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Towards Future Sustainable Infrastructure: The Role of Technical Audit in Tanzania's Public Works

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ABSTRACT

This study aimed to investigate the vital role and impact of technical audits in promoting sustainable infrastructure development in Tanzania. The role and effects of technical audits in long-term infrastructure development were studied using a mixed-methods approach with both quantitative and qualitative parts. Data were collected through analysis of technical audit documentation, a semi-structured questionnaire, and stakeholder interviews. The study revealed the various dimensions of infrastructure investment projects, including initiation and planning, design, procurement of contractors and consultants, contract management, environment, health, and safety. The technical audit findings reported weaknesses or non-performance issues in infrastructure planning at the national level and in infrastructure projects, programs, and portfolios at various stages of their lifecycle that need to be addressed. The implementation of governance approaches aims to address environmental, social, and economic impacts and achieve investment objectives. The audited entities received recommendations for improvements to address non-performance issues. Furthermore, the timely implementation of these recommendations significantly contributed to the achievement of infrastructure development objectives. Based on the findings, the research concluded that technical audits play a significant role in promoting sustainable infrastructure development in Tanzania. The study recommended strengthening the institutional capacity of organisations overseeing technical audits by investing in training programs, professional development initiatives, and knowledge-sharing platforms. These initiatives will help to improve the technical expertise and competency of auditors and project stakeholders, who will consequently benefit from the technical audit of infrastructure development.

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INTRODUCTION

The call for investment in infrastructure arises from the necessity to uphold, update, or substitute current infrastructure, as well as the requirement for supplementary infrastructure to facilitate novel approaches to work and lifestyle for a growing population (Moshood et al., 2023). Infrastructure plays a crucial role in stimulating economic growth. It can facilitate economic progress, especially in

developing nations, and aid in shifting towards a low-carbon economy (Mahmood et al., 2024; Diene, 2024). The increasing needs drive substantial infrastructure development in developing and developed countries, particularly in energy, transportation, healthcare, education, and flood mitigation (Pramono et al., 2023). Infrastructure development requires significant investment in long-lasting assets, typically part of broader development initiatives (Chan et al., 2022). Investing in new infrastructure can yield substantial environmental, economic, and social advantages, as it allows for the construction of resilient solutions to address the impacts of climate change (Moshood et al., 2023). Nevertheless, it can also incur substantial environmental expenses, encompassing building, utilisation, and decommissioning or disposal (Olurin et al., 2023; Barbhuiya & Das, 2023). The repercussions can have either a local or a wide-ranging effect, and the investment in infrastructure may not necessarily be advantageous to the individuals who encounter them (Blasi et al., 2022).

Tanzania's public works sector faces significant challenges related to the quality, safety, and resilience of infrastructure projects (Lauwo et al., 2022).

Inadequate oversight and monitoring during the project execution can result in subpar construction, cost overruns, delays, and even safety hazards (El-Wafa et al., 2024).

Additionally, the effects of climate change and rapid urbanisation further compound these challenges, underscoring the necessity of implementing robust infrastructure management and maintenance mechanisms (Dodman et al., 2022; Beitelmalet et al., 2024). Technical audit plays a pivotal role in addressing these challenges by ensuring infrastructure projects meet quality, safety, and sustainability standards (Thakur & Mishra, 2022; Zhuravlev et al., 2022). These audits are significant as they provide independent assessments of project performance and compliance with technical standards (Sichombo et al., 2009; Mogilny et al., 2020; Likha et al., 2022). As Tanzania works towards achieving its development goals and address the challenges regarding infrastructure development and operation, the role of technical audits in fostering resilience and sustainability of public works cannot be overstated (Dodman et al., 2022; Beitelmalet et al., 2024). Therefore, this study seeks to examine the crucial role of technical audits in advancing sustainable development within Tanzania's public works sector.

LITERATURE REVIEW

Definition and Conceptualisation of Technical Audits

A technical audit is a full evaluation of an organisation or project's technical infrastructure, systems, and processes (Chernousenko et al., 2020; Likha et al., 2022). The assessment aims to evaluate the current state of project, identify issues or potential risks, and recommend improvements to optimise performance, security, and compliance (LeBaron & Dauvergne, 2017; Likha et al., 2022). Technical audits are thorough evaluations performed by independent experts to evaluate the technical facets of infrastructure projects (Thakur & Mishra, 2022).

These audits cover multiple disciplines, including civil, structural, and environmental engineering, and evaluate all project phases from design and construction to operation, and maintenance (Osée, 2016; Zhuravlev et al., 2022; Rivadeneira et al., 2023).

The main objectives of technical audits are to verify compliance to standards, identify potential risks or inadequacies, and offer recommendations for further improvement (LeBaron & Dauvergne, 2017; Likha et al., 2022).

Technical audits scrutinize construction projects to verify compliance with the

technical specifications, building codes, and regulations (Likha et al., 2022). By identifying and recommending areas for improvement, these audits enhance the quality, safety, and efficiency of the construction works. Technical audits typically focus on four key areas (Likha et al., 2022; Thakur & Mishra, 2022).

Sustainability Impacts Arising from Infrastructure Development

Sustainability involves maintaining or supporting processes over the long term without depleting resources or harming the environment, economy, or society (Wiegant et al., 2024). It balances three main pillars: environmental protection, economic viability and social equity (Carlsen & Bruggemann, 2022; Wiegant et al., 2024).

Sustainable infrastructure refers to the design, construction, and operation of infrastructure systems that fulfil present requirements while minimising adverse environmental effects, conserving resources, and ensuring long term economic and social viability (Blasi et al., 2022; Hariram et al., 2023). It is a crucial element of sustainable development, balancing the goals of improving quality of life, fostering economic growth, and safeguarding the environment. Essential attributes of sustainable infrastructure encompass environmental responsibility, economic viability and social equity (Hariram et al., 2023; Pramono et al., 2023). Sustainable infrastructure is about creating systems that address present demands while safeguarding future generations' ability to meet their own needs (Ricciolini et al., 2022).

Infrastructure projects impact sustainability at every stage - construction, operation, upgrades, and decommissioning (INTOSAI, 2013; Laumann et al., 2022). A technical audit is one type of audit that auditors use to check the results of infrastructure development projects and ensure that planning and implementation are done properly throughout the project's life (Thakur & Mishra, 2022).

