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Influence of Innovation Leakages on Performance of Nairobi Water & Sewerage Company in Nairobi County, Kenya

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Abstract

The NCWSC was highly committed to ensuring effective water management. The company had achieved 80% of its strategic plan. However, it faced significant challenges between the years 2014/15 and 2018/19. In 2014/15, NCWSC produced 201.8 million cubic meters of water, while the amount sold was 124.7 million cubic meters. By 2018/19, both production and sales had declined to 180.1 million cubic meters and 114.5 million cubic meters, respectively. Additionally, Non-Revenue Water (NRW) losses due to physical leaks or inefficiencies stood at 36.4% in 2018/19, exceeding the sector's recommended maximum of 25%. Thus, the study examined the influence of innovation leakages on performance of Nairobi Water & Sewerage Company in Nairobi County Kenya. An extensive theoretical framework was developed to provide a solid theoretical foundation for the study, based on resource-based view theory. The study adopted a descriptive research design, focusing on 94 participants within NCWSC's Nairobi operations. Data was collected using questionnaires. The variables were analyzed using descriptive statistics and linear regressions. The results were presented in tabular format. The response rate was 93.6%, with 88 out of 94 questionnaires completed. The study found that innovation in water leak detection significantly influences Nairobi Water & Sewerage Company's performance, with regression analysis revealing a strong positive correlation between leak detection technologies and organizational performance, demonstrating that advanced technological interventions in leak management substantially contribute to operational effectiveness. The study concludes that innovation in water leak detection is a strategic imperative that transforms water management by enabling rapid leak identification, reducing water losses, and improving resource allocation. The study recommends that NWSC should invest in cutting-edge smart water technologies like advanced sensors, AI-driven monitoring, and Internet of Things-based leak detection systems. The organization should prioritize strategic infrastructure upgrades and regular maintenance plans to optimize water distribution and reduce non-revenue water losses. By embracing these technological innovations, NWSC can transform its operational model and become a forward-thinking, customer-centric utility service provider.

Keywords: *Innovation Leakages, Performance, Nairobi Water & Sewerage Company, Nairobi County Kenya*

1.0 Background of the Study

In developed nations, SMART water strategies encompass advanced technologies and sophisticated management practices aimed at enhancing water services efficiency, sustainability, and reliability. Countries like the United States, Germany, and Australia have pioneered innovative solutions including smart metering, data analytics, and real-time monitoring systems (Gupta et al., 2020). These technologies enable precise tracking of water usage, leak detection, and predictive maintenance, collectively reducing water loss and improving service delivery. For example, Los Angeles and New York have invested heavily in SMART water infrastructure to address water scarcity and aging infrastructure challenges, implementing sophisticated smart meters that provide real-time usage data for quick leak identification and repair (Jan et al., 2021). This proactive approach to leak detection has proven crucial in conserving water resources and enhancing system efficiency, allowing utilities to minimize losses and optimize their distribution networks.

Globally, developing nations are adopting SMART water strategies to address scarcity, inadequate infrastructure, and inefficient management. India and Brazil are exploring SMART technologies to improve distribution and reduce wastage (Singh & Ahmed, 2021). India's Smart Cities Mission implemented advanced solutions to support sustainable resources and reduce non-revenue water lost through leaks or unauthorized usage (Li et al., 2020). Pune's smart water management system includes automated meter reading technology that enables accurate billing while helping detect and reduce leaks. These innovations demonstrate how technological integration can significantly improve water system performance and reduce losses through leakages, transforming the management of water resources in regions where efficient distribution is particularly critical. The implementation of such technologies has shown promising results in minimizing water losses and improving service delivery in challenging urban environments.

In Africa, SMART water strategies are essential in addressing scarcity, pollution, and infrastructure challenges. South Africa and Ghana have pioneered these technologies to combat severe water management issues (Anghileri et al., 2024). Cape Town implemented a comprehensive strategy incorporating smart metering, demand management, and real-time monitoring to combat drought conditions that threatened the city's water security. Advanced metering infrastructure provided detailed insights into usage patterns and facilitated leak detection, substantially reducing consumption and ensuring reliable supply during droughts. This case exemplifies how innovation in leak detection can contribute significantly to water resource management in challenging environments, demonstrating the transformative potential of technological solutions when applied to critical water conservation challenges. The success of these implementations has provided valuable lessons for other African utilities seeking to address similar challenges.

