MAKERERE UNIVERSITY

MAKERERE UNIVERSITY BUSINESS SCHOOL

ASSESSING NON-REVENUE WATER MANAGEMENT AT NATIONAL WATER AND SEWERAGE CORPORATION KAMPALA

BY

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PLAN B

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DECLARATION

I hereby declare that tis dissertation is a direct result of my own original ideas and has never been submitted to any institution of higher learning for any academic award

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APPROVAL

This is to certify that this dissertation has been submitted with our approval as university supervisors.

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DEDICATION

I Basigirenda Birungi Betty dedicate this piece of work to my dear father Mr. Basigirenda Wilfred and husband Mr. Mugabi Arafat for supporting me through this entire journey**.** Truly without their presence and support, I wouldn't have achieved my goals.

I also dedicate this piece of work to the entire family, my mother Ms. Nalunga Sauda, Ms. Basigirenda Margret and my sister, Basigirenda Marion Stinta for encouraging me and pushing towards success.

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May the Almighty God reward you abundantly.

LIST OF ACRONYMS

WSPs: Water Service Providers

NRW: Non-Revenue Water

IWA: International Water Association

WASREB: Water Services Regulatory Board

IWSSM: International Center for Water Security and Sustainable Management

EWURA: Energy and Water Utilities Regulatory Authority

NWSC: National Water and Sewerage Corporation

SCAP: Service Coverage Acceleration Programme

GPR: Ground penetrating radar

AFWA: African Water Association

SCADA: Supervisory Control and Data Acquisition

AMI: Advanced Metering Infrastructure

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ABSTRACT

This study assesses Non-Revenue Water (NRW) management at the National Water and Sewerage Corporation (NWSC) in Kampala, Uganda, focusing on current practices, challenges, and strategies for improvement. Guided by three objectives, the research examines the state of NRW management, identifies associated challenges, and proposes strategies to enhance performance. Employing a cross-sectional research design with a quantitative approach, data was collected from 162 NWSC employees using structured questionnaires on a five-point Likert scale. The study utilized descriptive statistics for analysis, conducted via the Statistical Package for the Social Sciences (SPSS). Findings reveal a neutral perception of NRW management, indicating both strengths and significant gaps. Respondents acknowledged moderate use of advanced technologies like smart meters and IoT, alongside relatively accurate metering systems. However, infrastructure maintenance and financial resources for modern strategies were perceived as inadequate, reflecting persistent physical losses due to aging pipes and insufficient funding.

The study identifies critical challenges, including dilapidated infrastructure, worn-out meters, insufficient funding, corruption, and reactive maintenance practices. These factors, compounded by inadequate pressure control and obsolete record-keeping, exacerbate water and revenue losses, straining NWSC's financial sustainability and disproportionately affecting marginalized communities. Corruption, particularly illegal connections and overcharging, further inflates NRW, highlighting the need for robust governance. Proposed strategies received strong support, emphasizing advanced leak detection technologies (such as acoustic sensors, drones), pressure management through pressure-reducing valves, and smart metering to enhance billing accuracy. Infrastructure renewal, proactive maintenance, and customer engagement via conservation education and leak-reporting incentives were also endorsed. Additionally, integrating geographic information systems, SCADA, and AI-driven analytics, alongside staff training, was recommended to improve efficiency. Phased technology deployment and benchmarking against low-NRW countries were seen as viable approaches to overcome financial and technical barriers. Accordingly, NWSC must prioritize infrastructure upgrades, transparent governance, and community involvement to reduce NRW to the 30% target by 2029

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Water Service Providers (WSPs) or water utilities are responsible for the distribution of clean water and sewerage services to citizens. Their functions include sourcing, treating, preserving, and delivering potable water to end-users while invoicing consumers based on tariffs and quantities consumed. Given the capital-intensive nature of these operations, water utilities rely heavily on revenue from customer payments to sustain their services (Cobbinah et al., 2015). However, these utilities often face inefficiencies such as water losses, which result in non-revenue water (NRW) defined as the difference between the volume of water supplied into the distribution network and the volume billed to customers (Vandenberg, 2015).

The International Water Association (IWA, 2019) identifies several factors contributing to NRW, including unauthorized water use, inaccurate data collection, aging water networks, metering errors, and leakages or major pipe bursts. The persistence of NRW poses a significant challenge to water utilities globally, as it leads to both water and energy losses. Despite efforts by various utilities to address this issue, NRW remains a widespread problem, threatening the expansion and sustainability of water service providers (Abueltayef et al., 2023). Uncontrolled NRW undermines service delivery, affects water quality, and weakens stakeholder confidence. Addressing NRW effectively can enhance water availability, improve service reliability, and contribute to financial sustainability through the reduction of unnecessary operational costs (Liemberger & Wyatt, 2019).

Globally, NRW is estimated at 126 billion cubic meters of treated water lost annually, amounting to financial losses of approximately USD 39 billion (Liemberger & Wyatt, 2019). In Africa, an audit by the African Water Association (AFWA) in 2017 found that unaccounted-for water represented 37% of total water production, revealing governance and operational inefficiencies in many water utilities. High levels of NRW remain a critical issue in developing countries, as significant amounts of treated water are lost before reaching consumers, making sustainable water management a pressing priority (UNESCO & IWSSM, 2019). For instance, if a country produces 450,000 m^3 of water per day but loses 25% of it, it results in an annual financial loss exceeding USD 13 million in chemical, labor, and energy costs (World Bank, 2020).

In sub-Saharan Africa, outdated water distribution infrastructure, inaccurate meter readings, poor data management, and weak regulatory enforcement contribute to the rising NRW levels. The expected NRW threshold for sustainable urban utilities in the region is 23% (World Bank, 2020), yet several countries exceed this benchmark. Tanzania's Energy and Water Utilities Regulatory Authority (EWURA) reported an average NRW of 38%, surpassing the national target of 20% (Shushu et al., 2021). In Kenya, the Water Services Regulatory Board (WASREB) reported that NRW stands at 42% and has been increasing, with a national target to reduce it to 20% under Vision 2030 (WASREB, 2022). Similarly, South Africa recorded an NRW increase from 35% in 2015 to 46.4% in 2022, translating into an annual water loss of approximately 1,988.50 million cubic meters (Department of Water and Sanitation, 2022).

In Uganda, the National Water and Sewerage Corporation (NWSC) serves over 258 towns, with a strategic focus on achieving universal water access through the Service Coverage Acceleration Programme (SCAP) (NWSC Corporate Plan, 2018–2021). However, NRW remains a major constraint, currently standing at 34% nationally, with Kampala accounting for 43.7% as per the 2024/2025 fiscal year (NWSC Approved Budget, 2024). Since Kampala represents more than 65% of NWSC's operational area, its high NRW levels significantly impact the corporation's performance. The current NRW figures, averaging around 48% at NWSC, continue to impede efficient water delivery despite the corporation's efforts to reduce losses through customer sensitization, leak repair, meter servicing, and pressure management techniques. The persistent increase in NRW has resulted in rising operational costs, including frequent pipeline renovations and emergency repairs, thereby undermining NWSC's financial sustainability (NWSC, 2022). Moreover, NWSC loses close to 5 billion annually due to NRW (NWSC Corporate Plan, 2024).

As such, detailed assessment of NRW management at NWSC Kampala is crucial to examine the existing approaches to non-revenue water management at the National Water and Sewerage Corporation. This study aims to assess the challenges affecting effective nor revenue water management and suggest strategies to improve non-revenue water management at NWSC in Uganda.

1.2 Problem Statement

Efficient water resource management is a fundamental requirement for the sustainability of water utilities. As the primary provider of piped water in Uganda, the National Water and Sewerage Corporation (NWSC) is mandated to ensure reliable, affordable, and sustainable water supply. However, the persistent increase in non-revenue water (NRW) has posed a major challenge to NWSC's operational efficiency, financial stability, and service delivery. Despite various interventions such as leak repairs, customer awareness campaigns, and pressure management strategies, NWSC continues to experience significant water losses due to leakages, pipe bursts, illegal connections, meter inaccuracies, and outdated infrastructure**.** Many of these losses remain unresolved for extended periods due to delays in acquiring repair materials, further escalating water wastage. Existing data shows that NRW in Uganda has risen from 26% in 2021 to 34% in 2024, indicating a worsening trend (Corporate Plan, 2024). In financial terms, NWSC recorded 87 million cubic meters in water sales against a projected 137 million cubic meters, resulting in an annual revenue loss of approximately UGX 5 billion (NWSC Corporate Plan, 2024). Kampala Water alone accounts for 43.7% of the total NRW losses (Sarah Nabasa 2025)**,** making it the most affected region with most losses recorded under water theft. Currently, the global levels of NRW in NWSC stands at 33.9% and Kampala Water stands at 39.8% (The Intergreted Annual Report 2023/2024). These losses not only strain NWSC's revenue but also jeopardize its ability to infrastructure improvements, expand service coverage, and maintain operational efficiency. If the issue remains unaddressed, NWSC may struggle to sustain its operations, leading to potential service disruptions and increased dependence on government subsidies. Moreover, continued inefficiencies in water management undermine Uganda's efforts to achieve universal access to safe drinking water under Sustainable Development Goal (SDG) 6 of enhancing water use efficiency**.** Therefore, this study, therefore, seeks to assess NRW management at NWSC Kampala, evaluate the effectiveness of existing interventions, and propose practical solutions aligned with global best practices**.**

1.3 Purpose of the study

The study seeks to examine the management of Non-Revenue Water at National Water and Sewerage Corporation Kampala Area.

1.4 Objectives of the study

i. To examine the current state of Non-Revenue Water management at National Water and Sewerage Corporation Kampala Area.
ii. To establish the challenges associated with NRW management at NWSC-Kampala.
iii. To ascertain the strategies needed to address the challenges faced by the area in the management of NRW.

1.5 Research Questions

i. What is the current state of NRW management at NWSC Kampala?
ii. What are the NRW Management challenges?
iii. What strategies should be employed to improve NRW Management at NWSC Kampala?

1.6 Significance of the study

This study strives to assess how management at NWSC Kampala handles NRW in details and exposes its dos and don'ts and how they have led to a reduction or increase in the levels of NRW. The study will provide a deeper insight of how different WSPs operate visa vie NRW and also depict on how effective implementation of NRW reduction strategies improves service delivery, financial sustainability, stake holder involvement and commercial adaptability of the WSPs especially Kampala water through reduction of water losses hence ensuring efficient utilization of public resources for the benefit of all citizens in Kampala and Uganda at Large.

This study will also be of great help to water sector players, development partners, policy makers, project managers, contractors and the government to focus on NRW reduction in order to facilitate service delivery and guarantee financial sustainability in the water sector. The findings of this study are useful in formulating better strategies, policies and regulatory tools to enhance performance in the water sector.

