Journal of
Entreprenuership and
Project Management
(JEPM)

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CARI Journals

Journal of Entrepreneurship and Project Management
ISSN: 2520-9116 (Online)
Vol.11, Issue No.1, pp 46 – 63, 2026
www.carijournals.org

Design Control and Performance of Mega Dam Projects in Kenya

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Accepted: 10th April, 2026, Received in Revised Form: 24th April, 2026, Published: 6th May, 2026

ABSTRACT

Purpose: The aim of this study was to assess the influence of design control on performance of mega dam projects in Kenya.

Methodology: The study adopted a descriptive research design. The study targeted the 19 dam projects in the different counties in Kenya that were completed after independence. The study population was 300 project team members in charge of the projects. The study sample size was 171 respondents. The stratified random sampling was used to select the different project team members. Primary data was used in this study and it was collected using both closed and open questionnaire. Data was analyzed using the descriptive and inferential statistics. Pearson R correlation was used to measure strength and the direction of linear relationship between variables. Advanced statistical models that include diagnostic tests, multicollinearity and normality tests were conducted before performing the multiple regressions model. Multiple regression models were fitted to the data in order to determine how the independent variables affect the dependent variable. ANOVA was used to check the overall model significance.

Findings: The study found that design control positively and significantly influences performance of mega dam projects in Kenya.

Unique Contribution to Theory, Practice and Policy: Based on the findings, the study recommends that the management of mega dam projects in Kenya should prioritize thorough design reviews and approvals before and during implementation. This should include involving multidisciplinary experts in the design process, adopting advanced design technologies. The study contributes to theory by reinforcing contingency theory and establishing design control as a key determinant of mega dam project performance. Practically, it shows that strengthening design reviews, multidisciplinary involvement, and use of modern design technologies improves project outcomes. For policy, it recommends stricter regulations requiring mandatory design approvals and continuous compliance monitoring throughout project implementation.

Key Words: *Design Control, Mega Dam Projects, Project, Design Theory*

INTRODUCTION

Background to the Study

For over 5,000 years, civilizations have continuously refined their methods of utilizing water for various purposes, including navigation, irrigation, flood control, industrial applications, and wildlife conservation. Historical trends reveal that early dams were strategically constructed to provide vast areas with water, enabling agricultural productivity to sustain growing populations. In modern times, the efficient operation of dam projects remains a critical concern, ensuring a stable water supply for domestic, commercial, agricultural, and environmental purposes (Cellerino, Gadda, & Lucertoni, 2023). In the context of mega dam projects, successful project performance is a multifaceted achievement requiring adherence to timelines, budget constraints, quality standards, and user preferences while meeting complex technical requirements (Haarstrick & Bahadir, 2022). The criteria for project performance also encompass completion within budget, adherence to schedules, high-quality workmanship, and conformance to scope. The interdependence of cost, time, scope, and quality remains central to the successful execution of such projects, with each factor influencing overall project efficiency.

The performance indicators for mega dam projects extend beyond financial and time constraints to include compliance with technical specifications, environmental sustainability, and safety regulations (Ngcobo, 2023). These indicators not only determine the overall success of a project but also emphasize the broader responsibilities associated with dam construction, including long-term environmental and social sustainability. However, achieving and maintaining such high-performance standards requires a structured Quality Management System (QMS) to ensure process consistency, continuous monitoring, and adherence to international best practices.

A Quality Management System (QMS) provides an integrated framework that enhances project efficiency, reliability, and quality assurance. According to Maruszewska (2025), a QMS enables effective process control, systematic monitoring, and continuous improvement in project execution. Research by Mashwama, Aigbavboa, and Thwala (2023) highlights the critical role of QMS in preventing poor project quality and ensuring that dam construction meets both technical and regulatory requirements. However, Mohamed (2023) argues that a lack of awareness, misconceptions, and limited technical capacity among project teams can hinder the effective implementation of QMS, leading to cost overruns, quality lapses, and project inefficiencies. To ensure continuous improvement, project leaders must demonstrate full commitment to the principles of quality management, particularly in the planning, execution, and monitoring of large-scale projects. The fundamental principles of QMS, as outlined in ISO 9001:2015, provide a structured approach for ensuring project consistency and success, (Dzulkifli et al 2021). These principles guide the planning, execution, and evaluation of large-scale infrastructure projects, ensuring compliance with technical, environmental, and stakeholder expectations.

