Comparative Analysis of the Effectiveness of Water Conservation/Water Demand Management: A Case Study of Polokwane Local Municipality and City of Cape Town Metropolitan Municipality

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***Abstract*— Water conservation and demand management (WC/WDM) represents one of the most effective strategies for managing South Africa's scarce water resources sustainably. This study conducts a comparative analysis of the WC/WDM strategies effectiveness in the City of Cape Town Metropolitan Municipality and the Polokwane Local Municipality. The strengths, weaknesses, opportunities, and threats (SWOT) analysis framework was used to examine Cape Town's strategic response to the drought crisis of 2016 - 2018, emphasizing its proactive implementation of WC/WDM measures. However, PLM remains susceptible to drought patterns, with literature predicting severe droughts in the future. This comparative study was conducted between the two municipalities and data were collected through the analysis of municipal policies and reports' documents, and secondary sources (water use and population density data) to assess water supply versus water demand statistics and trend analysis. Threats such as climate change, population growth, and recurring droughts pose significant risks to water security in both municipalities. However, there are measures to improve water resilience, such as investing in sustainable technologies, raising community knowledge, and fostering peer learning. The findings of this study underscore the pressing need for adaptive and inclusive WC/WDM strategies tailored to the unique challenges faced by each municipality. This study offers valuable insights for inter-municipal benchmarking, improvement and implementation of policy frameworks.**

***Keywords*— Water Conservation, Water Demand Management, Comparative Analysis, Urban Water Governance**

I. Introduction

South Africa faces growing water scarcity, threatening both economic development and environmental sustainability. The implementation of WC/WDM strategies has become crucial for ensuring sustainable water use [29]. Projections from the Department of Water and Sanitation (DWS) suggest that if current consumption patterns continue, the country may encounter a 17% demand-supply gap by 2030 [9]. This increasing deficit is driven by a combination of factors, including climate variability, population growth, urban expansion, pollution, and the degradation of water infrastructure [11]. In response to these challenges, the DWS introduced principles for WC/WDM in 1999, later integrated into the 2004 National Water Resource Strategy (NWRS), and subsequently updated in 2023 [33]. These principles emphasize that successful WC/WDM initiatives are crucial for improving water resource planning, particularly in drought-affected regions. Droughts are a recurring challenge in South Africa; the 2015/2016 event was among the most severe, forcing many citizens to rely on unprotected water sources as surface and groundwater levels declined [22]. Similarly, the 2016–2018 drought experienced by the City of Cape Town Metropolitan Municipality (CCTMM) demonstrated both the severity of water insecurity and the potential effectiveness of WC/WDM when properly implemented [8]. Literature indicates that many municipalities in South Africa continue to experience significant challenges in the effective implementation of WC/WDM strategies. The Polokwane Local Municipality (PLM) exemplifies these challenges, as it continues to grapple with persistent issues such as water losses, deteriorating infrastructure, inaccurate billing systems, and limited water recycling [23].

These discrepancies between the CCTMM and PLM highlight the varying effectiveness of WC/WDM efforts across municipalities, influenced by their institutional capacity, resource availability, governance structures, and levels of community engagement. Although South Africa has an extensive legislative and policy framework for water management including the National Water Act (No. 36 of 1998), the Water Services Act (No. 108 of 1997), and the National Water Conservation and Demand Management Strategy [10], implementation at municipal level remains inconsistent. Many municipalities face capacity constraints, limited funding, poor data systems, and weak enforcement mechanisms [18]. Moreover, past WC/WDM projects have often been unsustainable, creating doubt among decision-makers and water managers [15]. These challenges highlight the importance of understanding not only the technical aspects of WC/WDM but also the institutional, behavioral, and socio-economic factors that shape its effectiveness at the local government level.