The outcomes of this investigation contributes to widening the requirements in the area of NRW management and hence provide a reference material to researchers who can critique it and get a basis for further research in the water sector. The results of this study will support the researcher by widening his or her knowledge as a master's student through discovering information that goes beyond class syllabus.

1.7 Scope of the study

1.7.1 Geographical scope

The geographical scope of the study is confined to National Water and Sewerage Cooperation Kampala water. Kampala, the capital of Uganda covers most of the corporation's operational area, registering more than 65% of its operations. It is also recognized as one the cities that have developed so fast in Africa and having an annual growth rate of about 5.6%. Over the past ten years, NWSC Kampala has expanded in all capacities including taking over the satellite towns such as Mukono, Entebbe, Mpigi, Bombo, Wakiso and the surrounding peri-urban areas. It registers the biggest percentage of NRW which is at 40% according to the current NWSC approved budget 2023/2024.

1.7.2 Contextual scope

The study's boundaries will be bound by its objectives and research queries, mainly focusing on finding out the current practices management is using to bridge the non-revenue water gap and how each practice is helping, the challenges it has faced, why the problem is still existing and the strategies that should be practiced to achieve a big improvement

1.7.3 Time scope

This survey was undertaken for two months between March, 2025-May 2025. Overall, the dissertation took 10 months August 2024 to May-2025. It included the following the following activities; document review, proposal writing and submission for examination (four months), data collection (one month), final report writing, submission for examination.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter elucidates the concept of NRW, a pervasive issue confronting water utilities, encompassing both tangible losses (leakages and burst) and intangible losses (unpermitted consumption and metering errors). The effective management of NRW is crucial for Water Service Providers to improve operational efficiency, service delivery, and financial sustainability. This literature review explores the current state of NRW management globally, the challenges and strategies with a focus on the specific context of Uganda especially at Kampala Water.

2.1 Non-Revenue Water management.

Non-Revenue Water (NRW) remains a critical challenge for water utilities globally, particularly in developing countries like Uganda, where the National Water and Sewerage Corporation (NWSC) reported an NRW level of 34% in 2024, with a target to reduce it to 30% by 2029 (NWSC, 2024). Recent scholarship emphasizes management's pivotal role in NRW reduction, aligning with older findings but introducing advanced technological and governance perspectives. Nwachuku et al. (2019) argued that organizational strategy implementation drives strategic performance, a view echoed in Ernest Engolo's (2022) Kenyan study, which recommended in-depth NRW assessments and resource allocation. Recent studies build on this. For instance, Smith et al. (2023) highlight how data-driven decision-making, enabled by machine learning and IoT (Internet of Things), enhances NRW management in urban utilities. They cite examples from Southeast Asia where real-time leak detection reduced NRW by 15% within two years. In Uganda, NWSC's efforts to expand metering (such as, smart meters in Kampala) align with this trend, but implementation lags

due to funding and technical capacity, suggesting a need for accelerated adoption to meet the 30% target.

Management's role in staff motivation remains key. Mamun and Khan (2020) noted recognition as a motivator, while Edwards (2014) emphasized leveraging financial and human resources. A 2024 study by Patel and Nguyen in Water Resources Management introduces gamification as a modern staff motivation tool, showing a 20% productivity increase in Indian utilities. In Uganda, where staff commitment varies across 276 towns under NWSC, such innovative approaches could complement traditional incentives, though cultural and resource constraints might limit scalability. Globally, recent scholarship underscores technology's role in NRW reduction. Li et al. (2024) in advocate for digital twins, virtual models of water networks to predict and mitigate losses, achieving NRW drops from 25% to 18% in Chinese cities. Comparatively, NWSC's reliance on bulk and consumer metering (Simukonda et al., 2018) is less advanced, with Kampala's historical 43.7% NRW (2021) indicating persistent infrastructure gaps. Uganda could benefit from pilot digital twin projects though high initial costs pose a barrier.

Apparent loss management, as Mutikanga et al. (2011) suggested, involves tackling unauthorized consumption and metering inaccuracies. A 2025 report by the International Water Association (IWA) highlights block chain-based billing systems reducing commercial losses by 10% in South Africa. In Uganda, illegal connections remain a challenge (such as, marginal districts noted by González-Gómez et al., 2011), and NWSC's public campaigns on leak reporting (X posts, Feb 2025) show intent but lack such advanced tech integration. Adopting block chain could bolster revenue, though it requires significant investment and regulatory support. Frauendorfer and Liemberger (2010) stressed utility owners' awareness of NRW costs, a point reinforced by McKinsey (2011). Recent work by Jones et al. (2023) in Environmental Science & Technology

argues for stakeholder-inclusive governance, noting a 12% NRW reduction in Brazil via community-led monitoring. In Uganda, NWSC's customer engagement, for instance, incentives for leak reporting (Nyende & Kiryowa, 2016) is nascent but promising. Expanding this could counter the 34% NRW, though political will and funding remain hurdles.

Compared to international trends, Uganda's NRW management lags in technological adoption (for instance, IoT, digital twins) but aligns with governance and motivation strategies. The 34% NRW exceeds the global best practice of 23% (World Bank, 2020). For the future, integrating advanced tech could accelerate reductions, but Uganda's financial constraints (5 billion shillings lost annually at 34% NRW) argue against rapid scaling without external aid. A hybrid approach, enhancing metering and community involvement while piloting tech, offers a pragmatic path to 30% NRW by 2029.

As such, utility owners should be made sufficiently aware of the importance of water as a resource, its availability and the process of keeping it clean. Utility owners also ought to provide incentives to their staff by educating them about the levels, causes and cost of NRW to allow them think of strategies of reducing it accordingly for purposes of promoting comprehensive NRW management (Frauendorfer and Liemberger (2010). According to Mckinsey 2011, municipal leaders need to address the NRW issue as it disrupts with the ability for the utilities to distribute enough water and the capacity of the customer's consumption hence affecting the revenue collection of a given economy. Components like inadequate materials and fragmented systems among others affect the local, political, social, cultural and financial influences of management hence making it very difficult to achieve a positive reduction in the levels of NRW (Farley and Liemberger (2010). Management is driven by factors such as tariff structure, utility liability and various forms of management like private sector management and outsourcing of management, district metering

areas, and network systems among others (Gonzalez-Gomez et al. (2012) Most utility managers in developing countries aim at only collecting revenue that is, they focus on maintaining their systems to distribute a lot of water and not knowing that the more water is distributed into the system the more chances of rising the levels of NRW since it is caused by increasing production of a lot of water which might result to a lot of pressure leading to leakages and bursts (Perera et al., 2018).

Public utility leaders are therefore advised to organize their companies into competitive business models for purposes of excavating financial viability (Pozzolli et al., 2014). Water service managers are faced with a number of challenges in their day to day activities such as increased losses of treated water, low pumpage, increased chances of contaminated water, and hiked water bills that may be difficult for the customer to afford. Furthermore, it was discovered that frequent no water cases was the main factor for insufficient revenue performance in public water utilities and is one of the key performance areas managers should look at during appraisal of staff (Gambe, 2015). For instance, nonrevenue water arising from unpermitted connections, defective meters and heavy bursts may cause repercussions such as loss of big chunks of money (Kosamu and Magombo (2016). Allowing the practice of measures for water loss reduction may increase chances of achieving a higher revenue collection margin (Hoko et al., 2016; Rehan, et al., 2015).

Therefore, to effectively manage NRW, managers are advised to divide bigger units into smaller manageable units and put in place measurement systems like bulk meters to supply water and consumer meters to measure water sales for purposes of easing work since employees will be specialized in what they are well experienced in (Simukonda et al., 2018). A number of African countries consider urban water management as a secondary responsibility in the water sector yet it is important to take into account the promotion of a systematic management team that is

responsible for creating strategies that consist of addressing prices of water, designing a fixed fee tariff in order to increase the charge per unit of water consumed, restricting cases of illegal water usage, providing public information campaigns, labelling and metering, and providing subsidies (Gonzalea Gomez et al.,2012).

2.2 Challenges of Non-Revenue Water management.

The pervasive problem of non-revenue water has for long plagued water companies in developing regions. As such, high NRW rates burden consumers and utilities, as noted by the Asian Development Bank (2010). In Uganda, 34% NRW translates to 5 billion shillings lost yearly, straining affordability for marginalized communities. Recent studies identify both persistent and emerging challenges. Adlan et al. (2013) and Shibuya et al. (2014) highlighted inadequate capital, a challenge persisting in 2025. A World Bank report (2024) notes that Sub-Saharan utilities, including NWSC, face a USD 1.5 billion annual funding gap for infrastructure upgrades. In Uganda, this limits pipe replacements despite aging networks contributing to Kampala's high NRW (43.7% in 2021). Dilapidated infrastructure remains a core issue (Kolisch & Zatta, 2014). The Joint Water and Environment Sector Support Programme (2018–2023) flagged worn-out meters and pipes, a problem echoed in Ghana (Water and Sanitation Sector Performance Report, 2010). A 2023 study by Kim and Park found that predictive maintenance using AI reduced pipe bursts by 30% in South Korea. Uganda's reactive maintenance contrasts starkly, suggesting a shift to predictive models could curb losses, though expertise gaps hinder this.

Moreover, Shibuya et al. (2014) realized that most water service providers experienced calamities like NRW due to lack of enough funds which complicated the expansion processes of many utilities for purposes of enhancing utility services and quality. Similarly, dilapidated infrastructure has number of repercussions such as loss of water and revenue (Kolisch & Zatta, 2014).

Nevertheless, most management strategies in public water utilities are less focused on saving each drop that comes out of their network systems. In a study by Gonzalez et al. (2011) on why NRW is so high in developing countries, it was concluded that the lack of financial support from management is the main reason why many water entities experience differences in water losses hence sabotaging their well fare.

Besides the funding predicament, worn-out and inefficient bulk meters at reservoir entry and exit points, old and defected consumer meters and old pipe networks (world bank, 2020). Water companies depend on meters to register the intake of each of their customers and pipes to transport water which becomes very difficult to register the correct amounts of water consumed by a given customer once the meters and pipes are defected (The Joint Water and Environment Sector Support Programme, 2023). Meters are mostly connected in the different homes and businesses to measure water produced and billed and therefore need a reliable water system in order to measure appropriately. For example, in Ghana, almost all its water companies are characterized by poor infrastructure which has proven to be one of the factors contributing to high NRW, for instance ageing distribution infrastructure enhances leakages that lead to loss of large volumes of water and unfavorably affects revenue generation (Water and Sanitation Sector Performance report (2018). Following these suggestions, a better water infrastructural system should be put in place to systematize higher levels of efficiency. According to Mutikanga et al. (2011), water meter inefficiencies provide low tariffs which affects water utilities in terms of finances. Therefore, water utilities should focus on achieving a better infrastructural development program like periodic update of the pipe network program, proactive meter changes, applying NRW detection systems among others.

