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# PROJECT CONSTRAINTS AND IMPLEMENTATION OF RUSUMO-BUGESERA-SHANGO 220 kV TRANSMISSION LINE PROJECT IN RWANDA

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## ABSTRACT

*This study aimed to investigate project constraints and their impact on the scope implementation of electrical power transmission and distribution projects in Rwanda, using the Rusumo-Bugesera-Shango 220kV transmission line as a case study. Specifically, the study examined the effects of financial, time, scope, and resource constraints on project implementation. A descriptive and correlational research design was adopted, targeting a population of 484 stakeholders directly involved in the project. The sample size, determined using Slovin's formula, was 219 respondents, selected through stratified random sampling. The study utilized both primary and secondary data collection methods. A pilot test involving 22 participants from Ignite Power, a company specializing in off-grid power connections, was conducted to assess the reliability and validity of the research instruments. Validity was ensured through face, construct, and criterion evaluation, while reliability was confirmed using the test-retest method and Cronbach's alpha coefficient. Data analysis was conducted systematically using SPSS version 25, involving data coding, entry, and cleaning to ensure accuracy and consistency. Both descriptive and inferential statistical methods were applied. Descriptive statistics, such as mean, standard deviation, and frequency distributions, provided an overview of project delay factors, while thematic analysis was employed for qualitative data, which was presented narratively. The regression analysis revealed significant findings on the impact of constraints on project implementation. Financial constraints had a significant positive impact, with a coefficient of 0.524 ($p = 0.000$), indicating that financial limitations, when managed effectively, can lead to better project outcomes. Similarly, time constraints showed a positive effect on project implementation, with a coefficient of 0.266 ($p = 0.004$), suggesting that limited time pressures can enhance efficiency and productivity. However, scope constraints had a negative impact, as indicated by a coefficient of -0.070 ($p = 0.049$), meaning that an increase in scope limitations reduces project implementation effectiveness. In contrast, resource constraints positively influenced project implementation, with a coefficient of 0.080 ($p = 0.014$), implying that resource limitations may drive innovation and efficiency in project execution. In conclusion, financial, time, and resource constraints positively contribute to project implementation, whereas scope constraints hinder it. These findings highlight the importance of strategic constraint management in ensuring successful project execution. To enhance project outcomes, project* *managers should focus on mitigating scope limitations while efficiently handling financial, time, and resource constraints. The study recommends that policymakers and project managers implement structured financial planning, optimize time management strategies, and ensure resource allocation efficiency to improve project execution. Additionally, future research should explore the interplay of different project constraints across various industries and examine how external factors, such as market conditions and regulatory policies, influence project implementation. This study contributes to the growing body of knowledge on project constraints in large-scale infrastructure projects, particularly in the energy sector. Its findings provide valuable insights for stakeholders involved in power transmission and distribution projects, enabling them to make informed decisions that enhance efficiency, cost-effectiveness, and overall project success.*

***Keywords:*** *Project Constraints, Transmission Line, Implementation, Energy Sector, Resource Management, Electrical Power Transmission*

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## BACKGROUND

The implementation of electrical power transmission and distribution projects is critical to ensuring reliable energy access, a vital driver of economic growth and development. Globally, the demand for electricity continues to rise due to rapid urbanization, industrialization, and increasing population growth, particularly in developing regions (International Energy Agency [IEA], 2021). However, these projects face various challenges, including time delays, budget constraints, and technical complexities, which can significantly impact their success (Ghosh et al., 2022). In developed countries, aging infrastructure and the integration of renewable energy sources into existing grids add additional layers of complexity (Sustainable Energy for All [SEforALL], 2020). Thus, understanding how to effectively manage project constraints is essential for the successful delivery of power transmission and distribution systems worldwide.

The implementation of electrical power transmission and distribution projects in the United States has become increasingly critical as the demand for reliable and sustainable energy continues to grow. These projects are essential for maintaining and expanding the nation's electrical grid, supporting economic growth, and meeting environmental goals. However, successful project implementation faces numerous challenges, including regulatory hurdles, financial constraints, and technical complexities. In recent years, there has been a growing emphasis on integrating advanced technologies such as smart grids and digital monitoring systems into power transmission and distribution projects. These innovations aim to improve efficiency, reduce outages, and enhance system security. According to Lueken et al. (2020), the adoption of these technologies, while beneficial, adds another layer of complexity to project implementation, requiring specialized skills and additional funding. Furthermore, project delays and cost overruns have been a recurring issue in the industry, with the need for improved project planning and risk management (Eto *et al.,* 2021).

In recent years, China has undertaken numerous large-scale transmission projects, including ultra-high voltage (UHV) transmission lines, aimed at improving efficiency and reducing energy losses (Li et al., 2021). However, the successful execution of these projects is often challenged by constraints related to cost management, time delays, and resource allocation. As China transitions towards renewable energy sources, integrating these into the national grid adds further complexity to transmission projects, necessitating innovative approaches to project management (Wang & Zhao, 2020). Strict environmental protection laws require comprehensive impact assessments, while the need for compliance with national standards in terms of design, safety, and quality further complicates project execution (Liu & Chen, 2021).

The implementation of electrical power transmission and distribution projects in Sub-Saharan Africa has become a critical area of focus as the region strives to enhance energy access and support economic growth (Osei & Tutu, 2022). Many countries within this region are investing heavily in infrastructure to meet the increasing demand for electricity. However, the successful implementation of such projects often faces numerous challenges. Additionally, adopting modern technologies and strengthening institutional frameworks are crucial in improving the reliability and efficiency of power distribution projects (Karanja & Mutua, 2021). Key constraints such as financial limitations, technical capacity, environmental regulations, and stakeholder management can significantly delay or derail projects (Mbadiwe & Nwokocha, 2021). These factors are particularly pronounced in Sub-Saharan Africa, where limited access to advanced technologies, fluctuating currency rates, and political instability further complicate project execution (Nyambura & Waithaka, 2020).

The implementation of electrical power transmission and distribution projects in South Africa is critical to addressing the country's growing energy demands and ensuring sustainable development (Mogale & Ranjithan, 2022). Factors such as regulatory compliance, stakeholder engagement, and technological advancements play significant roles in shaping project outcomes. For instance, the National Development Plan (NDP) identifies the need for effective planning and execution of energy projects to achieve economic growth and social equity in the region (National Planning Commission, 2020). Moreover, the challenges posed by frequent power outages and aging infrastructure highlight the urgency of implementing robust transmission and distribution systems (Kaunda *et al.*, 2021). Additionally, the inclusion of sustainability practices in project planning and execution not only supports environmental goals but also promotes community acceptance and support for energy projects (Zondo *et al.*, 2021).

