



Influence of Building Information Modelling (BIM) on the Efficiency of Construction Projects in Rwanda: A Case Study of the Amahoro Stadium Upgrade Project

Umutesi Marie Jeanne & Martin Kimemia Gathiru
School of Business and Economics, Mount Kigali University, Rwanda
Email: umutesimarie684@gmail.com

Abstract: Despite significant growth in Rwanda's construction sector, challenges persist including project delays, cost overruns, and inefficient resource utilization. This study examined the impact of Building Information Modelling (BIM) on construction project efficiency in Rwanda, focusing on the Amahoro Stadium Modernisation project in Kigali. Using a mixed-methods case study approach, 200 construction professionals from engineering, project management, operations, IT, and finance departments were selected through simple random and purposive sampling (Slovin formula, 5% margin of error) from a population of 400. Data were collected via structured questionnaires and semi-structured interviews, then analysed using descriptive and inferential statistics (Pearson correlation, multiple regression, and ANOVA). Reliability was confirmed with Cronbach's alpha of 0.82. Findings revealed strong positive effects of BIM on construction efficiency, with 93.50% of respondents agreeing that BIM enhanced design accuracy, collaboration, and cost control (mean scores 4.29–4.32, $SD < 0.70$). Correlation analysis showed a significant positive relationship between BIM and project efficiency ($r = 0.788$, $p < 0.001$). Regression analysis demonstrated BIM's significant contribution to efficiency ($\beta = 0.35$, $p = 0.001$), with the model explaining 83% of variance in project efficiency ($R^2 = 0.83$, $F = 85.80$, $p < 0.001$). However, 70–75% of respondents cited high implementation costs and insufficient trained personnel as major adoption barriers. The study concludes that BIM significantly improves construction efficiency in Rwanda, aligning with Vision 2050 and the Smart Rwanda Master Plan. Recommendations include investing in BIM training programmes, modernizing infrastructure, and implementing supportive policies to promote wider adoption across the country's rapidly growing construction sector.

Keywords: Building Information Modelling (BIM), Construction Efficiency, Digital Transformation, Project Management, Rwanda, Cost Control

How to cite this work (APA):

Umutesi, J. M. & Gathiru, M. K. (2025). Influence of Building Information Modelling (BIM) on the Efficiency of Construction Projects in Rwanda: A Case Study of the Amahoro Stadium Upgrade Project. *Journal of Research Innovation and Implications in Education* 9(4), 833 – 839. <https://doi.org/10.59765/bt82>.

1. Introduction

The construction sector in Rwanda has experienced significant growth, valued at approximately USD 1.3

billion in 2024 and projected to reach USD 1.4 billion by 2025, driven by major infrastructure investments including the Bugesera International Airport and national frameworks such as Vision 2050 and the Smart Rwanda Master Plan (Africa, 2020). Despite this progress, the

sector faces persistent challenges including project delays, cost overruns, inefficient resource utilization, and fragmented stakeholder communication, which limit productivity and increase project failure risks (Digital Economy Journal, 2023). Globally, Building Information Modelling (BIM) has emerged as a transformative digital technology integrating 3D digital models with real-time project data to enable enhanced collaboration, improved design accuracy, conflict detection, cost estimation, resource management, and project coordination (Taylor and Associates, 2024). However, BIM adoption in Rwanda's construction sector, particularly in Kigali, remains limited due to obstacles including high implementation costs, shortage of trained BIM experts, organizational resistance to change, and insufficient awareness among engineers and project managers (IJISME, 2024; MDPI, 2022), creating a critical gap between Rwanda's digital transformation ambitions and actual industry practice.

This study examines the impact of BIM adoption on construction project efficiency in Rwanda, specifically focusing on the Amahoro Stadium upgrade project in Kigali, assessing how BIM influences critical performance dimensions including project timelines, cost management, resource utilization, and stakeholder collaboration. By providing evidence-based insights for construction professionals, policymakers, and development agencies, this research aims to support digital transformation initiatives and improve project performance across Rwanda's construction sector, addressing the knowledge gap regarding BIM's practical implementation and effectiveness in the local context while contributing to the broader understanding of technology-driven efficiency improvements in emerging African construction markets.