The different categories of impacts present the effects on land since they impact the landscape, soils, and land use. Ecology impacts the ecology, biodiversity, and natural habitats of flora and fauna. Water resources and the water environment include impacts on groundwater, surface water (lakes, rivers, and streams), oceans and seas, wetlands and aquifers, rainwater, and wastewater. These impacts also affect the water cycle. The materials used during infrastructure construction have a significant impact on the environment. Energy, greenhouse gases, and other emissions to the air have impacts arising from energy use during the construction process, including the operation and use of machinery, transportation, lighting, and other electricity. The human environment (social and economic) impacts the local community, local and non-local economies, and the built historic environment, including heritage sites (INTOSAI, 2013; Blasi et al., 2022; Ojo, 2024).

The Stages in Infrastructure Development

Sustainability and environmental implications should be considered throughout an infrastructure project's lifecycle to minimise the adverse impacts and maximise take-up of the opportunities for benefit (Pramono et al., 2023; Akomea-Frimpong et al., 2023). Figure 1 is a general illustration of how infrastructure is usually built and how it is used. Any type of infrastructure project can be utilised in a variety of scenarios. It is applicable to road, water, building, irrigation, and rail projects, among others (Moshood et al., 2023; Mahmood et al., 2024).

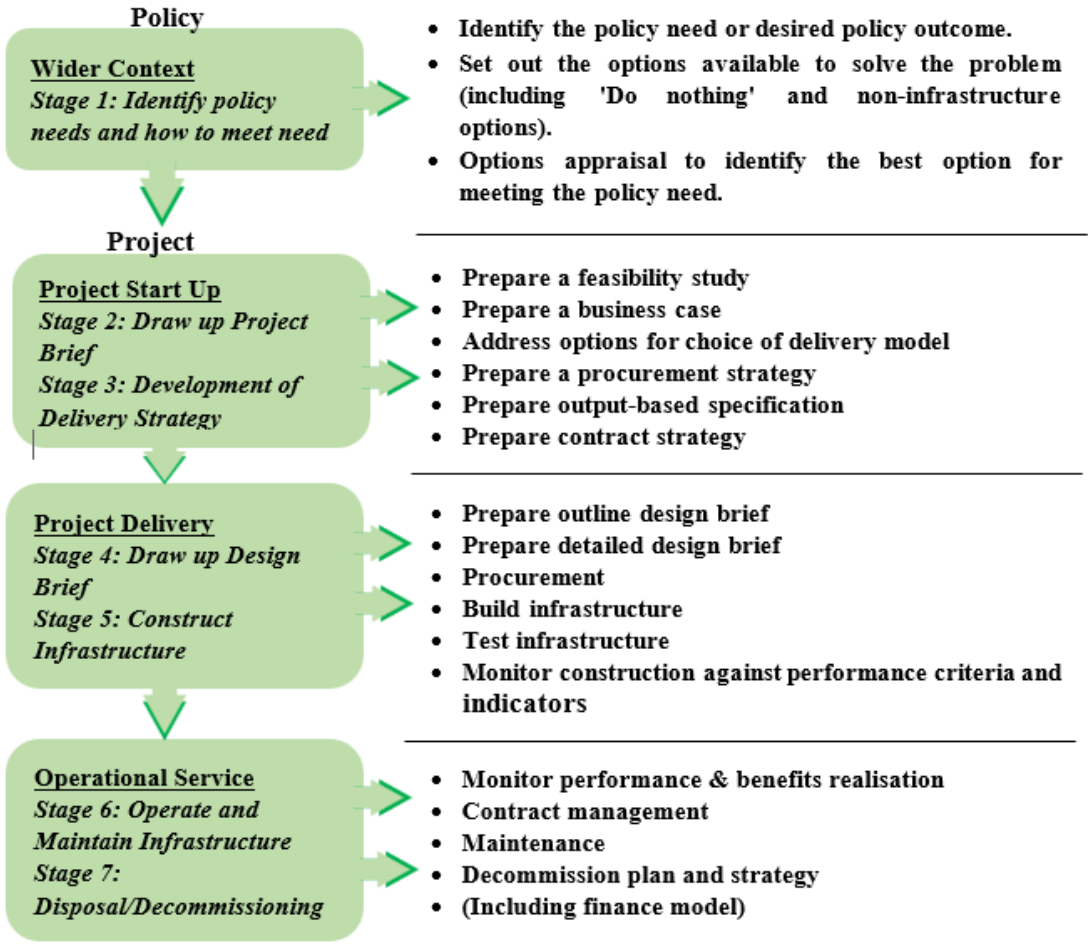

Figure 1: Model of Infrastructure Development (***Source:*** INTOSAI 2013; Sun et al., 2022).

Evaluation of Sustainability Impacts of Infrastructure Using Technical Audit

Specifically, the sustainability impact of infrastructure can be evaluated by conducting technical audits at different stages of infrastructure development and could focus on the following aspects: infrastructure planning at the national level, infrastructure projects, programs, and portfolios at various stages of their lifecycle; implementation of governance approaches aiming to address environmental, social, and economic impacts; and achievement of investment objectives (INTOSAI, 2013; Hirai & Comim, 2022; Ricciolini et al., 2022).

Sustainable Development and Infrastructure Management

As societies try to grow and develop, it's important to make sure they protect the environment and treat everyone equally (Chan et al., 2022; Blasi et al., 2022; Hariram et al., 2023) through sustainable development and infrastructure management. Carlsen and Bruggemann (2022) said that sustainable development is based on three pillars: (a) economic sustainability, which makes sure that economic activities generate enough wealth to last over time, encouraging efficiency and innovation while avoiding practices that deplete resources; (b) environmental sustainability, which protects biodiversity, keeps ecosystems healthy, and uses resources in a way that doesn't harm them or run out over time; and (c) social sustainability, which aims to make sure that everyone has the same chances, builds community, and makes sure that everyone shares in the benefits of development. The United Nations' 17 Sustainable Development Goals provide a global framework for sustainable development

(Carlsen & Bruggemann, 2022). Indicators and metrics for measuring progress falls into two catergories (Hirai & Comim, 2022; Ricciolin et al., 2022). The first type is environmental indicators, including carbon footprint, energy consumption, and waste generation. The second type covers social indicators, including poverty rates, access to education, and healthcare quality. The study by Sun et al. (2022) identified three main theoretical models and principles of infrastructure management. These are: (a) the Asset Management Framework, which is a structured approach involving inventory management, condition assessment, and performance evaluation to optimise infrastructure investments; (b) the Resilience Theory, which focuses on infrastructure systems' ability to optimize investments ensuring continued functionality under adverse conditions; and (c) Sustainable Infrastructure Models, which integrate sustainability principles into planning and development to minimise environmental and social harm. Of the three infrastructure management theories discussed, the study emphasises sustainable infrastructure models to address modern development challenges effectively.

