



Total Quality Management Practices and Performance of Construction Projects in Rwanda: A Case of ECOMECO Ltd

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Abstract: Rwanda's construction sector continues to face recurring quality deficiencies, schedule delays, and cost overruns, linked to inconsistent adoption of Total Quality Management (TQM) practices. This study examined the influence of quality planning, quality assurance, quality control, and quality improvement on overall project performance at ECOMECO Ltd, focusing on quality, scope, cost, time, and client satisfaction. A quantitative research design was employed, using a Likert-scale questionnaire administered to 109 stratified respondents, of whom 106 provided responses, representing a 97.2% response rate. The instrument demonstrated high content validity (CVI = 0.937) and good reliability (Cronbach's α = 0.826). Data were analyzed using SPSS version 25.0 through descriptive statistics, normality testing, Pearson correlation, multiple regression, and ANOVA. Findings showed that quality assurance (mean = 4.83) and quality improvement (mean = 4.41) very strong, while quality planning (mean = 3.64) and control (mean = 3.76) were generally high but lacked formal plans. Project performance was strong in scope compliance but weak in budget and schedule adherence. TQM practices predicted project performance ($R = 0.818$, $R^2 = 0.669$, $F = 50.974$, $p < 0.001$). Quality planning had the strongest effect ($\beta = 0.482$), followed by quality control ($\beta = 0.385$) and quality assurance ($\beta = 0.192$), while quality improvement showed a negative effect ($\beta = -0.165$). The study concludes that planning and control are pivotal and recommends formalizing TQM frameworks, institutionalizing audits, adopting improvement cycles, and integrating quality management with cost and schedule controls.

Keywords: Quality planning, Quality assurance, Quality control, Quality improvement, Project performance.

How to cite this work (APA):

Mutijima, J. & Mburamatare, D. (2026). Total Quality Management Practices and Performance of Construction Projects in Rwanda: A Case of ECOMECO Ltd. *Journal of Research Innovation and Implications in Education*, 10(3), 1890 – 1903. <https://doi.org/10.59765/lcw8t5>

1. Introduction

Globally, Total Quality Management (TQM) and formal quality management systems have become central to improving construction project outcomes by integrating quality planning, assurance, control, and continuous improvement into the project lifecycle (ASQ, 2023). Quality planning establishes measurable standards and customer requirements before construction begins; quality assurance embeds systematic processes and management commitment to prevent defects; quality control provides the on-site checks and verification needed to confirm compliance; and quality improvement closes the loop by using feedback and lessons learned to raise future performance. Recent international reviews show that when TQM principles are implemented holistically, construction projects report better schedule performance, lower defect rates, and higher client satisfaction (Alawag et al., 2024).

In the African context, adoption of TQM and formal quality management tools in construction is growing but remains uneven across countries and sectors (Okonta, 2024). Structured quality assurance and quality control practices, such as documented procedures and third-party inspections, are strongly associated with improved cost control and reduced rework, though outcomes depend on top-management ownership and adequate resourcing (Mlimi, 2024). Within East Africa, robust quality planning and proactive quality assurance reduce delays and defects, although project teams often struggle with on-site quality control due to shortages of skilled inspectors and weak enforcement of standards (Muhwezi, Baguma & Mubiru, 2021).

In Rwanda, the construction sector has expanded rapidly, and national stakeholders have prioritized quality and green standards in public and institutional projects. Formal quality planning, strengthened quality assurance and control processes, and continual improvement

practices have been shown to reduce rework, raise compliance with specifications, and improve schedule reliability (JRIIE, 2025). Nevertheless, Rwandan projects also face constraints familiar across the region, including skills gaps on site, variable contractor capacity, and the need for stronger institutional oversight. Quality planning in Rwanda's construction industry involves defining quality standards, setting project specifications, and establishing procedures before project execution; effective quality planning improves project performance by ensuring proper design completeness, accurate budgeting, and alignment with regulatory requirements, although incomplete designs at the tender stage and weak integration of quality plans into procurement processes still affect outcomes (Tuyishime and Gathiru, 2023). Quality assurance in Rwanda, through supervision, audits, and adherence to standard procedures, helps maintain consistency in workmanship and materials. However, limited technical capacity and insufficient contractor training often constrain its effectiveness (Batamuliza and Kwen, 2025). Quality control, involving inspection, testing, and verification of materials and completed works, contributes to minimizing defects and improving durability, but implementation is sometimes hindered by inadequate testing facilities and delayed detection of defects (Niyonzera, 2025). Quality improvement, supported by learning from past projects and continuous improvement models such as the PDCA cycle, helps organizations achieve better cost efficiency and client satisfaction, though resistance to change and limited feedback mechanisms can constrain its effectiveness (Uwayishima and Wabala, 2023).

Focusing on ECOMECO Ltd's construction project, available project reports show deliberate quality planning and performance objectives, with lender and client requirements used to enforce design standards, procurement oversight, and construction monitoring (ECOMEKO, 2024). Translating those plans into improved project performance depends on on-site quality control practices, contractor competence, and formal mechanisms for continuous improvement, making ECOMECO Ltd a timely case for studying how structured TQM practices, moving from planning through assurance, control, and improvement, influence measurable performance outcomes of a significant institutional construction project in Rwanda. The construction industry continues to face persistent challenges of inadequate quality, delays, cost overruns, and client dissatisfaction, rooted in the limited and inconsistent application of TQM practices, particularly in quality planning, assurance, control, and continuous improvement (Okonta, 2024).