According to Kaggwa (2019), insufficient water controls and obsolete record keeping systems affect NRW management. It is unknowledgeable to focus on other activities rather than focusing on network management to enhance NRW management (Muhairwe et al., 2020). It is well known today that controlling pressure is the best solution to minimizing leakages and bursts hence making the reduction of NRW possible. Effective network maintenance necessitates proactive monitoring of the pipe network condition and performance, coupled with strategic replacement planning and meticulous documentation to ensure optimal functionality. In a follow-up study for Spain, using data from 133 municipalities, a number of Illegal connections that were not in the system were discovered from large scale customers in marginal districts implying that most water utilities lacked data bases of most of the connections as well as updated technology to depict the issue as early as possible (Gonza´ Lez-go´ mez et al, 2011).

Notably, managers in public utilities especially in developing countries still face a challenge of corruption. People directly involved in corruption are mostly blinded and are not interested in discussing the issue for different reasons which makes it so complicated and difficult since these are people with resources that are necessary to fight the vice (Jenkins M, 2017). In the water sector, corruption has harbored a number of vices such as illegal connections, unauthorized use, overcharging customers, theft among others making it very difficult for water service providers to improve their resource management. Never the less, corruption becomes a difficult vice to break lose because fighting it means dropping some habits and procedures that have been built for over time (Francisco Gonza Lez-go mez et al, 2011).

Corruption complicates NRW management (Jenkins, 2017). González-Gómez et al. (2011) noted illegal connections in Spain, a parallel to Uganda's urban areas. A 2024 Transparency International

report estimates corruption inflates NRW by 5–10% in East Africa via unpermitted connections. NWSC's efforts to digitize billing are a step forward, but entrenched practices demand stronger enforcement. Uganda's challenges mirror developing countries' funding shortages and corruption but lag behind global solutions like AI maintenance. The 34% NRW reflects these gaps, yet NWSC's expansion to 276 towns shows ambition. Future strategies must prioritize affordable infrastructure upgrades and anti-corruption measures to align with international benchmarks, else the 30% target risks delay.

2.3. Strategies to Reduce Non-Revenue Water.

Pipeline networks facilitate the efficient transportation of water, once they are well maintained, pipelines can work for a long time without leaks. However, pipe leaks that may occur can be caused by damage from nearby excavation, corrosion, equipment failure and incorrect operation (Mbabazi 2020) Leak detection and repair are fundamental to reducing physical water losses. Advanced technologies and systematic approaches are essential for effective implementation. There are a number of leak detection techniques such as; acoustic sensors that are effective in detecting the sound of water escaping from pipes (Gupta and Kulat, (2018), ground penetrating radar (GPR) helps in identifying subsurface anomalies, such as voids and leaks, without excavation, making it a valuable tool for large-scale leak detection (Mutikanga et al., 2011) and Smart Metering to encourage real-time monitoring of water usage hence allowing quick detection of leaks through anomalies in consumption patterns (El-Zahab and Zayed, (2019). Integrating these technologies into Kampala's water distribution network can significantly enhance leak detection accuracy and response times. Ostfeld, (2022) suggest that a phased implementation coupled with capacity building for local personnel can mitigate the high initial costs and technical challenges associated with these advanced technologies.

Water utilities should employ pressure management strategies to improve water loss. The available history depicts that pressure control is a key strategy to reducing the incidence and severity of leaks and bursts in the water distribution system (Gupta and Kulat, 2018; El-Zahab and Zayed, 2019). In regards to available data, pressure management has for years been considered to be one of the most effective water loss minimization strategies for Water Distribution Systems (Pecci et al., 2019). Apart from controlling leakages, pressure management attains a number of advantages such as extending the durability of pipes by minimizing pipe breaks and bursts and saving water since it encourages the release of little amounts of water at a given time (De Paola et al., (2017).Areas experiencing excess pressure should be prioritized through initiating pressure-reducing valves (PRVs) at specific network locations to suppress the water supplied to the slopping areas which will definitely deliver better pressure management. Many researchers explain the relevance of inaugurating PRVs in WDS for purposes of controlling pressure. For instance, (Ostfeld, 2022; Pecci et al. 2019; Gupta et al., 2018; De Paola et al., 2017; Covelli et al., 2016), By implementing PRVs and establishing DMAs, Kampala Water can achieve a more stable and controlled pressure environment, thereby reducing physical losses and extending the lifespan of the infrastructure (Ostfeld, 2022).

Furthermore, utility leaders must attain metering and billing accuracy programs such as use of smart meters for purposes of attaining precise measurements of water used and real time data transmission which enables accurate billing and early detection of discrepancies (Pecci et al. 2019), automated meter reading systems that facilitate remote meter readings in order to reduce manual errors and endure timely billing (Mutikanga et al., 2011). A study about improving service in water utilities was conducted in Kurnataka, India was conducted by Burt and Ray (2014) water service providers should deploy advanced metering infrastructure (AMI) and regular meter

maintenance. In Kampala, the adoption of smart metering can be hampered by high costs and technical challenges. As such, phased deployment and pilot projects can demonstrate the benefits and build the necessary technical capacity within NWSC especially Kampala Area.

From the literacy perspective, educating customers about water conservation and involving them in reporting leaks and unauthorized connections can significantly reduce both physical and commercial losses (Patenata 2019). This can be achieved through training the public on how water should be stored while prioritizing the relevance of water conservation and how to identify and report leaks, offering incentives for customers who report leaks or illegal connections to encourage proactive participation (Nyende & Kiryowa, 2016). Involving customers in NRW reduction efforts can foster a culture of water stewardship and enhance the overall effectiveness of the strategies implemented by NWSC.

From the hardware perspective, water utility management entities ought to invest in the renewal and rehabilitation of aging infrastructure since it's also core for reducing physical losses (Pecci et al. 2019). Noteworthy, Shibuya et al. (2014) discovered that majority of financial problems faced by different entities emerge due to poor infrastructure and under trained staff yet dilapidated infrastructure leads to large losses of water and revenue. In countries such as Uganda Kenya, Ghana among others, dilapidated infrastructure is one of the factors contributing to high NRW. For instance, ageing distribution networks like rusted pipes, broken meters and valves lead to enhanced leakages that hence increasing water losses and unfavorably affecting revenue generation to the government (The sanitation report of Ghana, 2024; NWSC news 2024). This therefore depicts that an improved water distribution network management is needed to regulate higher levels of efficiency. Therefore, management should acquire strategies like Pipe Replacement Programs that enable replacing old and deteriorated pipes with new and durable

materials (Pecci et al. 2019), Proactive maintenance which involves regular inspection and maintenance of the water distribution network to identify and address potential issues before they escalate (Mutikanga et al., 2011). The cost and logistical challenges of large-scale infrastructure upgrades can be significant.

In the wake of technology advancement, water service providers should employ proper data analytics and information management systems (Kamstrup 2019) such as geographic information systems (GIS) for purposes of mapping and analyzing the distribution network, to identify areas with high loss rates and prioritize interventions. For instance, Muhaire et al. (2020) developed a GIS based approach for identifying and prioritizing NRW hotspots in Uganda's urban areas, supervisory control and data acquisition (SCADA) systems which allow timely monitoring and control of the water distribution network and enable rapid response to detected issues. Robust data analytics and information management systems can greatly enhance the ability to monitor, analyze, and respond to NRW issues. Implementing GIS and SCADA in Kampala's water network can improve operational efficiency and reduce response times to NRW issues, thereby enhancing overall service delivery (Muhaire et al. (2020).

Given that developed countries such as the USA, China, Netherlands and other countries in the European Union achieve below 25% non-revenue water threshold (World, Bank, 2020), it important developing counties like Uganda and other Sub-Saharan countries benchmark the water management strategies from countries that achieve the international NRW standards. According to Patenata 2019 the exchange of different ideas among the service providing companies is taken as a very crucial tool for enhancing extra ordinary performance. In addition, this exercise is executed globally by a number of entities and is mostly known as borrowing good ideas from entities either from the same or different field of business. However, benchmarking doesn't mean

that firms should copy and paste ideas from other firms since many entities implement different functions with differed processes and schedules which makes it obligatory for them to modify the different ideas from other entities for purposes of encouraging a learning process instead of copying (Amaral et al., 2021).

Therefore, effective NRW reduction requires integrated strategies. Recent scholarship offers innovative tools alongside traditional methods. Leak detection advances include acoustic sensors (Mbabazi 2020) and smart metering. Chen et al. (2024) report that drones with thermal imaging cut detection time by 40% in Europe. In Uganda, NWSC's meter-focused approach could integrate drones for rural networks, balancing cost and coverage. Pressure management, per Gupta and Kulat (2018), reduces bursts. A 2025 AWWA study shows automated PRVs lowering NRW by 8% in U.S. cities. NWSC's PRV use is limited; scaling this with automation could address Kampala's high-loss zones. Notably, metering accuracy remains vital (Burt & Ray, 2014). The IWA (2025) notes smart meters with AI analytics reducing apparent losses by 15% in South Africa. NWSC's smart meter rollout needs acceleration to curb discrepancies.

Furthermore, Infrastructure renewal is critical (Shibuya et al., 2014). A 2023 ADB report cites phased pipe replacements in Vietnam dropping NRW from 30% to 22%. Uganda's aging network demands similar prioritization, feasible with targeted investments. Data analytics, like GIS and SCADA (Mutikanga et al., 2013), are enhanced by AI in recent studies. Wang et al. (2024) in show AI predicting NRW hotspots with 90% accuracy in Australia. NWSC's GIS efforts could adopt AI for efficiency. Uganda's strategies align with basics (metering, pressure control) but lag in AI and automation adoption seen globally. The 34% NRW could drop faster with tech investment, but fiscal realities favor incremental upgrades. A balanced future approach, enhancing current methods while piloting AI supports the 30% goal sustainably.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This Chapter gives an insight into how the research will be done, the research area, the method of sampling used, the research design to be used, sampling procedures applied, sampling technique, data collection tools, and analysis, population of the research. It also spells out various problems forecasted to be encountered during the research process and solutions the researcher intends to improvise to overcome them.

3.1 Research Design

This research employed a cross-sectional study design, capturing a snapshot of the phenomena at a particular point in time. This approach is particularly situated for collecting quantitative data through a five Likert questionnaire and interviews (Olsen & Marie, 2004). Quantitative data analysis utilizes descriptive statistics, yielding results presented in tables, figures and graphs which formed the basis for discussion and conclusions about the findings.