The successful implementation of QMS in mega dam projects enhances efficiency, sustainability, and stakeholder confidence. A study by Adegbite et al. (2023) found that dams constructed with structured QMS frameworks demonstrated higher performance in water storage, irrigation capacity, and hydropower output compared to those without formalized quality management systems. However, challenges such as resistance to change, lack of awareness, and resource constraints continue to hinder QMS adoption in dam construction (Mwaniki & Rambo, 2022). Addressing these challenges requires capacity-building initiatives, integration of digital monitoring systems, and compliance with ISO 9001:2015 standards.

The success of mega dam projects in Kenya is closely tied to the implementation of QMS principles. By embracing customer focus, leadership commitment, process standardization, continuous improvement, and stakeholder engagement, dam projects can achieve higher efficiency, sustainability, and operational longevity. This study, therefore, sought to determine the influence of project quality management systems on the performance of mega dam projects in Kenya. By evaluating QMS principles and their impact on project execution, efficiency, and stakeholder satisfaction, the study aimed to provide valuable insights into improving quality management frameworks for large-scale water infrastructure projects.

Kenya faces a severe water scarcity problem, with an annual internal water availability of only 636 cubic meters per capita, far below the globally recognized threshold for water sufficiency (Thomas-Possee, 2023). The country's increasing population and expanding agricultural and industrial sectors have placed additional pressure on its limited water resources, necessitating significant investments in large-scale water storage infrastructure. In response, the Kenyan government has prioritized mega dam construction to enhance water security, improve irrigation capacity, and generate hydropower as part of its Vision 2030 development agenda (Asokan et al., 2020). The National Water Harvesting and Storage Strategy (2020–2025) outlines Kenya's commitment to increasing its water storage capacity from the current 124 million cubic meters to 4.5 billion cubic meters by 2030, ensuring a reliable supply for domestic, agricultural, and industrial use (Mulwa, 2021).

Kenya's mega dam projects play a critical role in addressing water scarcity, mitigating the effects of climate change, and supporting economic growth. The government has focused on the development of large reservoirs that can store vast amounts of water to be used during periods of drought and fluctuating rainfall. Mega dams also serve a multi-functional role, providing water for irrigation, urban supply, flood control, and hydropower generation. By investing in large-scale dam projects, Kenya aims to achieve long-term water security while reducing its dependence on seasonal rainfall for agriculture and domestic consumption (National Water Harvesting and Storage Authority, 2023).

Several mega dam projects in Kenya highlight the country's commitment to expanding its water infrastructure. The Masinga Dam, the largest reservoir in the country, provides critical irrigation and hydroelectric power for the national grid. Turkwel Dam serves multiple purposes, including

water storage, irrigation, and hydropower production, contributing to economic development in arid and semi-arid regions. Thiba Dam, a recently completed project, was developed to enhance rice irrigation in the Mwea region, reducing Kenya's reliance on rice imports and promoting food security (Mwai et al., 2022). These projects reflect Kenya's strategic approach to large-scale water storage and resource management.

Despite the benefits, Kenya's mega dam projects face several challenges that hinder their effectiveness. Financial constraints remain a significant issue, with many projects experiencing budget shortfalls and delays in funding, leading to prolonged construction timelines and incomplete projects (Mulwa, 2021). Governance and corruption concerns have also affected the sector, with reports of mismanagement and procurement irregularities slowing progress (Mwai et al., 2022). Environmental and social impacts, including the displacement of local communities and ecological disturbances, require more comprehensive mitigation strategies to balance development with sustainability (Berendes et al., 2023).