The relationship between Sustainable Development and Infrastructure Management

Sustainable development seeks to fulfil current needs without jeopardizing the ability of future generations to meet their needs. In infrastructure management, enhances economic, social, and environmental performance across the project lifecycle (Ojo, 2024). It integrates environmental concerns, promotes social equity, and ensures economic feasibility in infrastructure planning, design, construction, and operation (Blasi et al., 2022; Ojo, 2024).

The relationship between sustainable development and infrastructure management is defined by five key areas (Laumann et al., 2022; Chen et al., 2022). The first area is the aligning infrastructure management with SDGs. The second area involves implementing sustainable practices in design, construction, and operations to reduce environmental impacts, improve resource efficiency, and promote social benefits. The third area concerns designing adaptable infrastructure to handle future uncertainties contributing to overall resilience and sustainability. The fourth area relates to engaging stakeholders, to align infrastructure projects with sustainability goals. The last area is to emphasise long-term planning and foresight to balance current and future needs.

Role of Technical Audits in Sustainable Development

LeBaron & Dauvergne (2017), Likha et al. (2022), and Fedchenko et al. (2023) assert that technical audits are crucial for sustainable development as they provide individuals with the necessary tools and knowledge to ensure that projects and operations align with sustainability objectives. Technical audits support development by ensuring that projects align with sustainability objectives, optimise resource use, and contribute to long term environmental, economic, and social goals (Górecki & Núñez-Cacho, 2022; Fedchenko et al., 2023). Technical audits emphasise compliance, efficiency, risk management, performance improvement, and transparency, hence assisting organisations and communities in advancing towards a more sustainable future (Thakur & Mishra, 2022; Zhuravlelev et al., 2022; Fedchenko et al., 2023). Technical audits are an important way to promote long-term growth in Tanzania's public works sector, which is in line with the country's goals for economic growth, environmental protection, and social justice (Górecki & Núñez-Cacho, 2022; Chen et al., 2022; Fedchenko et al., 2023). Table 1 presents the eight (8) main institutions involved in technical audits of infrastructure projects in the country.

Table 1: Institutions Involved in Technical Audits of Infrastructure Projects in Tanzania

Institution	Explanations of the technical audit
National Construction Council (NCC)	Carry out technical audits of infrastructure projects
Office of Internal Auditor General (IAG) – Technical Audit Unit	Carry out technical audits of infrastructure projects
Public Procurement and Regulatory Authority (PPRA)	Carry out procurement, contract and value-for-money audits of projects
Road Fund Board	Carry out technical audits of road projects implemented by TANROADS and TARURA and financed through the road user charge, fuel levy, and other charges.
National Audit Office of Tanzania (NAOT)	Conduct technical audits of public works implemented by public authorities, Ministries, Departments, Agencies, Local Government Authorities and Other Bodies.
Architects and Quantity Surveyors Registration Board (AQRB)	Carry out technical audits of infrastructure projects
Engineers Registration Board (ERB)	Carry out technical audits of infrastructure projects
National Environmental Management Council (NEMC)	Carry out environmental audits of public and private projects

Figure 2 presents the conceptual framework that guided this study. The conceptual framework demonstrates the connections between the crucial elements in infrastructure development, technical auditing and environmental and sustainability impacts.

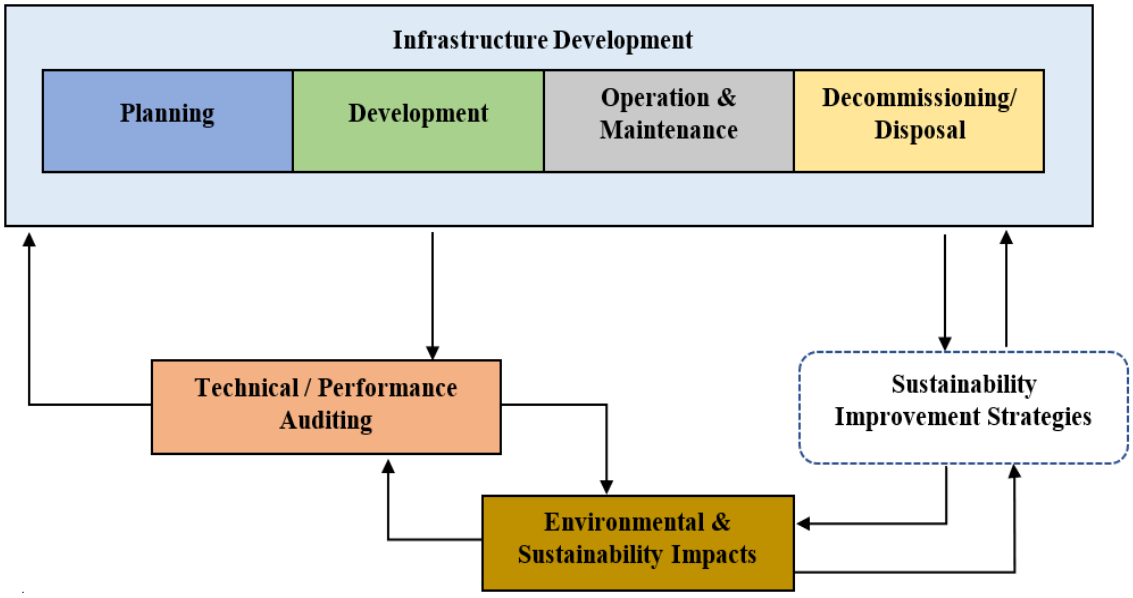

Figure 2: Conceptual Framework.

METHODS AND MATERIALS

This study adopts a mixed-methods approach to investigate the role of technical audits in Tanzanian public works projects (Leavy, 2022). The research design involves quantitative and qualitative components to comprehensively understand the subject matter (Leavy, 2022; Taherdoost, 2022). Quantitative methods were employed to analyse numerical data related to project outcomes, while qualitative methods were used to explore stakeholder perspectives and experiences (Taherdoost, 2022). Quantitative data was collected through analysis of technical audit documentation (Morgan, 2022). Audit documents such as audit reports, follow-up reports, and status

implementation reports on the implementation of recommendations were analysed to assess the impact of technical audits on project performance metrics such as cost, schedule adherence, and quality. Qualitative data is collected through semi-structured interviews with key stakeholders involved in technical audits of public works projects in Tanzania. A total of 128 respondents were selected purposively to ensure representation from technical auditors (two audit offices, six regulatory bodies and engineering firms) and audited entities (government agencies). Interviews were conducted to explore stakeholders' perceptions of the role of technical audits in promoting sustainable development and identifying challenges and opportunities associated with implementing effective audit systems (Del-Real et al., 2023).

