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EFFECT OF PROJECT RESOURCE MANAGEMENT ON PERFORMANCE OF CONSTRUCTION PROJECTS IN RWANDA. A CASE OF RUBAGABAGA HYDROPOWER PLANT CONSTRUCTION PROJECT

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ABSTRACT

The aim of the study was to analyze the effect of project resource management on the performance of construction projects in Rwanda. The specific objectives were to analyze the project resource management during Rubagabaga hydropower plant construction, to assess the level of Performance of Rubagabaga hydropower plant project and to assess the relationship between project resource management and performance of Rubagabaga hydropower plant. The researcher used descriptive research design and the data was collected from a sample size of 150 respondents. Data was collected through the questionnaire and interview and analyzed using SPSS v21 through the mean, standard deviation and regression analysis to test the hypotheses of the study. Findings revealed mean scores ranging from 4.01 to 4.57, indicating high satisfaction levels with various aspects of resource management, such as human resource allocation, materials resource allocation, risk management, financial resource management, and technology and equipment management. However, some weaknesses were identified, including lower scores in certain dimensions of risk management (mean = 3.52) and variability in stakeholder satisfaction (mean = 4.28, SD = 0.48). Additionally, project performance metrics assessed demonstrated positive perceptions, with mean scores ranging from 4.14 to 4.57. These metrics included quality of work, budget adherence, stakeholder satisfaction, and adaptability to change. Lastly, the study revealed significant positive correlations between resource management variables and project performance indicators, with coefficients ranging from 64.3% to 88.6%. Overall, the Rubagabaga hydropower plant exhibited strengths in project resource management, contributing to positive project outcomes. However, areas for improvement were identified, particularly in risk management, financial resource allocation, and stakeholder satisfaction. The study underscores the importance of effective resource allocation strategies in driving project success. To enhance project resource management and performance, the following actions are recommended; enhance risk identification and mitigation strategies to minimize project uncertainties. Improve budget allocation processes and financial monitoring mechanisms to optimize resource utilization, streamline materials procurement and distribution processes to minimize delays and enhance resource efficiency and continuously monitor stakeholder feedback and adjust resource management strategies to meet stakeholder expectations.

Key Words: *Project, Resource, Management, Performance, Construction*

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INTRODUCTION

The construction industry is a critical driver of economic growth and development, particularly in emerging economies like Rwanda. Infrastructure projects, such as roads, bridges, and hydropower plants, are essential for fostering industrialization, improving connectivity, and enhancing the quality of life for citizens. As Rwanda continues its journey towards achieving its ambitious national development goals, including becoming a middle-income country by 2035, the importance of efficient management of resources in construction projects cannot be overstated. One such project that exemplifies the strategic importance of resource management is the Rubagabaga Hydropower Plant. The hydropower sector is pivotal to Rwanda's renewable energy targets, and the successful execution of projects like Rubagabaga is integral to meeting the nation's energy needs (RDB, 2023).

Project resource management involves the systematic allocation, optimization, and oversight of essential project inputs, including materials, human capital, financial resources, and time. In construction, the effective management of these resources directly influences the project's success in terms of quality, timely completion, and adherence to budget constraints (Turner, 2018). In large-scale infrastructure projects like the Rubagabaga Hydropower Plant, the complexity of operations increases the challenges of resource management, demanding a high level of coordination and strategic foresight. Mismanagement of resources, whether through poor planning, lack of material availability, or inefficient labor deployment, can lead to significant project delays, cost overruns, and reduced stakeholder confidence (Love, 2017).

Despite the critical role of resource management in project success, many construction projects, especially in developing countries, struggle with inefficiencies in managing resources. Rwanda, like many other developing nations, has experienced setbacks in infrastructure projects due to insufficient resource allocation and poor planning practices (Munyaneza, 2023). The Rubagabaga Hydropower Plant project, which was undertaken from 2020 to 2022, faced various challenges related to resource management, including delays in the delivery of materials, workforce shortages, and financial mismanagement, all of which impacted its overall performance (Smith, 2020). These challenges highlight the importance of investigating the link between effective resource management and construction project outcomes.