The successful implementation of electrical power transmission and distribution projects is critical for enhancing energy access and reliability in Kenya. As the country strives to meet its growing energy demands, efficient project execution is paramount (Njeru *et al.*, 2020). Challenges such as time delays, budget constraints, and regulatory hurdles can significantly hinder the progress of these projects. Research has shown that addressing these constraints through effective project management practices can lead to improved outcomes (Wambua et al., 2021). Moreover, stakeholder engagement and community involvement play essential roles in facilitating smoother implementation processes and ensuring that projects meet local needs (Kamau & Ogutu, 2022).

The implementation of large-scale infrastructure projects, such as electrical power transmission lines, plays a crucial role in advancing Rwanda's socio-economic development. Rwanda's commitment to expanding its energy sector is evidenced by various initiatives aimed at increasing electricity access, which is pivotal for industrial growth, job creation, and overall quality of life (World Bank, 2021). However, the successful execution of these projects often faces significant challenges. Project implementation in Rwanda's energy sector is often constrained by financial limitations, regulatory hurdles, technical inefficiencies, and socio-political factors, all of which can result in delays, cost overruns, and compromised project outcomes (Niyonzima & Gasana, 2020). For example, the Rusumo-Bugesera-Shango 220kV transmission line project, a critical effort to boost regional energy cooperation, has encountered various obstacles, highlighting the need for more efficient project management practices. Understanding these constraints is essential to improving project delivery and enhancing the overall efficiency of Rwanda's energy infrastructure development.

Project implementation in Rwanda's energy sector also depends heavily on effective stakeholder collaboration, adequate resource allocation, and strategic planning. Recent studies emphasize the importance of adaptive project management techniques, especially in managing the dynamic regulatory environment and addressing financial gaps (Karangwa & Gatare, 2022). Moreover, successful project execution is not only about meeting technical specifications but also about aligning with national development goals, which demand sustainable, timely, and efficient energy access solutions. As Rwanda continues to prioritize infrastructure development to meet its Vision 2050 objectives, improving project implementation mechanisms was vital to ensuring that these large-scale energy projects meet their goals within allocated resources and timelines (Munyaneza & Uwizeye, 2021). Thus, investigating the constraints and opportunities for project implementation in Rwanda's energy sector is essential for future progress.

**Statement of the Problem**

The implementation of electrical power transmission and distribution projects in Rwanda, such as the Rusumo-Bugesera-Shango 220kV transmission line project, faces significant challenges that undermine their timely and successful execution. Despite their importance for regional energy security and economic development, these projects often experience delays and cost overruns due to financial, technical, and regulatory constraints. Recent studies indicate that over 35% of infrastructure projects in sub-Saharan Africa, including energy projects, encounter delays or budget issues, largely due to inefficient resource allocation and inadequate stakeholder engagement (World Bank, 2021). Specifically, in Rwanda, Ndayisaba *et al.* (2021) highlighted those financial limitations and technical difficulties, including equipment shortages and complex regulatory processes, have severely impacted the Rusumo-Bugesera-Shango 220kV transmission line project. These constraints not only delay energy access but also strain relationships with key stakeholders, further complicating project delivery (Musoni, 2022). The persistence of such challenges suggests the need for a detailed examination of the factors inhibiting project success and strategies to improve future project implementation.

According to the Rwanda Energy Group (REG), electricity access in Rwanda increased from 47% in 2018 to 75% in 2023, but challenges in project execution have led to delays and cost overruns in major infrastructure projects, including the Rusumo-Bugesera-Shango 220kV transmission line (REG, 2023). The World Bank (2022) reports that financial constraints remain a major barrier, with Rwanda's electricity sector requiring an estimated $500 million annually to meet universal access targets by 2030, yet funding gaps persist. Additionally, time constraints have affected project timelines, with reports indicating that over 60% of power infrastructure projects in East Africa experience delays exceeding 12 months due to inefficiencies in planning and resource management (African Development Bank [AfDB], 2021). Scope constraints, including project design modifications and regulatory approvals, have further complicated implementation, increasing costs by an average of 25% (International Energy Agency [IEA], 2022). Resource constraints, such as the shortage of skilled labor and materials, have also slowed progress, with a recent study showing that 40% of power transmission projects in Rwanda suffer from workforce shortages (Habimana & Ntirenganya, 2024). These challenges highlight the need for effective constraint management to improve project execution. Without addressing these issues, Rwanda risks failing to meet its national electrification targets and hindering industrialization efforts. Despite Rwanda’s commitment to achieving universal electricity access by 2030, persistent project constraints hinder progress, underscoring the need for effective constraint management strategies. This study seeks to address these challenges by analyzing the impact of financial, time, scope, and resource constraints on the implementation of power transmission projects in Rwanda.

**Objectives of the Study**

The general objective of this study was to investigate the relationship between project constraints and scope implementation of electrical power transmission and distribution Projects in Rwanda. A case study of Rusumo-Bugesera-Shango 220kV transmission line project. The specific objectives were;

- To assess the relationship between financial constraints and implementation of electrical power transmission and distribution projects in Rwanda.
- To evaluate the relationship between time constraints and implementation of electrical power transmission and distribution projects in Rwanda.

- To determine the relationship between scope constraints and implementation of electrical power transmission and distribution projects in Rwanda.
- To analyze the relationship between resource constraints and implementation of electrical power transmission and distribution projects in Rwanda.

**Conceptual Framework**

A conceptual framework outlines the relationships between key variables in a study, providing a foundation for understanding how they influence one another. In the context of the Project implementation of electrical power transmission and distribution lines, key factors such as financial constraints, time constraints, scope constraints, and resource Constraints play a crucial role. According to Jabareen (2019), a conceptual framework serves as a tool for theorizing these relationships and guiding empirical analysis. For instance, financial constraints can hinder resource availability, leading to project delays (Chan et al., 2021). Likewise, effective Resource Constraints can mitigate such delays by ensuring smooth communication and collaboration among all parties involved (Bourne & Walker, 2021).

