
Water Conservation Strategies and Their Impact on Sustainable Development: A Case Study of National Water and Sewerage Corporation (NWSC)

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Abstract.

This study examined the effectiveness of water conservation strategies implemented by the National Water and Sewerage Corporation (NWSC) in Uganda and their impact on sustainable development. The research aimed to assess the relationship between public awareness of water conservation practices and water consumption, evaluate the effects of these strategies on water supply sustainability, and explore their contribution to the achievement of the Sustainable Development Goals (SDGs). Data were collected through surveys administered to a sample of urban residents in Uganda, and various statistical methods, including descriptive statistics, regression analysis, and t-tests, were employed to analyze the data. The findings revealed that the majority of respondents used water on a daily basis, and awareness of water conservation strategies significantly influenced water consumption behavior, with higher awareness leading to reduced consumption. Additionally, NWSC's efforts in reducing water loss from 25% to 15% and increasing water supply reliability from 75% to 85% indicated the positive impact of infrastructure improvements. The study also demonstrated that these strategies contributed to SDG 6 (Clean Water and Sanitation), but had a less pronounced effect on SDG 13 (Climate Action). The study concluded that continued public education, further investment in water infrastructure, and the integration of water conservation with climate change strategies are essential to enhancing water sustainability. Recommendations were made to improve public awareness campaigns, strengthen water efficiency infrastructure, and align conservation efforts with broader climate action goals. The findings emphasized the importance of multi-faceted approaches in ensuring sustainable water management and contributing to Uganda's development objectives.

Key Words: Water Conservation Strategies and Sustainable Development

Background of the Study

Water is an essential resource for human survival, economic development, and environmental sustainability. However, increasing urbanization, industrialization, and population growth have placed significant pressure on water resources, leading to concerns about water scarcity and the need for effective management strategies. Water conservation has emerged as a critical strategy to address the growing demand for water while ensuring the sustainability of water resources (Shadabi & Ward, 2022). In Uganda, the National Water and Sewerage Corporation (NWSC) plays a central role in water supply and sanitation, providing water to urban and peri-urban areas across the country. The NWSC's role in implementing water conservation strategies has become crucial for ensuring that the available water resources are used efficiently and equitably to support sustainable development (Dickin & Gabrielsson, 2023).

The challenges faced by the NWSC in ensuring water availability and conservation are multi-faceted. Increasing population density, climate change, and pollution have led to a growing demand for clean water, often exceeding the available supply. Furthermore, the utility faces operational challenges, including aging

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infrastructure, inefficient water distribution systems, and a lack of public awareness regarding water conservation practices (Dickson-Gomez et al., 2023). These challenges necessitate the adoption of innovative water conservation strategies that not only aim to reduce water consumption but also improve the efficiency and sustainability of water supply systems. NWSC's strategies, such as promoting water-saving technologies, improving wastewater treatment, and enhancing public education, are essential components of its efforts to address these issues (MWE, 2020).

The impact of water conservation strategies on sustainable development cannot be overstated. Sustainable development involves balancing economic growth, social well-being, and environmental protection. In the context of water resources, sustainable development requires the efficient use and management of water to meet the needs of current and future generations (Ashrafuzzaman et al., 2023). By focusing on water conservation, NWSC aims to ensure the long-term availability of clean water while minimizing environmental degradation. The incorporation of water conservation into NWSC's operational framework contributes to reducing the ecological footprint of water use, ensuring that water resources are available for both present and future generations (Dobbin & Fencl, 2021). Moreover, water conservation plays a significant role in reducing the cost of water treatment and distribution, thus improving the financial sustainability of the utility.

The NWSC's water conservation efforts have had both direct and indirect impacts on sustainable development goals (SDGs), particularly those related to clean water and sanitation (SDG 6). Through strategic initiatives such as promoting water-efficient appliances, reducing leakage in water distribution networks, and raising public awareness about water conservation, NWSC has made significant strides toward achieving SDG 6. Additionally, these strategies contribute to other SDGs, such as affordable and clean energy (SDG 7), climate action (SDG 13), and responsible consumption and production (SDG 12) (Ashiraf et al., 2023). However, there remains a need for comprehensive research to evaluate the effectiveness of these strategies in achieving the broader objectives of sustainable development. This study seeks to investigate the water conservation strategies implemented by the NWSC and their impact on the utility's sustainability and the broader national development agenda (Rani, 2022).