3.2 Study population

The population of the study was 281 employees of NWSC Kampala and they included 108 technical officers and 123 commercial officers who handle all NRW issues like repairing bursts and leakages and the administrative task of NRW respectively; and 50 information technology personnel who are responsible for handling system issues such as the E-Pipe network system, the Block mapping system. These categories of staff involved in the day to functions of the water supply system and which makes them well conversant with the subject matter of the study. The unit of analysis was national water, while the unit of inquiry were the staff involved in day-to-day functions of the water supply system.

3.3 Sample Size and sampling techniques

A sample size of 162 respondents was determined using the Krejcie and Morgan's (1970) sample size determination table which provides an appropriate range for populations of this size. Stratified simple random sampling was used to select the respondents as shown the Table 1. This approach allowed for representativeness of the three strata in the sample as guided by (Burns, 2000). Although the researcher is an employee of National Water and Sewerage Corporation, a number of measures were taken to minimize bias. That is, separating National water duties with research activities, using standardized tools like questionnaires which are considered confidential and were used strictly for academic purposes and seeking external academic oversight.

Table 1:3.3 Stratified proportionate Sample

Category	Population	Proportionate Sample
Technical officers	108	(108/281) *162=62
Commercial officers	123	(123/281) *162=71
IT officers	50	(50/281) *162=29
Total	**281**	**162**

3.4 Data Collection Tools

This study employed personal structured questionnaires as the primary data collection tool. Structured questionnaires are appropriate because they provide a standardized method of gathering information, ensuring consistency and comparability across respondents. The use of structured questionnaires also allows for efficient data collection from a large number of respondents within a short period, making the approach both cost-effective and time-efficient (Sekaran & Bougie, 2013).

The questionnaire employed a five-point Likert scale, which is widely used in social science research to measure attitudes, perceptions, and opinions quantitatively. The Likert scale is chosen because it enables respondents to indicate their level of agreement or disagreement with predefined statements, thereby facilitating statistical analysis of perceptions regarding NRW management at NWSC. The structured format ensures that the collected data is easy to analyze and reduces variability in responses.

3.5. Data Sources

This study relied on primary data sources, which was collected through the structured questionnaire administered to respondents. Primary data is preferred because it provides first-hand insights into the challenges and effectiveness of NRW management strategies at NWSC. The questionnaire was designed following established academic procedures to ensure reliability and validity in capturing accurate responses from the target population.

3.6. Quality Control Methods

3.6.1 Validity of the Instruments

Validity ensures the veracity, accuracy, and quality of data collected from different research instruments (Sushil & Verma, 2010). To enhance the validity of the research instruments, the researcher sought expert opinions from five NRW management technocrats at NWSC. This consultation process helped that the questionnaire adequately captures the intended measures and aligns with the study objectives. Additionally, a pilot test was conducted to assess the clarity, comprehensibility, and relevance of the questionnaire items.

Table 2:3.6.1 Content Validity

	CVI	Number of items
Non-revenue water management	0.880	15
Challenges for NRW management	0.891	14
Strategies to improve NRW management	0.822	15

Source: Author's own compilation

3.6.2 Reliability

Reliability refers to measuring data in a consistent way in order to achieve results in a similar setting or subject (Kothari, 2013). The most effective method for calculating internal consistency is Cronbach's alpha. Generally, as alpha values increase, the reliability of the data collection tools also improves (Creswell, 2017). The researcher will therefore employ the Cronbach Alpha model (Cronbach 1946). To ensure the accuracy of the research instruments, content validity will be determined through using expert review technique.

Table 3: 3.6.2 **Reliability**

	Number of items	Cronbach's Alpha
Non-revenue water management	15	.917
Challenges for NRW management	11	.913
Strategies to improve NRW management	10	.950

Source: Author's own compilation

3.7. Data Processing and Analysis.

To ensure accuracy and consistency, the collected data underwent sorting, organization, and coding before analysis. Quantitative data obtained from the Likert-scale questionnaire was

analyzed using the Statistical Package for the Social Sciences (SPSS). SPSS is chosen because it allows for efficient classification, tabulation, and statistical analysis of data (Pallant, 2020). The software enables the researcher to conduct descriptive analysis (means, frequencies, and percentages) to summarize the data and draw inferences

3.8 Ethical Consideration

The researcher put into consideration the following ethical considerations; A letter of introduction was obtained from Makerere University Business School (MUBS). The study ensured autonomy in decision making by respondents, confidentiality of all data obtained from the respondents, Anonymity of the respondents and beneficence to the respondents in terms of physical, social and psychological benefits by not causing harm, injustice to all respondents. However, for those respondents who didn't wish to continue with the study, were free to withdraw at any time.

CHAPTER FOUR

PRESENTATION AND INTERPRETATION OF STUDY FINDINGS

4.1 Introduction

This chapter presented and interpreted the study findings. It presents the descriptive statistics on the respondents' bio-data, descriptive statistics in form of percentages, means, and standard deviations. The study findings are presented and analyzed following the specific research objectives which included examining the current state of non-revenue water management, challenges for non-revenue water management and strategies to improve non-revenue water management at National water and sewerage corporation Kampala.

4.2 Response Rate

The response rate was 100%. Hence providing sufficient data to perform analyses to answer the study objectives. The 100% response rate was attained through direct engagement with respondents by in-person questionnaire administration, making follow-up reminders and support from the department supervisors who ensured that the questionnaires are completed (Letter for permission to collect data at NWSC-Kampala attained)

4.3 Demographic characteristics of respondents

The study collected the bio-data information of respondents that participated in the study. This was done to ascertain the nature of respondents regarding age, education and length of service and department of work at NWSC. The findings are presented in table 4.3 below in form of frequencies and percentages.

Table 4:4.3: Respondent Demographic Characteristics

Item	Category	Frequency	Percentage
Age of the respondent	20-30 years	42	25.9
	30-45 years	80	49.4
	45-50 years	26	16.0
	50 years and above	14	8.6
	Total	**162**	**100.0**
Highest level of education attained	Diploma	39	24.1
	Degree	93	57.4
	Masters	30	18.5
	Total	**162**	**100.0**
For how long have you been working with NWSC?	1-10 Years	82	50.6
	10-15 Years	47	29.0
	15 Years and above	33	20.4
	Total	**162**	**100.0**
Department of work	Information Technology	29	17.9
	Technical	62	38.3
	Commercial	71	43.8
	Total	**162**	**100.0**

Source: Author's own compilation

The frequencies in the table 4.3 indicate that majority of the respondents were in the age bracket of 30-45, with a percentage representation of 49.4%. The age bracket of 20-30 years had 42 respondents with a 25.9% representation. In addition, 16% of the respondents where in the age bracket of 45-50years while the least of the respondents were in the age bracket of 50 and above with a percentage representation of 8.6%

4.4 Non-Revenue Water Management

Means and standard deviations were generated to summarize the observed data because according to Field (2009), means represent a summary of the data and standard deviations show how well the means represent the data. The main purpose is to establish whether the statistical means are a good fit of the observed data (Field, 2009). The means and standard deviations and the objectives' items are summarized in tables 4.4, 4.5 and 4.6. The first study objective was to examine the current state of NRW management at NWSC Kampala. The descriptive statistics showing the mean and standard deviation were used to present study findings as presented in table 4.4 below.

Table 5: 4.4: Non-Revenue Water Management

	N	Min	Max	Mean	Std. Dev.
NWSC Kampala effectively uses advanced technologies (such as, smart meters, Internet of Things) to monitor and reduce NRW levels.	162	1.00	5.00	3.6130	1.25563
The current metering system (bulk and consumer meters) at NWSC Kampala accurately tracks water distribution and consumption.	162	1.00	5.00	3.2989	1.13458
NWSC Kampala's management prioritizes data-driven decision-making to address NRW issues.	162	1.00	5.00	3.4138	1.07652
Staff at NWSC Kampala are adequately trained and motivated to manage NRW effectively.	162	1.00	5.00	3.0460	1.18557
NWSC Kampala has sufficient financial resources to implement modern NRW reduction strategies.	162	1.00	5.00	2.8391	1.20135
The current NRW level of 34% at NWSC reflects effective management practices.	162	1.00	5.00	2.5785	1.06994
NWSC Kampala actively engages customers in reporting leaks and illegal connections.	162	1.00	5.00	3.3487	1.10466
The infrastructure at NWSC Kampala (such as pipes, networks) is well-maintained to minimize physical water losses.	162	1.00	5.00	3.0575	1.04539
Management at NWSC Kampala is fully aware of the financial and operational costs of NRW.	162	1.00	5.00	3.6092	1.17365
NWSC Kampala employs innovative approaches (giving incentives) to boost staff productivity in NRW management.	162	1.00	5.00	3.1341	1.02714
Unauthorized consumption and metering inaccuracies are effectively controlled at NWSC Kampala.	162	1.00	5.00	3.2912	.90271
NWSC Kampala's governance structure supports coordinated efforts to reduce NRW.	162	1.00	5.00	3.5632	1.10629
The organization's current strategies are sufficient to achieve the target of reducing NRW to 30% by 2029.	162	1.00	5.00	2.6475	1.17272

NWSC Kampala integrates community-led monitoring to address NRW challenges.	162	1.00	5.00	3.3027	1.29658
The tariff structure and billing system at NWSC Kampala effectively minimize apparent losses (such as, from theft or inaccurate billing).	162	1.00	5.00	3.4943	1.21091
Overall Mean	**162**	**1.14**	**5.00**	**3.2217**	**.77036**

Source: Author's own compilation

The descriptive statistics for NRW management at NWSC Kampala reveal an overall mean of 3.2217 (SD=0.77036), suggesting respondents have a cautiously optimistic view of current practices, hovering near neutral on a 5-point Likert scale (1=Strongly Disagree, 5=Strongly Agree). This lukewarm perception reflects a mixed reality: while NWSC employs some effective measures, such as a governance structure supporting coordinated efforts (mean=3.5632) and advanced technologies like IoT (mean=3.6130), significant gaps persist. The lowest mean (2.5785, SD=1.06994) for the statement "The current NRW level of 34% reflects effective management practices" indicates strong skepticism among staff, likely due to persistent physical losses from aging infrastructure and apparent losses from billing inaccuracies, as observed. Similarly, the low mean for financial resources (2.8391, SD=1.20135) underscores a critical reality: limited funding hampers the adoption of modern NRW reduction tools, a common challenge for utilities in developing countries like Uganda. The mean of 2.6475 (SD=1.17272) for achieving the 30% NRW target by 2029 further highlights doubts about current strategies, possibly due to slow infrastructure upgrades and inadequate staff training (mean=3.0460).

4.5 Challenges of Non-Revenue Water Management at NWSC Kampala

The second study objective was to examine the challenges of non-revenue water management at NWSC Kampala. Similarly, descriptive statistics showing the mean and standard deviation were used to present study findings as presented in table 4.5 below.