Globally, organizations that fully integrate TQM principles achieve improved schedule adherence, reduced defect rates, and higher customer satisfaction; yet in many developing contexts, including Sub-Saharan Africa, the focus on immediate project delivery often

overshadows long-term quality improvement goals (Mlimi, 2024). In Rwanda, although the sector has grown substantially, project performance remains constrained by recurring defects, budget overruns, and delays caused by weak implementation of quality management systems, with quality standards often specified at tendering but inconsistently enforced through assurance and control mechanisms thereafter (Muhwezi, Baguma & Mubiru, 2021). Contractors and project managers also face skill gaps and limited tools for continuous quality improvement, and the ongoing ECOMECO Ltd construction project exemplifies this broader context, where achieving expected quality and sustainability outcomes depends heavily on the adequacy of its quality planning framework, compliance assurance systems, inspection routines, and continuous feedback processes (Niyonzima, Habimana & Tuyizere, 2023). This study therefore seeks to contribute to solving this problem by assessing how Total Quality Management practices quality planning, assurance, control, and improvement affect the performance of construction projects in Rwanda, using ECOMECO Ltd as a case study, to provide evidence-based recommendations that support contractors, project managers, and policymakers in designing and implementing robust TQM frameworks for sustainable performance and long-term institutional learning in Rwanda's construction sector.

1.1 Objective of the Study

1.1.1 General Objective

The general objective of this study was to assess the effect of Total Quality Management practices on the performance of construction projects in Rwanda, focusing on ECOMECO Ltd's construction project.

1.1.2 Specific Objectives

- i. To assess the effect of quality planning on the performance of construction projects in Rwanda, a case of ECOMECO Ltd's construction projects.
- ii. To assess the effect of quality assurance on the performance of construction projects in Rwanda, a case of ECOMECO Ltd's construction projects.
- iii. To assess the effect of quality control on the performance of construction projects in Rwanda, a case of ECOMECO Ltd's construction projects.
- iv. To assess the effect of quality improvement on the performance of construction projects in Rwanda, a case of ECOMECO Ltd's construction projects.

1.2 Hypotheses of the Study

H₀₁: Quality planning has no significant effect on the performance of construction projects in Rwanda, a case of ECOMECO Ltd's construction projects.

H₀₂: Quality assurance has no significant effect on the performance of construction projects in Rwanda, a case of ECOMECO Ltd's construction projects.

H₀₃: Quality control has no significant effect on the performance of construction projects in Rwanda, a case of ECOMECO Ltd's construction projects.

H₀₄: Quality improvement has no significant effect on the performance of construction projects in Rwanda, a case of ECOMECO Ltd's construction projects.

2. Literature Review

2.1 Conceptual Review

Quality planning is the foundational step in a quality management system, where an organization defines quality objectives aligned with customer expectations, regulatory requirements, and strategic goals, identifying the standards, resources, and sequence of activities needed to build quality into outputs from the outset (IET, 2025). Proactive quality planning minimizes waste, reduces rework and cost, and enhances stakeholder confidence (UNIDO, 2020; IHI, 2023). Quality Assurance (QA) is a proactive practice focused on ensuring that project processes are executed in accordance with predefined standards and procedures, embedding quality into every phase of the project lifecycle through process audits, training, and adherence to guidelines (FlashHub, 2021; Brown, 2025). Effective QA increases efficiency, reduces rework, and provides a framework for continuous improvement (Madison and Edwards, 2025). Quality Control (QC) focuses on monitoring and verifying that project deliverables meet defined quality standards through systematic inspection, testing, and measurement, aiming to ensure the final product is defect-free (ASQ, 2025). Effective QC enhances customer satisfaction, reduces the cost of rework, and enables organizations to learn from past projects to refine future processes (Invensis Learning, 2025). Quality Improvement (QI) is a systematic practice of enhancing processes to achieve better outcomes, using methodologies such as Plan-Do-Study-Act, Lean, and Six Sigma to streamline processes, eliminate waste, and reduce variability (Barr, 2024). QI increases stakeholder satisfaction, reduces costs, and improves project performance by enabling teams to identify and address root causes proactively (Puri, 2023). The primary purpose of this research was to assess the effect of Total Quality Management practices on the performance of construction projects in Rwanda, focusing on ECOMECO Ltd's construction project, by disaggregating TQM into its four constituent practices planning, assurance, control, and improvement and

examining the extent to which each practice, individually and jointly, explains variation in project performance outcomes such as quality and scope compliance, cost adherence, schedule adherence, and overall stakeholder satisfaction. This disaggregated approach responds directly to a recurring limitation in the literature, namely that many prior studies treat quality management as a single, undifferentiated construct, thereby obscuring which specific practices matter most, and under what conditions, for construction project performance in resource-constrained developing-country settings such as Rwanda.

2.2 Theoretical Framework

This study is anchored on four complementary theories. Deming's System of Profound Knowledge (Deming, 1993) posits that quality and organizational performance result from understanding systems, variation, psychology, and knowledge, supporting quality planning through a systems approach and data-driven decision-making that helps managers develop realistic standards and anticipate risks. Taguchi's Loss Function Theory (Taguchi, 1986) holds that the cost of poor quality extends beyond rework to affect customers and society, emphasizing prevention over detection; it aligns closely with Quality Assurance because it stresses process design and preventive measures rather than post-hoc inspection. Crosby's Zero Defects Theory (Crosby, 1979) argues that quality is conformance to requirements and that errors should be eliminated at the source, relating directly to Quality Control, which focuses on detecting and preventing defects in outputs. Finally, the Continuous Quality Improvement Theory (Ishikawa, 1990) emphasizes iterative improvement through employee involvement, feedback, and quality tools, linking directly to quality improvement through cycles such as Plan-Do-Check-Act that treat improvement as a continuous rather than one-time activity.

