Understanding Technical Conflict Drivers and Management of Construction of Public Water Works Projects in Uganda

Wesigomwe Jamil Mohammed*, Prof. Sabiti Makara, Assoc. Prof. Mesharch Walto Katusiimeh, Assoc. Prof. Lawrence Muhwezi

Kabale University, P. O. Box 317, Kabale, Uganda

ORCID ID: 0009-0003-4129-2943

***Corresponding Author**

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ABSTRACT

This research investigated the effect of technical conflict drivers on management of construction of public water works projects in Victoria, Albertine and Kyoga water management zones (WMZs) of eastern and southwestern regional centers of Uganda's water sector. A positivist paradigm underpinned the research where a cross-sectional design was applied. The population that was involved in this research was 690 from which 468 were simple randomly selected but 448 actually participated in this research. The Advanced Analysis of covariance (ADANCO) was used to analyze data where a Structural Equation Modeling (SEM) accompanied with Bootstrapping was performed to produce results that included measurement loadings, path coefficient and coefficient of determination. Key findings were drawing interpretations were the most causal factor of technical conflicts, followed by quality and workmanship, design changes, technical experience and design errors. There was a negative path coefficient (-0.827) between technical conflict causes and management of construction of public water works projects. Drawing interpretations were the most technical conflict cause that severely undermined management of construction of public water works projects, followed by quality and workmanship, design changes, technical experience and design errors.

Keywords: Technical Conflict Drivers, Management of Construction and Public Water Works Projects

INTRODUCTION

The investigation of this research was about the technical conflict drivers and their effect on management of construction of public water works projects in Victoria, Albertine and Kyoga water management zones (WMZs) of eastern and southwestern regional centers of Uganda's water sector.

This was because despite the Uganda Government and external funders investing a lot in these water projects (Ministry of Finance, Planning and Economic Development (MOFPED), 2025), the management of their construction faced challenges. Key issues included poor quality works, time overruns, budgeted costs overruns and stakeholder dissatisfaction. Poor quality works was in the form of substandard construction, frequent pipeline bursts and public water works projects failure (Ministry of Water and Environment (MWE), 2024). Water pipeline extensions across these regional centers often face delays sometimes requiring new contracts to reach completion (Kiiza & Kityamuweesi, 2025), hindering expansion to growing populations. Construction project schedule extensions and budget projections exceeding original estimates have been reported with some projects requiring multiple phases to reach 85% completion requiring additional cost expenses (MOFPED, 2025). All these have contributed to stakeholder dissatisfaction with these projects. In addition, technical conflicts have been prevalent during the construction of public water works projects in Victoria, Albertine and Kyoga WMZs (MWE, 2018). Technical conflicts in these zones have been reported to frequently occurs at various construction stages with those related to design variations (89% severity), material procurement issues

(19.4%) and weather-related delays (25%) (MWE, 2024). Frequent technical conflicts arise from inadequate feasibility studies leading to poor site (1.1%), inaccurate design specifications (1.5.8) and unforeseen topographical challenges (MWE, 2024). Frequent technical conflict issues arise from the failure of installed systems to meet designated water quality standards or hydraulic requirements (MWE, 2018). These conflicts have been driven by various causes such design errors, quality and workmanship, drawing interpretations, technical experience and design changes. However, empirical evidence show these technical conflict drivers affect the management of construction of public water works projects in these WMZs was lacking. Thus, this research addressed this empirical gap.

This research mattered because it sought to address the high failure rate, cost overruns and delays in public water infrastructure projects in Uganda that led to stakeholders' dissatisfaction by identifying that technical conflict drivers were central to project failure. By focusing on the Victoria, Albertine and Kyoga WMZs, the study provided localized, actionable data to improve water service delivery in these zones, which is crucial for achieving Uganda's national safe water coverage goals.

The Transaction Cost Economics (TCE) was applied in this research to analyze how technical conflict drivers increased hidden ex-post costs, renegotiations and disputes in Uganda's public water projects construction management (Williamson, 2025). The research utilized TCE to link technical conflict drivers directly to higher monitoring and enforcement costs, highlighting the need for improved governance to mitigate opportunistic behavior and cost overruns (Achyut, 2021). The explanation based on TCE theory was that in Uganda's Victoria, Albertine and Kyoga WMZs, technical conflict drivers directly increase the need for intensive oversight, causing higher monitoring and enforcement costs. These transaction costs arise due to bounded rationality (limited foresight) and opportunism (Cuypers, Hennart & Silverman, 2021). Technical conflict drivers in the Ugandan water sector act as triggers for these costs. For example, technical conflict due to frequent changes in work scope lead to high negotiation costs to amend contracts. Inadequate supervision, often caused by limited capacity in Uganda's local government water offices, forces managers to spend more on remedial inspections and conflict resolution. Poor materials or technical incompetence by contractors in Uganda contributes to technical conflicts necessitating increased monitoring (inspections) and enforcement (rework demands). Monitoring costs are expenditures incurred to ensure that contractors adhere to contractual obligations. When technical conflict drivers are high, project managers in the WMZs must increase site inspections, technical audits and testing, thus rising monitoring expenses. Technical complexities in remote areas of Kyoga create information gaps between the ministry and the contractor. Filling this gap requires higher costs for specialized inspectors. Enforcement costs are expenditures related to correcting, penalizing or litigating contract breaches (Fredikind, 2022). TCE shows that high technical uncertainty and weak initial contract design in Uganda's water projects compel higher expenditures on and time spent on, monitoring and enforcing contract compliance. TCE theory highlights the need for improved governance in Uganda's public water sector by identifying that high-stakes infrastructure projects, like those in the Victoria, Albertine and Kyoga WMZs, are prone to inefficiency due to contract incompleteness, asset specificity and opportunistic behavior (Ketokivi & Mahoney, 2015). TCE suggests that because contracts are inherently incomplete and parties are prone to opportunism (self-interest seeking with guile) under conditions of uncertainty and asset specificity (specialized equipment or design), improved governance - meaning better contract management, monitoring and institutional structures - is essential to mitigate these risks (Williamson, 2025).