In Kenya, Nairobi City Water and Sewerage Company (NCWSC) has adopted technologies to improve performance, including smart metering, data analytics, and mobile applications for more effective resource management (Mutschinski & Coles, 2021). These innovations represent a shift from traditional approaches to data-driven systems that better identify inefficiencies and address leakages in the distribution network. Using these innovations, NCWSC monitors usage in real-time, detects leaks promptly, and manages billing efficiently, thereby improving its overall operational

capabilities (Mvulirwenande & Wehn, 2021). The automated meter reading system provides accurate consumption data, enabling prompt leak detection and repair, which has contributed to reducing non-revenue water and improving the utility's financial performance. These technological implementations mark a significant advancement in NCWSC's approach to water management and demonstrate the company's commitment to adopting innovative solutions to address persistent challenges.

Mobile applications for customer engagement have strengthened utility-customer communication, enabling timely issue reporting and efficient complaint resolution throughout NCWSC's service area (Obunga, 2023). These platforms allow customers to report leaks, billing issues, and service interruptions in real-time, creating a more responsive and transparent relationship between the utility and its users. Despite these technological advancements, NCWSC continues to face significant challenges with water losses in its distribution system. Between 2014/15 and 2018/19, water production declined from 201.8 million cubic meters to 180.1 million cubic meters, with sales dropping from 124.7 million to 114.5 million cubic meters, indicating persistent inefficiencies. More critically, non-revenue water losses stood at 36.4% in 2018/19, substantially exceeding the sector's 25% recommended maximum (Lusweti, 2021). These statistics highlight the urgent need for enhanced innovation in leak detection and management to improve NCWSC's operational efficiency and service delivery in a rapidly growing urban environment.

The economic dimension of leak detection innovation is critical for NCWSC's financial performance and long-term sustainability. Advanced leak detection systems provide significant returns on investment, ranging from 300% to 700% over five years depending on baseline non-revenue water rates and implementation efficiency (Raza et al., 2022). For NCWSC, with its high percentage of non-revenue water, the economic case for investing in innovative leak detection technologies is particularly compelling and potentially transformative. Each 1% reduction in non-revenue water translates to approximately 2-3% revenue increase for utilities in growing urban areas like Nairobi, creating a multiplier effect that can significantly improve financial outcomes (Lusweti, 2021). These economic benefits extend beyond immediate revenue improvements to include reduced treatment costs, lower energy consumption, and extended infrastructure lifespan, creating a comprehensive business case for technological innovation in leak management.

Leak detection innovations also impact NCWSC's long-term sustainability and environmental performance in significant ways. Reduced leakage directly translates to lower energy consumption for water treatment and pumping, decreased chemical usage, and reduced carbon emissions, creating a more environmentally sustainable operation (Imran et al., 2018). For water-stressed regions like Nairobi, minimizing losses through innovative technologies represents a critical climate adaptation strategy that conserves precious resources and reduces environmental impact. Comprehensive leak detection programs typically reduce utilities' energy footprint by 15-25%, presenting an opportunity for NCWSC to improve both operational efficiency and environmental performance through innovation in this critical operational area (Gupta et al., 2020). These sustainability benefits align with global climate goals and strengthen the utility's resilience in the face of increasing resource constraints and environmental challenges.

This study therefore explored the influence of innovation leakages on NCWSC's

performance in Nairobi County, examining the multifaceted impacts of technological advancements on service delivery and resource management. By examining how technological innovations in leak detection impact operational, financial, and service performance metrics, this research aimed to provide recommendations that can guide strategic investments and policy decisions for the water utility sector. The findings are expected to contribute to the broader understanding of how innovation can transform water management practices in rapidly urbanizing environments, potentially offering valuable lessons for other utilities facing similar challenges across the region.