Another key challenge is the technical and logistical complexity of mega dam projects. Delays in project implementation, inefficiencies in contractor performance, and regulatory challenges have resulted in slow project execution and underutilization of completed infrastructure (Asokan et al., 2023). The lack of integration of modern quality management systems in project execution has also been identified as a factor contributing to inefficiencies in Kenya's water infrastructure development. Adopting best practices in project management, increasing stakeholder engagement, and ensuring adherence to global standards will be critical in improving the performance and sustainability of Kenya's mega dam projects.

As Kenya continues to expand its water infrastructure, addressing these challenges through improved governance, strategic financing, and environmental conservation measures will be essential. Ensuring that mega dam projects align with international quality and sustainability standards will not only enhance their efficiency but also contribute to long-term national development goals. The integration of quality management systems, better policy frameworks, and transparent decision-making processes will be key in ensuring that Kenya's mega dam projects fulfill their intended purpose and provide lasting benefits to the population.

Statement of the Problem

Kenya's Vision 2030 presents an ambitious roadmap for socio-economic transformation, placing mega dam infrastructures at the heart of national development (Kanda, Lusweti, & Odhiambo, 2023). These projects are envisioned to ensure water security, boost agricultural production through irrigation and supply clean energy to power industrialization and rural development (Government of Kenya, 2020). However, while the vision is bold and inspiring, many of these mega dams have significantly underperformed due to systemic failures in project quality management systems, revealing a consistent and troubling pattern of inefficiencies across Kenya (Baraza, 2020).

Bongei et al (2024) noted that project quality planning has a statistically significant impact on dam performance, with a correlation coefficient of $r = 0.869$ ($p < 0.05$) indicating that nearly 75% of performance variance in mega dam projects can be attributed to quality planning and related processes. Thwake Multipurpose Dam, initially budgeted at KSh 36.97 billion, has experienced a 32% cost overrun, reaching an additional KSh 9.3 billion. Moreover, environmental assessments indicate potential water contamination from upstream pollution, raising concerns about its viability (Kenya News Agency, 2024).

Mwashuma, and Kisimbii (2020) found that out of the 57 mega dam projects initiated by the government since 2009, only 20% have been completed successfully and majority of them have stalled. The Badasa Dam project in Marsabit County was envisioned as a pivotal component to enhance water security and foster socio-economic development in arid regions (Lango, 2024). Despite its strategic importance, the project has faced significant setbacks. Construction stalled by 2011 after approximately KES 2 billion had been expended.

Otieno (2024) highlights inefficiencies in Kenya's water service delivery caused by weak coordination, overlapping mandates, and limited autonomy, leading to resource duplication, delayed policies, and poor accountability, which undermine program performance across government and NGOs. Additionally, the World Bank's 2023 sector review underscores that despite numerous strategic plans, 41% of rural and 28% of urban households still lack reliable water access, primarily due to ineffective implementation and coordination. The Sondu-Miriu Hydropower Project experienced a four-year delay and an 11% cost overrun, largely attributed to weak quality assurance mechanisms and risk management (Kiplagat & Wang, 2021). Kenya's Vision 2030 projected a long-term electricity generation capacity of approximately 22,000 MW, aiming to support industrialization and universal energy access Takase, Kipkoech & Essandoh (2021). However, as of 2024, the actual installed capacity is approximately 3,038 MW, indicating a significant gap between planned and actual performance

The absence of robust, enforceable quality management frameworks undermines project timelines, budgets, and ultimate functionality. Audits have shown that fewer than 30% of public infrastructure projects in Kenya undergo rigorous quality vetting (Office of the Auditor General, 2024), exposing significant vulnerabilities in governance, oversight, and execution.