2.3 Empirical Studies

Okombe et al. (2023) used a descriptive survey grounded in the Deming Cycle and Iron Triangle to examine quality planning and project success in Kenyan electricity transmission projects, finding a significant positive relationship but limited generalizability beyond a single infrastructure domain. Boventura and Kisimbii (2022) found that formal quality management systems, including planning, assurance, control, and continuous improvement, positively affected time, cost, scope, and quality outcomes in Mombasa County construction projects, though the study offered limited insight into the causal mechanisms involved. Kamashara and Ogbe (2022) found that cost and risk planning were effectively implemented in Rwandan community development projects, but the absence of a formal work breakdown structure constrained coordination and scheduling.

Salvi and Kerkar (2024) found that QA and QC together improved quality, efficiency, and client satisfaction in infrastructure projects, though empirical evidence directly linking QA to measurable performance gains remained limited. Enyinna et al. (2024) found moderate-to-high adoption of quality management systems in Nigerian building projects, with managerial and organizational factors and auditing/documentation significantly associated with adoption ($r = 0.715$, $R^2 = 0.511$). Gacheru et al. (2024) identified process control, management responsibility, and inspection and testing as the most applied ISO-derived QA practices among Kenyan contractors. Munyaneza and Habimana (2023) found that systematic inspections, material testing, and documentation significantly enhanced performance of Rwandan road projects, though QA was under-applied during planning and post-construction phases.

Sophie (2025) found that management commitment, skilled personnel, and standardized procedures underpin effective quality control, with digital tools such as BIM enhancing transparency. Mwanza and Chimbomba (2025) found inconsistent QC implementation among Lusaka construction firms due to inadequate supervision and limited technical expertise, despite recognizing QC's importance. Hakizimana, Muhwezi and Acai (2024) found that time, quality, and cost factors significantly affected the performance of building projects in Masaka City, Uganda. Mbonigaba (2021) found that leadership commitment, training, and structured quality planning and control significantly boosted construction project performance in Kigali.

Ibrahim, Tarek and Lafhaj (2024) found that traditional cost-time-quality indicators remain important but that non-financial indicators are increasingly emphasized in construction performance measurement. Chin, Ting and Yong (2024) linked persistent quality problems to inadequate QA/QC activities and unclear process flows. Njoka, Simon and Okaka (2024) found moderate managerial performance (72.5% average) among Kenyan construction site personnel, with notable gaps in staffing and investigating functions. Niyonizera (2025) found a strong positive correlation ($r = 0.842$) and significant regression effect ($\beta = 0.671$, $p < 0.001$) between quality-control planning and performance of road projects in Karongi District, Rwanda, though the study was limited to a single TQM dimension and district.

Taken together, these empirical studies reveal a broadly consistent pattern across East African construction settings: quality planning and quality assurance tend to exert the strongest and most consistent positive influence on project performance, quality control delivers tangible tactical benefits but is frequently undermined by the absence of formal frameworks, and quality improvement, although valued descriptively, shows more variable and context-dependent effects on

measurable performance outcomes. Several studies also highlight that management commitment, staff competence, and adequate resourcing are recurring preconditions for the successful translation of TQM practices into improved cost, time, and quality outcomes (Salvi and Kerkar, 2024; Mbonigaba, 2021), reinforcing the theoretical proposition that quality is produced by the interaction of people, processes, and management decisions rather than by inspection alone (Deming, 1993).

Beyond the individual studies reviewed above, a broader synthesis of the empirical literature suggests that the effectiveness of any single TQM practice is rarely independent of the others: quality planning provides the standards against which assurance activities are audited, assurance provides the preventive discipline that reduces the burden on control, control provides the verification data that feeds into improvement cycles, and improvement, in turn, feeds lessons learned back into the planning of future projects or project phases. Where this cycle is broken for instance, where planning exists but is not formally documented, as observed in several of the studies discussed above the remaining practices tend to operate reactively rather than proactively, which is consistent with the pattern later observed in the ECOMECO Ltd data, where quality control and quality assurance scored highly on tactical indicators but quality planning and quality control both scored very poorly on the existence of a formal, documented plan.

2.4 Research Gap

The reviewed studies collectively confirm that quality planning, assurance, control, and improvement significantly influence the performance of construction and infrastructure projects across East Africa. However, several gaps remain. First, many studies are geographically and sectorally limited, restricting the generalizability of findings. Second, while the positive influence of quality practices on project outcomes is well established, few studies disentangle the specific sub-practices or mechanisms that drive these effects. Third, research on quality assurance and quality control reveals persistent implementation challenges weak technical capacity, inconsistent supervision, and limited digital integration yet lacks quantitative evidence linking these practices directly to measurable performance improvements. Fourth, studies on quality improvement and TQM remain narrow in scope, often isolating single dimensions such as material control or planning while overlooking holistic interactions among quality dimensions. Finally, gaps persist in understanding contextual moderators such as organizational culture, supply-chain dynamics, and stakeholder relationships. This study bridges these gaps by providing context-specific, quantitative evidence on how the four TQM dimensions jointly and individually affect the performance of ECOMECO Ltd's construction projects in Rwanda.