This research is highly original as it narrowed its focus to the specific intersection of technical conflicts and water infrastructure in three WMZs of Uganda, a specialized area with limited prior academic coverage. This research focused specifically on Victoria, Albertine and Kyoga WMZs, covering eastern and southwestern regions. This covered both established areas (Victoria) and high-development areas (Albertine region - oil sector). Unlike studies focusing on general public buildings or roads, this study focused on public water works, where specific technical issues prevailed. Despite the fact that studies have examined social tensions (land disputes) in Ugandan water projects, this research highlights technical construction factors.

This research contributes to the body of knowledge by analyzing the specific technical conflict drivers such as design errors, quality and workmanship, drawing interpretations, technical experience and design changes that

hinder the construction management of public water projects in Uganda's Victoria, Albertine and Kyoga WMZs. It delineates that while some technical conflict drivers are universal, their effect are specific to these zones. It moves beyond general conflict drivers to focus specifically on technical ones. By investigating the specific technical drivers, the research contributes to formulating targeted risk management plans for project managers, improving how they are handled in the context of the Ministry of Water and Environment (MWE) guidelines.

The audience for this research consisted of stakeholders involved in the planning, implementation and regulation of public water infrastructure in Uganda. Given the focus on technical conflict drivers, management and specific WMZs, the key audiences were MWE, particularly the Directorate of Water Development (DWD) and the Directorate of Water Resources Management (DWRM), which oversee the sector, project planning and the WMZs. Staff from the Victoria, Albertine and Kyoga zones responsible for implementing the water construction projects. National Water and Sewerage Corporation (NWSC) that is responsible managing large-scale infrastructure construction and urban water supply improvements. Included also were firms and engineers working on water projects and face technical challenges that lead to conflicts as well as local officials who directly supervise projects and manage community-level issues. Organizations such as the World Bank, GIZ and NGOs that fund and monitor projects to ensure conflict sensitivity. Academia and researchers interested in construction management, public project performance and water sector governance in Uganda.

The implications for practice for this research are that the findings have significant implications for practitioners and policymakers in the water sector. Key technical drivers often slow technical approval processes, resulting in project delays and cost overruns. Therefore, practitioners and policymakers are likely to use the findings to address the technical conflict drivers that this research investigated to improve the management of the construction of projects.

LITERATURE REVIEW

Technical conflict causes in public water construction project

This literature review synthesizes research on technical conflict drivers in construction projects focusing on design errors, quality/workmanship, drawing interpretation, technical experience and design changes. Design errors - comprising mistakes, omissions and conflicts in drawings and specifications - are identified as a top driver of construction conflicts (Azar, Militaru & Mattar, 2018). Conflicts arise when workmanship does not meet the specified standards outlined in the contract documents leading high amounts of rework, failure to meet quality requirements and safety violations (Kiilu, 2021). Ambiguities in drawings and specifications frequently lead to disagreements between contractors and designers regarding the scope of work (Koc & Gurgun, 2021). This occurs when technical specifications contradict drawings or when drawings lack necessary detail (incomplete information) leading to delays. The lack of technical experience, particularly among junior engineers or subcontractors, is a significant driver of design errors and poor quality contributing to conflicts (Silva, Domingo & Ali, 2023). Design changes during the construction stage are a major source of conflict, often initiated by the owner or mandated by unforeseen site conditions (Muhamad & Mohammad, 2018). These changes disrupt the workflow, requiring rework and resulting in claims for extra time and cost. Literature suggests that technical conflict drivers are highly interlinked. For instance, poor coordination (a technical issue) leads to drawing errors, which necessitate design changes, causing rework and workmanship conflicts.

Effect technical conflict causes on management of public water construction project

A literature review on the effects of technical conflict drivers on the management of public water works projects reveals that technical issues are primary catalysts for project delays, cost overruns and overall failure. These conflicts disrupt the construction process and force managers into reactive rather than proactive project management (Alsulamy, 2022). Literature suggests that technical conflicts are among the most influential factors hindering project success, particularly in public infrastructure (Salooma & Khodeir, 2016). In the context of public water works projects, technical issues such as design errors, poor quality/workmanship,

ambiguous drawings, low technical experience and frequent design changes are particularly damaging due to the high-stakes, specialized nature of water infrastructure, often leading to rework, site stoppages and ineffective management of the triple constraints (scope, cost and time) (Jaffar, Tharim & Shuib, 2022). Conflicts arising from technical problems, such as design amendments or site issues, are major causes of construction delays and increased budget costs (Mitropoulos & Howell, 2018). Conflicts related to defective designs that are a primary cause of rework lead to project cost overruns and additional direct/indirect costs of the contract value (Durand, 2019). Design errors cause disputes between consultants and contractors, leading to legal action and delays in project progress (Olowolayemo, Opeyemi, Oluwatunmise, Olotu & Oyegoke, 2024). Disagreements arise when contractors fail to meet the specified quality standards, causing rejection of work and subsequent conflicts (Gamage & Kumar, 2024). Discrepancies between architectural and structural details or between mechanical and civil plans in water works lead to disagreements on site that slows down project works (Alaloul, Hasaniyah & Tayeh, 2019). Lack of experience among design teams or project managers contribute to inappropriate technology choices and miscalculation of site risks associated with conflicts affecting the construction of projects (Sanni, Bello, Adu & Ojo. 2024). Conflicts occur due to design changes that are often inevitable and have detrimental effects on project cost and scheduling (Ikediashi, Ogunlana & Alotaibi, 2022).