1.1 Problem Statement

Securing sustainable and high-quality water sources, production, and storage; optimizing water transmission and ensuring equitable distribution; lowering non-revenue water; improving wastewater management; boosting revenue growth and customer loyalty; strengthening human resource management; improving financial stewardship; and developing brand equity alongside institutional capacity were the eight main themes of the NCWSC 2018–2022 strategic plan. These focus areas aimed at ensuring the company's operational efficiency and sustainability while meeting growing demand for water and sewerage services in Nairobi. This strategic plan is in line with the desired Vision 2030. The estimated cost to implement the strategic plan was Kshs 42 billion, in addition to the regular operations expenditure. In an ideal scenario, NCWSC envisioned achieving sustainable and high-quality water sources capable of meeting Nairobi's growing demands. The company aimed to optimize its transmission system to equitably distribute water, minimize losses, and ensure consistent supply. Reducing non-revenue water to the sector-recommended target of 25% was another critical goal, along with implementing robust wastewater management systems. The strategic plan also emphasized achieving significant revenue growth through improved billing and customer loyalty initiatives, ensuring prudent financial management, enhancing workforce efficiency, and strengthening the company's brand and institutional capacity.

However, the actual situation deviated from these goals. Despite achieving 80% of its strategic plan, NCWSC faced significant challenges. Water production dropped from 201.8 million cubic meters (M^3) in the financial year 2014/15 to 180.1 million M^3 in 2018/19, primarily due to climate changes and erratic rainfall patterns, including prolonged droughts in 2016 and 2017. A substantial amount of water was lost due to leaks, theft, and inefficiencies in the distribution system causing the non-revenue water (NRW) to be 36.4% in 2018/19. This is considerably higher than the recommended sector target of 25%. Additionally, water sales declined from 124.7 million M^3 in 2014/15 to 114.5 million M^3 in 2018/19, reflecting inefficiencies in both water production and distribution. The statistical trends highlight the challenges: water production decreased from 201.8 million M^3 in 2014/15 to 180.1 million M^3 in 2018/19, water sales fell from 124.7 million M^3 in 2014/15 to 114.5 million M^3 in 2018/19, and non-revenue water stood at 36.4% in 2018/19 against the recommended target of 25%.

The gap identified in this study was the discrepancy between the strategic goals set by NCWSC and the actual performance outcomes, particularly in water production, sales, and non-revenue water levels. The decline in water production and sales, coupled with high non-revenue water, highlighted inefficiencies and challenges in the existing water management practices. A number of studies have shown that smart water

technologies can improve water resource management. For instance, Gupta et al. (2020) found that smart technologies could significantly enhance water resource management and reduce water scarcity worldwide. However, these results might not have directly applied in the Kenyan context. A study by Shuma (2021) examined water management practices in Nairobi and determined that sufficient infrastructure is needed to deliver quality services, although the study focused primarily on service delivery. Therefore, the study sought to explore the influence of innovation leakages on the performance of Nairobi Water & Sewerage Company in Nairobi County Kenya.

1.2 Objective of the Study

To explore the influence of innovation leakages on the performance of Nairobi Water & Sewerage Company in Nairobi County, Kenya.

2.0 Literature Review

The literature review included the theoretical framework, empirical review and conceptual framework.

2.1 Theoretical Framework

The study was anchored on Resource-Based View (RBV) theory. The Resource-Based View (RBV) theory, developed by Wernerfelt in 1984, provides the theoretical foundation for this study. RBV posits that organizations gain competitive advantage through unique internal resources and capabilities that are valuable, rare, inimitable, and non-substitutable (VRIN). According to Barney (1991), sustainable competitive advantage stems from resources that cannot be easily replicated by competitors due to path-dependence and social complexity. This theory emphasizes that firms must strategically acquire, develop, and deploy key resources to enhance their competitive position, with organizational history, culture, and core competencies serving as fundamental factors for success. As Langlois (2010) notes, businesses increasingly depend on external suppliers for parts, software, expertise, and sales to achieve sustainable competitive advantages, gaining access to valuable resources otherwise unavailable to them.

Critics have identified several limitations of RBV theory. First, it lacks practical guidance for managers on identifying, developing, and deploying strategic resources, remaining more conceptual than practical. Second, RBV's focus on internal resources potentially creates strategic myopia by neglecting external factors such as market conditions and competitor actions. Third, determining which resources qualify as VRIN resources is subjective and challenging, especially in dynamic markets where resource value constantly evolves. This subjectivity reduces the theory's practical utility in strategic decision-making and may lead organizations to overemphasize internal capabilities while failing to adapt to external changes, potentially undermining the practical utility of RBV in guiding strategic decisions.