2.5 Conceptual Framework

Independent Variables: Total Quality Management Practices

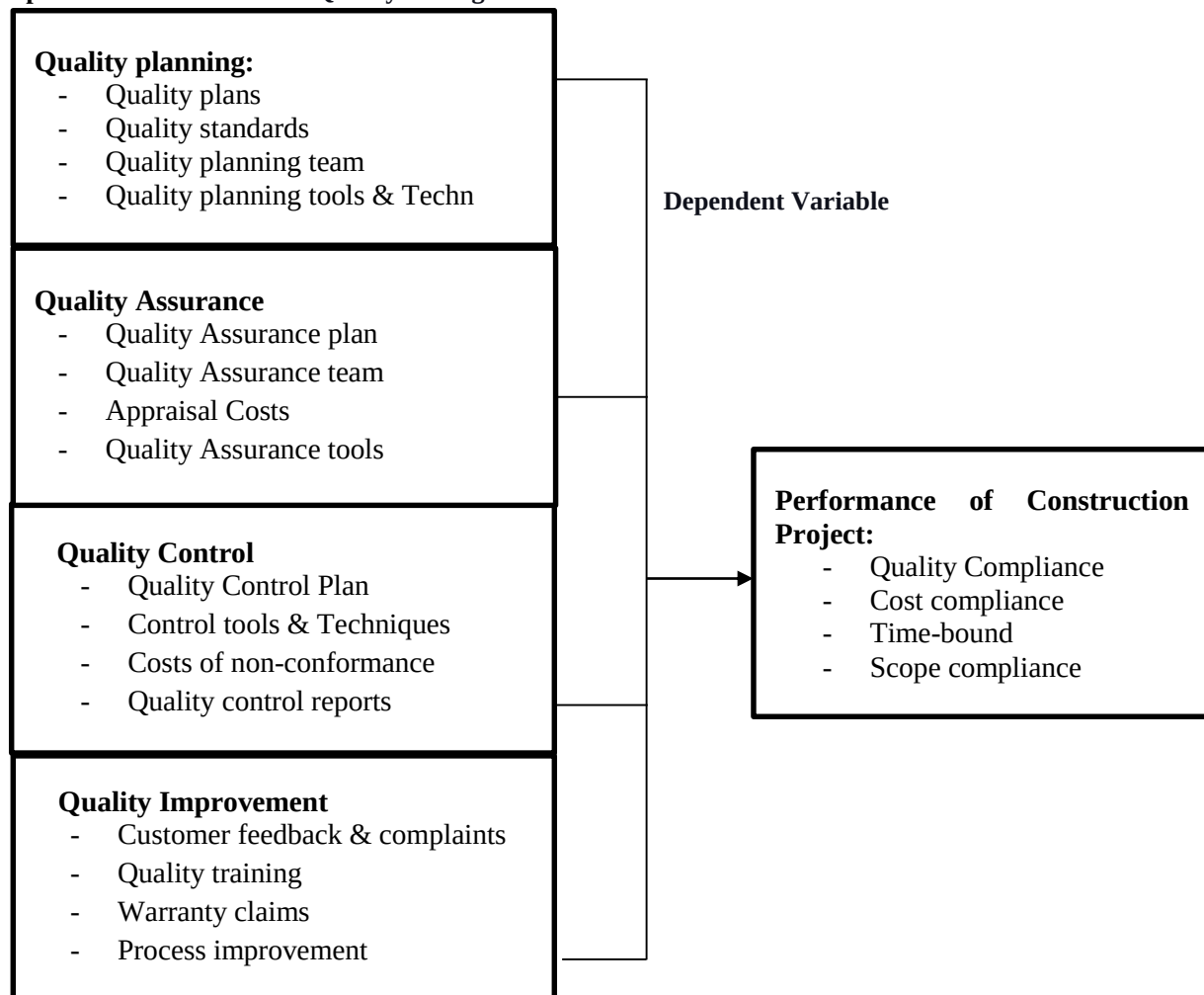


Figure 1: Conceptual Framework, Source: Researcher Conceptualization, 2026.

3. Methodology

This study adopted a quantitative research design combining descriptive and inferential statistical analysis to examine the effect of Total Quality Management practices on the performance of construction projects undertaken by ECOMECO Ltd in Ngoma District, Eastern Province of Rwanda, covering projects implemented between 2024 and 2026. The target population comprised 150 respondents drawn from ECOMECO management staff (35), ECOMECO engineers (35), stakeholder staff from World Vision and MINUBUMWE (20), and project beneficiaries from schools and citizens (60); applying Slovin's formula ($N = 150$, margin of error $e = 5\%$, 95% confidence interval) yielded a sample size of 109, allocated proportionately across the four strata using stratified random sampling to ensure representation of management, technical, stakeholder, and beneficiary perspectives. A structured Likert-scale questionnaire (1 = Strongly Disagree to 5 = Strongly Agree), organized into a demographic section

and a substantive section covering quality planning, quality assurance, quality control, quality improvement, and project performance, served as the primary data collection tool, complemented by a desk review of secondary literature such as journal articles, project reports, and institutional documents; of the 109 questionnaires distributed, 106 were returned and usable, a response rate of 97.2%, with the remaining 2.8% attributed to unavailable management staff.