Water conservation has gained significant attention globally as a response to the increasing challenges posed by water scarcity and environmental degradation. According to the (Abas Olwol et al., 2022), water scarcity affects over 2 billion people worldwide, a situation that has been exacerbated by climate change, over-extraction, and pollution (Turyasingura et al., 2023). In response, various water utilities and government agencies have implemented water conservation strategies, which include demand-side management, water reuse, improved water storage, and efficiency measures. A study by (Janssens & Carron, 2018) highlighted that effective water conservation strategies not only reduce water consumption but also contribute to the sustainability of water resources, particularly in urban areas with growing populations. The implementation of these strategies has been shown to improve the resilience of water supply systems and contribute to achieving sustainable development goals, particularly those related to water availability, sanitation, and ecosystem health. Research by (Wijesiri & Hettiarachchi, 2021) further emphasized that water conservation efforts must be complemented by public education and policy frameworks that incentivize sustainable water use behaviors across sectors.

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In Uganda, the National Water and Sewerage Corporation (NWSC) is at the forefront of addressing water challenges in urban and peri-urban areas. The NWSC has implemented several water conservation strategies aimed at improving efficiency in water use and ensuring sustainable water supply. A study by Bategeka and Lwasa (2016) highlighted the role of NWSC in addressing water access issues and the importance of water conservation in urban areas, where demand often outstrips supply (Han et al., 2020). The NWSC's efforts have included infrastructural improvements, such as the rehabilitation of old pipelines and the installation of water-saving technologies, as well as community outreach programs to promote water conservation awareness. Despite these efforts, there remains a gap in assessing the long-term impact of these strategies on both the utility's sustainability and the broader social-economic development of Uganda. Research by (Nduhura et al., 2022) stressed the need for comprehensive evaluations of water conservation measures to understand their full impact on resource management and community development. This literature underlines the importance of continuing research to evaluate the effectiveness of NWSC's conservation strategies, particularly in the context of Uganda's rapidly urbanizing population.

Problem Statement

Water scarcity is becoming an increasingly urgent issue in Uganda, particularly in urban and peri-urban areas where the demand for clean water is rising sharply due to rapid population growth, industrialization, and climate change. The National Water and Sewerage Corporation (NWSC), which is responsible for providing water to many of these areas, faces significant challenges in meeting the growing demand while maintaining water quality and sustainability (Jesus et al., 2023). Despite various efforts to manage water resources more efficiently, issues such as aging infrastructure, high levels of water loss due to leaks, and insufficient public awareness of water conservation practices continue to strain the NWSC's ability to deliver consistent and reliable water services (Khan & Sheikh, 2023). These challenges are compounded by the rising costs associated with water treatment and distribution, making it increasingly difficult to balance supply and demand. As a result, NWSC must explore more effective water conservation strategies that not only reduce consumption but also ensure the long-term availability of water resources.

Although the NWSC has implemented several water conservation initiatives, there is limited empirical research on the actual impact of these strategies on the utility's sustainability and on broader sustainable development outcomes in Uganda. The existing literature largely focuses on water conservation in general terms, but few studies have analyzed the specific strategies employed by the NWSC or assessed their effectiveness in the context of Uganda's unique socio-economic and environmental conditions (Ntirandekura & Mushamba, 2022). This gap in the literature highlights the need for a comprehensive evaluation of the NWSC's water conservation efforts, including an assessment of their contribution to achieving national and global sustainability goals. Understanding the impact of these strategies is critical for refining existing policies, optimizing resource use, and ensuring that the NWSC's efforts align with the broader objectives of sustainable development (Alexander, 2023). Thus, this study seeks to investigate the water conservation strategies employed by the NWSC and examine their effectiveness in enhancing both the utility's operational efficiency and Uganda's long-term water sustainability.

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Methods.

1. To assess the water conservation strategies implemented by the National Water and Sewerage Corporation (NWSC).
2. To evaluate the impact of NWSC's water conservation strategies on operational efficiency and water supply sustainability.
3. To explore the relationship between water conservation strategies and sustainable development goals (SDGs) in the context of Uganda.

Hypotheses

1. H1: The implementation of water conservation strategies by NWSC significantly reduces water consumption in urban and peri-urban areas.
2. H2: Water conservation strategies by NWSC improve the operational efficiency and sustainability of water supply systems.
3. H3: Water conservation strategies implemented by NWSC contribute positively to achieving sustainable development goals (SDGs) related to water and sanitation in Uganda.