Despite the weaknesses, the theory was considered relevant. The RBV theory is particularly relevant to examining innovation leakages at NCWSC, as it frames how the company's technological capabilities in leak detection represent valuable, rare resources that can significantly impact performance. The theory helps explain how

NCWSC's ability to develop or acquire innovative leak detection technologies—as unique internal resources-directly influences its capacity to reduce non-revenue water losses and improve operational efficiency. RBV illuminates why NCWSC's performance challenges partly stem from its inability to effectively deploy these innovative resources, with the high non-revenue water percentage (36.4%) indicating a gap in utilizing available technological capabilities. Furthermore, the theory clarifies how innovation in leak detection serves as a strategic response that depends on both resource availability and proper alignment with organizational structure.

2.2 Empirical Review

As part of their study, Klosok-Bazan et al. (2021) assessed the management of leakage in small water supply systems using performance indicators. Their study involved a comprehensive analysis of various PIs necessary for evaluating different leakage reduction methods, adopting a step-by-step method to identify data that is most relevant for analysis of leakage management at the network level. The performance indicators proposed in the study aimed at enhancing efficiency of leakage management in the small water supply systems. The authors aligned their methodology with the Deming cycle, which involves a systematic process of planning activities, executing them according to the plan, checking the execution against the set objectives, and making improvements based on the analyses and lessons learned. The findings indicated that implementing a comprehensive and systematically strategy that is improved could significantly enhance effectiveness of leakage management systems. However, it is worth noting that this research relied on secondary data for its analysis.

In their study, Hlalele, Ilunga, and Dinka (2021) investigated how and why leaks occur in water distribution systems and their causes. Using several leak detection systems in individual water pipes, a program of leak detection and repairs was prescribed to address NRW. In addition to Sahara and SmartBall leak detection technologies, Piper and satellite technologies were also used. As part of the proactive measures, various technologies were also employed, including Magnetic Tomography Method (MTM) Gradient and Long Range Guided Ultrasonic Waves Technology, which measured the walls of the pipes and determined what repair was needed in order to stop leaks. Rand Water was able to locate and identify many leaks and repair them with various leak detection and repair technologies. As a result, Rand Water will be able to lower preventable non-revenue water. However, qualitative data was employed in the study.

Barros et al. (2023) conducted an investigation into the impact of leakage on parameters of water quality within distribution networks, aiming to identify new sources of information to promote more sustainable water use. During leak occurrences, the study examined the hydraulic behavior of water networks, which affected key water quality parameters, including water age and chlorine concentration, in a study. Water data could serve as a valuable resource for identifying leaks, potentially influencing the development of future detection systems, according to the authors. Moreover, the study introduced the application of graph theory to the water network, suggesting that analyzing the shortest path between leak location and respective reservoir could yield significant insights for improving detection methods. Despite these contributions, the research employed a cross-sectional design, which

may limit the ability to observe changes over time and establish causal relationships.

In their study (2022), Murray et al. explored how advanced sensor technologies can be integrated into real-time leak detection to improve overall system performance. The study examined how Internet of Things (IoT) sensors and machine learning algorithms can be used to increase the accuracy and timeliness of leak detection. The results indicated that smart sensors and data analytics significantly improved leakage detection rates and operational efficiency, leading to reduced water loss and better resource management. The research applied a mixed-method approach, combining both quantitative data and case studies. The current study will fill this research gap in methodology by applying descriptive research design.

Zhang et al. (2023) examined the role of predictive maintenance strategies in reducing leakage and improving system performance. This study utilized both quantitative analysis of performance metrics and qualitative assessments of maintenance practices. The research focused on the application of predictive analytics to anticipate potential leaks before they occur, using historical data and real-time monitoring. The study demonstrated that predictive maintenance could decrease downtime, extend the lifespan of infrastructure, and enhance overall system reliability. Santos et al. (2022) explored the effect of smart water grids on leakage management and organizational performance. The study employed a comparative analysis of traditional and smart water grid systems to evaluate performance improvements. Using advanced metering infrastructure (AMI) and real-time data analytics, the study evaluated smart grid implementation. The findings highlighted that smart water grids facilitated more efficient leakage detection and management, leading to cost savings and improved service delivery.