Water supply coverage in Kenya is estimated at 57%, and per capita water availability is estimated at approximately 647m3 per person per year (FAO, 2020), which is significantly lower than the UN's benchmark of 1,000 m3 per capita per year. Despite the country's irrigation potential estimated at 1.34 million hectares, less than 16% has been realized (Njiru, 2021). This under-utilization is compounded by climate-related risks, inadequate infrastructure development, and poor inter-agency coordination, which continue to hinder effective water resource management and agricultural transformation (Otieno, 2024). Several research on quality management and project performance have been undertaken locally. Nderitu and Nyaegah

(2020) on determinants for adoption of quality Management system on projects implementation in the County Governments in Kenya revealed that the cost of project increased than budgeted.

Currently, less than 35% of mega infrastructure projects in Kenya meet their original quality and performance targets (National Infrastructure Authority, 2023). This alarming statistic signals an urgent need to interrogate how quality management systems impact mega dam project outcomes. This study sought to bridge this gap by critically assessing the influence of design control on performance of mega dam projects in Kenya.

General Objective of the Study

The general objective of the study is to assess the influence of design control on performance of mega dam projects in Kenya

LITERATURE REVIEW

Theoretical Framework

Project Design Theory

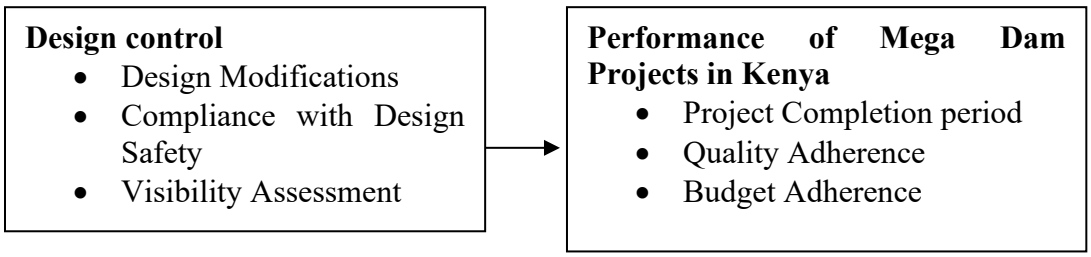
Pries-Heje and Baskerville (2008) indicated that design theory is used to solve problems. A problem is an incomplete and contradictory problem that changes over time and for which no classic linear decision model can be found. Many social, commercial or financial planning problems will be problematic because they won't keep still. Such problems are often refined, rather than solved, by alternative solutions. This can help to work towards a solution if not solve it. Wicked problems have some of the following five characteristics; there is no definitive formulation of the problem. There is need to understand the problem (better) through working with the solution. There is no stop signal embedded in the problem. This is because the process by which we solve the wicked problem is identical to the process by which we understand the problem. There are no true or false solutions but only solutions of varied goodness. Any solution to a problem is a unique one-time solution (Lee & Baskerville, 2020)

The design theory has two aims one for a problem (organizational change) and one for the problem of user involvement. Design theory is projectable across a very wide range of problem-solving settings. It has been actually projected into two instances. The project ability suggests that this theory has potential to be very important. However, the actual projections provide only the limited knowledge about its consequences in two instantiations. A good project design is one that clearly communicates the change, often expressed as a logic model, upon which the project or program is based. This means establishing causal links among inputs, outputs and outcomes. The theory explains the influence of design control on performance.

Conceptual Framework

The conceptual framework shows the relationship between the independent and dependent variables. The framework helps the reader see at a glance the proposed relationships between the

variables in the study graphically or diagrammatically. Orodho (2019) defines a conceptual framework as a graphical or a diagrammatical model of presentation of the relationship between variables in the study. It is a road map that the study intends to follow with the aim of looking for answers to the problems raised by the research questions. The independent variable is design control while the dependent variable is project performance.