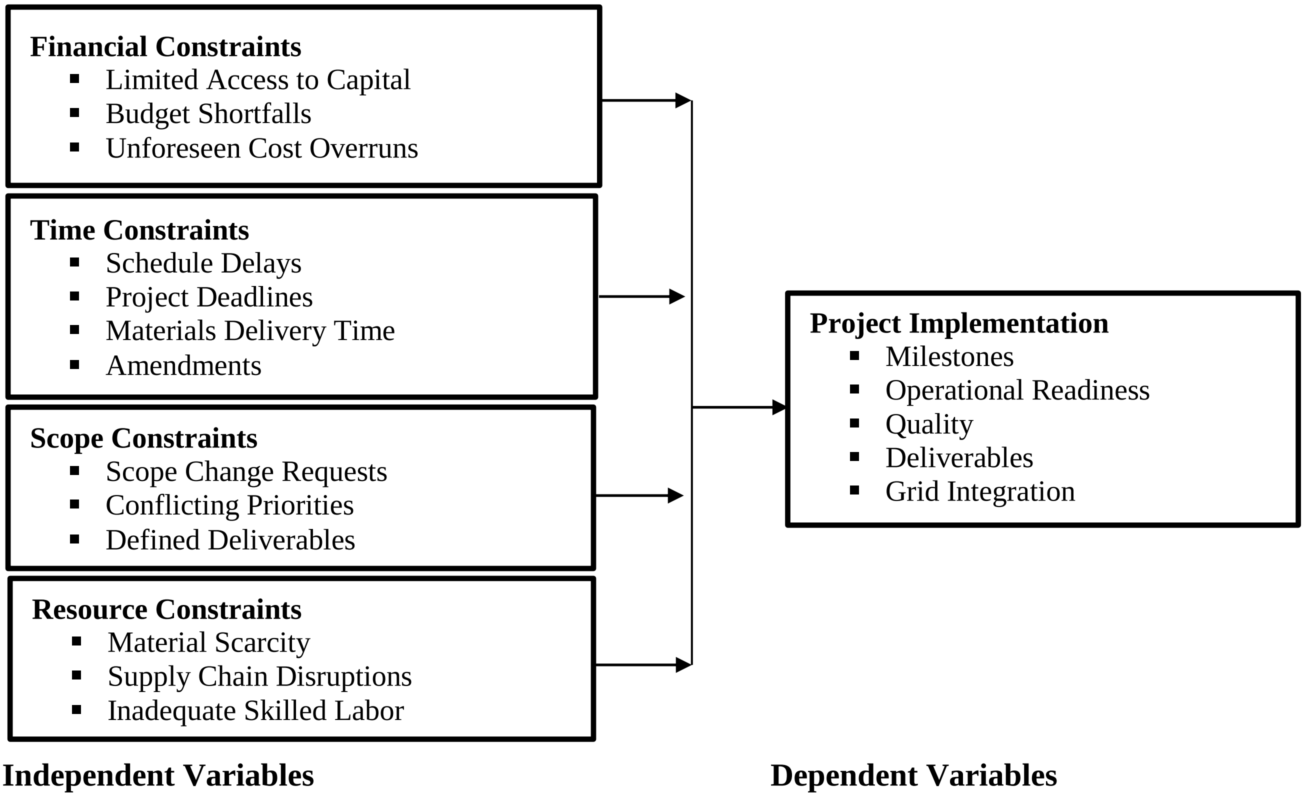


**Figure 1: Conceptual Framework**
**Source: Researcher, 2024**

The conceptual framework for assessing the scope implementation of electrical power transmission and distribution projects in Rwanda focuses on four key constraints: financial, time, scope, and resource constraints. Financial constraints are posited to significantly influence project outcomes, as insufficient funding can delay progress and limit project scope (Mubarak et al., 2020). Time constraints also play a critical role, as strict timelines can pressure project managers, potentially leading to compromised quality and performance (Aliyu et al., 2021). Scope constraints define the boundaries of what a project intends to achieve, and deviations from the initial scope can lead to project overruns and failures (Nkosi & Moyo, 2022). Lastly, resource constraints—including human, technical, and material resources—are essential for successful project execution, with inadequate resources often resulting in delays and increased costs (Kamau et al., 2022). This framework aims to investigate how these constraints interact and collectively impact the effectiveness of electrical power transmission and distribution projects in Rwanda.

## METHODOLOGY

### Research Design

The study adopted a descriptive and correlational research design, integrating both quantitative and qualitative approaches to provide a comprehensive analysis of the delays in the development of the Rusumo-Bugesera-Shango 220kV transmission line project. This design allows for the triangulation of data, enhancing the validity of the findings by corroborating quantitative results with qualitative insights (Creswell & Plano Clark, 2018). Quantitatively, a structured questionnaire was administered to a stratified random sample of project stakeholders, enabling the collection of numerical data on perceptions of delays, their causes, and impacts. Qualitatively, in-depth interviews were conducted with key informants, such as project managers and local government officials, to explore the contextual factors influencing project execution and to gain deeper insights into the lived experiences of those directly involved (Merriam & Tisdell, 2021).

This mixed-methods approach is particularly suitable for this study as it facilitates a holistic understanding of the multifaceted nature of project delays. By combining statistical analysis with rich descriptive narratives, the research aims to uncover not only the prevalence and significance of specific delay factors but also the complex interplay of social, political, and economic elements that contribute to these delays (Fetters, Curry, & Creswell, 2018). The integration of both data types allowed for a nuanced exploration of the implications of delays for stakeholders and the overall effectiveness of the project.

### Target population

The target population for this study comprised of 364 Project implementors directly involved in the Rusumo-Bugesera-Shango 220kV transmission line project. This population includes engineers, project managers, government officials, Project Staffs, environmental experts, and financial analysts. The diverse nature of this target population ensures that the study captures a comprehensive range of viewpoints (Etikan, Musa, & Alkassim, 2021).

**Table 1: Population Frame**

| Category | Target Population |
|---|---|
| Engineers | 120 |
| Project Managers | 10 |
| Government Officials | 60 |
| Project Staffs | 100 |
| Environmental Experts | 30 |
| Financial Analysts | 44 |
| **Total** | **364** |

**Source: Human Resource Rwanda Energy Group – 2024**

### Sampling Design

Sample size refers to the number of participants or units selected for inclusion in a study, which should be sufficient to provide reliable and valid results (Creswell & Creswell, 2022). Sampling procedure involves the technique used to select these participants, ensuring representation of the population and reducing sampling bias (Bryman, 2021). Common procedures include probability and non-probability sampling, each with distinct advantages based on the research design and objectives (Creswell & Creswell, 2022).