Moreover, the construction industry in Rwanda faces unique challenges related to resource availability, procurement processes, and regulatory frameworks, which further complicate project management (Karema, 2021). The Rubagabaga Hydropower Plant serves as a case study to understand how resource management practices can influence the success or failure of construction projects in Rwanda. Effective resource management not only ensures that the necessary materials and labor are available at the right time, but also plays a crucial role in mitigating risks associated with delays and budget overruns (Brown, 2019). By examining the Rubagabaga project, this study aims to shed light on the broader challenges of resource management in Rwandan construction projects and provide insights into strategies that can enhance project performance.

Thus, this research is designed to explore how the strategic management of resources—ranging from human capital to materials and finances—impacts the overall success of construction projects. The findings from this study will contribute to a deeper understanding of the importance of resource management in Rwanda's construction industry, with potential implications for policy-making and project execution in future infrastructure developments. Specifically, this study focuses on the Rubagabaga Hydropower Plant project as a case study to assess how resource management influences construction project performance.

LITERATURE REVIEW

In the construction industry, project performance is often measured by the ability to complete projects within the defined scope, time, and cost parameters. Achieving optimal project performance is heavily dependent on the effective management of various resources, including human resources, materials, finances, technology,

and equipment. The importance of project resource management cannot be overstated, as improper allocation or management of resources can lead to significant delays, cost overruns, and compromised project quality. According to Kerzner (2019), project resource management involves the process of planning, allocating, and controlling resources effectively to meet project objectives. This literature review explores the key aspects of project resource management, including human resource allocation, materials resource allocation, risk management, financial resource management, and technology and equipment management, and examines their impact on project performance.

Allocation of Human Resources

Human resources are one of the most critical components in the successful execution of any project. Proper allocation of human resources ensures that tasks are assigned to individuals with the necessary skills and experience, leading to increased efficiency and productivity. According to Hassan et al. (2020), well-managed human resources can reduce project delays and ensure timely completion. The authors argue that projects with effective human resource allocation have higher levels of team cohesion and collaboration, which are crucial for meeting project goals.

Human resource allocation also involves balancing the workload across team members to prevent burnout and inefficiency. Larson and Gray (2019) highlight that projects often fail when there is a mismatch between the skills of team members and the tasks they are assigned. A project manager must therefore identify the strengths and weaknesses of team members and ensure that resources are allocated in a way that maximizes output. Leadership also plays an important role in human resource allocation, as strong leadership can inspire team members to perform at their best (Turner, 2021). Properly allocated human resources not only improve project performance but also contribute to higher employee satisfaction and retention.

Materials Resource Allocation

Material resources, such as building materials, machinery, and supplies, are vital for the timely execution of construction projects. Efficient material resource allocation helps in preventing project delays and cost overruns. Koushki et al. (2019) note that material procurement delays are one of the major reasons for project timeline disruptions. The authors emphasize that construction projects that lack proper planning and timely material allocation often experience severe performance setbacks, including increased costs and compromised quality.

Effective materials management involves the use of inventory control systems that track material availability and forecast future needs. This ensures that materials are available when needed, reducing downtime and keeping the project on schedule (Olsson & Grafton, 2020). According to Bello and Mbamba (2022), material resource allocation also has a direct impact on the sustainability of the project. Projects that employ sustainable resource allocation practices—such as minimizing waste and recycling materials—are not only cost-effective but also align with global sustainability goals. The integration of technology, such as just-in-time inventory systems, has further enhanced material management, ensuring that projects have access to the right materials at the right time, which boosts overall performance.

Risk Management

Risk management is a fundamental component of project resource management, aimed at identifying potential risks, assessing their impact, and developing mitigation strategies. In the construction industry, risks can arise from various sources, including financial instability, material shortages, and workforce challenges. Ahmed et al. (2021) assert that proactive risk management improves project performance by allowing project teams to anticipate and prepare for potential disruptions. They found that construction projects with comprehensive risk management plans experienced fewer delays and were more likely to meet their performance goals.

One key aspect of risk management is resource allocation in response to emerging risks. According to Fang et al. (2022), risk management involves not only identifying risks but also reallocating resources, such as

personnel and materials, to mitigate the impact of these risks. For instance, if a construction project is facing delays due to inclement weather, reassigning human resources and material resources to other tasks can help keep the project on track. Effective risk management ensures that resources are used optimally, preventing wastage and improving overall project performance.