Independent Variables **Dependent Variables**

Figure 1: Conceptual Framework

Design Control

Project design is the starting point that involves a systematic and theoretical conceptions, tried primary assumptions, and credible information that which enable the delivery of a project within a specified timeline. Sanoff (2020) posits that designing of a project requires calculative thinking and investment because failure to this exposes the project to higher risk of failure or poor quality of implementation. Due to complexity and uniqueness of projects, Sanders & Binder (2025) posits that it is important to carefully select the most appropriate design method, tools and techniques to apply in a specific project. To make project design effective, Hussain and Sanders, (2023) advises that projects need to remain sensitive to the history and culture of the community where the project is implemented.

Design management refers to the management activities, methodologies, and competencies necessary to optimize and oversee design processes. Managing design for successful projects is not just about the control of a creative process; it is also about delivering outputs effectively, efficiently, and efficaciously, such as achieving project objectives and outcomes at all levels and meeting all stakeholders' requirements. The effective management of the design process helps decrease design-related problems in the project life cycle as well as minimize the overall project risks. This method also enables profitability maximization for the organization by providing a platform for continuous improvement (Murray & Thomas, 2024). Design verification is a crucial step in the engineering design process, where you check if your design meets the project objectives, requirements, and standards. It can help you avoid costly errors, improve quality, and ensure compliance (Sanoff, 2020).

Empirical Review

Design Control and Performance of Mega Dam Projects

Rahman-Abdul (2020) studied the impact of design changes on construction project performance. The objectives are to analyze the relationship of design changes and the consequent rework, to recognize their resulting impacts on project performance and to provide insights for directing further studies in Malaysian context. The findings indicate that design changes are identified as important causing factors to project delay and cost overruns. Similar results were found for studies done in both developed and developing countries round the world because construction projects commonly share key characteristics. On the contrary, preceding studies done in Malaysia that were published in the top-tier construction management journals failed to recognize design changes as a major cause of project schedule and cost overruns. Therefore, suggestions for future research are recognizing design changes as a major cause of schedule and cost overruns in construction project in Malaysia, identifying factors stimulating design changes and the ability to predict the resulting impacts on project performance. Thus, the analytical framework for future study is presented.

Hanyurwimfura (2025) studied the influence of project design documentation on the performance of government projects in Rwanda. The purpose of the study was therefore to assess the influence of documentation framework on the performance of government projects in Rwanda. A survey using a closed ended questionnaire was conducted on managers. Data collected was analyzed through SPSS version 21, for both descriptive and inferential statistics. The study found that the project had clear documentation specifications, ,the design of organized project documentation while, project design involved a team of multiple stakeholders represented, problems and needs were identified and 36 solutions strategized and impartial reviews were conducted to ensure specifications are met. The study concluded that the regulatory and legal conditions should be clear to the project team and a clear plan outlining timeframe for acquiring the products should be in place since it also affects performance of government projects in the district.

Abdi and Mbugua (2025) researched on project design factors influencing implementation of infrastructural development projects in devolved governments: A case of Marsabit and Isiolo Counties, Kenya. This purpose of this study was to investigate the project design factors influencing the implementation of infrastructural project in devolved governments; a case of Marsabit and Isiolo Counties. The study was guided by five objectives. The study was guided by descriptive research survey design. Data was collected using questionnaires for the personnel while interview was conducted for the household heads. Descriptive statistics were used to analyze the data while Pearson's product-moment correlation coefficient was used. Findings revealed that project planning, project leadership, community involvement, resources availability and commitment of project participants influenced the implementation of infrastructure projects in Marsabit and Isiolo counties.

Roth (2020) studied the effect of design thinking on project success. based on the existing design thinking literature, the study conceptualized the common themes underlying design thinking to describe the application level of design thinking practices in projects. The study elaborated on the performance relevance of design thinking. Besides a direct impact on project performance, the study drew on organizational behaviour literature and argue psychological empowerment to be a core mechanism through which design thinking affects project performance. The study tested the hypotheses. The study found the effect of the application level of design thinking practices on project performance to be fully mediated by psychological empowerment.