Mitigation strategies already attempted by the MWE to address technical conflict drivers in management of construction of public water works projects

The MWE in Uganda has implemented several mitigation strategies to address technical conflict drivers in public water works projects across the Victoria, Albertine, and Kyoga WMZs. For example, the MWE implemented Environmental and Social Impact Assessment (ESIA) and Resettlement Action Plans (RAP) for projects to identify technical bottlenecks (for example, pipe routing and land disputes) before construction began (Budget Monitoring and Accountability Unit, Ministry of Finance, Planning and Economic Development, 2025; MWE, 2025; MWE, 2022). It strengthened contract management by increased supervision by Regional Technical Support Units (RTSUs) and MWE technical staff to monitor contractor compliance with technical specifications, mitigating risks of poor workmanship (MWE, 2017). It conducted stakeholder consultations, key informant interviews and focus group discussions to identify and address concerns about technical aspects of projects (MWE, 2025). It conducted capacity building for local government engineers and user committees on operation and maintenance to reduce technical failures during the post-construction phase (MWE, 2025a). It established formalized channels to handle disputes including those arising from technical issues as part of the Social and Conflict Analysis (SCA) conducted for projects (MWE, 2025b).

METHODOLOGY

The pragmatism paradigm was relevant to this research because it allowed this research to adopt a mixed-methods approach to understand both the objective causes and subjective experiences of these conflicts (Elgeddawy & Abouraia, 2024). Pragmatism was justified in this research because combining different methods allowed triangulating data to identify the actual root causes of technical disputes their effect of management of the construction of the projects (Wescoat, Koshul & Muhammad, 2025). Therefore, this paradigm helped identify practical context-specific solutions for managing technical conflict causes (Kaushik & Walsh, 2019) in Uganda's public sector, rather than purely theoretical solutions that would fail in the field, aligning with the goal of improving service delivery.

Therefore, the utilization of large-scale surveys meant that a cross-sectional design was applied in this research. This design was relevant and suitable because it allowed for an efficient snapshot analysis of multiple ongoing or recently completed projects across different regions at a single point in time (Creswell & Creswell, 2018). Therefore, given this research covered three distinct WMZs (Victoria, Albertine, Kyoga), this design was the most efficient way to gather data simultaneously from widespread project sites. In addition, the design facilitated quick assessment of relationships between technical variables and project management outcomes across a broad sample.

The selection of the Victoria, Albertine and Kyoga WMZs for this research was justified by their critical roles in the national water sector, high-intensity construction activities and unique, complex and high-stakes operating environments. These three zones covered a substantial portion of Uganda's water and sanitation projects that were being constructed. The areas face specific technical challenges. Focusing on these three zones, the research targeted regions with the most severe infrastructure development bottlenecks, allowing for a comprehensive analysis of the interaction between technical constraints and stakeholder conflicts in Uganda's water sector and their effect on managing projects.

The population that was involved in this research was 690. This consisted consultancy firm management employees, contraction companies' employees, MoWE officials, District Local government officials and non-governmental organizations (NGOs) employees. The unity of inquiry was public water works construction projects' stakeholders in the Victoria, Albertine and Kyoga WMZs. The actual sample size for this research was 448 out of the targeted 468. Simple random was used in the selection of these stakeholders who were required provide the required data through a questionnaire.

Before collecting the data, data quality control was conducted to verify whether the questionnaire was suitable in terms of meeting the accepted statistical ranges. The analysis showed that the construct reliability was higher given that Dijkstra-Henseler's rho (ρA) was 0.9159 within the required range (Redouan, 2025), the Jöreskog's rho (ρc) was 0.8981 within the required range (Cheah, Memon & Chuah, 2018) and Cronbach's alpha (α) was 0.8895 within the required range (Adetayo, 2025). The convergent validity was good because the Average Variance Extracted (AVE) was 0.6451 within the required range of over 0.50 (Dos Santos & Cirillo, 2021).

The Advanced Analysis of covariance (ADANCO) was used to analyze data. This involved conducting the Structural Equation Modeling (SEM) accompanied with Bootstrapping. The first results included measurement loadings used to determine the technical conflict drivers with the highest to the lowest contribution to technical conflict. The second results included path coefficient used to determine the effect of technical conflict drivers on management of public water works projects and the third results included the coefficient of determination used to determine the percentage contribution of technical conflict drivers on management of public water works projects. In addition, qualitative data was analyzed using content analysis to identify themes and explain them for clarity.

RESULTS

Figure presents the first results obtained from the SEM Bootstrapping. These are interpreted after Figure 1.