Methods

The study employed a mixed-methods approach, combining both quantitative and qualitative techniques to evaluate the water conservation strategies implemented by the National Water and Sewerage Corporation (NWSC) and their impact on sustainable development in Uganda. The study targeted urban and peri-urban areas serviced by the NWSC, focusing on a sample of 10 cities and towns where water conservation initiatives have been actively implemented. A stratified random sampling technique was used to select households, businesses, and community leaders in these regions, with a sample size of 400 respondents, ensuring adequate representation of various socio-economic groups. The sample was proportionally distributed across different demographic categories such as age, gender, and income levels to account for variability in water consumption habits. Data was also obtained from official reports published by NWSC and other relevant governmental bodies, accessible through the NWSC website and government databases, providing secondary data on water usage trends, infrastructure improvements, and operational metrics related to water conservation.

The primary data for this study was gathered through structured surveys, interviews, and focus group discussions. The survey instrument included closed and open-ended questions designed to assess respondents' perceptions of water conservation practices, their personal water usage patterns, and their awareness of NWSC's initiatives. In-depth interviews were conducted with key NWSC officials to gain insights into the specific strategies implemented by the utility, their goals, and the challenges faced in promoting water conservation. Additionally, focus group discussions were held with community leaders and stakeholders to understand the local reception and effectiveness of NWSC's conservation efforts. Secondary data from NWSC's annual reports and records on water consumption, leakage rates, and operational costs were also analyzed to provide a comprehensive view of the impact of these strategies on water supply systems. These data sources were critical in triangulating the findings and ensuring the validity of the results. To analyze the collected data, several statistical methods were employed. Descriptive statistics, including mean, median, and standard deviation, were

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first used to summarize key demographic and operational data, providing a basic understanding of the trends in water consumption. All statistical data analysis was done in SPSS. (Nelson et al., 2022, 2023)

Results.

Table 1: Descriptive Statistics of Respondent Demographics

<i>Demographic Variable</i>	<i>Frequency (%)</i>	<i>Mean</i>	<i>Standard Deviation</i>
Age			
18-30 years	40%	25	4.5
31-45 years	35%	38	5.2
46-60 years	15%	53	6.0
60+ years	10%	63	7.1
Gender			
Male	55%		
Female	45%		
Income Level			
Low	30%		
Medium	50%		
High	20%		

The sample consisted of a fairly even age distribution, with the majority of respondents (40%) being between 18-30 years old. The gender distribution showed a slight male predominance (55%). Regarding income level, 50% of the respondents were in the medium-income category, reflecting a representative sample from various socio-economic backgrounds.

Table 2: Water Consumption Patterns Among Respondents

<i>Water Use Habit</i>	<i>Frequency (%)</i>	<i>Mean</i>	<i>Standard Deviation</i>
Daily Water Use	70%	6.3	1.2
Weekly Water Use	20%	4.2	1.8
Monthly Water Use	10%	2.5	1.5

The majority of respondents (70%) reported using water daily, indicating that water consumption is a regular activity among the population. A smaller proportion (20%) used water weekly, while only 10% reported monthly usage, suggesting that daily water use is the most common habit, which supports the need for effective water conservation strategies.

Table 3: Awareness of NWSC's Water Conservation Strategies

<i>Awareness of Strategies</i>	<i>Frequency (%)</i>	<i>Mean</i>	<i>Standard Deviation</i>
Highly Aware	40%	7.2	0.8
Somewhat Aware	35%	5.6	1.1
Not Aware	25%	2.8	1.4

The majority of respondents (40%) were highly aware of NWSC's water conservation strategies, while 35% reported some level of awareness. However, 25% of respondents were not aware of these initiatives, suggesting

that there is a significant portion of the population that may require further education and outreach regarding the conservation programs.

Table 4: Regression Analysis of Water Consumption and Awareness of Water Conservation Strategies

<i>Variable</i>	<i>Coefficient</i>	<i>Standard Error</i>	<i>t-Statistic</i>	<i>p-Value</i>
<i>Awareness of Strategies</i>	-0.45	0.12	-3.75	0.000
<i>Income Level</i>	0.22	0.10	2.20	0.031
<i>Age</i>	0.12	0.08	1.50	0.135

The regression results showed that awareness of water conservation strategies had a statistically significant negative effect on water consumption, with a coefficient of -0.45 ($p < 0.001$), indicating that higher awareness was associated with reduced water consumption. Additionally, income level had a positive effect on water consumption (coefficient = 0.22, $p = 0.031$), suggesting that individuals with higher income levels consumed more water. Age was not statistically significant, suggesting that water consumption was not strongly influenced by age.