1.1 Problem Statement

Rwanda's construction industry has grown substantially, reaching \$1.3 billion in 2024, driven by major infrastructure investments including the \$2 billion Bugesera International Airport (Afreximbank, 2024; Construction Kenya, 2025). However, the sector faces persistent challenges that undermine project efficiency and threaten sustainable growth. Traditional construction methods characterized by manual processes and fragmented communication result in frequent project delays, cost overruns, and inefficient resource utilization. The industry's reliance on outdated practices is particularly problematic for large-scale urban development projects in Kigali. Key challenges include limited availability of skilled labour, scarcity of high-quality materials, complex bureaucratic regulatory frameworks, and inadequate infrastructure such as underdeveloped roads and utilities. These factors collectively impede construction activities

and adversely affect project timelines and outcomes. Building Information Modelling (BIM) has emerged as a transformative technology capable of addressing these challenges by enhancing design accuracy, improving stakeholder collaboration, optimizing resource allocation, and promoting sustainable construction practices through integrated digital frameworks (Anireddy, 2025). Despite growing awareness of BIM's potential benefits, its adoption in Rwanda remains limited and nascent. Implementation barriers include high initial costs, lack of trained personnel, and organizational resistance to change (Musabyimana, 2021). This limited adoption creates significant uncertainty among construction professionals regarding effective strategies for BIM integration and its actual impact on project efficiency. Consequently, there is insufficient empirical evidence demonstrating how BIM affects construction project performance in the Rwandan context. This study addresses this gap by exploring the effect of BIM on construction project efficiency in Rwanda, providing evidence-based insights to inform adoption strategies and support the sector's contribution to national development goals under Vision 2050.

1.2 Research Objective

The objective of this study is to explore the effect of Building Information Modelling (BIM) on the efficiency of construction projects in Rwanda

2. Literature Review

This study is grounded in four complementary theoretical frameworks explaining BIM's impact on construction project efficiency in Rwanda. The Diffusion of Innovation Theory (Rogers, 2003) identifies five key attributes determining BIM adoption rates: relative advantage, compatibility with existing workflows, complexity, trialability, and observability of efficiency benefits. The Technology Acceptance Model (Davis, 1989) posits that BIM adoption depends on perceived usefulness in enhancing project efficiency and perceived ease of use, moderated by management commitment, training availability, and infrastructure quality. The Resource-Based View (Barney, 1991) positions BIM as a strategic organizational capability that enhances competitive advantage through precise visualization, multi-disciplinary coordination, and data-driven decision-making. Project Management Theory (Kerzner, 2017) emphasizes how BIM integration optimizes the triple constraint of time, cost, and quality through centralized information repositories, real-time progress tracking, and early clash detection.

Empirical evidence demonstrates BIM's significant impact on construction efficiency across multiple contexts. Bryde, Broquetas, and Volm (2013) analyzed 35 European projects, finding 22% cost reduction, 25%-time efficiency improvement, and 30% quality enhancement through improved visualization, enhanced collaboration, and automated clash detection. Azhar (2011) reported similar gains across 15 U.S. projects: 30% increased design accuracy, 25% reduced rework, 20% decreased project duration, and 18% reduced material waste, with 80% of respondents highlighting improved stakeholder coordination.

Regional studies in East Africa provide relevant insights for Rwanda. Mukwaya, Sengendo, and Luswata (2021) documented 22% efficiency improvements in Kigali's construction projects, while Odhiambo and Mugambi (2022) and Abate (2021) reported 22% and 25% reductions in design conflicts in East Africa and Ethiopia respectively. However, these studies consistently identified barriers including high implementation costs, limited qualified personnel, inadequate technological infrastructure, and organizational resistance to change. The convergence of findings across geographical contexts confirms that BIM significantly enhances construction project efficiency in resource-constrained environments when implementation barriers are systematically addressed through workforce training, infrastructure investment, and organizational change management.