To comprehensively analyse the impact of technical audits in Tanzanian public works projects, this study focused on technical audit reports produced by eight technical audit functions in the country. The sample for this study consists of a varied range of stakeholders in Tanzanian public work projects, including government officials, engineers, project managers, and community representatives. Participants were chosen through a purposive sampling technique to guarantee representation from various sectors in Tanzania's. The sample size was established according to the principles of saturation, wherein data collection continues until no additional themes or insights arise. An evaluation of the technical audit reports was performed to determine their impact. The evaluation encompassed 34 technical audit reports produced by the technical auditors of the infrastructure projects from 2020/2021 to 2023/2024.

Quantitative data obtained from surveys and project documents was analysed using statistical techniques including descriptive statistics, correlation analysis, and regression analysis (Unegbu et al., 2022; Thrane, 2022). These analyses offer insights into technical audits' frequency, effectiveness, and influence of technical audits on project performance metrics. Qualitative data obtained from was analysed using thematic analysis methods. Data coding and categorisation are employed to identify recurring themes, patterns, and linkages within the data (Thrane, 2022). The analytical procedure encompasses iterative coding, continuous comparison, and interpretation of results to derive insights into stakeholders' perspectives of technical audits and their significance in sustainable development (Locke et al., 2022).

RESULTS AND DISCUSSION

The Impacts of Technical Audits on Public Works Projects

The analysis of the effects of technical audits on infrastructure investment projects in Tanzania produced notable findings across multiple aspects, including initiation and planning, design, procurement of contractors and consultants, contract management, and environmental, health, and safety concerns. The technical audits concentrated on four key facets of infrastructure development: planning at the national level, implementing governance strategies to mitigate environmental, social, and economic impacts, and meeting investment objectives. The technical audit findings identified as influencing the sustainability of infrastructure investments are presented below and categorised by each of the four key areas.

Technical Audits on the National Approach to Infrastructure Planning

The national approach to infrastructure planning emphasised that technical audits concentrated on three fundamental aspects of infrastructure planning at an overall level. The three primary concerns in this area encompass prioritising national infrastructure investment, the effectiveness of prioritisation process, and the mobilisation of resources from public and private sources. Table 2 summarizes audit

findings on national infrastructure planning (CAG, 2021 - 2024).

Table 2: Findings addressing national approach to infrastructure planning

Aspect	Finding	Frequency (Number of TA Findings)	Percentage out of Total TA Findings
Prioritising National Infrastructure Investment	Inadequate identification of priorities at the national level	1	4
	Lack of coordination between different Ministries in identifying suitable projects	3	14
	Insufficient criteria for the prioritisation of national infrastructure	1	4
Effectiveness of the prioritisation process	Variation between a master plan and implementing agencies	4	19
	Multiple implementations of projects that constrain funds	6	28
	Mismatch between the prioritised infrastructure project and the allocation of funds	2	9
Mobilisation of resources from public and private sources	Lack of critical analysis of possible sources of funds	3	14
	Reliance on funds from a few sources (e.g., fuel levy, railway levy, etc.)	1	4
	Conditions of loans for construction projects not favourable to some projects	1	4
Total		**22**	**100**

Table 2 shows that out of the 34 reports reviewed, 22 highlighted issues that affected planning for infrastructure across the whole country. The results show that technical audits improved project efficiency by identifying and addressing planning flaws. The examined technical audit reports revealed potential issues regarding priorities for national infrastructure projects, how well the prioritisation process works, and the acquisition of resources from both public and private sectors. This scenario was also observed by INTOSAI (2013) and Prebanić & Vukomanović (2023) when they pointed out that governments can achieve more rational approach to decisions on infrastructure investment by comparing the economic benefits and other impacts of major proposals and prioritising them. This procedure may be seen more effective than decisions made within specific government entities as it facilitates the selection of priority projects that optimise economic growth or other national objectives, such as competitiveness. Moreover, as stated by Unegbu et al. (2022) and Wang et al. (20220), technical audits assess the effectiveness of this prioritisation process by examining the investment's requirements and identifying and quantifying its costs and benefits. In addition, technical audits address processes for mobilising resources from public and private sources, any barriers likely to affect deliveries, and government responses to tackle such barriers (Unegbu et al., 2022; Wang et al., 2022).

Technical Audits on Infrastructure Projects and Programmes

It was also noted that eight different organisations in Tanzania conducted these technical audits of infrastructure projects

and programs, underscoring their role in enhancing accountability and sustainability. The main goals of these audits were to make sure that projects were accountable for the money they cost, to find out how they affected or helped the environment, and to find lessons that could be used to improve the infrastructure or the planning of future infrastructure projects. The five main issues addressed in this area include initiation and planning, design, procurement of contractors and consultants, and contract management. Table 3 shows the results from the technical audit reports that were looked at from 2020/2021 to 2023/2024. It looks at infrastructure projects and programs at the program or project level (CAG, 2021; 2022; 2023; 2024).

Table 3: Findings addressing infrastructure projects and programmes

Aspect of the Project Management	Finding	Frequency (Number of TA Findings)	Percentage out of Total TA Findings
Initiation and planning	Inadequate feasibility studies of the infrastructure project	16	35
	Inadequate planning of the construction projects	13	29
	Unrealistic project duration estimates with a risk of project cost escalation	7	16
	Inadequate preparation of plans and strategies for monitoring the construction	6	13
	Mismatch between feasibility study reports and the actual employer's requirements	3	7
Subtotal - Initiation and planning		***45***	***100***
Design of the Infrastructure	Inadequate detailed designs and specifications of the infrastructure projects	24	32
	Inadequate preparation of bills of quantities in construction projects	15	20
	Non-compliance with standards, manuals, specifications, designs, and drawings	12	16
	Inadequate assessment of design parameters	9	12
	Challenges in the management of design changes and design review of the investment projects	9	12
	Unrealistic designs	6	8
***Subtotal* - Design of the Infrastructure**		***75***	***100***
Procurement of contractors and consultants	Delayed procurement of consultants/service providers and electromechanical equipment	9	17
	Irregularities in the evaluation process	7	13
	Undertaking of procurement without approving	6	12
	Delayed commencement of the procurement of works	6	12
	Weaknesses in the negotiation	5	10
	Inadequate procedures in awarding the contracts	5	10
	Unjustified Tender Board decisions	3	6
	Inconsistencies in tendering documents	3	6
	Incomplete bid documents	3	6
	Inadequate use of electronic	2	3