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This study compares the effectiveness of WC/WDM in the CCTMM and PLM, by analysing patterns of domestic water consumption, assessing implemented WC/WDM strategies, and comparing their impacts on overall water usage, the research underscores the factors that influence success or failure, including institutional capacity, technical measures, and socio-behavioral considerations [21]. Additionally, the study aligns with the South African Local Government Association's (SALGA) peer-review framework, which promotes collaboration, shared learning, and accountability among municipalities, facilitating operational improvement without punitive measures [25]. Through this comparative analysis, the research identifies best practices, operational gaps, and policy implications, contributing to the overarching objective of sustainable and effective water governance in South Africa.

II. Materials and Methods

The CCTMM, a category A municipality, was compared with PLM, a category B municipality under the Capricorn District Municipality. The selection of study areas in the two municipalities was guided by the population count from the 2016 Stats SA census. Water use in both areas, includes drinking and cooking, bathing, washing clothes, and flushing toilets. It's also used for leisure and home maintenance, like filling swimming pools, watering gardens, cleaning cars, and other routine indoor and outdoor chores.

A. Study Area 1 - Annandale Suburb (PLM)

Annandale is located approximately 2.5 km from the Polokwane City Centre, the area lies at coordinates 23°52'40'' S and 29°26'55'' E, as illustrated in Figure 1 below [26]. The region experiences a semi-arid climate. Based on the 2016 census, the suburb spans roughly 1.66 km² and consists of about 4,850 households with a total population of 13,602. Residents receive their water mainly from the Ebenezer and Olifantspoort supply schemes, which are managed by Lepelle Northern Water, while the Polokwane Local Municipality operates the Dalmada Water Treatment Works. The Ebenezer Dam, built on the Great Letaba River, is one of the main water sources, supported by 53 boreholes operated by the municipality. Households use either conventional or prepaid water meters.

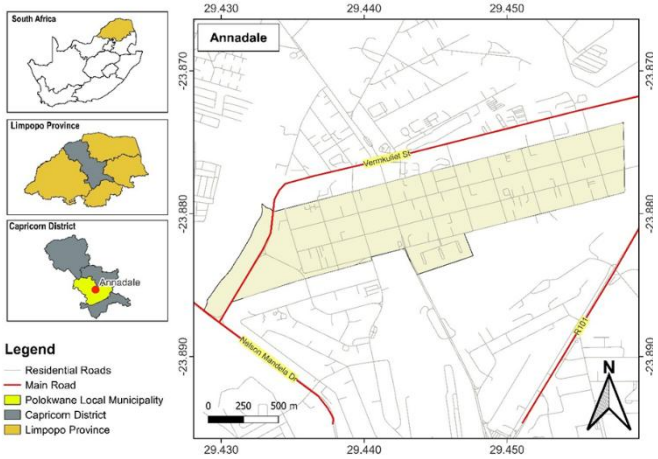

Fig. 1. Locality map of Annandale in Polokwane Local Municipality.

B. Study Area 2 - Simon's Town Surbub (CCTMM)

Simon's Town is located approximately 40 km from the city centre, the suburb lies at GPS coordinates 34°11'37.5504'' S and 18°26'8.3940'' E, as depicted in Figure 2 [14]. The region has a Mediterranean climate [28]. The suburb occupies an area of 19.81 km2 with a population count of 17,079 across around 6,024 households. Water is supplied by the municipality through the Kleinplaats and Lewis Gay Dams, which have capacities of 1,368 ML and 182 ML, respectively, and draw from the Bokram Spruit River. Conventional water meters are installed in all formal properties across the city, ensuring that consumers are billed accurately according to their usage [3].

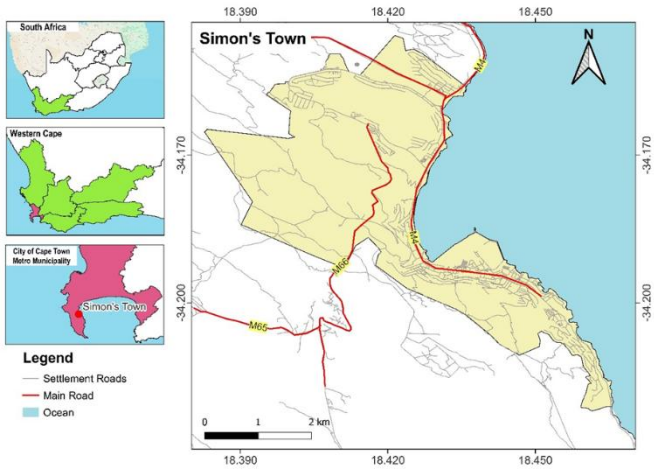

Fig. 2. Locality map of Simon's Town in City of Cape Town Metropolitan Municipality.