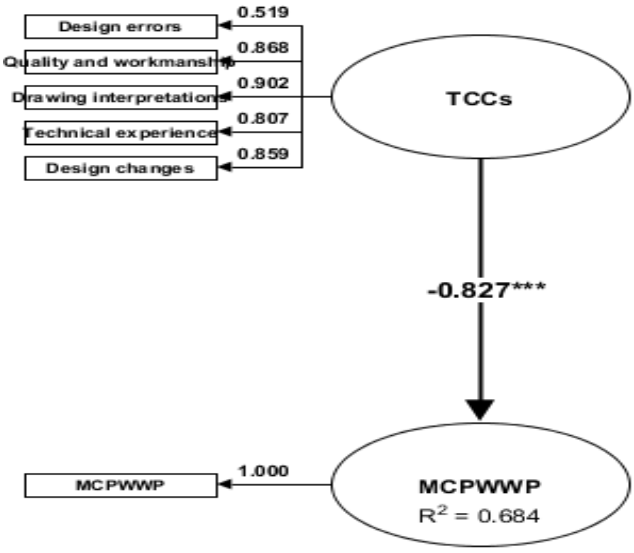

Figure 1: Effect of technical conflict causes on the management of construction of public water works projects in Uganda

NB: Significance level *** $p \leq 0.001$

Measurement model results are shown at the top in Figure 1. These show that drawing interpretations (0.902) had the highest indicator loading on technical conflict causes followed by quality and workmanship (0.868), design changes (0.859), technical experience (0.807) and design errors (0.519). These results show that drawing interpretations are the most causal factor of technical conflicts in construction of public water works projects in Victoria, Albertine and Kyoga WMZs in Uganda, followed by quality and workmanship, design changes, technical experience and design errors.

Interview results provided an in-depth explanation of how some of the most causal factor of technical conflicts. For example, the explanation related to drawing interpretations as causal factor of technical conflicts from key informant 1 focused on four themes. The first theme emphasized misinterpretation of complex drawings (***Competence Gap***) as this key informant revealed that some project workers and field staff lacked the technical skills to interpret complex blueprints, leading to structural or installation errors. These errors forced rework, causing disagreements about who was responsible for the extra cost and time delay during project construction works. The second theme in the explanation from key informant 1 related to drawing interpretations was unclear communication and misunderstanding (***Process Breakdown***) as this key informant observed that the design team sometimes did not provide clear information or some contractors/site workers did not understand the intent behind the drawings. This led to clashes (for example, pipes installed where they were not planned) until a resolution was negotiated. The third theme in the explanation from key informant 1 related to non-compliance with specifications (***Technical Failure***) in that some project workers ignored, misunderstood or failed to adhere to written specifications (details about material quality, dimensions and installation methods). Because of this, projects failed inspections or did not meet safety/functional standards, forcing conflict. The fourth theme in the explanation from key informant 1 related to technical documentation failures (***Design/Planning Errors***) because sometimes the documents themselves were at fault (containing mistakes, omissions or inconsistencies), which causes confusion during implementation leaving too much to interpretation by the contractor.

A detailed explanation of quality and workmanship from the qualitative results was provided by key informant 2 under the following three themes. The first theme was ***Poor Site Management*** where lack of oversight allowed problems to develop, go unnoticed and then worsen leading to conflicts. The second theme was ***Substandard Materials*** where the use of materials that do not meet the specified technical requirements compromises structural integrity and as such, these structural failures contribute to technical conflicts including legal disputes, contractual claims and site delays, as stakeholders disagree on responsibility for the resulting failures and necessary costly repairs. The third theme was ***Unqualified Contractors/Workers*** engaging personnel who lacked the necessary skills, experience or specialized knowledge for water-based infrastructure caused project failures in public pipe water construction leading conflicts from who was responsible for the failures.

Qualitative results from key informant 3 explained three themes of how design changes drove technical conflicts in public water construction projects. . The first theme was ***Site Condition Mismatches*** in that changes in design sometimes failed to align with unexpected ground conditions forcing field-level modifications that disagree with original structural designs and when construction fails to meet the desired expectations, conflicts arise between those who developed the original design and those who made the modifications. The second theme was ***Substitution Disputes*** that arose when changes in material specifications led to disagreements regarding long-term durability or compliance with required standards. The third theme was ***Rework Conflicts*** changes forced the destruction of completed work for example, re-digging trenches for a rerouted pipe, creating disputes over payment for non-value addition work.

Regarding technical experience, qualitative results from key informant 4 explained it terms of three themes. The first theme was ***Inadequate Worker Experience & Skills*** the inability of personnel to perform assigned tasks leads to poor workmanship and defects that resulted into conflicts among those involved. The second theme was ***Poor Site Management & Supervision*** where a lack of proactive management and inspection

meant that errors, such as non-compliance with drawings and specifications, were not identified early causing conflicts on who should take responsibility. The third theme was ***Communication Errors*** in that ineffective communication between contractors, consultants and clients resulted in incorrect instructions which created misunderstandings between these project stakeholders.

The qualitative results from key informant 5 explained the design errors in two themes. The first theme was ***Incompatible Pipe Material Specifications*** whereby specifying inappropriate pipe materials for specific soil conditions, ground pressure or water chemistry led to technical failures such as corrosion or leaks and conflicts over responsibility. The second theme was ***Change Orders and Rework*** in that when design drawings were ambiguous or incorrect, contractors had to stop work and issue change orders, which were major sources of conflict, especially when the government as the project owner refused to pay for additional costs.