Prior to full data collection, the instrument was piloted with 10 participants drawn from the same project to check clarity, relevance, and consistency; content validity was assessed by expert judgment and yielded a Content Validity Index of 0.937 (excellent), while internal consistency was assessed using Cronbach's Alpha, yielding a coefficient of 0.826 (good reliability), after which the questionnaire was revised and finalized for full distribution. Data were processed and analyzed using the Statistical Package for Social Sciences (SPSS) version 25.0: descriptive statistics (means and standard

deviations, with a standard deviation threshold of 0.50 used to distinguish homogeneous from heterogeneous responses) summarized respondents' views on each TQM dimension and on project performance, while inferential analysis comprising the Kolmogorov-Smirnov test of normality, Pearson correlation analysis, multiple linear regression, and ANOVA at a 5% significance level and 95% confidence interval was used to test the strength, direction, and statistical significance of relationships between the independent variables (quality planning X_1 , quality assurance X_2 , quality control X_3 , and quality improvement X_4) and the dependent variable (performance of construction projects, Y), following the multiple linear regression model $Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$, where α is the constant, β values are the coefficients of estimate for each independent variable, and ε is the error term. Ethical considerations, including informed consent, confidentiality, anonymity, safety, integrity, and proper referencing of all sources, were observed throughout the study to ensure the credibility and trustworthiness of the research process and findings.

4. Results and Discussion

This chapter presents the descriptive and inferential findings derived from the 106 valid questionnaires (97.2% response rate) analyzed using SPSS version 25.0, followed by hypotheses testing and a discussion of results in relation to prior empirical studies. The presentation follows the order of the study's specific objectives, beginning with descriptive statistics on quality planning, quality assurance, quality control, quality improvement, and project performance, before proceeding to correlation analysis, regression analysis, ANOVA, hypotheses testing, and an integrated discussion that situates ECOMECO Ltd's results within the broader empirical literature reviewed in Chapter Two.

4.1 Descriptive Statistics

The scale used for interpretation was: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. A standard deviation ≤ 0.50 was interpreted as homogeneity (closeness of responses to the mean), while a standard deviation > 0.50 indicated heterogeneity (dispersion of views).

4.1.1 Quality Planning

Table 1: Descriptive Analysis of Respondents' Views on Quality Planning

Statement	Mean	Std
ECOMEKO Ltd Projects follow a clear and detailed quality plan.	2.41	1.18
The project meets recognized construction quality standards.	3.65	.78
The project has a competent team handling quality planning.	3.79	.78
Quality tools and techniques are effectively used in the project.	3.71	.99
Quality planning has improved the project's overall performance.	4.66	.49
Overall Statistics	3.64	.84

Source: Field Data, 2026.

Table 1 shows that ECOMECO Ltd's construction projects generally excel in meeting quality standards, having a competent planning team, using quality tools effectively, and improving overall performance, evidenced by means ranging from 3.65 to 4.66 and an aggregated mean of 3.64. However, the absence of a clear and detailed quality plan is a notable weakness

(mean = 2.41, std = 1.18), indicating disagreement and dispersion of views that could undermine consistent project execution. These findings align with Boventura and Kisimbii (2022), whose study of Kenyan construction projects similarly found strong performance in standards, competence, and outcomes, alongside comparable gaps in detailed quality plans.

4.1.2 Quality Assurance

Table 2: Descriptive Analysis of Respondents' Views on Quality Assurance

Statement	Mean	Std
ECOMECO Ltd projects follow a clear quality assurance plan.	4.49	.62
The project has a skilled team ensuring quality assurance.	3.96	.77
Regular quality inspections help minimize rework and extra costs.	3.92	.89
Quality assurance tools are effectively used in the ECOMECO Ltd Projects.	4.12	.71
Quality assurance practices have improved the project's performance.	4.63	.50
Overall Statistics	4.83	.56

Source: Field Data, 2026.

Table 2 shows that ECOMECO Ltd performs strongly on quality assurance across all indicators a clear plan, a skilled team, effective inspections, functional tools, and improved performance with means ranging from 3.92 to 4.63 and a very high aggregated mean of 4.83. This suggests that while planning had gaps, robust QA

execution likely drives better project outcomes such as timeliness and stakeholder satisfaction. These results are consistent with Munyaneza and Habimana (2023), who found that inspections, testing, documentation, and skilled teams reduced defects, rework, and costs in Rwanda's road construction projects.

4.1.3 Quality Control

Table 3: Respondents' Views on Quality Control

Statement	Mean	Std
ECOMECO Ltd projects follow a well-defined quality control plan.	1.74	.44
Effective control tools and techniques are used to ensure construction quality.	4.14	.68
Inadequate quality work increases rework and extra costs in the project.	4.08	.79
Regular quality control reports help track and maintain project standards.	3.99	.78
Quality control practices have enhanced the overall performance of the ECOMECO Ltd Projects.	4.60	.49
Overall Statistics	3.76	.64

Source: Field Data, 2026.

Table 3 indicates strong agreement that effective control tools work well, poor quality drives rework and extra costs, regular reports maintain standards, and quality control practices boost overall performance (means 3.99–4.60), yet respondents overwhelmingly reject the existence of a well-defined quality control plan (mean = 1.74, std = 0.44). The aggregated mean of 3.76 depicts good tactical execution undermined by the absence of a

formal framework, echoing Mwanza and Chimbomba (2025), who found that construction firms in Lusaka delivered good tactical outcomes but suffered from weak supervision and the absence of structured control systems.