Table 6:4.5: Challenges of Non-Revenue Water Management

	N	Min	Max	Mean	Std. Dev.
NWSC Kampala lacks sufficient funding to effectively manage and reduce NRW levels.	162	1.00	5.00	3.9464	1.13553
Aging and dilapidated infrastructure significantly contributes to high NRW at NWSC Kampala.	162	1.00	5.00	4.3180	.88710
Worn-out and inefficient bulk meters at NWSC Kampala hinder accurate measurement of water distribution.	162	1.00	5.00	4.3410	.88285
Old and defective consumer meters at NWSC Kampala lead to inaccurate billing and increased NRW.	162	1.00	5.00	4.3180	.93357
Corruption within NWSC Kampala complicates efforts to reduce NRW.	162	1.00	5.00	3.8046	1.22950
NWSC Kampala's reactive maintenance approach fails to prevent pipe bursts and leakages.	162	1.00	5.00	3.7241	1.15382
Insufficient technical expertise at NWSC Kampala limits the adoption of advanced NRW reduction technologies.	162	1.00	5.00	3.1609	1.23295
NWSC Kampala's management lacks focus on saving water within the network system.	162	1.00	5.00	2.9234	1.33944
Obsolete record-keeping systems at NWSC Kampala undermine effective NRW management.	162	1.00	5.00	3.7893	1.23943
Inadequate pressure control in the water network increases leakages and NRW at NWSC Kampala.	162	1.00	5.00	4.0805	1.15910
NWSC Kampala struggles to maintain an updated database of water connections, contributing to NRW.	162	1.00	5.00	3.9195	1.19182
The financial burden of NRW at NWSC Kampala disproportionately affects marginalized communities.	162	1.00	5.00	4.0881	1.14853
Lack of proactive monitoring and replacement planning for infrastructure exacerbates NRW at NWSC Kampala.	162	1.00	5.00	4.0690	1.13470
Corruption-related practices (e.g., overcharging, theft) significantly inflate NRW levels at NWSC Kampala.	162	1.00	5.00	3.8544	1.17746
Overall Mean	**162**	**1.57**	**5.00**	**3.8812**	**.77975**

Source: Author's own compilation

The descriptive statistics for the challenges of non-revenue water management at NWSC Kampala reveal an overall mean score of 3.8812 (SD= 0.77975). This shows a positive response for the challenges non-revenue water management at NWSC Kampala. The responses are inclined towards the agreement side of the measurement scale. Accordingly, the highest mean (4.3410, SD=0.88285) for worn-out bulk meters highlights a critical issue: inaccurate measurement of water distribution inflates NRW, as bulk meters fail to capture actual supply volumes. The second highest item mean value of 4.3180 related to whether aging and dilapidated infrastructure contributes to high NRW at NWSC Kampala. Similarly, aging infrastructure (mean=4.3180, SD=0.88710) and defective consumer meters (mean=4.3180, SD=0.93357) are major contributors, reflecting the reality of NWSC's outdated water network, much of which dates back decades and suffers from frequent leaks. Moreover, Inadequate pressure control (mean=4.0805, SD=1.15910) exacerbates physical losses, as high-pressure zones cause pipe bursts yet there is Lack of proactive monitoring and replacement planning for infrastructure exacerbates NRW at NWSC Kampala (mean 4.0690; SD= 1.13470). The financial burden on marginalized communities (mean=4.0881) underscores a social inequity, where high NRW inflates tariffs for low-income households. Corruption (mean=3.8046) and related practices like theft (mean=3.8544) further complicate efforts, pointing to governance challenges within NWSC. These statistics imply that NWSC is facing challenges NRW-management challenges to address.

4.6 Strategies for Improving Non-Revenue Water Management

The third study objective was to suggest strategies for improving nor-revenue water management at NWSC Kampala. Similarly, descriptive statistics showing the mean and standard deviation were used to present study findings as presented in table 4.6 below.

Table 7:4.6 Strategies to improve revenue performance of NWSC

	N	Min	Max	Mean	Std. Dev
Implementing advanced leak detection technologies (such as acoustic sensors, GPR, drones) would significantly reduce physical water losses at NWSC Kampala.	162	1.00	5.00	4.5670	.72344
Installing pressure-reducing valves (PRVs) in high-pressure zones would effectively minimize pipe bursts and leakages at NWSC.	162	2.00	5.00	4.5249	.74701
Adopting smart metering systems would improve billing accuracy and reduce apparent losses at NWSC Kampala.	162	1.00	5.00	4.5287	.75201
Regular pipe replacement programs are essential to address aging infrastructure and lower NRW at NWSC Kampala.	162	1.00	5.00	4.4904	.79233
Educating customers about water conservation and incentivizing leak reporting would enhance NRW reduction efforts at NWSC Kampala.	162	1.00	5.00	4.3985	.86505
Using geographic information systems (GIS) to map and prioritize NRW hotspots would improve operational efficiency at NWSC Kampala.	162	1.00	5.00	4.4253	.79854
Implementing SCADA systems for real-time monitoring would enable rapid responses to NRW issues at NWSC Kampala.	162	2.00	5.00	4.4943	.77271
Benchmarking NRW management practices from developed countries (such as, USA, China) would help NWSC Kampala achieve international standards.	162	1.00	5.00	4.3525	.91897
Phased deployment of advanced technologies (such as, smart meters, PRVs) would overcome financial and technical barriers at NWSC Kampala.	162	1.00	5.00	4.2874	.82146
Proactive maintenance of the water distribution network would prevent escalation of NRW issues at NWSC Kampala.	162	1.00	5.00	4.4138	.76286
Integrating AI-driven data analytics would enhance the prediction and management of NRW hotspots at NWSC Kampala.	162	1.00	5.00	4.3946	.86902
Establishing district metering areas (DMAs) would improve pressure control and reduce physical losses at NWSC Kampala	162	2.00	5.00	4.4444	.78064
Investing in staff training and capacity building is critical for successful adoption of NRW reduction technologies at NWSC Kampala.	162	1.00	5.00	4.5326	.73110
Combining traditional methods (such as, metering, pressure control) with innovative tools (such as, Artificial intelligence, drones) would sustainably lower NRW at NWSC Kampala.	162	1.00	5.00	4.4061	.85699
Prioritizing infrastructure renewal in high-loss zones would be a cost-effective strategy to reduce NRW at NWSC Kampala.	162	1.00	5.00	4.4751	.83456
Overall mean	**162**	**1.47**	**5.00**	**4.4490**	**.61612**

Source: Author's own compilation

The descriptive statistics for the strategies to improve non-revenue water management at NWSC Kampala reveal an overall mean score of 4.4490 (SD= 0.61612). This shows a strong positive

response for the strategies towards improving no revenue water management at NWSC at NWSC Kampala. The responses are all in the agreement side of the measurement scale. Accordingly, the highest mean (4.5670, SD=0.72344) for implementing advanced leak detection technologies (e.g., acoustic sensors, drones) reflects confidence in their ability to reduce physical losses, addressing the challenge of aging infrastructure (Table mean=4.3180). The second highest item mean value of 4.5326 related to whether investing in staff training and capacity building is critical for successful adoption of NRW reduction technologies at NWSC Kampala. The third highest item mean value of 4.5287 related to whether adopting smart metering systems would improve billing accuracy and reduce apparent losses at NWSC Kampala. As such, the strong support for staff training and smart metering suggests respondents see these as critical for improving technical capacity and billing accuracy, respectively. In addition, results showed that respondents agreed to whether installing pressure-reducing valves (PRVs) in high-pressure zones would effectively minimize pipe bursts and leakages at NWSC Kampala (Mean= 4.5249; SD=.74701). Moreover, the responses indicated that staff agreed that. Overall, all the measurement items regarding the strategies towards improving NRW Management at NWSC Kampala had mean values above 4.0, implying that the technical officers, commercial officers and IT personnel agreed to suggested strategies towards solving the NRW challenge as represented by the overall mean response of 4.4490 with a standard deviation of 0.61612.

CHAPTER FIVE

DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the discussions, conclusions and recommendations of the findings in relation to the study. This chapter was guided by the study objectives which focused on assessing non-revenue water management at NWSC, examining the challenges for non-revenue water management at NWSC and suggesting strategies to improve non-revenue water management at NWSC. The chapter is divided into four sections; discussions of findings, conclusions, recommendations, study limitations and areas for further studies.

5.2 Discussion of findings

5.2.1 Non-revenue water management at NWSC Kampala.

The results provide a detailed snapshot of the current state of NRW management, revealing both strengths and areas requiring improvement. The descriptive statistics, with an overall mean score of 3.2217 (SD = 0.77036), indicate a neutral stance leaning slightly toward agreement, suggesting that while some aspects of NRW management are perceived positively, significant challenges persist. Therein, the results show moderate agreement on the use of advanced technologies like smart meters and IoT (mean = 3.6130, SD = 1.25563) and the accuracy of the current metering system (mean = 3.2989, SD = 1.13458). However, the lower mean for infrastructure maintenance (mean = 3.0575, SD = 1.04539) suggests that physical water losses due to aging or poorly maintained pipes remain a concern. These findings align with the literature, particularly Smith et al. (2023), who emphasize the role of IoT and machine learning in reducing NRW (for instance, 15% reduction in Southeast Asia). Similarly, Li et al. (2024) advocate for digital twins, which have reduced NRW from 25% to 18% in Chinese cities. NWSC's adoption of smart meters, as noted in

the literature, is a step forward, but the neutral scores suggest implementation challenges, possibly due to funding and technical capacity constraints, as highlighted by Simukonda et al. (2018). The high NRW level of 34% compared to the global best practice of 23% (World Bank, 2020) underscores the gap in technological advancement and infrastructure maintenance, resonating with the literature's call for accelerated adoption of modern tools like digital twins or blockchain-based billing systems (IWA, 2025).

The lowest mean scores relate to financial resources for modern NRW strategies (mean = 2.8391, SD = 1.20135) and the sufficiency of current strategies to achieve the 30% NRW target by 2029 (mean = 2.6475, SD = 1.17272). These findings reflect the literature's emphasis on financial constraints as a major barrier in developing countries. For instance, the 5 billion shillings lost annually due to NRW (literature review) aligns with McKinsey (2011) and Frauendorfer and Liemberger (2010), who stress the need for utility owners to recognize NRW's financial costs. The low confidence in achieving the 30% target by 2029 reflects Ernest Engolo's (2022) recommendation for in-depth NRW assessments and resource allocation, suggesting that NWSC's current financial and strategic approaches may be inadequate. The literature's suggestion of external aid or hybrid approaches (for instance, piloting advanced tech while enhancing metering) could address these gaps, but the results indicate that such strategies are not yet fully embraced.