Conceptual model results are shown between the two oval spheres in Figure 1. Results show a negative path coefficient (-0.827) between technical conflict causes and management of construction of public water works projects in Victoria, Albertine and Kyoga WMZs in Uganda. This indicated an inverse relationship between technical conflict causes (that included drawing interpretations, quality and workmanship, design changes, technical experience and design errors) and the management of construction projects in the mentioned WMZs. The coefficient of -0.827 is very high, suggesting that as technical conflict causes increase, the quality of construction management or the success of the project management significantly decreases. Increased technical conflict causes are acting as a major roadblock to successful management, hindering progress, causing delays and leading to poor project performance. In the context of Victoria, Albertine and Kyoga WMZs, this means that technical conflict drivers are undermining the ability of managers to keep projects on track, within budget and up to specification.

The second analysis from the SEM involved assessing how each of technical conflict drivers (design errors, quality and workmanship, drawing interpretations, technical experience and design changes) related with management of construction of public water works projects (MCPWWP) as shown in Table 1.

Table 1: Relationship between each of the technical conflict causes and management of construction of public water works projects in Uganda

Indicators of TCCs	MCPWWP
Drawing interpretations	-0.7462
Quality and workmanship	-0.7176
Design changes	-0.7102
Technical experience	-0.6674
Design errors	-0.4294

Source: Primary data

Results in Table 1 show that each of the technical conflict causes (design errors, quality and workmanship, drawing interpretations, technical experience and design changes) negatively related with management of construction of public water works projects in Victoria, Albertine and Kyoga WMZs in Uganda. A negative relationship signifies that as these technical problems increase, the quality of construction management decreases. This finding means that in the Victoria, Albertine and Kyoga WMZs of Uganda, technical issues related to design errors, quality and workmanship, drawing interpretations, technical experience and design changes are directly undermining the management and success of public water infrastructure projects. Furthermore, the highest correlation coefficient (-0.7462) shows that drawing interpretations are the most technical conflict cause that severely undermines management of construction of public water works projects in Victoria, Albertine and Kyoga WMZs in Uganda. This is followed by quality and workmanship with correlation of -0.7176, design changes with correlation of -0.7102, technical experience with correlation of -0.6674 and design errors with correlation of -0.4294.

Qualitative results explained more on how technical conflict causes affected management of construction of public water works projects in Uganda. For example, key informant 1 highlighted a common and destructive cycle in construction project management where technical design flaws translate into conflicts that led to financial losses and compromised final project output. Key informant 2 explained that disagreements regarding construction quality standards and the way they were implemented were not merely technical issues but were major catalysts for project failure, creating a ripple effect that compromised project timelines, budgets and team dynamics. Key informant 3 revealed that ambiguity, errors or poor communication regarding technical drawings in public water works projects led to their misinterpretation that acted as a catalyst for conflict, which subsequently causes project management, financial and contractual failures. Key informant 4 explained that when technical incompetence happened during planning, design or construction, it initiated a domino effect of negative outcomes starting with internal disputes and culminating in poor infrastructure delivery. Key informant 5 opined that when modifications were made to a project's design after the contract was signed often driven by owners, errors or unforeseen site conditions, it triggered a chain reaction of negative impacts including disputes, delays and budget breaches.

DISCUSSION

Importance of this research's findings

The finding of this research that drawing interpretations are the most causal factor of technical conflicts in construction of public water works projects in Victoria, Albertine and Kyoga WMZs in Uganda, followed by other technical conflict causes is critical because it identifies the root causes of delays, cost overruns and failures in critical infrastructure projects. Specifically, identifying drawing interpretation as the primary cause of technical conflicts above design errors or technical experience shifts the focus from merely improving initial designs to enhancing the communication and interpretation of those designs on-site. The following discussion is why these specific findings matter for water works projects in Victoria, Albertine and Kyoga WMZs. The findings of this research emphasized communication gaps (drawing interpretation). When contractors misinterpret drawings, they build components incorrectly. Identifying this as the top issue means the focus should be on better, more detailed drawings, better technical training and improved communication between engineers and site supervisors rather than just blaming the initial design, preventing expensive and time-consuming rework. The findings suggested addressing specific technical challenges. Quality and workmanship was the second-highest cause of technical conflicts pointing to a need for better skilled labor and supervision. Poorly interpreted designs lead directly to poor workmanship, which is critical in water infrastructure where leaks and structural failures can occur (Fatawu, Adamu, Sidik & Fortunatus, 2020). Recognizing that design changes and design errors are major factors contributing to technical conflicts in water construction projects allows for better, more robust planning stages. This reduces the need for costly mid-project design revisions that pause work, which is common in large public works (Shamsudeen, 2016). Poor interpretation of technical drawings often leads to infrastructure that does not work, such as poor pipe alignment or improperly placed water tanks, which can render new water-points useless (Yogen, 2022). The research provides a targeted checklist for project managers. By focusing on 3D modeling, clash detection and pre-construction reviews of drawings, practitioners can reduce the top causes of technical conflicts ensuring projects are completed on time and within budget. Quintessentially, these findings matter because they provide actionable insights to directly reduce the technical conflicts that lead to project failure.