C. Data Collection

This study adopted a qualitative approach, relying on secondary data, to inform the comparative analysis between both municipalities. Using these sources were advantageous as the datasets were readily accessible. Historic domestic water consumption data was collected from municipal databases for a nine-month period, from June 2024 to February 2025. This timeframe was chosen to capture seasonal variations, focusing on summer and winter, since seasonal changes affect both the volume of water used and types of activities. In addition to consumption data, policy documents, reports, and WC/WDM plans were collected from both municipalities. A study conducted by [16], shows that the most effective strategies for managing and conserving water include investing in advanced metering systems, implementing leak detection programs, reducing non-revenue water, conducting educational and public awareness campaigns, promoting water-saving devices, restricting outdoor water use, and adopting innovative water technologies. A comparative analysis was conducted to investigate similarities and differences between the two municipalities using SWOT analysis.

D. Data Analysis

Statistical analysis was performed using Microsoft Excel to analyze water consumption datasets obtained from both municipalities. Furthermore, descriptive statistics were employed to better understand the patterns and trends in household water consumption. A SWOT analysis tool was used

to identify the strengths, weaknesses, opportunities, and threats associated with the implemented WC/WDM strategies.

III. RESULTS AND DISCUSSIONS

A. *Domestic water usage patterns in the PLM*

Figure 3 demonstrates how change in seasons affects consumption trends. The trend shows that the water uses peaks in summer and decreases in winter. Literature review indicates that higher temperatures lead to more frequent and longer showers, garden watering, and drinking more water, resulting in greater water consumption [24]. This shows the significance of WC/WDM strategies in managing water demand and reducing consumption amidst the impacts of socio-economic household conditions and seasonality, among other factors. In PLM, the estimated water consumption consistently exceeds the international benchmark of 180 l/p/d. A study conducted by [17], indicates that the average household water use in PLM is 308 l/p/d.

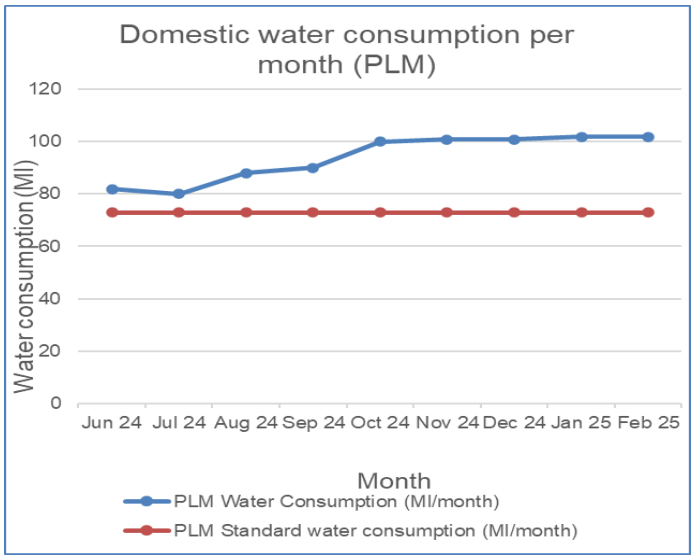

Fig. 3. Monthly domestic water consumption in Annandale, PLM.

B. *Domestic water usage patterns in the CCTMM*

In contrast to PLM, the domestic water consumption patterns in Simon's Town, are more closely aligned with international benchmarks of 180 l/p/d as shown in Figure 4. This trend illustrates that the legacy of the 2016 - 2018 "Day Zero" drought continues to have an impact in this municipality, as emergency interventions including tariff increases, water restrictions, pressure reduction, and extensive public awareness campaigns successfully reduced domestic demand [1]. Although consumption has gradually risen following the easing of restrictions, it has yet to return to pre-drought levels, indicating a partial persistence of water-saving habits. The city is implementing an updated WC/WDM strategy, which includes measures such as pressure reduction, leak detection and repair, meter management and replacement, public education campaigns, and the reuse of treated effluent for industrial purposes. These initiatives are projected to achieve savings of approximately 69 Ml/d by 2027 [2].