Aspect of the Project Management	Finding	Frequency (Number of TA Findings)	Percentage out of Total TA Findings
	procurement systems		
	Abnormal prices for procurement of services	2	3
	Inadequate bid clarification	1	2
Subtotal - Procurement of contractors and consultants		***52***	***100***
Contract management	Delayed payment	19	18
	Delayed project completion	17	16
	Cost overrun	8	8
	Key staff and equipment were not deployed at the site	7	7
	Inadequate management of performance guarantee, security and bond of the contractor	7	7
	Inadequate quality assurance	6	6
	Materials delivered to the site and constructed items were not tested for quality	6	6
	Delay in site handling over	5	5
	Lack of proof of project securities	4	4
	Delay in engaging supervising consultants	4	4
	Change in scope of work without approval	4	4
	Executed works did not adequately conform to the specifications	3	3
	Inadequate approval of variation orders	3	3
	Variation of the contract price	2	2
	Inadequate recovery of advance payment	2	2
	Payments without supporting documents/justifications	2	2
	Double payment of preliminaries, double pricing/payment of items	1	1
	Abnormal increase in supervision contracts	1	1
	Varying minimum threshold of interim payment certificates	1	1
Subtotal - Contract management		**102**	**100**

According to Table 3, 45 of the reviewed technical audit reports from the last four years were about starting and planning, 52 were about hiring contractors and consultants, and 102 were about managing contracts, mainly project cost, scope, and completion time. The results also show that technical audits make public works projects more efficient by finding and fixing problems in the beginning and planning stages, hiring contractors and consultants, and managing and carrying out the contract. The reviewed technical audits have come up with critical findings addressing project cost, scope, and completion time challenges. Once those identified weaknesses are addressed as a result of a technical audit, it would help to streamline project workflows, optimise resource allocation, and mitigate delays, leading to improved project performance and the timely delivery of infrastructure assets (Odili, 2024).

Technical Audits on the Environmental Impacts of Infrastructure

Various entities, eight technical audit functions in Tanzania, conducted technical audits to address the safety and environmental impact of the infrastructure.

These audits focused on examining the projects to ensure compliance with the health, safety, and environmental laws and regulations governing infrastructure projects' development and operationalisation. Table 4 shows the results of the technical audit reports that NAOT made and put out from 2020/2021 to 2023/2024. These reports looked at risks to health, the environment, and safety (CAG, 2021; 2022; 2023; 2024).

Table 4: Findings addressing environmental, health, and safety risks

Finding	Frequency (Number of TA Findings)	Percentage out of Total TA Findings
Inadequate measures to meet safety requirements and failure to provide adequate safety gear to workers	15	25
Absence of environmental impact assessment	13	21
Inappropriate disposal of wastes within the project area	13	21
Inadequacy of approval of environmental and social impact assessment	5	8
Absence of HIV awareness campaigns	5	8
Inadequate implementation of the Environmental and Social Management Plan	4	6
Non-reinstatement of areas where borrow pit was extracted	2	3
Inadequate advice by consultants on the management of Health, Social and Environment (HSE)	1	2
Ineffective adherence to environmental and social impact mitigation measures	1	2
Use of H&SE plan without being approved	1	2
Lack of fences, signboards, and safety signs on all sites during construction	1	2
Total	**61**	**100**

Findings from Table 4 indicate that out of the reviewed technical audit reports carried out for the last four years, 61 findings addressed matters regarding the environment, health, and safety. One-quarter of the findings from those audit reports highlighted the impending challenge of inadequate measures to meet safety requirements, including lack of safety gear. The other major findings from the technical audit reports include the absence of environmental impact assessment and inappropriate waste disposal within the project area. These results agree with what Zhang et al. (2022) found: technical audits are a beneficial way to reduce the risks that come with public works projects, such as health, safety, and environmental risks. They further pointed out that technical audits help to identify deficiencies and vulnerabilities in health and safety, whereas environmental audits assess the environmental impact of projects and recommend mitigation measures.

Technical Audits on the Attainment of Infrastructure Objectives

Technical audits were reviewed to assess the achievement of infrastructure objects. The analysis of the reviewed reports revealed that all technical audits aimed to determine the value for money of the infrastructure projects. Under that line of inquiry, a detailed analysis of the value-for-money components was conducted, assessing five key areas: economy, efficiency, effectiveness, equity, and environment. All 34 reports reviewed generally showed that all infrastructure projects met their objectives despite some experiencing delays due to delayed project completions. Others also noted that they could achieve their goals only after incurring significant additional costs, primarily due to inadequate design and supervision. This observation aligns with Williams et al. (2023), who reported that achieving value for money necessitates the

project's completeness and initial use, enabling the intended users to reap its benefits. It can be beneficial to users.

Issuance and Implementation of Technical Audit Recommendations

Another important way to see how the technical audit affected things is by looking at how well the affected organisations carried out construction projects after following the suggestions made by the auditors (Thakur & Mishra, 2022; Cao et al., 2022; Wang et al., 2022). The detailed analysis of the extent of implementation of recommendations was made by categorising the level of implementation into three main parts, i.e., fully implemented (when all aspects of the recommendations have been implemented to the fullest and the issue is fully addressed), partially implemented (when some aspects of the recommendations have been implemented but not to the fullest and the issue is partially addressed), and not implemented (when all aspects of the recommendations have not been implemented and the issue is not addressed) (Lengnick-Hall et al., 2022; Chillayil et al., 2022). The number of technical audit findings seen in different areas of project management and the number of recommendations made are shown in Figure 2 (CAG, 2021, 2022, 2023, 2024).

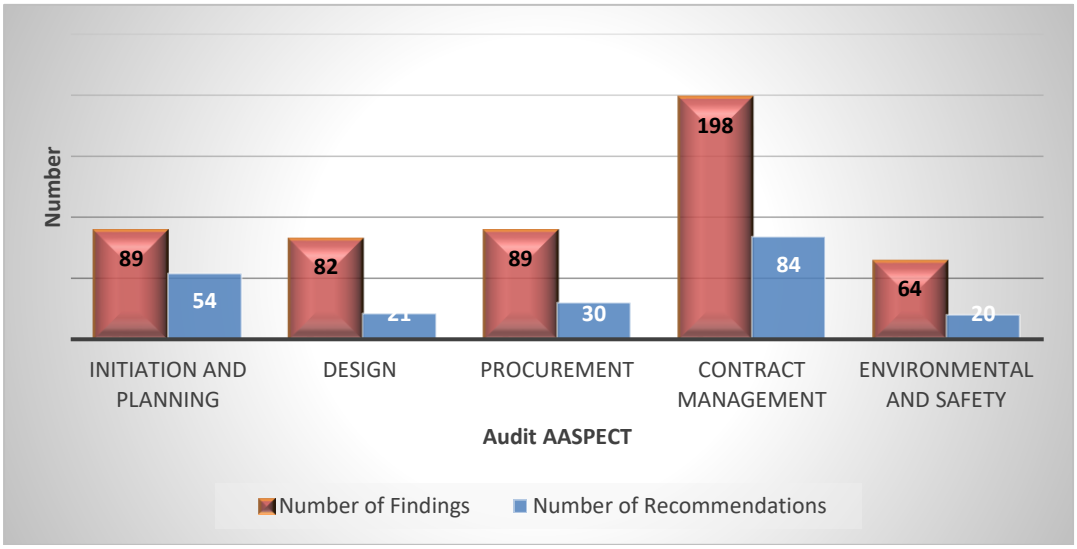

Figure 2: Comparison of the number of technical audit findings and recommendations issued.