The research finding identifying a coefficient of -0.827 between technical conflict causes and project success matters because it provides strong, quantitative evidence that technical issues are not merely minor inconveniences, but primary drivers of project failure. A coefficient close to -1 indicates an almost direct, extremely high negative correlation, meaning as technical conflicts rise, the quality of construction management and the overall project success drastically drop. Technical conflict causes can ruin project quality (Jaffar, Tharim & Shuib, 2022). This study highlights that resolving these technical issues is the most effective way to prevent the cascading failures that lead to project termination, legal disputes or immense rework. High technical conflict directly leads to poor quality management, creating a vicious cycle of rework, delays and cost overruns (Mitropoulos & Howell, 2018). By recognizing this, managers can intervene early to prevent

these excessive costs. Because the correlation is so high, this finding instructs project managers to focus on proactive technical management - such as detailed early planning, enhanced quality assurance/quality control (QA/QC) and improved supervision - rather than just reacting to the technical conflicts.

The highest correlation coefficient (-0.7462) showing that drawing interpretations is the most technical conflict cause that severely undermines management of construction of public water works projects in Victoria, Albertine and Kyoga WMZs in Uganda followed by other technical conflict causes is crucial. This is because it provides actionable, data-driven insights to identify the root causes of failure in public water infrastructure, which is essential for achieving sustainability and efficiency in Uganda's water sector. The high negative correlation (-0.7462) indicates that as problems with drawing interpretations increase, the effectiveness of project management severely decreases, identifying it as the primary technical conflict undermining these projects. Drawing interpretations (-0.7462) highlights a major skills gap or communication breakdown between designers and contractors. Quality and workmanship (-0.7176) pinpoint that poor execution is as critical as design issues, often causing rework and budget overruns. Design changes (-0.7102) show that lack of early planning and scope creep are destroying project timelines. Technical experience (-0.6674) highlights that contractor incompetence is a significant factor in project delays. By identifying these specific causes, the research allows policy makers and project managers to move away from general assumptions and toward targeted solutions - such as increased quality testing, stricter contractor selection and better review of technical documents. Solving these technical conflict causes is necessary to prevent the use until it breaks down mentality and to boost the 70-85% functionality rates of water sources in Uganda, which have stagnated due to poor maintenance and weak management. The findings emphasize that addressing these technical conflicts is not just an engineering issue, but a critical step to ensure that water investments in Uganda actually provide sustainable, safe and reliable water services to the community.

Linkage of this research's findings to public administration and management

Public administration and management is linked to the finding that drawing interpretations are the most causal factor of technical conflicts in construction of public water works projects in Victoria, Albertine and Kyoga WMZs in Uganda, followed by quality and workmanship, design changes, technical experience and design errors in the following ways. This research finding highlights a critical failure in the administrative, technical and oversight functions of the public sector. The causal factors - drawing interpretations, quality and workmanship, design changes, technical experience and design errors - are directly linked to public administration and management in Uganda through the lens of governance, procurement and competency. The finding show inadequate project governance and oversight. First, in terms of weak supervision - the high incidence of technical conflicts due to drawing interpretation indicates a failure of the supervising consultants and project managers (usually acting on behalf of the Ministry of Water and Environment) to provide clear, actionable and verified technical documents before construction begins. Second, in terms of lack of proper procurement - design errors and technical experience gaps suggest shortcomings in the procurement process, where public officials may be selecting contractors or consultants based on lowest cost rather than technical capacity. The finding show failure in public policy implementation explained as follows. The first issue relates to weakness in monitoring and evaluation - public sector reform studies in Uganda often highlight that, despite guidelines, the actual monitoring and evaluation (M&E) of projects are weak. This study points to failures to verify work quality on-site, leading to disputes over workmanship. The second issue is poor coordination - the findings reflect an information gap between the design phase (central ministry) and implementation phase (contractor/site staff) indicating poor administrative coordination. Furthermore, the findings of this research show human resource and capacity gaps which are explained as follows. First is the technical competence - the issue of technical experience points directly to the capacity of public officers and hired contractors to interpret modern water supply design manuals. Second is lack of capacity building - the findings indicate that, despite training efforts, there is a persistent lack of skill in navigating and managing complex construction projects in the Albertine, Victoria and Kyoga zones. The findings also highlight administrative discrepancy and corruption explained as follows. First are the design variations/changes - frequent design changes can be a red flag for corruption or poor planning, often used in public procurement to inflate project costs or allow for fraudulent contractor claims. Second relates to weak contract administration - the inability to resolve technical

interpretations swiftly leading to conflict shows a lack of proactive contract administration, which is a core function of public management. Lastly, the findings highlight failure in social accountability and community support as they imply that local government officials (district water officers) are not engaging in sufficient consultation to prevent these technical issues from developing into community-level conflicts over water infrastructure.

Public administration and management is linked to the finding that the coefficient of -0.827 is very high, suggesting that as technical conflict causes increase, the quality of construction management significantly decreases in the following ways. The findings relates to Public-Private Partnerships (PPPs). Public water construction projects in Uganda use the PPP model, which involves complex, long-term interactions between public sector agencies (governments) and private firms (International Finance Corporation, IFC, 2013). Technical conflict drivers often arise from inherently divergent stances and institutional logics, as contractors may seek to minimize costs by exploiting design ambiguities. When technical conflict drivers increase, they disrupt the collaborative process, directly leading to lower-quality public infrastructure. The finding is also linked to Failure in public project governance. Public administration is responsible for project governance, which includes setting value systems, processes and policies that ensure accountability, fairness and transparency. A high negative coefficient indicates a breakdown in this governance. Furthermore, the finding is linked to the impact on public accountability and funds. Public officials are accountable for the efficient use of public resources. The finding that conflicts reduce project success implies cost overruns - increased technical conflicts often lead to disputes, arbitration and increased project costs, undermining financial stewardship and reduced quality performance - the findings show that technical challenges directly correlate to a higher frequency of defects, rework and failure to meet specifications. Lastly, the finding related to the need for proactive public management as this research suggests that public administrators cannot passively manage projects. To counter this negative correlation, the findings imply that public administration must adopt proactive conflict management such as investing in detailed planning, hiring experienced personnel and implementing regular communication.