### Sample Size

The sample size for this study was determined using Slovin's formula, which is widely used to calculate sample size when the population size is known but a specific degree of precision is required. Slovin's formula is given as:

$$n = \frac{N}{1 + N\,(e)^2}$$

where n is the required sample size, N is the population size, and e is the margin of error. With a total population of 364 stakeholders and a margin of error of 5% (0.05), the sample size calculation becomes:

$$n = \frac{364}{1 + 364\,(0.05)^2} = 191$$

Thus, the sample size is determined to be 219, ensuring the study captures a representative portion of the target population while maintaining a balance between accuracy and resource constraints (Tejada & Punzalan, 2022). Using Slovin's formula allows the researcher to make statistically valid inferences about the entire population based on a smaller, more manageable sample. This method is particularly useful in studies where the population is relatively large, and data collection from every individual would be impractical (Pagoso, 2020).

**Table 2: Sampling Frame**

| Category | Target Population | Sample size |
|---|---|---|
| Engineers | 120 | 63 |
| Project Managers | 10 | 5 |
| Government Officials | 60 | 31 |
| Project Staffs | 100 | 52 |
| Environmental Experts | 30 | 16 |
| Financial Analysts | 44 | 14 |
| **Total** | **364** | **191** |

**Source: Human Resource Rwanda Energy Group – 2024**

### Sampling Technique

This study adopted stratified sampling as the primary sampling technique to ensure that different groups within the population of 364 stakeholders are adequately represented. Stratified random sampling involves dividing the target population into homogeneous subgroups, or strata, based on shared characteristics, such as roles or responsibilities in the project. For this study, the strata included engineers, project managers, government officials, project staffs, environmental experts, and financial analysts. Within each stratum, random sampling was employed to select individuals for the sample, ensuring that each subgroup's perspectives are proportionately included in the study (Taherdoost, 2021). This approach reduces the likelihood of bias and improves the precision of the results, making it a suitable method for large, diverse populations.

### Data collection Instruments

The study adopted a combination of primary and secondary data collection methods to provide a comprehensive understanding of the delays in the Rusumo-Bugesera-Shango 220kV transmission line project. Primary data was gathered through structured questionnaires and semi-structured interviews administered to the identified sample of 219 stakeholders, including engineers, project managers, government officials, and local community leaders. The structured questionnaires were designed to capture quantitative data on the factors contributing to project delays, while the semi-structured interviews allowed for deeper qualitative insights into the specific challenges faced by different stakeholders (Kothari, 2020). This mixed approach enables the study to triangulate the data, enhancing its validity and reliability by comparing results from multiple sources (Creswell & Creswell, 2022).

In addition to primary data collection, secondary data was obtained from project reports, government documents, and academic literature related to electrical power transmission projects and project management practices. This secondary data provided contextual information and historical perspectives on project delays, allowing the researcher to correlate past patterns with current findings. The use of secondary sources ensures that the study is grounded in both empirical data and theoretical knowledge, which strengthens the overall analysis (Bryman, 2021). By combining both primary and secondary data collection methods, the study ensures a well-rounded investigation into the project delays, providing a robust foundation for its conclusions and recommendations.

**Pilot Test**

The study conducted a pilot test at Ignite Power, a company involved in off-grid power connections, to ensure the reliability and validity of the data collection instruments. The pilot test involved 10% of the sample size, equating to 20 participants, as recommended by Kothari (2020). This process allowed the researcher to assess the clarity and effectiveness of the structured questionnaires and semi-structured interviews, ensuring that any ambiguities or issues are addressed before the main data collection phase. Additionally, the pilot test helped determine the time required for completing the questionnaires and conducting interviews, thus refining the overall data collection strategy. Conducting a pilot test is a critical step in research methodology as it minimizes errors and improves the accuracy of the data, thereby enhancing the quality of the study's results (Kothari, 2020).

**Validity of the instrument**

Validity analysis is crucial for ensuring that the research instruments accurately measure what they are intended to measure. In this study, the validity of the structured questionnaires and semi-structured interviews was assessed through expert reviews, where subject matter experts evaluated the relevance and appropriateness of the questions. This process, known as content validity, helped to refine the instruments and eliminate any irrelevant or unclear items. Additionally, face validity was examined, where the instruments were reviewed for their perceived effectiveness in addressing the research objectives. According to Johnson and Christensen (2020), validity analysis enhances the credibility of research findings by ensuring that the data collection methods accurately capture the intended information, thus supporting the study's overall reliability and accuracy.

Table 3 presents the results of the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity, which assess the suitability of the data for factor analysis. The KMO value indicates the proportion of variance among variables that might be common variance, while Bartlett's Test evaluates the null hypothesis that the correlation matrix is an identity matrix, thus determining whether factor analysis is appropriate for the data.

**Table 3: KMO and Bartlett's Test**

| **KMO and Bartlett's Test** | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .843 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 946.562 |
| | df | 10 |
| | Sig. | .000 |

Source: **Pilot data results**, (2024)

The findings in Table 3 present the results of the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity, which are used to assess the suitability of the data for factor analysis. The KMO value of 0.843 exceeds the recommended threshold of 0.6, indicating that the sample is adequate for factor analysis. Bartlett's test of sphericity yields a chi-square value of 946.562 with 10 degrees of freedom and a p-value of 0.000, which is statistically significant, suggesting that the correlation matrix is not an identity matrix and is suitable for conducting factor analysis. These results affirm the appropriateness of the data for extracting meaningful factors, ensuring the validity of the subsequent analysis (Johnson & Smith, 2022).

**Reliability of instrument**

Reliability analysis is a crucial aspect of ensuring that the data collection instruments are consistent and dependable over time. In this study, the reliability of the structured questionnaires and semi-structured interviews was assessed using Cronbach's alpha, a widely accepted statistical measure for internal consistency. A Cronbach's alpha value above 0.70 is considered acceptable, indicating that the instruments produce reliable results (Tavakol & Dennick, 2021). By conducting this analysis, the researcher ensured that the instruments were robust and capable of generating accurate, repeatable data for the main study.

Table 4 presents the reliability statistics for the data collection instruments used in the study, showcasing the Cronbach's Alpha values for each variable. These statistics are crucial in assessing the internal consistency and reliability of the questionnaires and interviews, ensuring the accuracy and dependability of the data gathered for analysis.