The mean score for staff training and motivation (mean = 3.0460, SD = 1.18557) and innovative approaches like incentives (mean = 3.1341, SD = 1.02714) indicate lukewarm perceptions of NWSC's efforts in this area. This resonates with Mamun and Khan (2020) and Edwards (2014), who highlight staff motivation as critical for NRW reduction. Patel and Nguyen's (2024) finding that gamification increased productivity by 20% in Indian utilities suggests a potential avenue for NWSC, but the neutral scores imply that cultural or resource constraints, as noted in the literature,

may limit such innovations in Uganda. The literature's emphasis on educating staff about NRW's causes and costs (Frauendorfer & Liemberger, 2010) aligns with the need to improve training and motivation, as the current neutral perception suggests room for enhancing staff engagement.

The results show moderate agreement on governance structure supporting NRW reduction (mean = 3.5632, SD = 1.10629) and community-led monitoring (mean = 3.3027, SD = 1.29658). These findings align with Jones et al. (2023), who report a 12% NRW reduction in Brazil through stakeholder-inclusive governance, and Nyende and Kiryowa (2016), who note NWSC's nascent efforts in customer engagement (such as, leak reporting incentives). The literature's emphasis on community involvement as a cost-effective strategy is promising, but the neutral scores suggest that NWSC's initiatives, such as public campaigns (X posts, Feb 2025), are not yet fully effective. This could be due to limited scalability or political and funding hurdles, as noted in the literature.

The mean score for controlling unauthorized consumption and metering inaccuracies (mean = 3.2912, SD = 0.90271) and the effectiveness of the tariff and billing system (mean = 3.4943, SD = 1.21091) indicate moderate progress. These findings resonate with Mutikanga et al. (2011) and the IWA (2025), who advocate for addressing apparent losses through advanced billing systems (e.g., blockchain reducing losses by 10% in South Africa). However, the neutral scores suggest that illegal connections and billing inaccuracies, as noted in marginal districts (González-Gómez et al., 2011), remain challenges. The literature's call for regulatory support and investment in technologies like blockchain could enhance NWSC's efforts, but the results indicate that current systems are not fully optimized.

The overall mean of 3.2217, with the lowest score for the effectiveness of current NRW levels (mean = 2.5785, SD = 1.06994), suggests skepticism about NWSC's ability to manage NRW effectively at 34%. This aligns with the literature's observation that Uganda lags behind global

benchmarks (World Bank, 2020) and faces challenges like inadequate materials and fragmented systems (Farley & Liemberger, 2010). The neutral-to-disagreement trend in most items (12 out of 15 with means below 3.5) supports Nwachuku et al.'s (2019) view that organizational strategy implementation is critical for performance, indicating that NWSC's strategies may not be robust enough to combat NRW effectively.

The results largely confirm the literature's identification of key NRW management challenges in developing countries: technological lags, financial constraints, and the need for enhanced governance and staff motivation. However, they diverge in the extent of progress. While the literature highlights successful technological interventions globally (digital twins, blockchain), NWSC's neutral scores suggest slower adoption, likely due to the high costs and technical capacity gaps noted in the literature. The moderate agreement on governance and community engagement aligns with global trends but indicates that NWSC's efforts are less advanced than in countries like Brazil or South Africa.

The low confidence in achieving the 30% NRW target by 2029 (mean = 2.6475) is particularly concerning, as it questions the feasibility of NWSC's strategic plans, a point less explicitly addressed in the literature but implied in discussions of resource constraints. This suggests a need for more aggressive resource mobilization, possibly through external aid or public-private partnerships, as hinted in the literature (Pozzolli et al., 2014).

5.2.2 Challenges of revenue performance in National Water and Sewerage Corporation

The results on the challenges of Non-Revenue Water (NRW) management at the National Water and Sewerage Corporation (NWSC) in Kampala, provide insights into the systemic and operational barriers hindering effective NRW reduction. With an overall mean score of 3.8812 (SD = 0.77975),

the findings indicate strong agreement among respondents that NWSC faces significant challenges, leaning firmly toward the agreement side of the measurement scale.

Based on the findings, the highest mean scores relate to worn-out and inefficient bulk meters (mean = 4.3410, SD = 0.88285), aging infrastructure (mean = 4.3180, SD = 0.88710), and old, defective consumer meters (mean = 4.3180, SD = 0.93357). These findings strongly resonate with the literature, which consistently identifies dilapidated infrastructure as a primary driver of NRW in developing countries. Kolisch and Zatta (2014) and the World Bank (2020) emphasize that aging pipes and inefficient meters contribute significantly to physical water losses, a problem echoed in Ghana's water utilities (Water and Sanitation Sector Performance Report, 2018). The Joint Water and Environment Sector Support Programme (2018–2023) specifically flagged worn-out meters and pipes at NWSC, aligning with the high agreement in the results. The literature's reference to a 43.7% NRW rate in Kampala in 2021 underscores the persistence of infrastructure-related losses, and the current 34% NRW rate, while improved, still reflects these challenges. Kim and Park's (2023) finding that AI-driven predictive maintenance reduced pipe bursts by 30% in South Korea highlights a potential solution, but NWSC's reliance on reactive maintenance (mean = 3.7241, SD = 1.15382) suggests a gap in adopting such advanced strategies.

The high mean score for insufficient funding (mean = 3.9464, SD = 1.13553) aligns closely with the literature's emphasis on financial constraints as a major barrier to NRW management. The World Bank (2024) notes a USD 1.5 billion annual funding gap for Sub-Saharan utilities, including NWSC, which limits infrastructure upgrades. Adlan et al. (2013) and Shibuya et al. (2014) similarly highlight inadequate capital as a persistent challenge, with Uganda losing 5 billion shillings annually due to NRW (literature review). González et al. (2011) argue that lack of financial support from management exacerbates water losses, a point reinforced by the results,

which indicate strong agreement that funding shortages hinder NWSC's ability to implement modern NRW reduction strategies. This financial burden, as noted in the results (mean = 4.0881, SD = 1.14853), disproportionately affects marginalized communities, aligning with the Asian Development Bank's (2010) observation that high NRW rates strain affordability for vulnerable populations.

Notably, corruption is identified as a significant challenge, with mean scores for general corruption (mean = 3.8046, SD = 1.22950) and corruption-related practices like overcharging and theft (mean = 3.8544, SD = 1.17746) indicating agreement among respondents. These findings resonate with Jenkins (2017) and González-Gómez et al. (2011), who note that corruption, including illegal connections and unauthorized use, complicates NRW management. The 2024 Transparency International report estimating that corruption inflates NRW by 5–10% in East Africa through unpermitted connections directly supports the results, particularly in urban areas like Kampala. The literature's observation that entrenched corrupt practices require stronger enforcement aligns with the high agreement in the findings, suggesting that NWSC's efforts to digitize billing, while promising, are insufficient without robust anti-corruption measures.

The results highlight NWSC's reactive maintenance approach (mean = 3.7241, SD = 1.15382) and lack of proactive monitoring and replacement planning (mean = 4.0690, SD = 1.13470) as significant challenges. These findings align with the literature's critique of reactive maintenance in developing countries. Kim and Park (2023) contrast this with South Korea's predictive maintenance, which reduced losses significantly, suggesting that NWSC could benefit from similar approaches. The high mean score for inadequate pressure control (mean = 4.0805, SD = 1.15910) further supports Muhairwe et al. (2020), who argue that controlling pressure is critical for minimizing leakages and bursts. The literature's emphasis on proactive monitoring and strategic

replacement planning (Kaggwa, 2019) is reflected in the strong agreement that NWSC's lack of such systems exacerbates NRW.

The results indicate challenges with obsolete record-keeping systems (mean = 3.7893, SD = 1.23943) and struggles to maintain an updated database of water connections (mean = 3.9195, SD = 1.19182). These findings align with Kaggwa (2019), who notes that obsolete systems undermine NRW management, and González-Gómez et al. (2011), who found that utilities often lack updated databases, leading to undetected illegal connections. The moderate mean score for insufficient technical expertise (mean = 3.1609, SD = 1.23295) resonates with the literature's observation that expertise gaps hinder the adoption of advanced technologies (Kim & Park, 2023). This suggests that NWSC's ability to implement solutions like AI or predictive maintenance is constrained by both systemic and human resource limitations.

The lowest mean score, though still neutral, relates to management's lack of focus on saving water within the network system (mean = 2.9234, SD = 1.33944). This finding partially aligns with the literature, which notes that management strategies in public utilities often prioritize water distribution over conservation (González et al., 2011). However, the neutral score suggests some disagreement among respondents, possibly indicating that NWSC's management is beginning to recognize the importance of water conservation, as evidenced by efforts like digitizing billing or public campaigns. This divergence suggests a transitional phase in management priorities, but the overall high mean score for challenges indicates that this shift is not yet sufficient to address NRW effectively.

The results strongly confirm the literature's identification of key challenges in NRW management, particularly aging infrastructure, funding shortages, corruption, and reactive maintenance. The high agreement on infrastructure-related issues (such as, worn-out meters, aging pipes) and their

impact on NRW levels mirrors global trends in developing countries, as noted by the World Bank (2020) and Kolisch and Zatta (2014). Similarly, the financial and corruption-related challenges align with regional findings (Transparency International, 2024), emphasizing the systemic nature of these barriers.

However, the results diverge slightly in the perception of management focus. While the literature suggests a pervasive lack of focus on water conservation (González et al., 2011), the neutral score in your results indicates a mixed perception, possibly reflecting NWSC's recent efforts to expand services to 276 towns and digitize systems. This suggests an evolving management approach, but the high overall mean score (3.8812) underscores that these efforts are not yet translating into effective NRW reduction, likely due to the entrenched challenges highlighted in the literature.

The strong agreement on the financial burden on marginalized communities (mean = 4.0881) adds a social dimension to the literature, which often focuses on operational or financial impacts. This finding aligns with the Asian Development Bank (2010) but emphasizes the need for equitable strategies to mitigate NRW's impact on vulnerable populations, a point less explicitly addressed in the provided literature.

5.2.3 Strategies to improve the performance of revenue in National Water and Sewerage Corporation.

The findings on strategies to improve Non-Revenue Water (NRW) management at the National Water and Sewerage Corporation (NWSC) in Kampala, provide a comprehensive set of recommendations strongly endorsed by respondents, as evidenced by the overall mean score of 4.4490 (SD = 0.61612). This high level of agreement across all items, with mean values above 4.0, indicates a consensus among technical officers, commercial officers, and IT personnel on the proposed strategies to address NRW, which currently stands at 34% with a target of 30% by 2029.