The analysis from Figure 2 indicates that there is a positive correlation between the number of technical audit findings and the recommendations issued. The area of contract management yielded a significant number of technical audit findings. This implies that significant modifications are required in that domain to enhance the efficiency and effectiveness of construction projects. Hence, the number of technical recommendations issued is much higher than other aspects of project management. This analysis agrees with the results presented by DeZoort and Pollard (2023), who recommended that to address any noted weaknesses in the audit, one has to deal with the root cause of the weaknesses. Identifying and addressing a single root cause can potentially address multiple identified weaknesses. In the same way, Nolder and Sunderland (2023) said that making suggestions for every audit finding might not get to the root cause of the problems that were found because it would be too focused on fixing each problem individually.

Case Studies and Empirical Evidence

Example of Successful Technical Audits in Tanzanian Public Works

There are several well-known examples of successful technical audits in Tanzanian public works projects that show how

rigorous auditing can improve project outcomes and support long-term growth. These examples showcase the application of technical audits across various infrastructure sectors, including transportation and energy. The level of implementation of the technical audit recommendations was also carefully looked at in a major capital project in the country, the Bus Rapid Transit (BRT), to see if there have been any real improvements since the recommendations were made public. The analysis was made through a review of follow-up on the implementation of recommendations issued from the CAG's Annual Report on Projects.

Dar es Salaam Bus Rapid Transit (BRT) System

The implementation of the Dar es Salaam Bus Rapid Transit (BRT) system represents a successful case of technical audits in the transportation sector. Technical audits were conducted at various stages of the project, including planning, design, construction, and operation, to ensure compliance with safety, quality, and efficiency standards. Auditors identified design flaws, construction defects, and operational challenges through thorough inspections and assessments, leading to timely corrective measures and improvements in project performance. As a result, the Dar es Salaam BRT system has become a model for sustainable urban transport in Tanzania, providing reliable, affordable, and environmentally friendly mobility solutions to millions of commuters in the city.

Level of Implementation of Recommendations and Improvements Made on BRT Project

The analysis from the CAG's Annual Report on Projects (2023) indicated that 41 technical audit recommendations were issued in the technical audit of BRT (Phases I & II). The analysis of the level of implementation of recommendations is presented in Table 5 (CAG, 2023).

Table 5: Implementation of recommendations and improved areas on the brt project

Audited Entity	Number of Issued Recommendations	Number of Recommendations Implemented		
		Fully Implemented	Partially Implemented (Ongoing)	Not Implemented
TANROADS	40	22	18	0
DART	1	0	1	0
Total	**41**	**22**	**19**	**0**
Percentage	**100**	**54**	**46**	**0**

Source: *CAG (2023)*

The analysis from Table 5 shows that two audited entities, i.e., TANROADS and DART, have implemented all recommendations at different levels of implementation. Generally, all recommendations have either been fully or partially implemented. This means that audited entities, TANROADS and DART, have tried to implement the identified gaps. This indicates that the situation is improving, considering that all recommendations have been actioned, and those that are yet to be completed are ongoing since the project is still being implemented in different parts of Dar es Salaam. Costanza-Chock et al. (2022) pointed out that for the audit to have an impact, the implementation rate has to be higher, and if possible, more than 50 per cent of all issued recommendations should be able to experience improvements. The findings presented in this study is consistent with the observations of DeZoort and Pollard (2023) and Nolder and Sunderland (2023).

The example illustrates the transforming influence of technical audits on public work

projects in Tanzania, showcasing its effectiveness in guaranteeing the quality, safety, and sustainability of infrastructure investments. Through rigorous audits and implementation of recommendations, Tanzania can continue to advance its sustainable development agenda and build resilient infrastructure systems that meet the needs of present and future generations.

Challenges and Opportunities

Looking at the pros and cons of technical audits in Tanzanian public works projects taught us a lot about improving capability and skills, getting stakeholders involved and working together, and changing institutions so that auditing systems work better.

Capacity Building and Skills Development

Four things that make technical auditing less effective were looked at. These things had to do with building the technical auditors' skills and knowledge, and the people who answered were asked to rate how much they helped make technical audits of development projects more effective. Therefore, the respondents were asked to rank four factors to address these factors contributing to ineffective technical auditing. All respondents used five Likert scales to rank their importance (very high, high, neutral, low, or not relevant). The results of the analysis from 128 respondents are presented in Table 6.

Table 6: Capacity building and skills development for the technical auditors

Factors Contributing to Ineffective Technical Audits	***Level of Contribution***					***Statistics***	
	Not at all	*Low*	*Neutral*	*High*	*Very High*		
	%	%	%	%	%	*Mean*	*S. D*
Limited technical expertise and professional development opportunities among auditors	4	12	21	39	24	9.6	9.7
Project stakeholders hinder the quality and effectiveness of audit processes	0	2	7	52	39	20.4	17.0
Inadequate training programs and educational resources in emerging technologies	1	1	6	56	36	20.8	17.4
Sustainable practices constrain the ability of stakeholders to leverage innovative solutions and address evolving challenges in infrastructure development	1	3	10	53	33	18.4	15.5

Findings from Table 6 show that developing skills and building up people's abilities are big problems when it comes to doing technical audits of Tanzanian public works projects correctly. Limited technical expertise and professional development opportunities among auditors and project stakeholders hinder the quality and effectiveness of audit processes. Not having enough educational resources and training programs in new technologies and environmentally friendly methods also makes it hard for people involved in infrastructure development to use creative solutions and deal with new problems that come up.

However, the study also identifies capacity-building opportunities through targeted training programs, knowledge-sharing initiatives, and collaboration with academic institutions and international partners (Ebirim, 2024). Tanzania can improve technical auditors' and project stakeholders' capability by spending resources on skill development and professional training (Mosavi, 2024), which will also improve the quality and impact of technical audits on public works projects.

Stakeholder Engagement and Collaboration

Three things that make technical auditing less effective were looked at: how stakeholders were involved and how well they worked together during the audit; respondents were also asked to rate how much they helped make technical audits of development projects more effective. Therefore, the respondents were asked to rank three factors to address the factors contributing to ineffective technical auditing. All respondents used five Likert scales to rank their importance (very high, high, neutral, low, or not relevant). The results are presented in Table 7.