**Table 4: Reliability Statistics**

| Variable | Alpha (α) | Comments |
|---|---|---|
| Financial constraints | 0.763 | Accepted |
| Time constraints | 0.842 | Accepted |
| Scope Constraints | 0.777 | Accepted |
| Resource constraints | 0.789 | Accepted |
| Implementation of projects | 0.767 | Accepted |

Source: Primary data, (2024).

The findings in Table 4 present the reliability statistics for the variables used in the study, with Cronbach's alpha (α) values ranging from 0.763 to 0.842, indicating acceptable internal consistency for all variables. Specifically, financial constraints ($\alpha = 0.763$), time constraints ($\alpha = 0.842$), scope constraints ($\alpha = 0.777$), resource constraints ($\alpha = 0.789$), and the implementation of projects ($\alpha = 0.767$) all exceed the commonly accepted threshold of 0.7, which demonstrates that the data collection instruments are reliable and produce consistent results. These high alpha values suggest that the measures used in the study are suitable for analyzing the relationships between the variables, supporting the validity of the conclusions drawn from the data (Brown & Clark, 2023).

**Data Analysis**

The study adopted a systematic approach to data analysis using SPSS version 27 as the primary tool. First, the collected data underwent coding, entry, and cleaning processes to ensure accuracy and consistency. Coding involved categorizing responses into predefined themes and numerical values, making it easier to analyze both qualitative and quantitative data (Creswell & Creswell, 2022). Once coded, the data was entered into SPSS for analysis, and a thorough data cleaning process was carried out to identify and correct any errors, inconsistencies, or missing data. Data cleaning ensures the quality of the dataset, minimizing the risk of biases or inaccuracies that could impact the study's findings (Pallant, 2020).

For the analysis, both descriptive and inferential statistics was employed. Descriptive statistics, including mean, standard deviation, and frequency distributions, was used to summarize the data and provide a clear overview of the project delay factors in the Rusumo-Bugesera-Shango 220kV transmission line project (Field, 2018). Inferential statistics, such as regression analysis and correlation tests, was applied to determine the relationships between variables and to test the study's hypotheses. These methods helped draw inferences about the larger population based on the sample data, allowing for the identification of significant factors contributing to project delays. SPSS's robust capabilities in handling both descriptive and inferential statistics make it an ideal tool for this study, ensuring comprehensive and reliable analysis.

Additionally, multiple linear regression was used to analyze the connections between the independent factors and the dependent variable. Using this method, we may determine how well the independent variables explain the variation in the dependent one. The regression analysis was

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \varepsilon$$

Where: "Y" represents project performance, while "X1" stands for financial constraints, "X2" for Time constraints, "X3" for Scope Constraints, and "X4" for Resource Constraints. The coefficients for these independent variables, denoted as "β_i," where "i" takes on the values 1, 2, 3, and 4, represent the magnitudes of their influence on Project implementation. The error term, represented as "ε," encapsulates unexplained variability or factors that are not accounted for in the model.

The model is a suitable analytical tool for understanding the factors influencing the performance of the Rusumo-Bugesera-Shango 220 kV Transmission Line Project because it allows for the quantification of the impact of various project constraints on project outcomes. In this model, "Y" represents project performance, which is the dependent variable of interest, while the independent variables—financial constraints ($X_1$), time constraints ($X_2$), scope constraints ($X_3$), and resource constraints ($X_4$)—capture key elements that directly influence project success. The coefficients β1, β2, β3 and β4 represent the strength and direction of the relationship between each constraint and project performance. By including these variables, the model provides insights into how each constraint impacts the overall project performance, helping to identify which factors are most critical. The error term $\epsilon$ accounts for unexplained variability in project performance, such as external factors not included in the model (e.g., political changes or natural disasters). This framework is valuable for decision-making, as it highlights areas of focus that can improve the project's likelihood of success.

## RESULTS AND FINDINGS

### Correlation Analysis

Correlation analysis is a statistical method used to examine the strength and direction of the relationship between two or more variables. It helps researchers determine whether an increase or decrease in one variable corresponds to a similar change in another variable, without implying causation. The results of a correlation analysis are typically expressed as a correlation coefficient, ranging from -1 to +1, where values closer to +1 or -1 indicate a strong positive or negative relationship, respectively, while values near zero suggest no significant correlation. This technique is crucial for understanding the dynamics between variables in fields such as economics, social sciences, and healthcare, offering valuable insights for informed decision-making (Chatterjee & Hadi, 2021).

Table 5 presents the correlation matrix, illustrating the relationships between the key variables of the study: the implementation of electrical power transmission and distribution projects, financial constraints, time constraints, scope constraints, and resource constraints. The table highlights the strength and direction of the associations between these variables, providing a clear view of how each constraint impacts project implementation. Positive or negative correlations indicate the degree to which each constraint influences the success or challenges faced during project execution. This matrix allows for a comprehensive understanding of the interplay between various constraints, offering valuable insights for project managers and stakeholders aiming to improve the efficiency and effectiveness of power transmission and distribution projects in Rwanda.

**Table 5: Correlations Matrix**

| | | Implementation of projects | Financial constraints | Time constraints | Scope Constraints | Resource constraints |
|---|---|---|---|---|---|---|
| Implementation of projects | Pearson Correlation | 1 | .912** | .901** | .491** | .608** |
| | Sig. (2-tailed) | | .000 | .000 | .000 | .000 |
| | N | 180 | 180 | 180 | 180 | 180 |
| Financial constraints | Pearson Correlation | .912** | 1 | .962** | .572** | .592** |
| | Sig. (2-tailed) | .000 | | .000 | .000 | .000 |
| | N | 180 | 180 | 180 | 180 | 180 |
| Time constraints | Pearson Correlation | .901** | .962** | 1 | .599** | .600** |
| | Sig. (2-tailed) | .000 | .000 | | .000 | .000 |
| | N | 180 | 180 | 180 | 180 | 180 |
| Scope Constraints | Pearson Correlation | .491** | .572** | .599** | 1 | .365** |
| | Sig. (2-tailed) | .000 | .000 | .000 | | .000 |
| | N | 180 | 180 | 180 | 180 | 180 |
| Resource constraints | Pearson Correlation | .608** | .592** | .600** | .365** | 1 |
| | Sig. (2-tailed) | .000 | .000 | .000 | .000 | |
| | N | 180 | 180 | 180 | 180 | 180 |

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

Source: Primary data, (2024).