4.1.4 Quality Improvement

Table 4: Respondents' Views on Quality Improvement

Statement	Mean	Std
ECOMECO Ltd Projects considers client feedback to improve projects.	4.33	.47
Workers receive regular quality improvement training on the ECOMECO Ltd Projects.	4.35	.47
Warranty claims are used to identify and correct quality weaknesses in the project.	4.51	.50
Continuous process improvement practices are applied during construction.	4.37	.54
Quality improvement efforts have enhanced the overall performance of the ECOMECO Ltd Projects.	4.49	.50
Overall Statistics	4.41	.49

Table 4 confirms strong quality improvement practices at ECOMECO Ltd, including client feedback consideration, regular worker training, warranty-based correction, continuous process improvement, and enhanced overall performance, with means ranging from 4.33 to 4.51 and an aggregated mean of 4.41. These findings are strongly supported by Niyonizera (2025),

whose study on TQM in road construction projects found a robust link between structured quality practices and enhanced project performance using similar quantitative methods and a comparably high respondent consensus.

4.1.5 Performance of Construction Projects

Table 5: Descriptive Analysis of Respondents' Views on Performance of Construction Projects

Statement	Mean	Std
ECOMECO Ltd Projects met the required quality standards.	4.56	.49
The project was completed within the approved budget.	1.45	.50
ECOMECO Ltd's construction was completed within the planned schedule.	1.52	.50
All planned project work and specifications were fully achieved.	4.38	.49
The overall performance targets of the ECOMECO Ltd Projects were successfully achieved.	1.42	.49
Overall Statistics	2.67	.49

Source: Field Data, 2026.

Table 5 shows that ECOMECO Ltd's projects excelled in quality standards and scope fulfilment (means 4.38–4.56, std $\approx$ 0.49) but performed poorly on budget adherence, schedule adherence, and overall targets (means 1.42–1.52), pulling the aggregated mean down to 2.67. This implies that TQM at ECOMECO Ltd delivers strongly on quality but needs stronger integration with cost and schedule controls to avoid the holistic project failures common in the construction industry.

Before conducting inferential tests, a Kolmogorov-Smirnov test of normality was performed. The results yielded a statistic of 0.209 (df = 106, p = 0.065), which, being greater than 0.05, confirmed that the data were normally distributed, warranting the use of parametric tests (Pearson correlation, ANOVA, and multiple regression) for further inferential analysis.

4.2.1 Correlation Analysis

4.2 Inferential Analysis

Table 6: Pearson Correlation Analysis

Variable	X ₁	X ₂	X ₃	X ₄	Y
Quality Planning (X ₁)	1	.683**	.399**	.363**	.707**
Quality Assurance (X ₂)	.683**	1	.537**	.177	.699**
Quality Control (X ₃)	.399**	.537**	1	.482**	.601**
Quality Improvement (X ₄)	.363**	.177	.482**	1	.230*
Performance of Projects (Y)	.707**	.699**	.601**	.230*	1

****Correlation is significant at the 0.01 level; * significant at the 0.05 level. Source: Field Data, 2026.**

Table 6 shows that quality planning (R = 0.707) and quality assurance (R = 0.699) have the strongest positive correlation with construction project performance at ECOMECO Ltd, followed by quality control (R = 0.601) and a comparatively weaker quality improvement (R = 0.230). All correlations were statistically significant (p < 0.05). This pattern is consistent with project management

theory that emphasizes preventing issues early rather than fixing them later, and it underscores the value of investing in upfront planning and preventive process checks to reduce risks and defects.

4.2.2 Regression Analysis

Table 7: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of Estimate
1	.818 ^a	.669	.656	.812

a. Predictors: (Constant), Quality Planning, Quality Assurance, Quality Control, Quality Improvement. Source: Field Data, 2026.

Table 7 indicates a strong positive overall correlation ($R = 0.818$) between the independent and dependent variables. The model fit was good ($R^2 = 0.669$), meaning the four TQM practices jointly explain 66.9% of the variance in the performance of ECOMECO Ltd's

construction projects, leaving 33.1% explained by unstudied factors. The adjusted R^2 of 0.656 confirms the model's robustness when accounting for the number of predictors.

Table 8: Analysis of Variance (ANOVA)

Model	Sum of Squares	df	Mean Square	F	p-value
Regression	134.366	4	33.592	50.974	.000 ^b
Residual	66.577	101	.659		
Total	200.943	105			

a. Dependent Variable: Performance of Construction Projects. b. Predictors: (Constant), Quality Planning, Quality Assurance, Quality Control, Quality Improvement. Source: Field Data, 2026.

Table 8 shows an F-statistic of 50.974 ($p = 0.000 < 0.05$), confirming the overall statistical significance of the regression model in predicting construction project performance. This validates that the four TQM practices

jointly and significantly influence project outcomes, providing evidence-based confidence for practitioners to adopt these variables in resource allocation decisions.

Table 9: Regression Coefficients and Significance of Independent Variables

Model	B	Std. Error	Beta	t	p-value
(Constant)	.284	.201		1.413	.160
Quality Planning	.554	.097	.482	5.711	.000
Quality Assurance	.221	.103	.192	2.145	.035
Quality Control	.535	.108	.385	4.953	.000
Quality Improvement	-.312	.133	-.165	-2.345	.021

a. Dependent Variable: Performance of Construction Projects. Source: Field Data, 2026.