Table 7: Stakeholder engagement and collaboration during the technical audit

Factors Contributing to Ineffective Technical Audits	***Level of Contribution***					***Statistics***	
	Not at all	*Low*	*Neutral*	*High*	*Very High*		
	%	%	%	%	%	*Mean*	*S. D*
Limited stakeholder participation	0	7	13	52	28	16.0	13.7
Collaboration poses challenges to the identification and mitigation of project risks	0	1	5	76	18	22.4	19.2
Adoption of innovative solutions and best practices	2	4	7	54	33	18.8	15.8

Table 7 shows that collaboration and involvement of stakeholders are two important factors that affect the success of technical audits in Tanzanian public works projects. Limited stakeholder participation and collaboration pose challenges to the identification and mitigation of project risks, as well as the adoption of innovative solutions and best practices. Not having good ways to communicate and work together makes these problems even worse, causing uneven information, mistrust, and inefficient project delivery.

However, the study finds ways to improve stakeholder collaboration and engagement by using public consultations, multi-stakeholder forums, and decision-making processes where everyone has a say (McDevitt, 2022). Tanzania can harness stakeholders' collective expertise and resources to address complex infrastructure challenges and promote sustainable development by fostering a culture of openness, transparency, and inclusivity (Mulati, 2022).

Institutional Reforms for Effective Auditing Systems

Three factors related to institutional reforms that contribute to ineffective technical auditing were assessed, and the respondents were given a chance to comment on how much these factors impact the effectiveness of technical audits in development projects. Therefore, the respondents were asked to rank three factors to address the factors contributing to ineffective technical auditing. All respondents used 5 Likert scales to rank the importance of each (very high, high, neutral, low, or not relevant). The results are presented in Table 8.

Table 8: Institutional reforms for effective technical auditing systems

Factors Contributing to Ineffective Technical Audits	***Level of Contribution***					***Statistics***	
	Not at all	*Low*	*Neutral*	*High*	*Very High*		
	%	%	%	%	%	*Mean*	*S. D*
Inadequate regulatory frameworks for technical auditing	0	0	9	38	53	20.4	17.0
Fragmented institutional responsibilities for the technical auditing	0	6	13	44	37	16.4	14.0
Limited enforcement mechanisms for the technical audit	3	8	7	56	26	16.8	14.3

The results in Table 8 show that institutional reforms are needed to make auditing systems in Tanzanian public works projects more effective and trustworthy. The results show systemic problems, such as weak regulatory frameworks, scattered institutional responsibilities, and few enforcement mechanisms, make technical audits less reliable and independent.

However, the study finds ways to improve institutional changes through the establishment of independent audit bodies, the enactment robust legislation and strengthening oversight systems (Upadhyay, 2022: Kurniawan, 2023). Through strengthening institutional capacity, autonomy, and accountability, Tanzania can guarantee the integrity and effectiveness of technical audits, thus optimising their impact to sustainable development outcomes.

Discussion

This study explores the role of technical audits in Tanzanian infrastructure projects, analysing their impact on project management processes, environmental compliance, safety, accountability, and value for money. The findings highlight both the strengths and areas for improvement in the current audit practices, offering insights into national infrastructure planning, project implementation, and the broader institutional framework for auditing in Tanzania.

One of the primary findings of this study was that, technical audits in Tanzania focus heavily on evaluating how national infrastructure investments are prioritized, the efficiency of the prioritization process, and the mobilisation of resources from public and private sources. This is a crucial area, as the capacity to efficiently select and prioritise infrastructure investments is directly tied to national development goals. Previous studies, such as those Jafarzadeh et al. (2002) and Arefazar et al. (2022), underscores the necessity of an effective prioritization approach to guarantee that resources directed towards projects with the highest potential benefit. However, challenges remain in ensuring transparency and long-term alignment with the national development objectives. Furthermore, mobilising resources from both public and private sectors is essential for the success of large-scale infrastructure projects. This corresponds with global trends identified by Akomea-Frimpong et al. (2023), who contended that hybrid financial models are crucial for sustainable infrastructure. While the audits indicate that Tanzania has made progress in this area, however, additional efforts are required to enhance private sector engagement and promote public private partnerships to guarantee the financial sustainability of infrastructure development.

The study also highlighted that technical audit in Tanzania emphasise financial accountability in project expenses, evaluating the environmental impacts to ensure compliance with regulations, and extracting lessons learnt to guide future infrastructure developments. The methodology conforms to international best practices in infrastructure auditing, as

indicated by Pramono et al. (2023) who advocate that audit should emphasise financial accountability, environmental sustainability, and operational effectiveness. The analysis of aspects including project initiation, planning, design, procurement and contract management aligns with findings from Latilo et al. (2024), who recognised these areas as critical touchpoints for addressing inefficiencies in public infrastructure projects. Through identifying lessons learnt from prior projects, technical audits in Tanzania provide a mechanism for continuous improvement, much like those in other countries where audits have become essential for optimising project implementation over time (Wiegant et al., 2024). The findings indicate that although Tanzania's audits have effectively identified deficiencies and formulated corrective measures, there is potential for greater integration of lessons acquired into the broader planning and implementation phases of future projects.

The study revealed that technical audits in Tanzania constantly emphasise adherence to health, safety, and environmental laws and regulations pertaining infrastructure projects. This is especially pertinent since the worldwide dialogue on infrastructure development increasingly focuses on sustainability and adherence to environmental regulations. Prior studies, notably by Olurin et al. (2023) and Barbhuiya & Das (2023), underscores the significance of complying with environmental and safety regulations across the whole the lifecycles of infrastructure projects. The emphasis on safety and environmental impact in Tanzanian audits is commendable although it underscores the necessity for further expertise. The growing complexity of environmental regulations calls for more specialised technical audit functions capable of assessing regulatory compliance and the broader social and environmental outcomes of projects. Strengthening these audits could guarantee that infrastructure development in Tanzania aligns more closely with global sustainability goals.

A main finding of this study was that every technical audit examined included a distinct line of inquiry aimed at assessing whether infrastructure projects delivered value for money. This component of auditing, focusing on the five key areas of economy, efficiency, effectiveness, equity, and environment, mirrors the comprehensive approach used in advanced auditing systems worldwide (Rivadeneira et al., 2023). The findings revealed that the majority of projects achieved their goals despite delays and cost overruns, frequently attributed to insufficient design or supervision. This finding aligns with the broader literature, including Jayakumari (2022) and Schumacher & Schumacher (2023), which observed that delays and cost overruns are prevalent in large infrastructure projects but do not inherently undermine the overall success of the outcomes, which correspond with the intended objectives. The Tanzanian audits effectively identify areas for improvement, emphasising refining project design and implementation processes to minimise cost overruns. This strategy corresponds with the global focus on assessing infrastructure projects not solely based on cost but also considering their wider social and environmental impact, an area where Tanzania might enhance its value for money assessments.