Financial Resource Management

Financial resource management plays a crucial role in determining the success of construction projects. Proper financial planning, budgeting, and cost control measures ensure that the project has adequate funds at each stage of development. Ika et al. (2019) argue that financial mismanagement is one of the leading causes of project failures. Projects that overrun their budgets often face delays, reduced quality, or even termination. Financial resource management involves accurate cost estimation, cash flow monitoring, and financial audits to ensure that project expenses are within the allocated budget.

Matipa et al. (2020) emphasize the importance of maintaining a steady cash flow to ensure that resources, such as labor and materials, are always available when needed. Projects that experience financial constraints often have to pause operations, leading to delays and increased costs. Additionally, effective financial resource management includes the implementation of cost-saving measures, such as negotiating better prices for materials or reducing unnecessary expenses. Financial discipline within a project ensures that resources are allocated efficiently, contributing to the project's overall performance (Chin & Anumba, 2021).

Technology and Equipment Management

The integration of technology and proper equipment management is essential for the successful completion of construction projects. The use of advanced technologies such as Building Information Modeling (BIM), drones, and automated machinery has significantly improved the efficiency and accuracy of construction projects (Alaloul et al., 2020). These technologies enable better project planning, real-time monitoring, and more precise resource allocation. Projects that leverage technology tend to experience fewer errors and delays, resulting in improved performance.

Equipment management is equally important in construction projects. According to Heravi et al. (2021), well-maintained and efficiently managed equipment can significantly reduce downtime and operational costs. Equipment failures often lead to costly project delays, as construction work cannot proceed without functioning machinery. Gunduz and Almuajebh (2022) argue that regular maintenance, timely equipment upgrades, and efficient equipment allocation are key factors in improving project performance. Projects that implement proactive equipment management practices tend to be completed on time and within budget.

Project Performance

Project performance is typically assessed by evaluating how well a project meets its scope, cost, and time objectives. Bryde et al. (2020) highlight that effective project resource management directly impacts key performance indicators such as project quality, stakeholder satisfaction, and return on investment. Projects that successfully manage their resources are more likely to achieve their goals and deliver value to stakeholders. Kerzner (2019) adds that resource management is not only about the allocation of tangible resources but also involves the management of intangible factors such as communication, stakeholder engagement, and project leadership. These factors, combined with efficient resource management, lead to enhanced project performance.

Effective project resource management—encompassing human, material, financial, technological, and risk management—plays a critical role in the success of construction projects. Proper allocation and management of these resources lead to improved project performance, ensuring that projects are completed on time, within budget, and according to specified quality standards. Research shows that resource management practices directly influence the efficiency, sustainability, and overall outcomes of construction projects. Therefore, project managers must focus on optimizing resource management to ensure the success of their projects.

METHODOLOGY

Research design

The research design for this study is a mixed-methods approach, combining both quantitative and qualitative methods. This approach allows for a comprehensive understanding of project resource management and its influence on project performance. The quantitative data provided statistical analysis of stakeholder perceptions and project success indicators, while the qualitative data offered in-depth insights into stakeholders & experiences and perspectives. Stringer, (2021)

Data collection and analysis

To investigate the project resource management, case of Rubagabaga hydropower plant, a structured questionnaire was distributed to 112 respondents were the stakeholders during the construction of the plnt. The questionnaire comprised both closed and open-ended questions, aiming to gather quantitative and qualitative data.

Respondents were categorized based on their roles, and the questionnaire, designed with clarity, sought to explore the effect of project resource management and performance of Rubagabaga hydropower plant construction. Participants were assured of the confidentiality of their responses to encourage honesty. Data analysis involved statistical techniques for closed-ended questions and thematic analysis for open-ended responses. The systematic application of the questionnaire across various department in I&M Bank Plc ensured a comprehensive understanding of the specific effect of resource management on project performance.

In this study, Statistical Package for the Social Sciences (SPSS) was used by researcher in processing and analysis, of data which informed the presentation of findings, analysis and interpretation. The presentation focused on the research questions. Quantitative data analysis was used to analyze numerical data, this data results was presented in form of tables and graphs to enhance its proper understanding. Data obtained from close-ended responses was analyzed using the SPSS (Statistical package social scientist) computer package.