Figure 4 shows a gradual increase in domestic water consumption of Simon's Town population from June 2024 to February 2025. Literature review indicates that CCTMM is among the most water-efficient municipalities in South Africa, achieving an average of approximately 160 l/p/d [31]. Warmer months on average drive higher household consumption, as a peak is observed from August 2024 to February 2025. Previous studies shows that the summer-winter consumption gap, indicative of outdoor water usage, remains around 200 Ml/d [7].

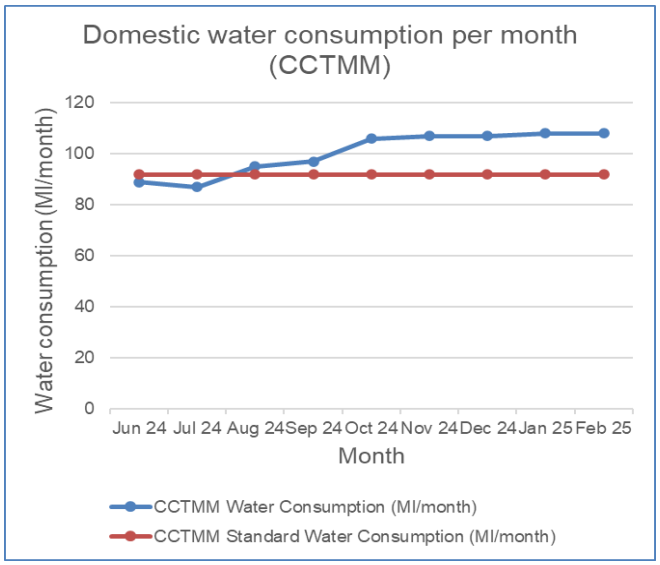

Fig. 4. Monthly domestic water consumption in Simon's Town in the CCTMM.

C. *Comparative analysis of the effectiveness of WC/WDM in PLM and CCTMM.*

The CCTMM implemented its WC/WDM strategy before the 2016 - 2018 drought, emphasizing the use of groundwater, greywater, and rainwater [2]. While, PLM currently lacks a formal WC/WDM strategy/plan, resulting in limited and largely ineffective household-level interventions [34]. Nonetheless, the municipality is actively engaged in developing and implementing a strategy to reduce significant water losses and address leaks [24]. Both municipalities have implemented WC/WDM interventions to regulate water use and promote sustainability. However, the effectiveness of these strategies differs due to their distinct approaches, resources, and challenges, as illustrated by the SWOT analysis in Figure 5 and 6 and domestic water consumption trends in Figure 3 and 4.

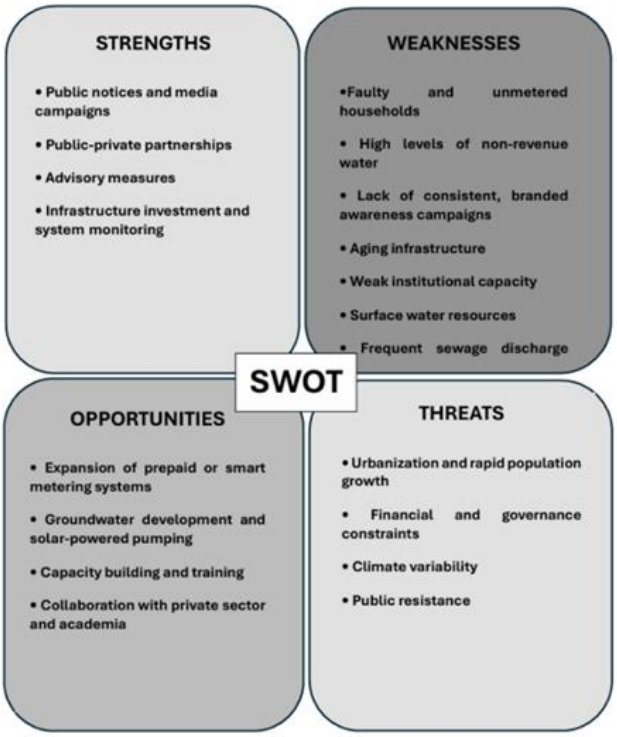

Fig.5. SWOT analysis findings for WC/WDM interventions in PLM.