Odhiambo (2021) studied the effects of project design practices on implementation of projects in the Coast of Kenya. This research was carried out in Kwale, Mombasa and Kilifi counties in the coast of Kenya. The research was based on the logical framework, results-based approach, capabilities approach, and participatory development that provide the foundation for project design and implementation. A combination of quantitative and qualitative research approaches was adopted for this study. The qualitative approach included in-depth interviews and key informant interviews that were conducted using interview guides. Descriptive analysis, factor analysis, regression analysis was carried out. The findings revealed that the dependent variable, implementation of projects can be adequately measured by satisfaction and outcome effectiveness. Based on the pattern matrix, situation analysis practices had two important factors namely stakeholder analysis and needs assessment, project formulation practices had three factors namely food security, political goodwill and project ownership. Implementation planning practices had two important factors, appropriate budgeting and assignment of responsibilities. Monitoring and evaluation planning had two factors, tracking progress and timeliness. Attitude toward mari culture was a moderating variable with two factors namely attitudes towards benefits of mariculture and attitudes towards costs of mariculture.

RESEARCH METHODOLOGY

Positivism was adopted in this study. The study adopted a descriptive research design. It is an effective method to get information that can be used to develop hypotheses and propose associations. Hence, it was used to assess the influence of design control on performance of mega dam projects in Kenya.

This study focused on 19 mega dam projects in Kenya, as identified by the Ministry of Water, Sanitation, and Irrigation (2023). These dams are strategically distributed across various counties, including Thwake Dam (Makueni), Masinga Dam (Machakos), Thiba Dam (Kirinyaga), Chemususu Dam (Baringo), Koru-Soin Dam (Kisumu/Kericho), and others listed in Appendix V. These dams were selected based on their classification by the Ministry of Water, Sanitation, and Irrigation (2023) as mega dam projects.

The unit of observation consists of 300 key personnel involved in the planning, implementation, and management of these projects. The study targets: Project Managers – Overseeing construction and implementation; Project Coordinators – Ensuring day-to-day project execution aligns with objectives; Project Administrators – Handling project documentation and compliance; Project Analysts – Evaluating performance metrics; Project Directors – Providing high-level strategic guidance; and Project Steering Committee Members – Representing stakeholders and ensuring regulatory compliance. In this study the sample frame was the list of mega dam projects distributed in different counties in Kenya.

The sample size is a term used for defining the number of subjects included in a sample size. The study sample size was selected from the project team population. The study used Yamane (1967) formula to calculate the sample as

The study sample size was 171 respondents. This was 57% of the study population. According to Mugenda (2019), a sample size of at least 30% is adequate for a study. The stratified random sampling was used to select the different project team members.

Primary data was used in this study and it was collected using a questionnaire. Pilot was hence conducted with 17 respondents selected randomly from the target population who were not included in the actual study. The pilot helped to determine the reliability and validity of the research instrument.

Data collected was checked for completeness and edited. Data was analyzed by use of SPSS version 26.0 and excel. Data was analyzed using the descriptive and inferential statistics. Descriptive analysis included variability measurements such as range, variance, and standard deviation, dispersion and central tendency metrics such as mean, mode, and median. Inferential statistics include the correlational and regression analysis. Pearson R correlation will be used to measure strength and the direction of linear relationship between variables.

FINDINGS AND DISCUSSION

Descriptive Analysis of Study Variables

Descriptive analysis was conducted to summarize the responses on design control and performance of mega dam projects. The analysis involves the computation of frequency distributions, mean scores, and standard deviations to assess respondents' level of agreement with various statements related to each variable. The findings provide insights into the extent of implementation and perceived influence of design control in mega dam projects in Kenya. A 5-point likert scale of Strongly Disagree, Disagree, Moderate, Agree, or Strongly Agree was used. The findings and discussions are presented in sub-sections below.

Design Control

The first objective of the study was to assess the influence of design control on performance of mega dam projects in Kenya. Design control ensures that mega dam projects adhere to approved

technical specifications, comply with safety standards, and mitigate risks throughout the project lifecycle. It involves proper documentation, independent verification, and compliance with regulatory frameworks to minimize errors and ensure high-quality outcomes. Respondents were asked to indicate the extent to which they agreed with various statements on design control. Table 3 presents summary of findings obtained.