The analysis revealed that a strong correlation exists between the audit findings and the recommendations issued in contract management. This observation aligns with other studies, such as by McDermot et al. (2022), which identified contract management as a key factor in project success. (Sanni-Anibire et al., 2022). The high number of audit findings in contract management signifies the necessity for strong governance structure and improved supervision system. Strengthening contract management processes through more detailed audits and providing clear recommendations for

improvement helps optimise infrastructure delivery. This finding corresponds with the research conducted by Gurgun & Koc (2022), which indicated that improvements in contract management can markedly mitigate risks and enhance project results.
Finally, the study identified several challenges and opportunities in relation to capacity building, stakeholder engagement, and institutional reforms. These findings indicate an increasing acknowledgement that technical audits cannot achieve full effective without the institutions conducting them being well prepared with requisite skills, tools, and support. This is aligning with research by Tetteh et al. (2023) and Ayogu (2023), who emphasised that strengthening auditing systems through capacity building and institutional reforms is critical for improving the effectiveness of audits. Stakeholder engagement is another crucial aspect that surfaced from the findings. The success of technical audits relies not solely on auditors' competencies but also on the collaboration between various stakeholders, including government entities, contractors, and the private sector. According to Ayogu (2023), promoting a collaborative approach to auditing ensures that all parties engaged in the process, hence increasing the likelihood of implementing recommendations.

Lessons Learnt and Best Practices of Technical Audits in Tanzanian Public Works

The implementation of technical audits in Tanzanian public works project has produced valuable lessons and good practices that can guide future endeavour and improve the effectiveness of audit processes. These lessons emphasise the significance of robust audit frameworks, stakeholder involvement, capacity building, and continuous improvement in ensuring the integrity and impact of technical audits.

Establishing robust audit frameworks is critical for successfully implementing technical audits in Tanzanian public work projects: Standardised audit procedures, guidelines, and criteria are essential to maintain the uniformity, transparency, and accountability of audit activities (Upadhyay, 2022). Furthermore, strong regulatory frameworks and oversight mechanisms maintains audit integrity, (Kurniawan, 2023).

Stakeholder Engagement: Effective stakeholder engagement is critical for the success of technical audits in public work projects. Engaging stakeholders at all stages, from project planning to implementation and reporting, enhances transparency, inclusivity and ownership of audit outcomes (Mulati, 2022). Collaborative approaches such as public consultations, multi-stakeholder forums, and participatory decision-making facilitate knowledge sharing, consensus building, and cooperative problem solving. This enhances the use and significance of audit outcomes (McDevitt, 2022).
Capacity Building: Investing in capacity building is essential for enhancing the technical competency and professionalism of auditors and project stakeholders involved in technical audits (Mosavi, 2024). To develop skills in auditing methodologies, technical standards, and emerging technologies relevant to public works projects, entities should provide training programs, workshops, and seminars. Continuous professional development initiatives, knowledge-sharing platforms, and mentorship programs enhance auditor competency and effectiveness (Mosavi, 2024).
Continuous Improvement: Promoting a culture of continuous improvement is essential for maximising the effectiveness and impact of technical audits in Tanzanian public works projects (Mosavi, 2024). Establishing feedback, evaluation, and learning mechanisms enables auditors and project stakeholders to identify areas for improvement, implement corrective actions, and adopt best practices. Regular

review and update of audit methodologies, standards, and procedures ensure their relevance and alignment with evolving industry trends and international best practices (Ebirim, 2024).

CONCLUSION AND RECOMMENDATIONS

Policy Implications and Recommendations

These findings have significant policy implications for strengthening technical audit systems in Tanzanian public works projects and addressing the challenges identified in the study. The study proposes the following policy recommendations to bolster the effectiveness and impact of technical audits: First, the government should focus on enhancing the institutional capacity of government agencies that oversee technical audits. This may involve investing in training programs, professional development initiatives, and knowledge-sharing platforms to enhance auditors' and project stakeholders' technical expertise and competency. Second, to address the challenge of capacity building and skills development, the government should invest in training programs, workshops, and seminars to enhance the technical competency of auditors and project stakeholders. Partnerships with academic institutions and international organisations could facilitate knowledge transfer and skills exchange in emerging technologies and sustainable practices. Third, institutional reforms are essential for addressing systemic challenges and ensuring the effectiveness of technical audit systems. The government should undertake comprehensive reforms to streamline bureaucratic processes, enhance regulatory oversight, and strengthen enforcement mechanisms to prevent corruption and political interference in audit activities.

Conclusion

This study thoroughly explores the role and impact of technical audits on Tanzanian infrastructure projects, revealing key insights into the effectiveness of infrastructure planning, resource mobilisation, and the assessment of value for money. The findings underscore the importance of technical audits in addressing critical issues such as prioritising national infrastructure investment, ensuring financial accountability, and promoting environmental sustainability. The audits demonstrated a clear focus on enhancing the efficiency of public works projects, particularly through detailed examinations of project initiation, procurement processes, and contract management. It was evident that, while most infrastructure projects achieved their objectives, challenges such as delays and cost overruns, often stemming from inadequate design and supervision, highlight the need for stronger oversight mechanisms. The correlation between audit findings and the number of recommendations suggests a critical area for improvement in contract management, which has emerged as a focal point for enhancing project performance and governance.

Moreover, the study highlights the significant role of technical audits in assessing environmental impacts, safety compliance, and broader value-for-money components such as economy, efficiency, effectiveness, equity, and environmental sustainability. This comprehensive evaluation framework is integral to ensuring that infrastructure projects meet immediate needs and are sustainable and beneficial in the long term. In addition, the study identifies several key challenges and opportunities for strengthening technical auditing systems in Tanzania. The importance of capacity building, stakeholder engagement, and institutional reforms cannot be overstated, as these elements are vital for creating more robust, transparent, and collaborative auditing practices that will improve infrastructure

project delivery. In conclusion, while technical audits have proven invaluable for monitoring and improving infrastructure projects in Tanzania, this study highlights the need for continuous improvement in auditing practices, governance, and project management processes. In addressing the gaps identified in this research, Tanzania can enhance its infrastructure development's effectiveness, efficiency, and sustainability, ensuring that it meets both current and future needs in an equitable and environmentally responsible manner.

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