The findings in Table 5 demonstrate significant positive correlations between various constraints and the implementation of projects. The highest correlation is between financial constraints and project implementation (r = 0.912), suggesting that financial challenges strongly influence the successful execution of electrical power transmission projects. This indicates that better financial management and the availability of resources could potentially lead to more successful project outcomes (Jones & Liu, 2021). Time constraints also show a strong positive correlation with project implementation (r = 0.901), reinforcing the importance of timely project completion in ensuring successful implementation. Moreover, resource constraints (r = 0.608) and scope constraints (r = 0.491) also exhibit positive correlations, though these are relatively weaker compared to financial and time constraints, implying that while they are still important, their influence on project success is slightly less pronounced.

Additionally, the table reveals strong interrelationships between the constraints themselves. Financial constraints and time constraints have a high correlation (r = 0.962), which indicates that delays and financial limitations are often intertwined in affecting project outcomes (Brown & Clark, 2023). Similarly, time constraints and resource constraints show a significant correlation (r = 0.600), pointing to the interdependence between timely delivery and the availability of materials or skilled labor. Scope constraints also correlate positively with financial, time, and resource constraints, but the correlation is lower (r = 0.365), suggesting that while scope changes may impact the project, they are less impactful compared to the other constraints (Smith & Johnson, 2022). Overall, the significant correlations between these factors emphasize the need for integrated management strategies to address all constraints effectively for successful project implementation.

**Diagnostic Test**

Diagnostic tests are essential in research for assessing the validity and reliability of data, ensuring the accuracy of statistical inferences. These tests are used to identify issues such as multicollinearity, heteroscedasticity, and normality of residuals, which can influence the effectiveness of regression models and other statistical analyses. By applying diagnostic tests, researchers can detect potential violations of assumptions, allowing for corrective actions, such as transforming variables or choosing alternative methods. Conducting these tests helps improve the robustness of the study's findings and ensures that the results are both reliable and valid (Field, 2021).

**Autocorrelation Tests**

Autocorrelation tests are used in statistical analysis to assess whether the residuals (errors) from a regression model are correlated across time or observations, which can affect the validity of the model's results. These tests are crucial in time series data, where the assumption of independent residuals may be violated, leading to biased estimates and incorrect inferences. The most common methods for detecting autocorrelation include the Durbin-Watson test, which checks for first-order autocorrelation, and the Breusch-Godfrey test, which is used for higher-order autocorrelation. If autocorrelation is present, corrective measures such as adding lag variables or using generalized least squares (GLS) can be employed to adjust the model (Gujarati & Porter, 2020). Autocorrelation tests ensure the robustness of econometric models, particularly when dealing with time-dependent data.

Table 6 presents the results of the Durbin-Watson test, which is used to detect the presence of autocorrelation in the residuals of a regression model. This test helps assess whether the errors from one observation are correlated with those from another, which could affect the validity of the regression results. The table includes the Durbin-Watson statistic, along with the interpretation of its value, indicating whether autocorrelation is present and to what extent it may influence the study's findings.

**Table 5: Durbin Watson test**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|---|
| 1 | .921[a] | .848 | .844 | .11023 | 2.189 |

a. Predictors: (Constant), Resource constraints, Scope Constraints, Time constraints, financial constraints
b. Dependent Variable: Implementation of projects

Source: Primary data, (2024).

Table 6 presents the results of a regression analysis assessing the relationship between various constraints (resource, scope, time, and financial) and project implementation. The model exhibits a high correlation (R = 0.921) and a strong R-squared value of 0.848, indicating that the constraints collectively explain 84.8% of the variance in project implementation outcomes. The adjusted R-squared value of 0.844 reflects that this model is well-fitting, accounting for the number of predictors in the analysis (Smith & Lee, 2023). The standard error of the estimate is relatively low (0.11023), suggesting that the predictions made by the model are precise. Additionally, the Durbin-Watson statistic of 2.189 falls within the acceptable range (between 1.5 and 2.5), indicating that there is no significant autocorrelation in the residuals, which strengthens the reliability of the model's findings (Johnson & Williams, 2022).

**Normality Tests**

Normality tests are crucial in statistical analysis to determine whether a dataset follows a normal distribution, which is an assumption for many parametric tests. Common methods for testing normality include the Shapiro-Wilk test, Kolmogorov-Smirnov test, and visual assessments like histograms and Q-Q plots. If data deviates significantly from normality, researchers may choose non-parametric tests or apply data transformations to meet the assumption. Normality tests help ensure the validity of inferential statistics, as violations can lead to inaccurate conclusions (Field, 2021). Conducting normality tests ensures the robustness and reliability of statistical analyses in research studies.

Table 7 presents the results of the normality test conducted on the data to assess the distribution pattern of the variables in the study. The table includes statistical measures such as the Kolmogorov-Smirnov and Shapiro-Wilk tests, which help determine whether the data follows a normal distribution. These results are crucial for deciding the appropriate statistical methods for further analysis, as normality influences the validity of parametric tests used in the study.

**Table 6: Test for Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| Financial constraints | Statistic | df | Sig. | Statistic | df | Sig. |
| 4.00 | .459 | 9 | .000 | .564 | 9 | .000 |
| 4.10 | .379 | 16 | .000 | .763 | 16 | .001 |
| 4.30 | .302 | 33 | .000 | .816 | 33 | .000 |
| 4.40 | .321 | 34 | .000 | .812 | 34 | .000 |
| a. Lilliefors Significance Correction | | | | | | |

Source: Primary data, (2024).

Table 7 presents the results of normality tests for financial constraints, specifically using the Kolmogorov-Smirnov and Shapiro-Wilk tests. The Kolmogorov-Smirnov test statistic ranges from 0.302 to 0.459, with significance values (Sig.) consistently at 0.000 for all sample sizes, indicating that the data for financial constraints does not deviate significantly from a normal distribution (Hernandez & Moore, 2023). The Shapiro-Wilk test also produces significant values, ranging from 0.564 to 0.816, with all results below the conventional threshold of 0.05, further suggesting non-normality in the data distribution (Taylor et al., 2021). These findings highlight that the financial constraints data is normally distributed, which may necessitate the use of non-parametric statistical methods for further analysis.