Figure 5 shows that PLM's strengths are limited, however, they remain commendable. The municipality's proactive public communication efforts, which include media statements and notices urging residents to conserve water during periods of low reservoir levels, demonstrate a commitment to managing water demand. Furthermore, collaborations with private partners such as the *Polokwane Water Partnership* and *Solar-Powered Borehole Projects* signal an increasing recognition of sustainable solutions [32]. The city struggles with more severe weaknesses that hinder the effectiveness of its WDM strategies, challenges such as faulty metering system, a significant number of unmetered households, and illegal connections. The challenges have led to insufficient oversight of unaccounted-for water, severely limiting the efficacy of existing tariff structures [20]. Additionally, inadequate plumbing maintenance exacerbates ongoing leaks and drives excessive household consumption. The PLM opportunities lie in the rehabilitation of its aging infrastructure and the potential expansion of groundwater utilization through the implementation of solar-powered boreholes. The municipality could benefit from fostering partnerships with private sector entities and academic institutions to initiate community-based water audits and awareness campaigns learning from the CCTMM. Current efforts embodied in the Polokwane Water Partnership provide a foundation framework upon which collaborative innovations can be effectively developed and up scaled.

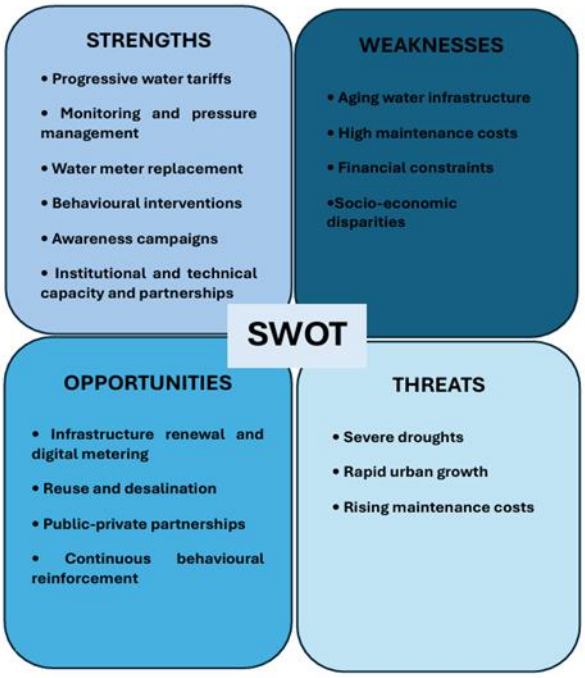

Fig.6. SWOT analysis findings for WC/WDM interventions in the CCTMM.

Figure 6 shows that the CCTMM have several notable internal strengths that improves its WC/WDM efforts. A significant advantage is its progressive water tariff structure, which plays a crucial role in shaping consumer behaviour, particularly among high-demand households in wealthier areas [12]. The municipality's ability to manage water pressure effectively, conduct leak detection, and enforce tariffs through traditional metering systems ensures continuous monitoring and regulation [19]. The 2023 water meter replacement program has improved operational efficiency by allowing for more accurate billing, enabling consumers to track their usage, and reducing wastage [6]. Additionally, the well-established public engagement and awareness initiatives such as *"Find and Fix Water Leaks at Home*" and "*DIY Water Meter Reading Guide"* equip residents with practical tools for leak detection and efficient water use [4][5]. Furthermore, the municipality's digital platforms for reporting leaks enhance community participation and responsiveness. These initiatives reflect an institutional culture that effectively connect technical management with strategies for behavioural change.