2.3 Conceptual Framework

Figure 1 presents the conceptual framework that includes pictorial representations of the independent and dependent variables.

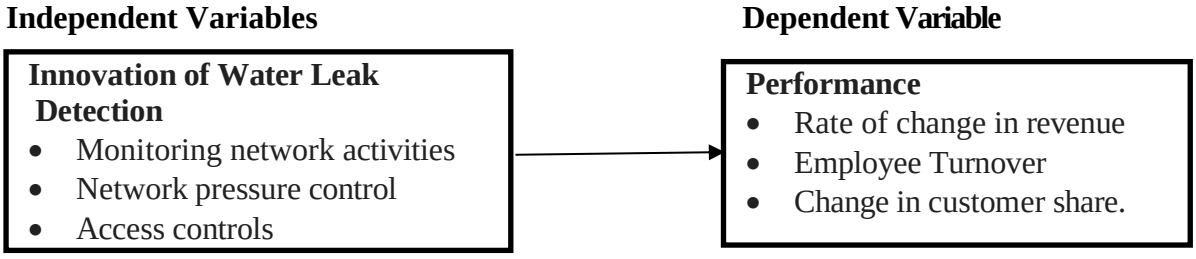

Figure 1: Conceptual framework

3.0 Research Methodology

The research employed a descriptive research design, targeting a total population of 94 employees involved in innovation roles. Using a census sampling technique, the entire population was included in the study. This comprehensive approach ensured a thorough and representative examination of innovation practices within the organization. The methodology was carefully structured to capture nuanced insights into the complex dynamics of water utility management. Data collection was conducted through semi-structured questionnaires featuring a 5-point Likert scale. The data analysis approach utilized descriptive statistics, including mean and standard deviation, and linear regression analysis to examine variable correlations. Ethical

considerations were paramount, with consent obtained from Kenyatta University Graduate School and NACOSTI, and measures implemented to protect participant anonymity and data confidentiality. The research presented the findings in Tables.

4.0 Research Findings and Discussions

Based on the data collected in the field, this chapter presents findings, including response rates, descriptive statistics results and regression results.

4.1 Response Rate

The overall response rate for the study is represented in Table 1 and is based on 94 questionnaires administered to managers and staff members who are responsible for innovation at Nairobi Water and Sewerage Company.

Table 1: Response Rate

Category	Frequency	Percentage
Response	88	93.6
Non response	6	6.4
Total	**94**	**100**

Source: Research Data (2024)

According to the findings in Table 1, the study had a 93.6% response rate and a 6.4% non-response rate. Baruch and Holtom (2014) state that a response rate of 80% or more is adequate for data processing. Consequently, a 93.6% study response rate was judged suitable for data analysis. The high response rate of the study led to acceptance and credibility of the research findings.

4.2 Descriptive Statistics Results

The study sought to identify the effect of innovation of Water Leak Detection on Smart water strategies and organizational performance of Nairobi water and sewerage company in Nairobi city County, Kenya. The descriptive results are presented in Table 2

Table 2: Innovation of Water Leak Detection and Performance

Statements	M	SD
Cutting-edge water leak detection technology can help companies identify and locate leaks quickly and accurately.	3.91	1.073
Innovative of water leak detection help the organization save money on costly repairs, water bills, and potential damage to infrastructure or equipment caused by water leaks.	3.77	0.814
Innovative of water leak detection enable companies to monitor their water usage and identify areas of improvement.	4.01	0.812
Innovative of water leak detection help companies maintain the integrity of their assets and ensure uninterrupted operations	4.06	0.647
Innovative of water leak detection allow the organization to collect and analyze data on water usage, leak patterns, and trends.	4.33	0.714
Innovative of water leak detection help identify leaks early on, preventing the growth of these hazards and ensuring a safe and healthy working environment.	4.57	1.514
Aggregate score	**4.11**	**0.327**

Source: Research Data (2024)

Based on a 5-point Likert scale, the respondents agreed on statements describing the impact of innovation in water leak detection on smart water strategies and organizational performance of Nairobi Water and Sewerage Company in Nairobi City County, Kenya, as indicated by the results shown in Table 2 which also shows the standard deviation of 0.327 and the aggregate mean of 4.11. Ogundele (2017) examined the effectiveness of smart water techniques to improve NWSC's organizational performance, with a particular emphasis on access controls, network pressure control, and activity monitoring. The study hypothesized a link between effective network monitoring and operational efficiency, as well as the relationship between strategic pressure regulation and sustainable water management. The findings highlighted the importance of implementing smart water strategies in optimizing service delivery and improving overall organizational performance.