The findings in Table 4.8 indicate that the majority of respondents agreed that proper documentation and approval of design modifications were conducted in their projects, with a mean score of 3.864 and a standard deviation of 0.865. This aligns with the argument by Rahman-Abdul (2020), who emphasized that well-documented design modifications are crucial for ensuring project success, as they minimize rework and prevent cost overruns. The relatively low standard deviation suggests a consensus among respondents regarding the importance of this process in their respective projects.

Similarly, compliance with design safety standards was largely affirmed, with 52.3% of respondents agreeing and 20.9% strongly agreeing, leading to a mean of 3.890 and a standard deviation of 0.852. This result corroborates the findings of Abdi and Mbugua (2025), who found that ensuring compliance with design safety standards at every stage of project implementation enhances overall project efficiency and mitigates potential hazards. The minimal disagreement (only 4.6%) highlights the strong adherence to safety protocols in mega dam projects.

Regular visibility assessments, an integral aspect of project design, were also widely acknowledged, with a mean score of 3.889 and a standard deviation of 0.857. These findings align with the study by Odhiambo (2021), which highlighted the role of continuous visibility assessments in ensuring the alignment of project activities with established quality benchmarks. The substantial agreement among respondents suggests that most projects prioritize real-time monitoring as a tool for performance improvement.

The project design's alignment with environmental and safety regulations also garnered substantial agreement, reflected in a mean score of 3.855 and a standard deviation of 0.879. This is consistent with research by Zhang et al. (2022), who emphasized the importance of integrating environmental and safety compliance into project designs to ensure sustainability and regulatory adherence. The standard deviation in this case indicates slight variations in perceptions, likely influenced by differences in regulatory enforcement across projects.

Independent verification and validation of project designs before implementation had a mean score of 3.875, indicating a widespread acknowledgment of its importance. This finding echoes the sentiments of Roth (2020), who stressed that independent verification ensures design integrity and minimizes design-related errors, ultimately improving project efficiency. The relatively low standard deviation (0.862) suggests a strong consensus among project teams about the necessity of third-party validation. The findings also show that the inclusion of structured approval processes for design changes received a mean score of 3.872, confirming that changes

are reviewed and approved systematically. This finding aligns with the recommendations of Hanyurwimfura (2025), who asserted that structured approval processes enhance project execution by ensuring all modifications align with project goals and regulatory requirements.

Lastly, the assessment of design risk analysis and mitigation before construction scored a mean of 3.895, reinforcing its significance in project success. This finding resonates with research by Sanoff (2020), which argued that proactive design risk mitigation enhances project resilience and prevents costly design flaws from manifesting during implementation.

The aggregate mean score of 3.877 indicates that most respondents acknowledge the importance of robust design controls in mega dam projects. These findings reinforce the assertion that well-structured design processes enhance project quality and long-term performance. Given the relatively low standard deviation across the board, it is evident that these principles are widely accepted and consistently implemented in mega dam projects. These findings therefore align with Njuguna and Kimani (2021), who argue that robust design control minimizes risks, improves construction efficiency, and ensures adherence to industry standards.

Table 3: Descriptive Statistics for Design Control

Statement	Strongly Disagree F(%)	Disagree F(%)	Moderate F(%)	Agree F(%)	Strongly Agree F(%)	Mean	Std. Dev.
There is proper documentation and approval of design modifications.	2.0%	3.3%	23.5%	49.7%	21.6%	3.864	0.865
Compliance with design safety standards is ensured at every stage.	1.3%	3.3%	22.2%	52.3%	20.9%	3.890	0.852
Regular visibility assessments are conducted to check project progress.	1.3%	2.6%	24.8%	48.4%	22.9%	3.889	0.857
The project design is aligned with environmental and safety regulations.	2.6%	3.3%	22.2%	50.3%	21.6%	3.855	0.879
The project design undergoes independent verification and validation before implementation.	2.0%	2.6%	23.5%	52.3%	19.6%	3.875	0.862
Any design changes follow a structured approval process before implementation.	1.3%	2.6%	22.9%	51.0%	22.2%	3.872	0.860
Design risks are analyzed and mitigated before construction begins.	2.0%	2.0%	21.6%	51.6%	22.9%	3.895	0.868
Aggregate Score	-	-	-	-	-	**3.877**	**0.863**