Table 9 yields the regression model: $Y = 0.284 + 0.554X_1 + 0.221X_2 + 0.535X_3 - 0.312X_4 + \varepsilon$, where Y is the performance of construction projects, X_1 is quality planning, X_2 is quality assurance, X_3 is quality control, and X_4 is quality improvement. When all independent variables are zero, project performance stands at a baseline of 0.284. A one-unit increase in quality planning raises performance by 0.554; a one-unit increase in quality assurance raises performance by 0.221; a one-unit increase in quality control raises performance by 0.535; while a one-unit increase in quality improvement

is associated with a 0.312-unit decrease in performance, suggesting that standalone, post-execution improvement efforts may hinder outcomes if not properly integrated. Ranked by standardized beta and t-values, quality planning ($\beta = 0.482$, $t = 5.711$) is the strongest contributor, followed by quality control ($\beta = 0.385$, $t = 4.953$), quality assurance ($\beta = 0.192$, $t = 2.145$), and quality improvement ($\beta = -0.165$, $t = -2.345$).

4.3 Hypotheses Testing

Table 10: Hypotheses Testing Results

Hypothesis	Beta	t	p-value	Decision
H ₀₁ : Quality planning has no significant effect on performance.	.482	5.711	.000	Rejected ($p \leq 0.05$)
H ₀₂ : Quality assurance has no significant effect on performance.	.192	2.145	.035	Rejected ($p \leq 0.05$)
H ₀₃ : Quality control has no significant effect on performance.	.385	4.953	.000	Rejected ($p \leq 0.05$)
H ₀₄ : Quality improvement has no significant effect on performance.	-.165	-2.345	.021	Rejected ($p \leq 0.05$)

Source: Researcher Analytics, 2026.

Table 10 shows that all four null hypotheses were rejected, confirming that each TQM practice

significantly shapes construction project performance at ECOMECO Ltd. For H₀₁, quality planning ($\beta = 0.482$, t

= 5.711, $p = 0.000$) was rejected, indicating that teams that establish upfront standards and processes achieve smoother timelines and fewer costly rework loops. For H_{02} , quality assurance ($\beta = 0.192$, $t = 2.145$, $p = 0.035$) was rejected, confirming that process audits and preventive checks meaningfully reduce execution risks such as material waste and delays. For H_{03} , quality control ($\beta = 0.385$, $t = 4.953$, $p = 0.000$) was rejected, showing that inspecting outputs in time boosts quality delivery, reduces callbacks, and protects budgets. For H_{04} , quality improvement ($\beta = -0.165$, $t = -2.345$, $p = 0.021$) was rejected, but with a negative coefficient signaling that standalone post-project improvement efforts may have adverse short-term effects unless integrated iteratively throughout the project lifecycle.

4.4 Discussion of Results

The findings collectively confirm that Total Quality Management practices significantly and substantially influence the performance of construction projects at ECOMECO Ltd, explaining approximately 67% of the variance in project performance. Quality planning emerged as the most influential practice, consistent with Biventura and Kisimbii (2022), who found that structured planning curbs variability in Kenyan construction projects, though both studies identified persistent gaps in the existence of formal, detailed plans. Quality assurance was found to be the strongest performer descriptively, mirroring the findings of Munyaneza and Habimana (2023) in Rwanda's road sector, where inspections, documentation, and skilled teams similarly reduced defects and improved timelines.

Quality control, while tactically effective (high means for tools, reports, and awareness of rework risk), suffered from the absence of a defined control plan, echoing Mwanza and Chimbomba (2025), who found that Zambian construction firms' tactical successes were undermined by the lack of an ISO-aligned framework. Quality improvement, despite very strong descriptive ratings, showed a statistically significant but negative regression coefficient, suggesting that standalone, post-execution improvement initiatives may not translate into immediate performance gains unless embedded iteratively into ongoing project cycles, a nuance that extends Niyonizera's (2025) finding of a strong positive TQM-performance relationship in Rwandan road projects by highlighting the importance of the timing and integration of improvement efforts.

Overall, ECOMECO Ltd's projects excelled on quality and scope compliance but consistently underperformed on budget and schedule adherence, a pattern broadly consistent with the regional literature indicating that quality-focused practices often outpace cost and time controls in developing construction sectors (Hakizimana, Muhwezi & Acai, 2024; Njoka, Simon & Okaka, 2024). This suggests that TQM implementation at ECOMECO Ltd needs to be more tightly integrated with cost and

schedule management systems to achieve holistic project success. From a theoretical standpoint, the dominance of quality planning and quality control as the strongest predictors of performance lends empirical support to Deming's systems-based view of quality and to Crosby's emphasis on eliminating errors at the source, since both practices concern the design and verification of processes before and during execution rather than after-the-fact correction. The comparatively moderate contribution of quality assurance is consistent with Taguchi's Loss Function Theory, which frames assurance as a preventive but incremental safeguard rather than the primary driver of performance. The negative short-term coefficient for quality improvement, meanwhile, complicates a straightforward application of the Continuous Quality Improvement Theory: while Ishikawa's framework assumes that iterative, feedback-driven improvement steadily raises performance, the ECOMECO Ltd findings suggest that when improvement activities are implemented as isolated, end-of-project interventions rather than as an ongoing cycle embedded within planning, assurance, and control, they may temporarily divert resources or attention without producing measurable gains, reinforcing the argument that continuous improvement must be genuinely continuous, and not merely a corrective afterthought, to deliver its expected benefits.