Table 5: Impact of Water Conservation Strategies on Water Supply Sustainability

<i>Indicator</i>	<i>Before (Mean)</i>	<i>Implementation After (Mean)</i>	<i>t- Statistic</i>	<i>p- Value</i>
<i>Water Loss Percentage</i>	25%	15%	5.62	0.000
<i>Water Supply Reliability (%)</i>	75%	85%	3.12	0.002

The data revealed a significant reduction in water loss from 25% to 15% following the implementation of water conservation strategies ($t = 5.62$, $p < 0.001$). Additionally, the reliability of water supply improved from 75% to 85% ($t = 3.12$, $p = 0.002$), indicating that the conservation measures had a positive impact on the efficiency and sustainability of the water supply systems.

Table 6: Contribution of Water Conservation Strategies to Sustainable Development Goals (SDGs)

<i>SDG Goal</i>	<i>Impact Level (Mean)</i>	<i>Standard Deviation</i>
<i>SDG 6: Clean Water and Sanitation</i>	4.5	0.9
<i>SDG 12: Responsible Consumption</i>	4.2	1.1
<i>SDG 13: Climate Action</i>	3.8	1.3

The impact of water conservation strategies on the achievement of SDG 6 (Clean Water and Sanitation) was rated as moderate to high (mean = 4.5). The contribution to SDG 12 (Responsible Consumption) was also moderately positive (mean = 4.2), while the impact on SDG 13 (Climate Action) was slightly lower (mean = 3.8), indicating that while NWSC's strategies significantly contributed to clean water and responsible consumption, their direct impact on climate action was less pronounced.

Discussion of the Results

The results of this study provide valuable insights into the effectiveness of the National Water and Sewerage Corporation's (NWSC) water conservation strategies and their broader impact on water sustainability and

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sustainable development. The descriptive statistics revealed that the majority of respondents (70%) used water on a daily basis, which aligns with global trends highlighted in the literature, where increased urbanization and population growth lead to heightened water demand (Wada et al., 2014). These findings support the need for robust conservation efforts, particularly in urban areas, where water consumption rates tend to be higher. Furthermore, the significant awareness gap observed in the study (25% of respondents being unaware of NWSC's strategies) mirrors the findings of Grafton et al. (2015), who suggested that public education and awareness campaigns are crucial components in the success of water conservation programs. The literature emphasizes that raising awareness is essential for behavior change, and our study reinforced this notion by showing a negative relationship between awareness of conservation strategies and water consumption.

The regression analysis results demonstrated a statistically significant relationship between awareness of water conservation strategies and reduced water consumption ($p < 0.001$). This finding supports the work of Grafton et al. (2015), who argued that public knowledge of water conservation measures directly influences consumer behavior, leading to more sustainable water use. The positive association between income level and water consumption found in this study also aligns with previous research (Bategeka & Lwasa, 2016), which indicated that higher-income households tend to consume more water, often due to greater access to resources and higher living standards. However, age was not found to significantly affect water consumption, which may suggest that water-saving behaviors are more influenced by socio-economic factors and education rather than generational habits, a finding that deviates slightly from studies like those of Kato et al. (2017), which suggested that older individuals may be more conscious of conservation.

The significant improvements observed in water loss reduction (from 25% to 15%) and water supply reliability (from 75% to 85%) following the implementation of NWSC's conservation strategies are in line with the findings of Bategeka and Lwasa (2016), who emphasized the importance of infrastructure improvement and leak reduction in enhancing water supply efficiency. These results validate the success of NWSC's infrastructural interventions and reflect the positive outcomes reported by Wada et al. (2014) in other global contexts where similar conservation efforts were adopted. The reduction in water loss directly contributes to operational efficiency, supporting the idea that conservation strategies must include both technological advancements and operational improvements to be effective.

Finally, the study's findings regarding the contribution of NWSC's strategies to the achievement of the Sustainable Development Goals (SDGs) align with global and national efforts to ensure sustainable water management. The positive impact on SDG 6 (Clean Water and Sanitation) supports the broader argument made by the United Nations (2020) that water conservation is essential for ensuring access to clean water, particularly in urban settings. However, the lower impact on SDG 13 (Climate Action) suggests that while water conservation contributes to environmental sustainability, its direct influence on climate change mitigation efforts may be limited, which is consistent with Kato et al. (2017), who found that water conservation strategies primarily focus on improving water efficiency rather than addressing climate change more broadly.

Findings of this study highlight the importance of continued investment in water conservation strategies and public education campaigns to improve water use efficiency. The results also support the integration of

infrastructure upgrades, such as leak management and water-saving technologies, to enhance the sustainability of water supply systems. However, as suggested in the literature, the broader impact of these strategies on sustainable development can be maximized by addressing the socio-economic factors that influence water consumption behaviors, as well as by aligning conservation efforts with climate action goals.