Public administration and management is linked to how each of the technical conflict causes undermined management of construction of public water works projects in Victoria, Albertine and Kyoga WMZs in Uganda in the following ways. The first linkage of public administration and management is the breakdown of administrative control and accountability. There was weak project oversight because the strong negative correlation (-0.7462) between drawing interpretations and management of construction of public water works projects highlights a failure in supervision by public officials. It indicates that those responsible for managing the projects (contract managers, technical staff) lacked the expertise in interpreting, approving or enforcing proper technical designs, directly impacting project quality. In addition, there was failure in contract administration as the finding points to poor contract administration, where the government fails to manage contract relationships, monitor quality, or handle disputes effectively. The second linkage of public administration and management is the mismanagement of public procurement and quality. Poor quality and workmanship (-0.7176) indicates that public procurement processes often award contracts to firms lacking capacity. It points to failure in the technical evaluation stage, resulting in substandard infrastructure. Design changes and errors (-0.7102 and -0.4294) indicate frequent design changes suggesting inadequate project planning and feasibility studies, which are core public administrative functions, leading to increased costs and time overruns. The third linkage of public administration and management is the institutional weaknesses and inefficiencies. Institutional capacity gaps as the findings suggest that local government and the MWE lack sufficient technical capacity to manage public water works projects, which in turn leads to poor oversight and management. Limited conflict management capacity as the high negative correlations represent substantial conflicts that public managers cannot resolve, leading to disputes that stall projects and waste taxpayer money.

Relationship of this research's findings to transactional cost economic theory

TCE Theory explains that technical conflicts in Ugandan public water works projects arise because contracts are inherently incomplete and parties behave opportunistically to minimize their own risks, leading to high transaction costs - such as rework, delays and dispute resolution expenses (Achyut, 2021). The findings

suggest that drawing interpretations, quality/workmanship, design changes, technical experience and design errors are not merely technical issues but indicators of governance failures in managing the contractor-client relationship. Related to drawing interpretations (most causal factor) & design errors, under TCE, these constitute information asymmetry and bounded rationality (Cuypers et al., 2021). The client (government) cannot provide a perfect, unambiguous design and the contractor cannot fully understand it. This incompleteness allows contractors to interpret ambiguous drawings in their own favor (opportunism) or results in technical errors that necessitate costly ex-post renegotiations. As for quality and workmanship, this relates to performance measurement and monitoring costs (Fredikind, 2022). Poor quality often results from a contractor cutting corners (opportunistic behavior) to maximize profits because they believe the cost of being caught is lower than the cost of compliance, a classic transaction cost problem. Related to design changes, these represent ex-post adaptations due to incomplete contracts (Ketokivi & Mahoney, 2015). When initial drawings are insufficient, changes are required during construction, leading to bargaining over "claims" and increasing the transaction costs of the project, often escalating the total cost beyond the original budget. Related to technical experience, a lack of expertise directly relates to high searching and screening costs (ex-ante transaction costs) (Fredikind, 2022). Failing to select a contractor with the appropriate skills leads to increased surveillance needs and conflict during the project execution.

TCE provides a framework for explaining why a high negative coefficient (-0.827) exists between technical conflict and project management success in public construction. According to TCE, this finding suggests that increased technical conflict drives up post-contract transaction costs - the expenses of managing, negotiating and disputes arising after a contract is signed - which in turn severely disrupts the governance efficiency of a project (Cuypers et al., 2021). Public construction projects often involve complex, unique and long-term contracts. TCE posits that contracts are incompletable, meaning they cannot foresee every potential technical issue (Ketokivi & Mahoney, 2015). As technical conflict causes (such as technical disputes over design, unforeseen site conditions) increase, the incompleteness of the contract becomes problematic. This creates behavioral uncertainty and triggers opportunism (Fredikind, 2022), where parties (contractor/public owner) engage in haggling or bargaining over claims rather than focusing on quality, reducing project success. These technical conflict drivers act as direct triggers for high transaction costs (ex-post costs) (Achyut, 2021) that include haggling costs (time and money spent negotiating changes), monitoring costs (increased inspection needed to ensure quality) and dispute settlement (costs associated with arbitration or litigation). As more project resources (time, money, management attention) are diverted to managing these disputes (transactional activity), less is available for the actual, high-quality production of the construction, reducing overall success. TCE's bounded rationality explanation also applies to the high negative coefficient (-0.827) because the inability of actors to process all information instantly means technical disputes quickly overwhelm the project team. A high number of technical conflict causes exceed the ability of public project managers to govern the contract effectively, leading to lower quality and delayed schedules. Therefore, to summarize in the context of public administration, TCE implies that technical conflict is not just a nuisance; it is a hidden cost driver. The -0.827 coefficient highlights that if public sector organizations do not proactively manage these conflict drivers - through better contract design or early engagement - the resulting surge in transaction costs systematically erodes project quality and success.