Practically, these findings imply that ECOMECO Ltd and similar construction firms in Rwanda stand to gain the most from front-loading investment in quality planning and quality control systems, since these two practices jointly account for the largest share of the explained variance in project performance. At the same time, the consistently poor performance on budget and schedule targets, despite strong quality and scope outcomes, indicates that technical quality management alone is not sufficient; it must be deliberately coupled with cost-estimation discipline, schedule-risk management, and stakeholder communication if construction firms are to achieve balanced success across the classic project performance dimensions of quality, cost, time, and satisfaction.

Finally, the pattern of results across the descriptive, correlational, and regression analyses converges on a coherent narrative for ECOMECO Ltd: preventive, upfront practices (planning and, to a lesser extent, control) generate the largest performance dividends, reactive assurance mechanisms provide a smaller but still significant boost, and improvement practices, though highly valued by respondents on a day-to-day basis, have not yet been organized in a way that translates into measurable short-term performance gains. This narrative is broadly consistent with the Iron Triangle and PMBOK perspectives referenced in the empirical literature (Okombe et al., 2023), which similarly privilege early-stage planning and control disciplines as the most reliable levers for project success, while cautioning that improvement initiatives require sustained, structural

integration rather than episodic application to yield their full benefit.

5. Conclusion and Recommendations

5.1 Conclusion

The general objective of this study was to assess the effect of Total Quality Management practices on the performance of construction projects undertaken by ECOMECO Ltd. Based on the findings, the study concludes that thoughtfully applied TQM practices quality planning, assurance, control, and improvement markedly boost project outcomes, explaining a substantial portion of performance variance despite lingering implementation gaps. Quality planning plays a pivotal role in enhancing performance, with descriptive strengths in team competence, tool use, and standards adherence overshadowed by the critical absence of clear, detailed plans; inferential analysis confirmed its top correlation and regression impact, rejecting the corresponding null hypothesis. Quality assurance strongly drives performance, excelling across clear plans, skilled teams, cost-saving inspections, and effective tools, with robust inferential support affirming that preventive audits reduce waste and delays. Quality control significantly bolsters performance through effective tools and tracking reports, despite a stark absence of a defined control plan, highlighting the value of reactive inspections in protecting budgets. Quality improvement meaningfully shapes outcomes through client feedback, training, and continuous process tweaks, though its short-term negative regression effect signals that iterative integration, rather than standalone application, is needed for sustained gains.

Overall, ECOMECO Ltd's projects consistently meet quality and scope requirements but fall short on budget and schedule targets, confirming that TQM needs tighter integration with cost and schedule controls for holistic project success in Rwanda's construction sector. In addition, the study concludes that the strength of the overall regression model ($R^2 = 0.669$) demonstrates that Total Quality Management practices are not merely descriptively popular among respondents but are statistically substantial determinants of construction project performance at ECOMECO Ltd, accounting for two-thirds of the variance observed. The remaining 33.1% of unexplained variance points to other unstudied factors such as contractor financing arrangements, supply-chain reliability, weather-related delays, and regulatory bottlenecks that likely interact with TQM practices to shape final project outcomes, and which future research should investigate. The consistent rejection of all four null hypotheses affirms that quality planning, quality assurance, quality control, and quality improvement are each statistically significant, non-trivial contributors to project performance, even though their relative magnitude and direction of effect differ,

underscoring that a one-size-fits-all approach to TQM implementation is unlikely to be optimal; instead, ECOMECO Ltd and similar firms should calibrate their investment in each practice according to its demonstrated contribution, while remaining attentive to the interactions among practices revealed by the correlation analysis.

5.2 Recommendations

Based on the findings, the study recommends the following:

1. *Strengthen quality planning and control:* ECOMECO Ltd should formalize quality plans, control systems, digital monitoring, and ISO 9001 practices to ensure consistent project quality.
2. *Improve staff competence and training:* The company should strengthen staff skills through continuous training involving RSB, RTDA, universities, and experienced construction professionals, with emphasis on PMBOK and TQM standards.
3. *Institutionalize quality assurance:* Regular audits, inspections, stakeholder involvement, and preventive quality measures should be integrated into all projects and linked to cost management.
4. *Integrate quality improvement throughout projects:* Quality improvement should be continuous rather than an end-of-project activity, supported by post-project reviews, warranty-claim analysis, and corrective actions.
5. *Strengthen cost and schedule management:* ECOMECO Ltd should improve cost estimation and schedule-risk management and ensure that quality, cost, and time are managed as interconnected aspects of project performance.
6. *Expand research on TQM:* Future researchers should conduct longitudinal studies and examine short-term quality-improvement effects, iterative TQM models, cost overruns, delays, resource utilization, and financial risks.
7. *Strengthen national TQM practices:* Policymakers should promote TQM training through universities and TVET institutions and incorporate integrated quality, cost, and schedule requirements into public procurement.
8. *Promote public-private collaboration:* Government and private-sector partnerships should replicate successful quality-management practices while addressing weaknesses in project budgets and timelines.
9. *Support sustainable infrastructure:* Integrated management of quality, cost, and time should be promoted to improve infrastructure sustainability, economic development, public services, and quality of life.

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