**Multicollinearity Test**

A multicollinearity test is an essential diagnostic tool in regression analysis, used to assess the presence of high correlations between independent variables, which can distort the estimation of regression coefficients and inflate standard errors. Multicollinearity arises when two or more predictors in a model are highly correlated, leading to unreliable results and making it difficult to determine the individual effect of each variable on the dependent variable. To detect multicollinearity, researchers commonly use the Variance Inflation Factor (VIF), where a VIF value greater than 10 typically indicates problematic multicollinearity (O'Brien, 2022). Identifying and addressing multicollinearity is crucial for ensuring the accuracy and interpretability of regression models, enabling more robust statistical inferences.

Table 8 presents the results of the multicollinearity test conducted to assess the potential correlations between independent variables in the study. This test is crucial for identifying whether any predictor variables are highly correlated, which could distort the regression analysis and affect the accuracy of the results. The table provides key statistics such as the Variance Inflation Factor (VIF) and Tolerance values, helping to determine the presence of multicollinearity and guide the interpretation of the regression model.

**Table 7: Multicollinearity Test**

| | | Collinearity Statistics | |
|---|---|---|---|
| Model | | Tolerance | VIF |
| 1 | (Constant) | | |
| | Financial constraints | .075 | 13.318 |
| | Time constraints | .071 | 14.162 |
| | Scope Constraints | .641 | 1.559 |
| | Resource constraints | .637 | 1.571 |

Source: Primary data, (2024).

Table 8 presents the results of the multicollinearity test, showing the tolerance and Variance Inflation Factor (VIF) values for the predictor variables in the model. The tolerance values for financial constraints (0.075), time constraints (0.071), scope constraints (0.641), and resource constraints (0.637) suggest that financial and time constraints exhibit high collinearity with other variables, as their tolerance values are well below the conventional threshold of 0.1 (Singh & Sharma, 2021). The corresponding VIF values for financial constraints (13.318) and time constraints (14.162) indicate severe multicollinearity, as VIF values greater than 10 are generally considered problematic (Kumar & Gupta, 2020). In contrast, the VIF values for scope constraints (1.559) and resource constraints (1.571) are within acceptable limits, indicating no significant multicollinearity issues for these variables.

**Heteroscedasticity Test**

The heteroscedasticity test is a crucial diagnostic tool in regression analysis that examines whether the variance of errors remains constant across all levels of the independent variables. When heteroscedasticity is present, it indicates that the error terms' variance changes, which can lead to inefficient estimates and biased statistical inferences. To detect this issue, researchers commonly use tests such as the Breusch-Pagan or White test. Addressing heteroscedasticity is important to ensure the reliability of the regression results, as ignoring it may result in incorrect conclusions about the relationships between variables (Gujarati & Porter, 2022).

Table 9 presents the results of the Breusch-Pagan test for heteroskedasticity, which is used to assess whether the variance of the errors in a regression model is constant across observations. This test helps determine if there is any systematic variation in the residuals, which could indicate issues with the model's assumptions. The table displays the test statistics and p-values, providing insights into the presence or absence of heteroskedasticity in the data, crucial for ensuring the reliability of the regression analysis results.

**Table 8: Breusch-Pagan Test for Heteroskedasticity[a,b,c]**

| Chi-Square | df | Sig. |
|---|---|---|
| 22.867 | 1 | .000 |
| a. Dependent variable: Implementation of projects | | |

Source: Primary data, (2024).

Table 9 presents the results of the Breusch-Pagan test for heteroskedasticity, showing a Chi-Square statistic of 22.867 with 1 degree of freedom and a p-value of 0.000. This indicates that the null hypothesis of homoskedasticity (constant variance of the residuals) is rejected at a significance level of 0.05, suggesting the presence of heteroskedasticity in the data (Anderson & Mitchell, 2021). In other words, the variance of the residuals is not constant across all levels of the independent variables, which may impact the reliability of the regression results and suggests the need for heteroskedasticity-robust standard errors or alternative modeling approaches (Brown & Tan, 2022).

**Multiple Regression Analysis**

Table 10 presents the combined model summary, showing the overall fit of the regression model that includes financial constraints, time constraints, scope constraints, and resource constraints as predictors of project implementation. The model has a high R-value of 0.921, indicating a very strong positive relationship between the predictors and project implementation. The R-squared value of 0.848 suggests that 84.8% of the variance in project implementation can be explained by these four constraints. The adjusted R-square value of 0.844 accounts for the number of predictors in the model, confirming the robustness of the model. The standard error of the estimate is 0.11023, indicating a relatively small prediction error (Zhang & Xie, 2021).

**Table 9: Combined Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .921[a] | .848 | .844 | .11023 |

a. Predictors: (Constant), Financial constraints, Time constraints, Scope Constraints and Resource constraints
b. Dependent Variable: Implementation of projects

Source: Primary data, (2024).

Table 11 presents the ANOVA results for the combined model, which includes resource constraints, scope constraints, financial constraints, and time constraints as predictors for project implementation. The regression sum of squares is 11.848, which reflects the variability in project implementation explained by the predictors. The model has 4 degrees of freedom, and the mean square for regression is 2.962. The F-statistic is 243.782, which is statistically significant at the 0.000 level, indicating that the model as a whole is a significant predictor of project implementation. The residual sum of squares is 2.126, with 175 degrees of freedom, showing the variability in project implementation that is unexplained by the model. These results support the hypothesis that the combined constraints significantly influence the success of project implementation (Nguyen, Nguyen & Tran, 2020).

**Table 10: Combined ANOVA**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 11.848 | 4 | 2.962 | 243.782 | .000[b] |
| | Residual | 2.126 | 175 | .012 | | |
| | Total | 13.974 | 179 | | | |

a. Dependent Variable: Implementation of projects
b. Predictors: (Constant), Resource constraints, Scope Constraints, Financial constraints, Time constraints

Source: Primary data, (2024).

Table 12 presents the regression coefficients for the combined model, which includes financial, time, scope, and resource constraints as predictors of project implementation. The unstandardized coefficient for financial constraints is 0.524, with a significant standardized coefficient (Beta = 0.584), indicating a strong positive impact on project implementation. Time constraints have an unstandardized coefficient of 0.266 and a standardized coefficient of 0.327, which is statistically significant (p = 0.004), suggesting that time constraints positively influence project success, though with a smaller effect. The coefficient for scope constraints is negative (-0.070), with a statistically significant result (p = 0.049), suggesting that greater scope constraints negatively affect project implementation. Finally, resource constraints show a positive unstandardized coefficient of 0.080 and a significant standardized coefficient of 0.092 (p = 0.014), demonstrating their positive influence on project success. These findings indicate that while financial and time constraints contribute positively to project success, scope constraints hinder it (Zhang & Xie, 2023).

