes. Specifically, Accessibility emerged as the most critical factor, demonstrating a strong and statistically significant positive effect on performance. This implies that ensuring physical and logistical accessibility significantly boosts the success of rural bridge construction.

Social Infrastructure Contribution, while having a smaller effect than Accessibility, also positively influences project performance. Its significance indicates

the value of involving and supporting communities through infrastructure that meets social needs.

Interestingly, the Degree of Institutionalization showed a statistically significant but negative relationship with project performance. This may suggest that overly rigid institutional frameworks or bureaucratic delays could hinder project execution unless properly streamlined and coordinated.

In summary, the regression analysis provides robust evidence that targeted improvements in infrastructure management practices particularly in enhancing accessibility and social infrastructure, while optimizing institutional frameworks can lead to substantial gains in the performance of rural bridge construction projects. These insights are essential for policymakers, engineers, and development partners seeking to implement efficient and impactful infrastructure solutions in rural areas of Rwanda.

4.2 Hypothesis testing

In order to test the study's three formulated hypotheses, the t-statistic was used to determine whether a B-value is significantly different from zero ($H_0: \beta = 0$). The study conducted a simple regression analysis to test the hypotheses. For p-values less than 0.05, hypotheses H_{01} , H_{02} , and H_{03} were rejected.

4.2.1 Testing Research Hypothesis One

H_{01} : There is no significant effect of the accessibility of the trail bridge on the performance of the rural Mushepari bridge construction project in Rubavu district.

As evident in Table 4, the unstandardized beta value for the accessibility of the trail bridge on the performance of the rural Mushepari bridge construction project was significantly greater than zero ($\beta_1 = 0.931$, p-value = $0.000 < 0.05$, $t = 12.481$). The null hypothesis was rejected because the p-value of 0.000 is less than 0.05. Therefore, accessibility has a significant effect on the performance of the rural Mushepari bridge construction project.

4.2.2 Testing Research Hypothesis Two

H_{02} : There is no significant effect of social infrastructure contribution of trial bridges on the performance of the rural Mushepari bridge construction project in Rubavu district.

As shown in Table 4, the unstandardized beta value for social infrastructure contribution of trial bridges on the project's performance was significantly different from zero ($\beta_2 = -0.208$, p-value = $0.001 < 0.05$, $t = 3.275$). The null hypothesis was rejected because the p-value of 0.001 is less than 0.05. Hence, social infrastructure contribution has a significant effect on the performance of the rural Mushepari bridge construction project.

4.2.3 Testing Research Hypothesis Three

H_{03} : There is no significant influence of the institutionalization degree of trial bridges on the performance of the rural Mushepari bridge construction project in Rubavu district. As shown in Table 4, the unstandardized beta value for the institutionalization degree of trial bridges on project performance was insignificantly greater than zero ($\beta_3 = -0.081$, p-value = $0.031 < 0.05$, $t = -0.242$). The null hypothesis was rejected because the p-value of 0.031 is less than 0.05. Therefore, the institutionalization degree significantly influences the performance of the rural Mushepari bridge construction project.

5. Conclusion and Recommendations

5.1 Conclusion

The study concluded that infrastructure management practices significantly influence the performance of rural bridge construction projects in Rwanda, based on the case of the Mushepari bridge in Rubavu District.

5.2. Recommendations

According to the results of this study, the study provides the following recommendations:

1. It is recommended to implement a robust monitoring and evaluation framework for future infrastructure projects. Ongoing assessment of factors such as accessibility, social contributions, and institutional practices will provide real-time insights and enable timely adjustments to project management strategies.
2. The Ministry of Infrastructure (MINIFRA) is advised to introduce comprehensive training programs for project managers and construction teams. These programs should focus on best practices in infrastructure management to enhance efficiency and effectiveness in project execution.
3. Furthermore, MINIFRA should establish a standardized framework for continuous monitoring and evaluation. This will not only assess the effectiveness of current management practices but also ensure that lessons learned are systematically integrated into the planning and implementation of future projects.

5.3 Suggestion for Further Research

Future research should consider conducting comparative studies of infrastructure management practices across

different regions of Rwanda or in neighboring countries. Such studies could shed light on region-specific challenges and successes in bridge construction, offering valuable insights into how contextual factors influence project performance. This broader perspective would contribute to a more nuanced and comprehensive understanding of effective infrastructure management in diverse settings.

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