TCE applies to how each of the technical conflict causes undermined management of construction of public water works projects in Victoria, Albertine and Kyoga WMZs in Uganda in the following ways. Transaction Cost Economics (TCE) helps to understand that the high negative correlations (-0.7462 to -0.4294) in the findings of this research represent transaction costs - the hidden, non-production expenses incurred when managing the exchange, monitoring performance and resolving disputes (Ketokivi & Mahoney, 2015). The application of TCE concept of information asymmetry and bounded rationality (Achyut, 2021) is on drawing interpretations (-0.7462) and technical experience (-0.6674). The explanation is that contractors and consultants often have different interpretations of technical drawings, leading to information asymmetry (one party knowing more than another). When contractors lack experience or misunderstand drawings, they must stop work to seek clarification or make incorrect assumptions (bounded rationality). This necessitates high monitoring, re-design or dispute resolution costs, strongly undermining project management. The application of TCE concept of behavioral uncertainty (opportunism) is on quality and workmanship (-0.7176). The

explanation is that poor workmanship often stems from contractors cutting corners to reduce their own costs (opportunism) or due to lack of skill. The result is that the owner (government) has to increase costs for inspection, quality testing and enforcement to ensure compliance, leading to high transaction costs. The application of TCE concept of environmental uncertainty and incomplete contracting is on design changes (-0.7102) and design errors (-0.4294). The explanation is that public water works in Uganda face high uncertainty due to unforeseen site conditions or poor initial planning and as such, contracts are rarely complete, leaving gaps. The result is that design errors and changes require negotiating new contract terms (change orders), leading to high bargaining costs and project delays (lowered management performance).

CONCLUSIONS

Based on the finding that drawing interpretations are the primary cause of technical conflicts, with subsequent factors including quality/workmanship, design changes, experience and errors, the following conclusions can be drawn for public water works projects in the Victoria, Albertine and Kyoga WMZs. The dominance of drawing interpretations as the top causal factor of technical conflicts indicates critical failures in the communication chain, where design intent is not being accurately translated to the physical site by contractors or consultants. The identified order of factors suggests a linear chain of conflict where poor or ambiguous initial documentation (design errors) causes confusion (drawing interpretation), leading to in-field mistakes (quality) and culminating in costly variations. Given the high topography of the Albertine WMZ and the water quality issues in Victoria/Kyoga, these technical conflicts suggest a mismatch between the provided technical designs and the complex site-specific physical conditions, indicating a need for greater emphasis on pre-construction site investigations and interdisciplinary review of drawings. The ranking highlights a concurrent problem of low contractor technical experience and inadequate supervision, which prevents the effective implementation of even moderately complex designs.

Based on the high negative coefficient of -0.827, the findings demonstrate that technical conflicts are a critical, detrimental factor in construction management. The research concludes that an increase in technical conflict causes leads to a significant, direct decline in both the quality of construction management and overall project success (in terms of budget, time and stakeholder satisfaction). The strong relationship suggests that mitigating technical conflicts must be a top priority. This involves adopting comprehensive, early-phase project planning and implementing robust, clear and detailed design documentation to avoid subsequent changes. The findings imply that employing highly experienced consultants and contractors is essential to reducing errors that lead to technical conflicts. The findings imply that investing in high-quality technical planning and management at the beginning of the project acts as a protective mechanism against technical disputes and poor project performance.

Ethical Compliance

Statement of ethical considerations

These were the principles and procedures applied to this research ensuring compliance with research standards and regulations.

Voluntary Participation: The project managers, engineers and contractors voluntarily engaged in this research, with the freedom to withdraw at any time without penalty or pressure.

Informed Consent: The project managers, engineers, consultants, contractors and other key stakeholders received a clear explanation of the research purpose, methods and risks. Verbal consent was secured, ensuring they understood the study's implications, particularly because the research touched conflict management - potentially sensitive issue.

Contextual Approach: In line with Ugandan water sector research standards, as the researcher, I ensured that consent from the line Ministry and local community representatives was obtained through appropriate engagement channels.

Protection of Identity: Given that the study examined technical conflict drivers and management issues which could implicate professionals in poor performance or mismanagement, strict anonymity was maintained. Participants' names were not linked to their responses.

Data Security: Data from the questionnaire was securely stored with access restricted to me as the researcher and my research supervisors.

Anonymized Reporting: All findings have been reported in an aggregated or anonymized manner to ensure that no individual can be identified, preventing professional or personal repercussions.

Statement of data availability

The data for this study is available from the researcher, a student of Kabale University, Uganda. It can be accessible upon request from me through my e-mail. The quantitative data regarding technical conflict drivers and management of construction of public water works projects was collected from key informants, including project managers, engineers, consultants, contractors and other key stakeholders in the Victoria, Albertine and Kyoga Water WMZs. Only anonymized, aggregated datasets and findings are available upon request to me - the corresponding author.

Statement of conflicts of interest

The authors of this research declare that they have no known competing financial interests, personal relationships or allegiances to particular construction firms, consultants or regional water offices in the Victoria, Albertine, or Kyoga WMZs that could have appeared to influence the work reported in this article. The findings were not swayed by affiliations with the contractors or clients (Ministry/NWSC). The study acknowledges the challenges in the Uganda's Water Sector, such as corruption, political interference or site-related issues mentioned in this research. No authors of this research were actively managing or supervising the specific construction contracts in the studied zones during the research period.

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