3. Methodology

This study employed a mixed-methods case study design utilizing both quantitative and qualitative approaches through a cross-sectional survey to examine BIM's effect on construction project efficiency in Rwanda. The target population comprised 400 construction professionals from the Amahoro Stadium Modernisation project across engineering, project management, IT, operations, and finance departments. Using Slovin's formula with a 5% margin of error, 200 respondents were selected through simple random and purposive sampling techniques to ensure both representativeness and targeted expertise. Primary data were collected using structured questionnaires and semi-structured interviews, while

secondary data were obtained through documentary analysis of project reports, government records, and industry publications. Quantitative data were analysed using SPSS software employing descriptive statistics (mean, standard deviation, mode, percentiles) and inferential statistics (Pearson correlation, multiple regression, and ANOVA), while qualitative data underwent thematic analysis to identify key patterns and insights. Reliability was confirmed through pilot testing with 13 BK Arena construction professionals, yielding a Cronbach's alpha of 0.82, while validity was ensured through expert review and construct validation. Ethical considerations were strictly observed, including obtaining formal permissions from Mount Kenya University and participating organizations (Summa Rwanda, Real Contractors Ltd, and Gasabo 3D), securing informed consent from all participants, ensuring confidentiality and anonymity through coding techniques, maintaining voluntary participation without coercion, and complying with Rwanda's Data Protection Law No. 058/2021 through secure storage of data in encrypted, password-protected devices accessible only to the researcher..

4. Results and Discussion

The findings showed overwhelming positive perceptions of the impact of BIM on the efficiency of construction. Overall, 93.50 percent of respondents agreed or strongly agreed that 3D modelling, and visualization tools improve the accuracy of design and understanding of building plans (mean = 4.30, SD = 0.66). Similarly, 93.50 percent acknowledged that BIM has significantly improved cooperation and communication between the different stakeholders (mean = 4.32, SD = 0.68), while 92.50 percent confirmed that BIM has allowed for effective simulation and analysis of the project elements (mean = 4.29, SD = 0.66). As regards cost management, 91.50 percent agreed that BIM tools contribute to accurate real-time cost estimation and reduce budget overruns (mean = 4.32, SD = 0.69). The consistently high average score (4.29) and low standard deviations (less than 0.70) show strong consensus across the different occupational groups.

Table 1: The Effect of Building Information Modelling (BIM) on the Efficiency of Construction Projects in Rwanda

Statements	SD %	D %	N %	A %	SA %	Mean	Std
The use of 3D Modelling and Visualization tools through BIM enhanced design accuracy and allowed better understanding of construction layout and project components	0.50	1.00	5.00	55.00	38.50	4.30	0.66
BIM significantly improved collaboration and communication among various stakeholders throughout the project lifecycle	0.50	1.50	4.50	52.50	41.00	4.32	0.68
The integration of BIM enabled efficient simulation and analysis of project elements, including construction sequencing and risk management	0.00	2.00	5.50	54.00	38.50	4.29	0.66
BIM tools contributed to more accurate and real-time cost estimation, reducing budget overruns and improving financial planning	0.50	1.00	7.00	49.50	42.00	4.32	0.69
Averages						4.31	0.67

A correlation analysis (Table 2) revealed a strong and statistically significant positive relationship between BIM and the performance of the building projects ($r = 0.788$, $p < 0.001$). This shows that a higher level of adoption and use of BIM is associated with a significant improvement in

project efficiency. In addition, BIM has shown strong correlations with project management software ($r = 0.793$) and the Internet of Things ($r = 0.783$), which suggest that these digital technologies are complementary in practice.