Test for Hypothesis One

The first objective of the study was to assess the influence of design control on performance of mega dam projects in Kenya. The corresponding hypothesis was design control does not significantly influence performance of mega dam projects in Kenya.

A univariate analysis was therefore conducted to test the null hypothesis. From the model summary findings in Table 4, the r-squared for the relationship between design control and performance of mega dam projects in Kenya was 0.309; this is an indication that at 95% confidence interval, 30.9% variation in performance of mega dam projects in Kenya can be attributed to changes in design control. Therefore, design control can be used to explain 30.9% change in performance of mega dam projects in Kenya. However, the remaining 69.1% variation in performance of mega dam projects in Kenya suggests that there are other factors other than design control that explain performance of mega dam projects in Kenya. The study findings are in line with Mashwama, Aigbavboa, and Thwala (2023) who revealed that design changes influences construction project performance

Table 4: Model Summary for Design Control

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.556	.309	.308	.75632

a. Predictors: (Constant), design control

The analysis of variance was used to determine whether the regression model is a good fit for the data. From the analysis of variance (ANOVA) findings in Table 5, the study found out that that Prob>$F_{1, 151}$= 0.000 was less than the selected 0.05 level of significance. This suggests that the model as constituted was fit to predict performance of mega dam projects in Kenya. Further, the F-calculated, from the table (67.683) was greater than the F-critical, from f-distribution tables (3.904) supporting the findings that design control can be used to predict to performance of mega dam projects in Kenya.

Table 5: ANOVA for Design Control

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18.816	1	18.816	67.683	.000[b]
	Residual	42.038	151	0.278		
	Total	60.854	152			

a. Dependent Variable: performance of mega dam projects in Kenya

b. Predictors: (Constant), design control

From the results in table 6, the following regression model was fitted.

$$Y = 0.272 + 0.366\ X_3$$

(X_3 is Design Control)

The coefficient results showed that the constant had a coefficient of 0.272 suggesting that if design control was held constant at zero, performance of mega dam projects in Kenya would be at 0.272 units. In addition, results showed that design control coefficient was 0.366 indicating that a unit increase in design control would result in a 0.366 unit improvement in performance of mega dam projects in Kenya. It was also noted that the P-value for design control was 0.000 which is less than the set 0.05 significance level indicating that design control was significant. Based on these results, the study rejected the null hypothesis and accepted the alternative that design control has positive significant influence on performance of mega dam projects in Kenya. The results are in line with the findings of Odhiambo (2021) who revealed that project design practices influence implementation of projects

Table 6: Beta Coefficients for Design Control

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.272	.070		3.886	.000
	design control	0.366	0.094	0.367	3.894	0.000

a. Dependent Variable: performance of mega dam projects in Kenya

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Design Control and Project Performance

The first null hypothesis test was 'Design control does not significantly influence performance of mega dam projects in Kenya. The study found that design control is statistically significant in explaining performance of mega dam projects in Kenya. The influence was found to be positive. This means that unit improvement in design control would lead to an increase in performance of mega dam projects in Kenya. Based on the findings, the study concluded that design control positively and significantly influences performance of mega dam projects in Kenya.

Recommendations

The study therefore recommends that the management of mega dam projects in Kenya should prioritize thorough design reviews and approvals before and during implementation. This should include involving multidisciplinary experts in the design process, adopting advanced design technologies.

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