A progression from basic linear regression is multiple regression. When a researcher wishes to make a prediction about the value of a particular variable based on the values of two or more other variables, they use this technique. The dependent variable is the one that needs to be predicted (or sometimes, the outcome, target or criterion variable). The expected results or a priori expectation regarding the econometric models that have been constructed, it is expected that all independent sub variables had significant effect on each dependent variable. This kind of effect is to positively check for each econometric model.

X = Project resource management

Y = Construction p management

$Y = f(x)$

Where,

X = (X1= Loan diversification, X2=Credit risk management, X3=Loan monitoring and reporting, X4=Loan loss provision, X5=Collection and Recovery, X6=Diversifications Strategy)

Therefore, the model used in the study took the form below :

$$Y= \alpha+\beta_1X_1+ \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 +ę$$

RESULTS

A study was conducted using multiple linear regression analysis to determine how the independent variables an assessment worker The investigator utilized multiple linear regressions with a 95% confidence interval to determine the correlation between the independent and dependent variables. According to the summary of the model, the coefficient of determination (R squared) functions as a comprehensive indicator of the intensity of the connection between the independent and dependent variables.

Table 1: Model Summary

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.899[a]	.808	.799	3.05218	.808	9300.026	5	106	.000

a. Predictors: (Constant), Allocation of human resource, materials resource allocation, risk management**,** financial resource management, technology and equipment management**.**

The model summary presented in Table 1 provides an overview of the regression model's performance in predicting the project performance of the Rubagabaga hydropower plant based on various project resource management variables. The coefficient of determination (R-squared) indicates that approximately 99.8% of the variability in project performance can be explained by the predictors included in the model. This high R-squared value suggests that the regression model effectively captures the relationship between the predictor variables (i.e., allocation of human resource, materials resource allocation, risk management, financial resource management, technology and equipment management) and project performance.

Furthermore, the adjusted R-squared value (99.8%) accounts for the number of predictors and adjusts the R-squared value accordingly, providing a more accurate reflection of the model's explanatory power. The adjusted R-squared value indicates that the inclusion of the predictor variables significantly contributes to the model's predictive ability while considering the complexity of the model.

The standard error of the estimate (3.05218) represents the average deviation of the observed values from the predicted values by the regression model. A lower standard error indicates a better fit of the model to the data, suggesting that the model provides relatively accurate predictions of project performance based on the selected predictor variables.

The change statistics highlight the impact of adding the predictor variables to the model. The R-squared change statistic (0.998) indicates the increase in the coefficient of determination when the predictor variables are included in the model. Additionally, the F-change statistic (9300.026) and its associated p-value (0.000) indicate that the overall regression model is statistically significant, suggesting that the predictor variables collectively have a significant effect on project performance.

In summary, the regression model demonstrates a strong predictive ability for project performance based on project resource management variables, including allocation of human resource, materials resource allocation, risk management, financial resource management, and technology and equipment management. These findings underscore the importance of effective resource management practices in driving project success at the Rubagabaga hydropower plant in Rwanda.

Table 2: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	433186.314	5	86637.2628	9.300	.000[a]
	Residual	1875.686	106	17.695		
	Total	435062.000	111			

a. Predictors: (Constant), a. Predictors: (Constant), Allocation of human resource, materials resource allocation, risk management**,** financial resource management, technology and equipment management
b. Dependent Variable: Rubagabaga project performance

Table 2 presents the analysis of variance (ANOVA) results for the regression model predicting project performance of the Rubagabaga hydropower plant. The regression component accounts for the variability in project performance explained by the predictor variables, including allocation of human resource, materials resource allocation, risk management, financial resource management, and technology and equipment management. The sum of squares for regression is 433186.314, representing 99.6% of the total variability in project performance. This indicates that the predictor variables collectively explain 99.6% of the variation in project performance.

Meanwhile, the residual component captures the unexplained variability in project performance not accounted for by the predictor variables. The sum of squares for the residual is 1875.686, representing 0.4% of the total variability in project performance. This suggests that there is a small amount of variability in project performance that is not explained by the predictor variables.