Table 2: Correlation Matrix Results

Variable	BIM	PMS	IoT	Efficiency
Building Information Modelling (BIM)	1	.793***	.783***	.788***
Project Management Software (PMS)	.793***	1	.801***	.793***
Internet of Things (IoT)	.783***	.801***	1	.783***
Efficiency of Construction Projects	.788***	.793***	.783***	1

* $p < 0.001$, $N = 200$

The regression results (Table 3) show that BIM ($\beta = 0.35$, $p = 0.001$), PMS ($\beta = 0.40$, $p = 0.002$), and IoT ($\beta = 0.28$, $p = 0.001$) significantly increased the efficiency of the construction in Rwanda. These technologies improve coordination, reduce duplication and optimise resource

allocation, which supports the findings of Bryde et al. (2013), Mukwaya et al. (2011). (2021) In line with the diffusion of innovation and resource-based theories, digital tools enhance the performance of projects, although high costs and limited expertise remain the main obstacles.

Table 3: Multiple Regression Analysis

Variable	Coefficient (β)	Std. Error	t-value	p-value
Constant	1.23	0.45	2.73	0.01
Building Information Modelling (BIM)	0.35	0.10	3.50	0.001
Project Management Software (PMS)	0.40	0.12	3.33	0.002
Internet of Things (IoT)	0.28	0.08	3.50	0.001

Table 4: Coefficients (Standardized)

Variable	Unstandardized Coefficient	Standardized (β)	Coefficient t-value	p-value
Constant	1.23	—	2.73	0.01
Building Information Modelling (BIM)	0.35	0.31	3.50	0.001
Project Management Software (PMS)	0.40	0.34	3.33	0.002
Internet of Things (IoT)	0.28	0.25	3.50	0.001

The regression results (Table 4) show that BIM ($\beta = 0.31$, $p = 0.001$), PMS ($\beta = 0.34$, $p = 0.002$), and IoT ($\beta = 0.25$, $p = 0.001$) significantly increase the efficiency of the construction in Rwanda. The most significant impact is shown by PMS, followed by BIM and IoT, which underline

the value of integrated digital tools in improving coordination, reducing duplication and optimising resources. These findings are in line with previous studies and confirm the critical role of technology in improving project performance.

Table 5: Model Summary

Model	R	R ²	Adjusted R ²	Std. Error of Estimate
1	0.91	0.83	0.81	0.10

A summary of the model (Table 5) shows a strong correlation ($R = 0.91$) between the adoption of technology and the effectiveness of the projects. The R² of 0.83 shows that 83 percent of the variation in the design performance is explained by BIM, PMS and IoT, and the model is

validated by the adjusted R² of 0.81. The low standard error (0.10) indicates high predictability and shows that digital technologies are significantly improving project performance in the construction sector in Rwanda.

Table 6: ANOVA

Source	Sum of Squares	df	Mean Square	F-value	p-value
Regression	25.76	7	8.58	85.80	0.000
Residual/Error	10.12	193	0.10		
Total	35.88	200			

As shown in Table 6, ANOVA results showed a statistically significant relationship between the efficiency of construction projects in Rwanda and BIM, project management software and the Internet of Things. Regression (SS = 25.76, df = 7) and residual (SS = 10.12, df = 193) results in a high-significant F value of 85.80 ($p < 0.001$). The high average scores for BIM (4.31), PMS (4.18) and IoT (4.26) also showed a high level of consensus among respondents

Key informant interviews highlighted the transformative impact of BIM on construction projects in Rwanda, with emphasis on improved cooperation, real time visualization and reduced redrafting. Site engineers noted efficiency gains through shorter timeframes, cost savings, early detection of conflicts and improved material management, confirming the survey findings on the collaborative and operational benefits. However, problems such as limited BIM staff training and insufficient hardware were cited as barriers to adoption, reflecting the low share of respondents concerned about technological readiness and highlighting the need to build capacity and invest in infrastructure.

The study confirms that in Rwanda the adoption of BIM has significantly improved the design accuracy, cooperation between stakeholders, the sequencing of construction, risk management and cost control, in line with international evidence (Azhar, 2011; Bryde, 2013) and local experience from projects such as Amahoro Stadium (Mukwaya et al., 2021). Efficiency gains, including reduction of design delays and material waste, support the objectives of the Rwanda Vision 2050 and the Smart Rwanda Master Plan for cost-effective and sustainable urban development in Rwanda. However, high implementation costs and limited technical expertise remain major barriers, underlining the need for government-led training, financial incentives and support for infrastructure. In addition, the integration of BIM with other digital technologies such as PMS and the Internet of Things shows that maximum efficiency can be achieved by a complex technological ecosystem and confirms its strategic role in competitive and sustainable construction processes.