Despite the significant strengths demonstrated by the CCTMM in WC/WDM, it faces considerable internal weaknesses that hinder its full potential. A primary concern is the aging infrastructure, which leads to recurrent leaks and pipe bursts, resulting in an estimated loss of 25% in non-revenue water [27]. These losses do not only undermine the effectiveness of household-level conservation initiatives but also increase operational costs. The adoption of smart metering technologies, coupled with advancements in digital infrastructure, constitutes a substantial opportunity for improved real-time monitoring and a reduction in non-revenue water losses. The existing frameworks for citizen engagement offer a robust platform for amplifying educational initiatives around water reuse, while also embracing technologies like IoT

based leak detection systems and AI-supported consumption analytics [13].

D. Threats in PLM and the CCTMM.

Cape Town's WC/WDM initiatives have largely surpassed those of Polokwane, primarily due to Cape Town's enhanced institutional capacity, robust infrastructure, and technological advancements that promote effective water management. However, both municipalities are exposed to external threats that challenge their WC/WDM efforts. The CCTMM remains susceptible to extreme drought conditions that could surpass the efficacy of even the most well-implemented conservation strategies [30]. Climate variability introduces a persistent uncertainty regarding the stability of future water supplies. Meanwhile, PLM faces a critical threat arising from its deteriorating wastewater treatment infrastructure, which discharges over 50 million liters of untreated wastewater to freshwater sources daily, attributable to malfunctioning facilities and contaminated rivers [32]. These inefficiencies do not only compromise water quality but also erode public confidence in the municipality's capacity to manage resources responsibly.

IV. CONCLUSION

The findings of this study highlight that despite both PLM and the CCTMM having dire water supply issues, the effectiveness of their WC/WDM strategies is guided by context-specific governance and operational conditions. The CCTMM's WC/WDM interventions are more effective due to its metropolitan scale, greater technical capacity, and experience in crisis-driven water governance. While PLM continues to struggle with systemic issues that limit the success of its conservation and demand management initiatives. This underscores the pressing need for adaptive and inclusive WC/WDM strategies tailored to the unique challenges faced by each municipality. While promoting peer learning and knowledge exchange, offering both municipalities an opportunity to learn from one another, fostering collaboration and mutual support without the threat of penalties.

V. RECOMMENDATIONS

The PLM shall implement a local WC/WDM strategy through practical programs that target leak reduction, maintenance efficiency and community awareness. In addition, collaborate with ward councillors to identify and remove unauthorized water users. Undertake a comprehensive registration drive to capture all active connections in the municipal billing database. Municipal teams can conduct regular inspections to check for hidden leaks, dripping taps, or faulty appliances that may be quietly wasting water. Residents can also be guided on simple ways to detect, and fix leaks themselves, supported by easy-to-follow tips or training workshops. The PLM shall ensure that all household connections are metered and the newly installed prepaid water meters, which are replacing conventional meters, are properly operated and maintained. This will ensure accurate billing, which will eliminate standard rate billing, and encourages efficient water use. Improved metering system can reduce non-recovered revenue, which will alleviate funds constraints in WC/WDM implementation.

The PLM shall consider implementing local projects where residents collectively treat and reuse greywater for non-potable uses such as gardening, and toilet flushing. Provide clear guidelines and monitoring frameworks to ensure public health and environmental safety. This initiative will reduce the water demand on municipal water supply and promote local self-sufficiency, given the strain on wastewater infrastructure. This can be achieved by implementing the Guidelines for Greywater Management and Reuse in South Africa, Water Research Commission Report TT746/17. In addition, PLM shall reduce reliance on surface water and transfers by expanding borehole networks tapping into deeper aquifers. Implement artificial aquifer recharge schemes, where excess stormwater or treated wastewater replenishes groundwater reserves, ensuring long-term water security despite drought vulnerability.

ACKNOWLEDGMENT

The authors appreciate the support, and resources provided by the University of Limpopo, Polokwane Local Municipality and the City of Cape Town Metropolitan Municipality, which made this study possible.

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