The significant F-value of 9.300 ($p < 0.001$) indicates that the regression model as a whole provides a good fit to the data and significantly predicts project performance based on the selected predictor variables. This underscores the importance of comprehensive resource management strategies, including human resource allocation, materials resource allocation, risk management, financial resource management, and technology and equipment management, in influencing project outcomes at the Rubagabaga hydropower plant in Rwanda.

Table 3: Regression coefficients

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.
(Constant)	4.701	1.531		3.070	.003
Allocation of human resource	.539	.311	.050	1.734	.086
Materials resource allocation	.503	.355	.046	1.416	.160
Risk management	1.514	.482	.155	3.139	.002
Financial resource management	2.313	.371	.225	6.228	.000
Technology and equipment management	1.001	.006	.782	162.422	.000

a. Dependent Variable: Construction project performance

Table 3 presents the results of hypotheses testing for the relationship between project resource management and the performance of the Rubagabaga hydropower plant. The regression coefficients indicate the strength and direction of the relationship between each predictor variable (allocation of human resource, materials resource allocation, risk management, financial resource management, and technology and equipment management) and project performance.

The unstandardized coefficients (B) represent the change in the dependent variable (project performance) for a one-unit change in the predictor variable, holding all other variables constant. The standardized coefficients (Beta) provide a measure of the relative importance of each predictor variable in explaining the variance in the dependent variable.

The results show that risk management (Beta = 0.155, p = 0.002), financial resource management (Beta = 0.225, p < 0.001), and technology and equipment management (Beta = 0.782, p < 0.001) have significant positive relationships with project performance. This implies that effective risk mitigation, prudent financial planning, and advanced technological solutions positively influence the performance of the Rubagabaga hydropower plant.

However, the allocation of human resource (Beta = 0.050, p = 0.086) and materials resource allocation (Beta = 0.046, p = 0.160) show weaker, non-significant relationships with project performance. While these variables may still have some impact on project outcomes, their effects are not statistically significant in this analysis.

Overall, these findings support the rejection of the null hypothesis (H01) and the acceptance of the alternative hypothesis (H02), indicating a significant relationship between project resource management and the performance of the Rubagabaga hydropower plant. These results emphasize the importance of effective resource management strategies in optimizing project performance and achieving successful project outcomes.

Discussion

The discussion of findings begins by revisiting the core topic and specific objectives of the study. Focused on understanding the impact of project resource management on construction project performance in Rwanda, particularly examining the Rubagabaga hydropower plant, the study's objectives centered on assessing resource allocation and gauging its influence on project performance, stakeholder satisfaction, and adaptability to change. Through an in-depth analysis of various tables presenting survey data, key insights emerge regarding the perceived effectiveness of resource allocation strategies and their implications for project outcomes. These findings are further discussed in relation to previous research, underscoring the significance of effective resource management practices in driving project success and stakeholder satisfaction.

However, the correlations and regression analyses presented in Tables 2 and 3 reveal some nuances in the relationship between resource management variables and project performance. While risk management, financial resource management, and technology and equipment management demonstrate significant positive correlations and regression coefficients with project performance, the relationships for human resource allocation and materials resource allocation are weaker and non-significant. These findings suggest that while certain aspects of resource management have a pronounced impact on project performance, others may require further attention or refinement to achieve optimal outcomes.

These implications align with previous studies in the field. For instance, the significant positive relationship between risk management and project performance is consistent with findings from Smith et al. (2018), emphasizing the importance of proactive risk mitigation strategies in enhancing project success. Similarly, the importance of financial resource management in driving project performance echoes the conclusions drawn by Liu et al. (2020), highlighting the critical role of prudent financial planning and budgetary control measures in achieving favorable project outcomes.

Moreover, the findings regarding technology and equipment management align with the insights provided by Hwang et al. (2019), emphasizing the transformative impact of technology adoption on project efficiency and effectiveness. However, the weaker relationships observed for human resource allocation and materials resource allocation variables suggest areas for further investigation and improvement, resonating with the need for ongoing research and refinement of resource management practices in construction projects.

In summary, the implications drawn from the study's findings underscore the importance of effective resource management strategies, particularly in risk management, financial resource management, and technology and equipment management, in driving the performance of construction projects such as the Rubagabaga hydropower plant. These implications contribute to the existing body of knowledge in the field and provide valuable insights for project managers and stakeholders seeking to optimize resource allocation practices and enhance project success.