The respondents strongly agreed that; Innovative of water leak detection help identify leaks early on, preventing the growth of these hazards and ensuring a safe and healthy working environment (M=4.57, SD=1.514). Nwokolo (2017) investigated the effectiveness of smart water strategies in enhancing organizational performance. The study analyzed data using descriptive statistics, Chi-square tests, and a t-test for independence. The findings revealed that monitoring network activities, network pressure control, and access controls play a significant role in improving the efficiency and reliability of water service delivery, ultimately enhancing the performance of water utilities.

The respondents agreed that; Innovative of water leak detection allow the organization to collect and analyze data on water usage, leak patterns, and trends (M=4.33, SD=0.714), Innovative of water leak detection help companies maintain the integrity of their assets and ensure uninterrupted operations (M=4.06, SD=0.647), Innovative of water leak detection enable companies to monitor their water usage and identify areas of improvement (M=4.01, SD=0.812), Cutting-edge water leak detection technology can help companies identify and locate leaks quickly and accurately(M=3.91, SD=1.073) and Innovative of water leak detection help the organization save money on costly repairs, water bills, and potential damage to infrastructure or equipment caused by water leaks (M=3.77, SD=0.814). Onsomu (2010) investigated the role of monitoring network activities, network pressure control, and access controls in enhancing the operational efficiency of Nairobi Water and Sewerage Company. The study's findings highlight the significance of these smart water strategies in optimizing water distribution, minimizing losses, and ensuring reliable service delivery, ultimately contributing to improved organizational performance. The study also sought to investigate organizational performance of Smart water strategies of Nairobi water and sewerage company in Nairobi city County, Kenya. The descriptive results are presented in Table 3.

Table 3: Performance of Smart water strategies

Statements	M	SD
The revenue collected has increased making the organization expand its operations	3.65	1.348
The revenue collected has increased enabling the organization to invest in new products or services	4.11	0.890
The organization has a larger workforce that allows for a greater division of labor, enabling tasks to be allocated more efficiently and completed in a shorter amount of time.	3.94	1.060
The organization has a larger workforce that enhances the organization's ability to handle larger workloads and meet deadlines	3.57	1.429
There is an increased customer base that has enabled the organization to increase its brand visibility and awareness.	3.87,	0.529)
There is an increased customer base that enabled the organization to enjoy economies of scale	4.29	0.709
Aggregate score	**3.912**	**0.307**

Source: Research Data (2024)

According to the results presented in Table 3, the respondents agreed that; The revenue collected has increased making the organization expand its operations (M=3.65, SD=1.348), The revenue collected has increased enabling the organization to invest in new products or services (M=4.11, SD=0.890), The organization has a larger workforce that allows for a greater division of labor, enabling tasks to be allocated more efficiently and completed in a shorter amount of time (M=3.94, SD=1.060), The organization has a larger workforce that enhances the organization's ability to handle larger workloads and meet deadlines (M=3.57, SD=1.429), There is an increased customer base that enabled the organization to enjoy economies of scale (M=4.29, SD=0.709) and There is an increased customer base that has enabled the organization to increase its brand visibility and awareness (M=3.87, SD=0.529). Organizational performance is influenced by various factors, including financial stability, workforce retention, and customer engagement. In the context of NWSC, the effectiveness of smart water strategies can be assessed through key performance indicators such as the rate of change in revenue, employee turnover, and changes in customer share. A well-managed water utility that implements innovative water management solutions can enhance service delivery, reduce operational inefficiencies, and improve financial sustainability, ultimately leading to increased customer satisfaction and reduced workforce attrition.