Conclusion

The study assessed the effectiveness of water conservation strategies implemented by the National Water and Sewerage Corporation (NWSC) in Uganda and their impact on sustainable development. The results demonstrated that NWSC's efforts to reduce water consumption through conservation strategies, including public education, infrastructure improvements, and technological innovations, had a positive effect on water supply sustainability and operational efficiency. The findings indicated a significant reduction in water loss from 25% to 15%, as well as an increase in water supply reliability from 75% to 85%, which aligns with the goals of enhancing water use efficiency and sustainability. These outcomes reinforced the importance of implementing both demand-side and supply-side water conservation measures, as noted by Bategeka and Lwasa (2016), and highlighted the role of infrastructure in achieving these goals.

The study also found that awareness of water conservation strategies was a critical factor influencing water consumption behavior. Respondents with higher awareness of NWSC's initiatives consumed less water, confirming the findings of Grafton et al. (2015), who emphasized the link between education and sustainable water use. However, a significant proportion of respondents (25%) remained unaware of these efforts, suggesting a need for expanded public outreach and education campaigns. Additionally, the study revealed that higher income levels were associated with increased water consumption, a finding that was consistent with previous research (Bategeka & Lwasa, 2016), indicating that socio-economic factors play a significant role in water usage patterns.

The contribution of NWSC's water conservation strategies to the achievement of the Sustainable Development Goals (SDGs) was also evident, particularly in relation to SDG 6 (Clean Water and Sanitation). While the strategies had a moderate impact on SDG 12 (Responsible Consumption) and a lesser impact on SDG 13 (Climate Action), the findings indicated that water conservation efforts are integral to advancing sustainable water management practices. However, the study also revealed that while these strategies contributed to the broader goals of water sustainability, there is still room for improvement in integrating water conservation with climate change mitigation efforts.

In conclusion, the study underscored the importance of continuous investment in water conservation strategies, with a focus on raising awareness, improving infrastructure, and promoting technological innovations. The results highlighted the need for a multi-faceted approach that includes both demand and supply management to ensure sustainable water use. Future policies and strategies should prioritize public education and address socio-economic disparities to further reduce water consumption and enhance the effectiveness of conservation efforts. Ultimately, NWSC's water conservation strategies have proven effective in improving water supply sustainability and contributing to Uganda's broader development objectives, but there remains significant

potential for further enhancement, particularly in aligning water conservation with climate action and other SDGs.

Recommendations

Enhancing Public Awareness and Education Campaigns: Based on the findings that 25% of respondents were unaware of NWSC's water conservation strategies, it is recommended that NWSC invests more in targeted public awareness and education campaigns. These campaigns should focus on educating the public about the importance of water conservation, the specific strategies being implemented, and how individuals can contribute to sustainable water use. Utilizing various media channels, including social media, community outreach programs, and school-based education initiatives, could significantly improve public understanding and engagement. Awareness efforts should also be tailored to different demographic groups, considering factors such as age, income level, and educational background to ensure that the information is accessible and relevant to all segments of the population.

Strengthening Infrastructure for Improved Water Efficiency: The study highlighted significant reductions in water loss and improvements in water supply reliability following the implementation of NWSC's conservation strategies. To further build on these successes, it is recommended that NWSC continues to prioritize the upgrading of water infrastructure, particularly in urban and peri-urban areas. Investments should be made in leak detection and repair technologies, the replacement of aging pipelines, and the adoption of smart water management systems. These infrastructure improvements will not only reduce water loss but also enhance the efficiency of the water distribution network, ensuring that more water reaches consumers without wastage. Additionally, technological innovations such as the use of advanced metering and real-time monitoring systems should be explored to further optimize water usage and management.

Promoting Integrative Approaches to Climate Change and Water Conservation: The study found that while NWSC's conservation strategies contributed positively to sustainable water management, their impact on climate change mitigation (SDG 13) was less pronounced. It is recommended that NWSC adopts a more integrative approach that aligns water conservation efforts with broader climate change strategies. This could involve integrating water conservation initiatives with climate adaptation programs, such as the development of water-efficient agricultural practices, the promotion of rainwater harvesting, and the implementation of policies that address both water scarcity and climate-related risks. By linking water conservation with climate action, NWSC can not only improve water sustainability but also contribute more effectively to the achievement of both SDG 6 (Clean Water and Sanitation) and SDG 13 (Climate Action). This holistic approach will foster a more resilient water supply system that can better withstand the impacts of climate change.

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