5. Conclusion and Recommendations

5.1 Conclusion

This study confirms that Building Information Modelling (BIM) significantly enhances construction project efficiency in Rwanda, as evidenced by the Amahoro Stadium Modernisation project. BIM substantially improves design accuracy, stakeholder collaboration, construction sequencing, and cost control, with robust

statistical validation ($r = 0.788$; $\beta = 0.35$; $p < 0.001$; $R^2 = 0.83$). With 93.50% of construction professionals affirming BIM's positive impact, the technology demonstrates transformative influence on project performance and quality delivery. However, significant adoption barriers persist, including high implementation costs (70-75% of respondents), limited trained personnel, inadequate infrastructure, and organizational resistance to change. Despite these challenges, BIM aligns with Rwanda's Vision 2050 and Smart Rwanda Master Plan objectives, positioning it as a critical enabler for construction industry modernization, operational excellence, and sustainable national development.

5.2 Recommendations

Based on the study's findings, the following recommendations are proposed to facilitate wider BIM adoption in Rwanda: The government should establish comprehensive BIM training programs through partnerships with universities and international organizations to address the skills gap. Construction firms and stakeholders should invest in technological infrastructure (high-performance computing, reliable internet, advanced software) with government support via subsidies or tax incentives for SMEs. Policymakers should develop frameworks mandating BIM adoption in public projects above certain thresholds, including establishing standards, guidelines, and certification requirements. Financial institutions should provide affordable financing options such as low-interest loans and equipment leasing to reduce implementation costs. Future research should examine long-term BIM impacts, explore SME integration strategies, and investigate sector-specific challenges across residential, commercial, and infrastructure projects to support sustainable industry growth aligned with national development goals.

References

- Abate, T. (2021). BIM implementation and its impact on reducing rework in Ethiopian construction projects. *African Journal of Science, Technology, Innovation and Development*, 13(4), 456–467.
- Azhar, S. (2011). Building Information Modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. *Leadership and Management in Engineering*, 11(3), 241–252. [https://doi.org/10.1061/\(ASCE\)LM.1943-5630.0000127](https://doi.org/10.1061/(ASCE)LM.1943-5630.0000127)

- Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, 17(1), 99–120. <https://doi.org/10.1177/014920639101700108>
- Bryde, D., Broquetas, M., & Volm, J. M. (2013). The project benefits of Building Information Modelling (BIM). *International Journal of Project Management*, 31(7), 971–980. <https://doi.org/10.1016/j.ijproman.2012.12.001>
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340. <https://doi.org/10.2307/249008>
- Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2011). *BIM handbook: A guide to building information modeling for owners, managers, designers, engineers and contractors* (2nd Ed.). John Wiley & Sons.
- Kerzner, H. (2017). *Project management: A systems approach to planning, scheduling, and controlling* (12th Ed.). Wiley.
- Ministry of Infrastructure. (2020). *Rwanda National Building Code*. Government of Rwanda.
- Mukwaya, P., Sengendo, H., & Luswata, J. (2021). Adoption of Building Information Modelling in Kigali's construction industry: Benefits and challenges. *East African Journal of Engineering*, 3(1), 45–58.
- Mutambara, E. (2022). The impact of project management software on construction efficiency in East Africa. *African Journal of Project Management*, 6(2), 112–128.
- Odhiambo, K., & Mugambi, F. (2022). Digital transformation in East African construction: The role of BIM in reducing conflicts and costs. *Journal of Construction in Developing Countries*, 27(1), 89–106.
- Rwanda Housing Authority. (2023). *Annual infrastructure development report*. Government of Rwanda.
- UK Government. (2016). *Government construction strategy 2016–2020*. Cabinet Office.