CONCLUSION AND RECOMMENDATIONS

In In conclusion, this research investigated the effect of project resource management on the performance of the Rubagabaga hydropower plant in Rwanda. Through an analysis of project resource management practices, project performance indicators, and their relationship, several key findings emerged. Firstly, the Rubagabaga project demonstrated effective resource management across various domains, including human resource allocation, materials resource allocation, risk management, financial resource management, and technology and equipment management. These findings suggest a robust framework for resource allocation and utilization within the project. Secondly, the assessment of project performance revealed favorable outcomes, with high ratings in quality of work, budget adherence, stakeholder satisfaction, and adaptability to change. These findings reflect the project's ability to meet performance objectives and stakeholders' expectations. Lastly, the analysis of the relationship between project resource management and performance highlighted significant positive correlations between resource management variables and project performance metrics. The strong associations observed underscore the importance of effective resource management in driving project success. Overall, this study contributes to the understanding of how project resource management practices impact the performance of construction projects, providing valuable insights for project managers and stakeholders involved in similar endeavors.

This study makes several contributions to the academic field of project management and construction engineering. Firstly, it adds to the existing body of literature by providing empirical evidence of the relationship between project resource management and project performance, specifically in the context of construction projects such as the Rubagabaga hydropower plant. By examining various dimensions of resource management and their impact on project outcomes, this research contributes valuable insights into the factors that drive success in construction projects.

Secondly, the study offers practical implications for project managers and stakeholders involved in construction projects. By identifying the critical aspects of resource management that significantly influence project performance, such as human resource allocation, materials management, risk mitigation, financial planning, and technology utilization, the findings provide actionable recommendations for enhancing project success. Project managers can leverage these insights to optimize resource allocation strategies, mitigate risks, and improve overall project management practices.

Furthermore, the study contributes to the development of methodologies for assessing and evaluating project performance in construction projects. By examining key performance indicators such as quality of work, budget adherence, stakeholder satisfaction, and adaptability to change, the research provides a comprehensive framework for evaluating project success. This framework can be used by researchers and practitioners alike to assess the effectiveness of resource management practices and identify areas for improvement in future projects.

Overall, this study advances our understanding of the complex interplay between project resource management and project performance in construction projects, offering both theoretical insights and practical implications for project management practice. By elucidating the factors that contribute to project success, the research contributes to the ongoing discourse on effective project management strategies and lays the groundwork for future research in this area.

Based on the weaker means identified in the study, several recommendations can be proposed to enhance project resource management and improve project performance at the Rubagabaga hydropower plant and similar construction projects:

Inadequate Risk Management: The moderate satisfaction levels reported, particularly regarding the effectiveness of mitigation plans, indicate room for improvement in risk identification and mitigation strategies. To address this weakness, project managers should prioritize comprehensive risk assessments to identify potential threats and vulnerabilities. They should then develop proactive mitigation strategies and contingency plans to address identified risks effectively. Actionable steps include conducting regular risk assessments, involving relevant stakeholders in risk identification processes, and allocating resources for risk mitigation measures.

Limited Financial Resource Management: While overall satisfaction with financial resource management was relatively high, it is suggested some variability in perceptions, indicating potential inconsistencies or inefficiencies in budget allocation and financial monitoring. To improve financial resource management, project managers should implement robust financial tracking systems to monitor project expenditures and ensure adherence to budgetary constraints. They should conduct regular audits to identify discrepancies and take corrective actions promptly. Additionally, fostering transparency and accountability in financial decision-making processes through clear communication channels and stakeholder engagement can enhance financial resource management practices.

Suboptimal Technology and Equipment Management: Despite the relatively high mean score for technology and equipment management, suggests some level of inconsistency in perceptions. To address this weakness, project managers should explore opportunities to integrate advanced technologies, such as construction management software and Internet of Things (IoT) devices, to streamline project workflows and improve efficiency. Providing training to personnel to enhance their technological proficiency is essential. Additionally, regular maintenance schedules and investment in upgrading outdated equipment can contribute to more effective technology and equipment management practices.

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