4.3 Regression Analysis Results

The regression analysis results are presented in Table 4

Table 4: Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	0.771	.215		3.586	.002
Innovation of Water Leak Detection	0.851	.145	.3652	5.869	.001

Source: Research Data (2024)

The study results show that innovation in water leak detection significantly influences the performance of Nairobi Water & Sewerage Company, with regression analysis revealing a strong positive correlation between leak detection technologies and organizational performance. The coefficient of 0.851 for innovation of water leak detection, coupled with a standardized beta value of 0.3652 and a highly significant p-value of 0.001, demonstrates that advanced technological interventions in leak management substantially contribute to operational effectiveness. The findings indicate that smart sensors, AI-driven monitoring, and automated warning systems enable the organization to rapidly detect and address leaks, resulting in lower operating expenses, reduced water losses, and more strategic resource allocation. Respondents strongly agreed that these innovative technologies help identify leaks early, prevent potential hazards, maintain asset integrity, and ensure uninterrupted operations. The research conclusively establishes that leak detection innovations provide multifaceted advantages, including improved data collection and analysis of water usage patterns, enhanced operational efficiency, and significant financial performance improvements.

5.0 Conclusions

The study concludes that innovation in water leak detection has a profound and transformative impact on the performance of Nairobi Water & Sewerage Company in Nairobi County, Kenya. The research findings definitively demonstrate that advanced leak detection technologies significantly enhance operational sustainability and efficiency through multiple critical mechanisms. The study conclusively reveals that smart sensors, AI-driven monitoring, and automated warning systems enable the organization to detect and address leaks more rapidly and accurately than traditional methods. This technological innovation directly translates to substantial operational benefits, including lower operating expenses, reduced water losses, and improved resource allocation. The regression analysis results further substantiate this conclusion, showing a significant positive correlation between water leak detection innovation and organizational performance, with a beta coefficient of 0.3652 and a highly significant p-value of 0. 001.The research findings highlight that innovative leak detection technologies provide multifaceted advantages beyond immediate cost savings. These technologies allow the organization to collect and analyze comprehensive data on water usage, leak patterns, and trends, enabling more strategic decision-making.

The study found that respondents strongly agreed that such innovations help identify

leaks early, prevent potential hazards, maintain asset integrity, and ensure uninterrupted operations. Moreover, the leak detection innovations contribute to broader organizational performance metrics. The research demonstrated that these technologies directly support the company's ability to expand operations, invest in new services, optimize workforce efficiency, and ultimately enhance brand visibility. By reducing water waste and maximizing resource allocation, these innovations not only strengthen water conservation efforts but also significantly boost the organization's financial performance and operational sustainability. In conclusion, the study unequivocally establishes that innovation in water leak detection is not merely a technological upgrade but a strategic imperative for modern water utilities. For Nairobi Water & Sewerage Company, embracing these advanced leak detection technologies represents a critical pathway to improved operational efficiency, financial performance, and sustainable water management.

6.0 Recommendations

The study recommends that Nairobi Water & Sewerage Company (NWSC) should implement a comprehensive strategy to enhance its operational performance through technological innovation and strategic management. The organization should prioritize the adoption of cutting-edge smart water technologies. NWSC should invest in advanced smart meters, automated water management systems, and predictive analytics that can transform data into actionable insights for improved revenue collection and water distribution efficiency. The company should conduct detailed feasibility studies to strategically place water storage facilities, identifying optimal locations for additional tanks and reservoirs. NWSC should expand and optimize storage infrastructure to ensure more equitable water distribution across Nairobi City County, reduce supply interruptions, and significantly improve customer satisfaction. The organization should leverage technology to enhance customer service, implementing mobile-based water tokens and digital payment systems that should streamline billing processes, increase transparency, and provide consumers with more convenient interaction channels.

NWSC should deploy contemporary leak detection technologies, including satellite imaging, acoustic monitoring, and Internet of Things-based sensors. The company should dramatically reduce water losses, lower operating expenses, and provide real-time insights into the water distribution network. The organization should adopt a proactive approach, prioritizing infrastructure upgrades, implementing regular maintenance plans, and should foster a culture of continuous research and development in water-saving technologies. By embracing these recommendations, NWSC should transform its operational model, moving from a traditional utility service to a data-driven, customer-centric organization. The proposed strategies should not only address immediate performance challenges but also position the company as a forward-thinking utility that should adapt to the evolving urban water management landscape. Ultimately, the recommendations should create a more sustainable, efficient, and responsive water service that should meet the growing demands of Nairobi City County while conserving critical water resources.

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