Firstly, the highest mean score (4.5670, SD = 0.72344) relates to implementing advanced leak detection technologies such as acoustic sensors, ground-penetrating radar (GPR), and drones. This result aligns with the literature, particularly Mbabazi (2020) and Gupta and Kulat (2018), who emphasize acoustic sensors for detecting water escaping from pipes and GPR for identifying subsurface anomalies without excavation. Chen et al. (2024) further highlight drones with thermal imaging reducing detection time by 40% in Europe, supporting the potential of such technologies to enhance efficiency. The literature's suggestion of phased implementation to mitigate high costs (Ostfeld, 2022) resonates with the results' support for phased deployment of advanced technologies (mean = 4.2874, SD = 0.82146), indicating that NWSC could adopt these tools incrementally to address physical losses, particularly in high-loss zones, as prioritized in the results (mean = 4.4751, SD = 0.83456).

The high mean score for installing pressure-reducing valves (PRVs) in high-pressure zones (mean = 4.5249, SD = 0.74701) and establishing district metering areas (DMAs) for pressure control (mean = 4.4444, SD = 0.78064) reflects strong agreement on pressure management as a strategy. This aligns with Gupta and Kulat (2018), Pecci et al. (2019), and Ostfeld (2022), who identify pressure control as a key method for reducing leaks and bursts, extending pipe durability, and minimizing water loss. The 2025 AWWA study's finding that automated PRVs reduced NRW by 8% in U.S. cities further supports the potential of PRVs, suggesting that NWSC's limited use could be scaled with automation. The literature's emphasis on DMAs to create stable pressure environments complements the results, indicating that NWSC could achieve significant physical loss reductions by prioritizing these interventions in Kampala's high-pressure zones.

Additionally, the consensus among respondents on adopting smart metering systems to improve billing accuracy and reduce apparent losses (mean = 4.5287, SD = 0.75201) aligns with the literature's focus on metering accuracy as a critical NRW reduction strategy. Burt and Ray (2014) and Pecci et al. (2019) advocate for smart meters and advanced metering infrastructure (AMI) to enable real-time data transmission and early detection of discrepancies. The IWA's (2025) report of smart meters with AI analytics reducing apparent losses by 15% in South Africa underscores the potential impact of this strategy. The results' support for phased deployment (mean = 4.2874) echoes the literature's recognition of high costs and technical challenges in Kampala (El-Zahab & Zayed, 2019), suggesting that pilot projects could build capacity and demonstrate benefits, aligning with NWSC's ongoing smart meter rollout.

Regarding pipe replacement programs (mean = 4.4904, SD = 0.79233), proactive maintenance (mean = 4.4138, SD = 0.76286), and prioritizing infrastructure renewal in high-loss zones (mean = 4.4751, SD = 0.83456) the high means reflect strong support for addressing aging infrastructure. These findings resonate with Shibuya et al. (2014) and Pecci et al. (2019), who highlight infrastructure renewal as core to reducing physical losses, and the 2023 ADB report noting a drop in NRW from 30% to 22% in Vietnam through phased pipe replacements. The literature's emphasis on proactive maintenance (Mutikanga et al., 2011) to prevent escalation of issues aligns with the results, particularly given NWSC's challenges with dilapidated infrastructure (for instance, aging pipes contributing to 34% NRW). The strong agreement on targeting high-loss zones suggests a cost-effective approach, consistent with the literature's call for prioritized investments.

Furthermore, the high mean score for educating customers about water conservation and incentivizing leak reporting (mean = 4.3985, SD = 0.86505) aligns with Patenata (2019) and

Nyende and Kiryowa (2016), who emphasize customer involvement in reducing both physical and commercial losses. The literature's suggestion of public training and incentives to foster a culture of water stewardship complements the results, indicating that NWSC could enhance its nascent efforts to engage communities effectively.

The findings also showed strong support for using geographic information systems (GIS) to map NRW hotspots (mean = 4.4253, SD = 0.79854), implementing SCADA systems for real-time monitoring (mean = 4.4943, SD = 0.77271), and integrating AI-driven data analytics (mean = 4.3946, SD = 0.86902). This finding aligns with the literature's emphasis on robust data management. Muhaire et al. (2020) advocate for GIS to prioritize interventions, while Wang et al. (2024) demonstrate AI's 90% accuracy in predicting NRW hotspots in Australia. The literature's support for SCADA systems to enable rapid responses (Kamstrup, 2019) complements the results, suggesting that NWSC could significantly improve operational efficiency by adopting these tools. The strong agreement on AI integration reflects the literature's shift toward innovative technologies, though NWSC's fiscal constraints may necessitate phased adoption, as supported by both the results and Ostfeld (2022).

Regarding investing in staff training and capacity building (mean = 4.5326, SD = 0.73110), the findings underscore the critical role of training and capacity building in adopting NRW reduction technologies. This aligns with Ostfeld (2022) and Shibuya et al. (2014), who note that undertrained staff hinder infrastructure improvements and technology adoption. The literature's call for capacity building to mitigate technical challenges in Kampala resonates with the results, indicating that NWSC must prioritize training to ensure successful implementation of smart meters, AI analytics, and other advanced tools. This strategy is essential for bridging the expertise gaps identified in the challenges to NRW management.

The results strongly confirm the literature's recommendations for NRW reduction, particularly the emphasis on advanced technologies (leak detection, smart metering, AI), pressure management, infrastructure renewal, and community engagement. However, the results diverge slightly in their strong endorsement of AI-driven analytics (mean = 4.3946), which is less prominent in the provided literature for Uganda's context. While Wang et al. (2024) highlight AI's potential globally, NWSC's current technological lag (such as, limited SCADA use) suggests that this strategy may face implementation challenges not fully addressed in the literature. Similarly, the high agreement on benchmarking (mean = 4.3525) contrasts with Amaral et al.'s (2021) caution against direct copying, indicating that NWSC must carefully adapt global practices to Kampala's unique infrastructure and socioeconomic conditions.

5.3 Conclusions

The current study was anchored on examining NRW management, examining challenges caused by NRW and Suggesting strategies to improve NRW management in National Water and Sewerage Corporation majorly Kampala. Summarily, regarding overcoming NRW challenges to enhance other activities such as revenue collection, water production and quality as well as staff welfare.

The study's results paint a picture of cautious optimism tempered by significant challenges in NRW management at NWSC Kampala. They resonate with the literature's emphasis on technology, governance, and motivation as critical levers for NRW reduction but highlight implementation gaps due to financial and technical constraints. By aligning strategies with global trends such as adopting advanced technologies, enhancing staff and community engagement, and securing funding, NWSC can move closer to its 30% NRW target by 2029, contributing to sustainable water management in Uganda.

The study's results highlight a critical set of challenges impeding NRW management at NWSC Kampala, with strong agreement on infrastructure deficiencies, funding shortages, corruption, and reactive maintenance. These findings closely align with the literature's depiction of systemic barriers in developing countries, reinforcing the need for comprehensive strategies to address the 34% NRW rate. While NWSC shows ambition through service expansion and digitization, the high mean score of 3.8812 underscores the urgency of tackling these challenges to achieve the 30% NRW target by 2029. By prioritizing infrastructure upgrades, anti-corruption measures, and proactive management, NWSC can align with global benchmarks and enhance water service sustainability in Uganda.

The study's results demonstrate strong support for a multifaceted approach to improving NRW management at NWSC Kampala, with high agreement on advanced technologies, pressure management, smart metering, infrastructure renewal, community engagement, data analytics, and staff training. These findings closely align with the literature's emphasis on integrated strategies combining traditional and innovative methods, as seen in global successes (IWA, 2025; ADB, 2023). While fiscal and technical constraints pose challenges, the results' focus on phased deployment and capacity building offers a pragmatic path to achieving the 30% NRW target by 2029. By prioritizing these strategies, NWSC can enhance operational efficiency, reduce losses, and move toward international benchmarks for sustainable water management in Uganda.

5.4 Recommendations

Based on the study findings, the following recommendations were put forward.

NWSC should implement a phased rollout of advanced technologies, starting with pilot projects for smart meters, acoustic sensors, and AI analytics in high-loss zones. These initiatives should be supported by targeted training programs to build technical capacity, addressing expertise gaps and ensuring effective use. External funding or public-private partnerships, as suggested by Pozzolli et al. (2014), can mitigate financial constraints, enabling NWSC to modernize infrastructure and reduce both physical and apparent losses. Additionally, The IWA (2025) notes smart meters with AI analytics reduced apparent losses by 15% in South Africa. NWSC's smart meter rollout needs acceleration to curb discrepancies.

NWSC should enhance governance by implementing transparent, digitized billing and monitoring systems to curb corruption and illegal connections. Simultaneously, scale up community engagement through public campaigns and incentives for leak reporting, fostering water stewardship as a cost-effective strategy. Establishing community-led monitoring groups, as per tariff can address unauthorized consumption and support equitable water access, particularly for marginalized communities burdened by NRW costs.

NWSC should prioritize infrastructure renewal by launching targeted pipe and meter replacement programs in high-loss zones, coupled with proactive maintenance using predictive tools like AI to prevent leaks and bursts. Installing PRVs in high-pressure areas and establishing district metering areas (DMAs) will enhance pressure control, reducing physical losses. Phased implementation and external funding, as per the World Bank can address the funding gap, ensuring sustainable infrastructure upgrades.

5.5 Limitation of the Study

The researcher was a staff of NWSC, hence the potential bias in the study. However, bias was delt with by Relying on structured instruments rather than ad hoc questions to limit subjectivity at the design stage and data collection stage. In addition, during data collection, respondents were assured that their responses are confidential and will not affect their work. Moreover, the research instrument was anonymous.

Some respondents were hesitant to complete the survey. They questioned questioning the confidentiality and purpose. Nevertheless, with the help of the introductory letters, the researcher explained to them that the information was to be only used for academic purpose and held with utmost confidentiality.

Respondents requested for some facilitation, particularly monetary gains before completing the survey instrument. However, the researcher explained to them that the research was not for any economic gain, it was purely for academic purpose.

The researcher was faced with a challenge of some respondents taking a long time to respond and send back feedback. However, the researcher made follow up calls to ensure feedback was given.

5.6 Areas for further research

Future researchers could investigate the synergistic effects of integrating advanced technologies (smart meters, AI analytics) with community engagement initiatives (leak reporting incentives) on NRW reduction at NWSC. A mixed-methods study could quantify loss reductions and qualitatively explore community and staff perceptions, addressing implementation barriers like corruption and expertise gaps.

Conduct a cost-benefit analysis of targeted infrastructure renewal (such as, pipe and meter replacements) and pressure management strategies (such as, PRVs, DMAs) at NWSC. This study should assess financial and operational impacts, comparing phased versus large-scale approaches and exploring funding models to address the USD 1.5 billion gap.