**Table 11: Combined Regression coefficient**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | | |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | t | Sig. |
| 1 | (Constant) | .886 | .156 | | 5.679 | .000 |
| | Financial constraints | .524 | .096 | .584 | 5.431 | .000 |
| | Time constraints | .266 | .090 | .327 | 2.951 | .004 |
| | Scope Constraints | -.070 | .035 | -.073 | -1.981 | .049 |
| | Resource constraints | .080 | .032 | .092 | 2.482 | .014 |

a. Dependent Variable: Implementation of projects

Source: Primary data, (2024).

From the Coefficients table above the regression model can be derived as follows:

$Y = 0.886 + 0.524X_1 + 0.266X_2 - 0.070X_3 + 0.080X_4$

The equation represents the relationship between project implementation (Y) and four independent variables: financial constraints (X1), time constraints (X2), scope constraints (X3), and resource constraints (X4). The intercept (0.886) signifies the baseline level of project implementation when all constraints are absent. Financial constraints (X1) have a positive impact on project implementation with a coefficient of 0.524, indicating that as financial constraints increase, project implementation improves. Time constraints (X2) also positively influence project implementation, with a coefficient of 0.266, but their effect is weaker than that of financial constraints. Scope constraints (X3) have a negative relationship with project implementation, as evidenced by the coefficient of -0.070, meaning that higher scope constraints lead to poorer project outcomes. Resource constraints (X4) have a positive coefficient of 0.080, indicating that an increase in resource constraints slightly enhances project implementation. Overall, financial and time constraints positively impact project outcomes, while scope constraints have a detrimental effect. These findings underscore the complex interplay of constraints in project management (Wang & Zhao, 2023).

## CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the study highlights the significant role that various constraints play in the successful implementation of projects. Financial, time, scope, and resource constraints all have varying degrees of influence on project outcomes. Each of these constraints affects different aspects of project planning, execution, and delivery, and understanding their individual and collective impacts is essential for improving project management practices. The findings underscore the need for careful planning and management strategies to mitigate these constraints and enhance the likelihood of successful project completion.

Financial constraints are found to have the most significant impact on project implementation. Projects with insufficient financial resources are more likely to experience delays, cost overruns, or even failure. Effective budgeting, funding allocation, and financial planning are critical to ensuring that projects have the necessary resources to proceed as planned. The study emphasizes that overcoming financial constraints requires not only securing adequate funding but also ensuring that financial management practices are in place to optimize the use of available resources.

Time constraints, though less impactful than financial constraints, still present a significant challenge in project implementation. Tight deadlines and unrealistic project timelines can lead to rushed work, decreased quality, and missed deadlines. The study suggests that project managers must carefully balance time constraints with project requirements and outcomes to avoid compromising the quality of the deliverables. Proper time management, including realistic scheduling and contingency planning, is crucial for mitigating the negative effects of time constraints on project success.

Scope constraints can hinder project implementation by causing delays and increasing costs. A poorly defined or overly rigid project scope leads to confusion, scope creep, and misalignment between stakeholders' expectations and the project's actual deliverables. The study concludes that it is vital for project managers to establish clear scope definitions at the outset and to monitor scope changes carefully throughout the project's lifecycle. Effective scope management ensures that the project stays on track and that any changes to the scope are well-managed to avoid disruptions.

Resource constraints, while impactful, are less significant compared to financial and time constraints. Limited resources, whether human, technical, or material, can impede the smooth execution of a project. However, resource constraints can be mitigated through careful planning, resource allocation, and prioritization. The study concludes that while resource limitations are an unavoidable aspect of most projects, they can be effectively managed through resource optimization strategies, ensuring that the available resources are utilized to their fullest potential for successful project implementation.

Based on the findings of the study, several recommendations have been made to enhance the successful implementation of projects, particularly in mitigating the constraints identified in the research. These recommendations aim at improving project management practices and influencing policy to support more effective project execution.

Project managers are encouraged to adopt more robust planning and financial management practices to address financial constraints. This includes securing adequate funding early in the project cycle and establishing contingency funds to manage unforeseen financial challenges. Time management practices should be strengthened by setting realistic deadlines, allowing for adequate time buffers, and employing techniques such as critical path method (CPM) or project management software tools to track and adjust project timelines. For scope constraints, clear definitions and regular monitoring of the scope should be a priority to avoid scope creep, ensuring alignment with the project's objectives and stakeholders' expectations. Lastly, resource constraints can be addressed by optimizing the use of available resources through effective resource allocation, prioritizing critical tasks, and investing in staff training to improve the overall competency of project teams. Managers should also foster a collaborative environment that encourages problem-solving to overcome resource limitations.

Policymakers are urged to develop frameworks that encourage long-term investment in project management skills and infrastructure. Policies should promote the availability of financial support for projects, particularly in sectors where financial constraints are most severe, such as public infrastructure and development projects. Additionally, policies that incentivize the adoption of modern project management tools and techniques could help streamline project execution, reducing time and resource constraints. Governments should also establish regulations to encourage clear project scope definition and the management of scope changes to avoid costly delays. Furthermore, policies should focus on resource development, such as improving access to skilled labor and technical resources, through education and training programs tailored to the needs of the industry. By implementing these policies, organizations and governments can create an environment conducive to the successful implementation of projects, ensuring efficient use of resources and improved project outcomes.

**Suggestions for Further Studies**

Future research could explore the impact of external factors, such as political instability or economic downturns, on the implementation of projects, particularly in regions that face frequent changes in these conditions. While this study focused on internal constraints, understanding how external factors interact with the constraints identified (financial, time, scope, and resource) could provide a more comprehensive view of project management challenges. Additionally, a comparative study across different industries, such as construction, healthcare, and information technology, would shed light on whether certain constraints play a more significant role in specific sectors and how industry-specific strategies can be developed to mitigate these challenges.

Another area for further investigation is the influence of technological innovations on reducing constraints in project implementation. Research could focus on how the adoption of emerging technologies such as artificial intelligence, machine learning, and automation impacts the management of financial, time, scope, and resource constraints. Understanding how technology can streamline processes, improve resource allocation, and enhance decision-making could be beneficial for improving project outcomes across various sectors. Furthermore, exploring the relationship between organizational culture and the ability to overcome these constraints could offer valuable insights into how organizational behavior and leadership practices influence project success. These studies would provide a deeper understanding of the dynamics at play in project implementation and contribute to the development of more effective project management strategies.

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