Explore the feasibility and impact of adapting NRW management practices from low-NRW countries (for instance, USA, China) to NWSC's operations. A comparative case study could identify transferable strategies (for instance, AI analytics, automated PRVs) and assess modifications needed to address local constraints like funding and infrastructure conditions, informing a tailored benchmarking framework.

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APPENDIX I: QUESTIONNAIRE

Dear Respondent,

My name is Basigirenda Birungi Betty, a student pursuing a Master's Degree in Business Administration at Makerere University Business School. Am taking on a study bout Assessing non-revenue water at National Water and Sewerage Corporation a case study of Kampala. I humbly request you to take time and read through, fill in and tick the most suitable answer for questions presented below. The study is purely academic; therefore, all the responses received will be treated with utmost confidentiality and will in no way be linked to you.

Section A: Bio-data

Please put a tick mark (√) in the option boxes provided or fill in the spaces provided.

1. Age of respondent

20-30 ☐

30-45 ☐

45-50 ☐

50+ ☐

2. Highest level of education attained

Diploma ☐

Degree ☐

Masters ☐

Others: .....

3. How many years have you taken working for the corporation?

   1-10 years ☐

   10-15 years ☐

4. 15 years above ☐

For questions in Section B, C and D, show your level of agreement or disagreement with statements given below basing on the ranking scale.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree

SECTION B: CURRENT STATE OF NRW MANAGEMENT

Code	Item	Ranking				
		1	2	3	4	5
NRM1	NWSC Kampala effectively uses advanced technologies (such as, smart meters, Internet of Things) to monitor and reduce NRW levels.					
NRM2	The current metering system (bulk and consumer meters) at NWSC Kampala accurately tracks water distribution and consumption.					
NRM3	NWSC Kampala's management prioritizes data-driven decision-making to address NRW issues.					
NRM4	Staff at NWSC Kampala are adequately trained and motivated to manage NRW effectively.					
NRM5	NWSC Kampala has sufficient financial resources to implement modern NRW reduction strategies.					
NRM6	The current NRW level of 34% at NWSC reflects effective management practices.					
NRM7	NWSC Kampala actively engages customers in reporting leaks and illegal connections.					
NRM8	The infrastructure at NWSC Kampala (such as pipes, networks) is well-maintained to minimize physical water losses.					
NRM9	Management at NWSC Kampala is fully aware of the financial and operational costs of NRW.					

NRM10	NWSC Kampala employs innovative approaches (giving incentives) to boost staff productivity in NRW management.					
NRM11	Unauthorized consumption and metering inaccuracies are effectively controlled at NWSC Kampala.					
NRM12	NWSC Kampala's governance structure supports coordinated efforts to reduce NRW.					
NRM13	The organization's current strategies are sufficient to achieve the target of reducing NRW to 30% by 2029.					
NRM14	NWSC Kampala integrates community-led monitoring to address NRW challenges.					
NRM15	The tariff structure and billing system at NWSC Kampala effectively minimize apparent losses (such as, from theft or inaccurate billing).					

SECTION C: CHALLENGES FACED BY NRW MANAGEMENT

Code	Item	Ranking				
		1	2	3	4	5
CNRWM1	NWSC Kampala lacks sufficient funding to effectively manage and reduce NRW levels.					
CNRWM2	Aging and dilapidated infrastructure significantly contributes to high NRW at NWSC Kampala.					
CNRWM3	Worn-out and inefficient bulk meters at NWSC Kampala hinder accurate measurement of water distribution.					
CNRWM4	Old and defective consumer meters at NWSC Kampala lead to inaccurate billing and increased NRW.					
CNRWM5	Corruption within NWSC Kampala complicates efforts to reduce NRW.					
CNRWM6	NWSC Kampala's reactive maintenance approach fails to prevent pipe bursts and leakages.					

CNRW M7	Insufficient technical expertise at NWSC Kampala limits the adoption of advanced NRW reduction technologies.					
CNRW M8	NWSC Kampala's management lacks focus on saving water within the network system.					
CNRW M9	Obsolete record-keeping systems at NWSC Kampala undermine effective NRW management.					
CNRW M10	Inadequate pressure control in the water network increases leakages and NRW at NWSC Kampala.					
CNRW M11	NWSC Kampala struggles to maintain an updated database of water connections, contributing to NRW.					
CNRW M12	The financial burden of NRW at NWSC Kampala disproportionately affects marginalized communities.					
CNRW M13	Lack of proactive monitoring and replacement planning for infrastructure exacerbates NRW at NWSC Kampala.					
CNRW M14	Corruption-related practices (e.g., overcharging, theft) significantly inflate NRW levels at NWSC Kampala.					

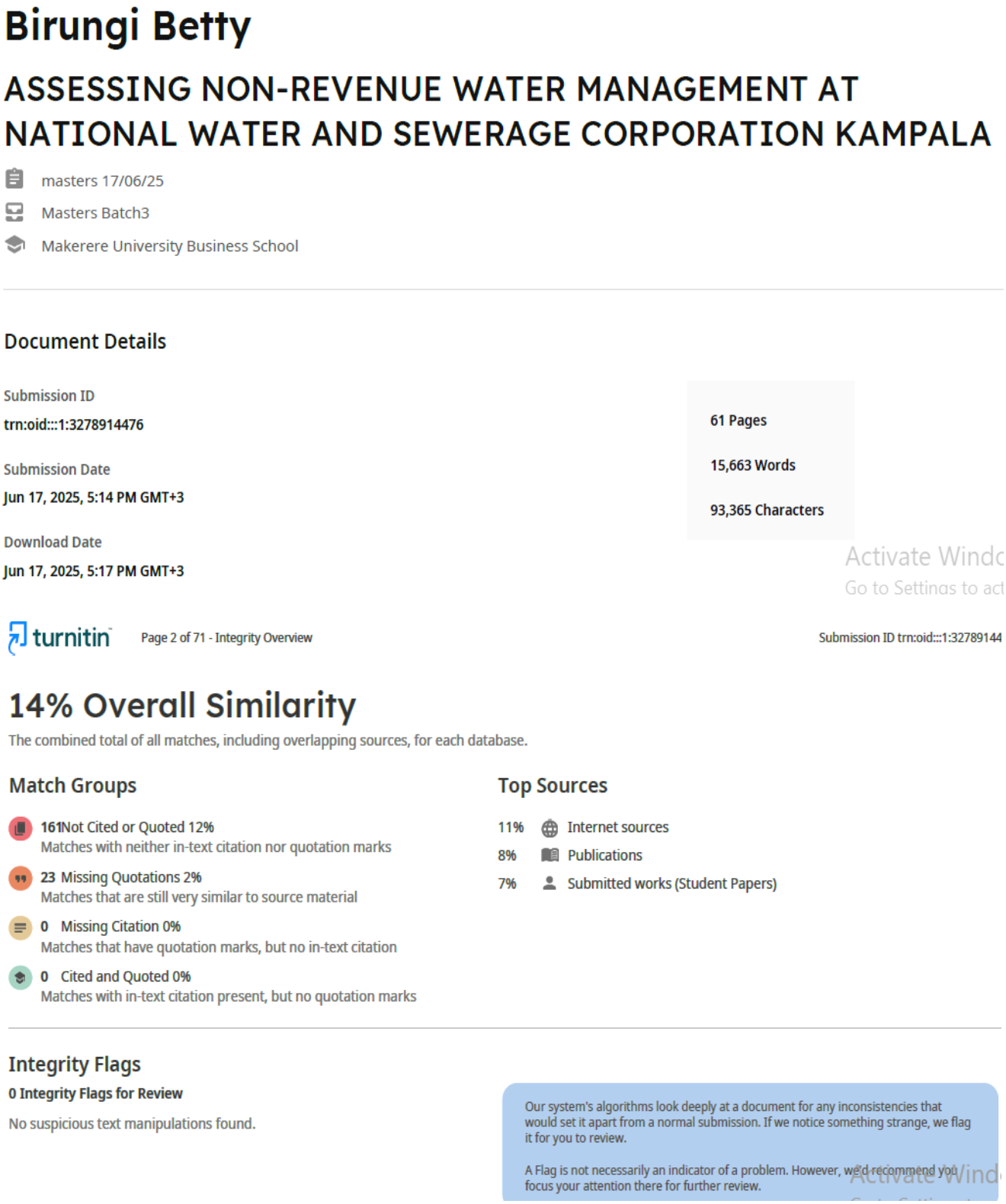
SECTION D: STRATEGIES FOR IMPROVING NRW MANAGEMENT

Code	Item	Ranking				
		1	2	3	4	5
ST1	Implementing advanced leak detection technologies (such as acoustic sensors, GPR, drones) would significantly reduce physical water losses at NWSC Kampala.					
ST2	Installing pressure-reducing valves (PRVs) in high-pressure zones would effectively minimize pipe bursts and leakages at NWSC Kampala.					
ST3	Adopting smart metering systems would improve billing accuracy and reduce apparent losses at NWSC Kampala.					
ST4	Regular pipe replacement programs are essential to address aging infrastructure and lower NRW at NWSC Kampala.					
ST5	Educating customers about water conservation and incentivizing leak reporting would enhance NRW reduction efforts at NWSC Kampala.					
ST6	Using geographic information systems (GIS) to map and prioritize NRW hotspots would improve operational efficiency at NWSC Kampala.					
ST7	Implementing SCADA systems for real-time monitoring would enable rapid responses to NRW issues at NWSC Kampala.					
ST8	Benchmarking NRW management practices from developed countries (such as, USA, China) would help NWSC Kampala achieve international standards.					
ST9	Phased deployment of advanced technologies (such as, smart meters, PRVs) would overcome financial and technical barriers at NWSC Kampala.					
ST10	Proactive maintenance of the water distribution network would prevent escalation of NRW issues at NWSC Kampala.					

ST11	Integrating AI-driven data analytics would enhance the prediction and management of NRW hotspots at NWSC Kampala.					
ST12	Establishing district metering areas (DMAs) would improve pressure control and reduce physical losses at NWSC Kampala					
ST13	Investing in staff training and capacity building is critical for successful adoption of NRW reduction technologies at NWSC Kampala.					
ST14	Combining traditional methods (such as, metering, pressure control) with innovative tools (such as, Artificial intelligence, drones) would sustainably lower NRW at NWSC Kampala.					
	Prioritizing infrastructure renewal in high-loss zones would be a cost-effective strategy to reduce NRW at NWSC Kampala.					

END: THANK YOU

APPENDIX II: PLAGIARISM CHECK REPORT



Birungi Betty

ASSESSING NON-REVENUE WATER MANAGEMENT AT NATIONAL WATER AND SEWERAGE CORPORATION KAMPALA

masters 17/06/25

Masters Batch3

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