



To Establish Economic Viability of District Metered Areas: A Case Study of DAWASA's Kinondoni Service Area, Tanzania

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Abstract

District Metered Area (DMA) systems promoted as a strategy for reducing Non-Revenue Water (NRW) and improving operational efficiency in urban water supply networks, yet their financial viability in Sub-Saharan Africa remains uncertain. This study assessed the economic feasibility of implementing 13 DMAs in Kinondoni Service Area under the Dar es Salaam Water Supply and Sewerage Authority (DAWASA) between 2023 and 2025. Using a cost benefit framework that combined Capital Expenditure (CapEx), Operational Expenditure (OpEx), and Net Revenue Gain (NRG), four indicators, Return on Investment (ROI), Cost-Benefit Ratio (CBR), Payback Period (PP), and Financial Sustainability Index (FSI) applied. Results showed poor short-term viability (ROI -96.5%, CBR 0.035, PP 23.1 years, FSI -0.797), driven by high initial costs and modest revenue gains. Scenario analysis identified NRG as the most decisive factor for financial recovery. The study concludes that DMA investments are not currently financially sustainable, but phased implementation in high-NRW zones, supported by tariff reform and donor cost sharing, could improve long-term economic viability. These findings provide important guidance for DAWASA, regulators, and development partners in designing policies and financing models for sustainable water supply management.

Keywords · District Metered Areas, Non-Revenue Water, Economic Viability, Financial Modeling, DAWASA.

1 Introduction

District Metered Area (DMA) systems have emerged globally as a proven approach to reducing NRW by dividing networks into hydraulically isolated zones equipped with bulk meters, pressure-reducing valves, and monitoring devices (Hou, 2018). International case studies, such as in Singapore and Cyprus, show that DMA implementation can reduce both physical and commercial losses by up to 30% when paired with smart monitoring technologies (Bui et al., 2020; Kanakoudis & Gonelas, 2016). In East Africa, DMA adoption is gaining traction, but

outcomes vary due to financial and institutional challenges (Augustus et al., 2023). DAWASA's pilot DMA program in Kinondoni Service Area as in Figure 1, the most densely populated and socio-economically diverse area in DAWASA, Represents a strategic attempt to introduce data-driven NRW management. Kinondoni service area was selected due to its high NRW baseline (>40%), recurrent customer complaints, and technical complexity (DAWASA, 2023). Within Kinondoni service area, the 13 DMA zones prioritized based on a combination of historical NRW levels, network age, population density, and frequency of

service interruptions, making it a suitable case for assessing both technical and financial outcomes.

While there is a growing body of technical research on DMA performance, particularly in engineering aspects such as pressure regulation, leak detection, and flow measurement (Elkharbotly et al., 2022), there is limited evidence on their economic viability. Few studies in Sub-Saharan Africa have applied financial indicators, such as Return on Investment (ROI), Cost-Benefit Ratio (CBR), Payback Period (PP), or Financial Sustainability Index (FSI), to evaluate whether DMA investments are financially

questions: (i) what are the capital and operational costs of implementing 13 DMAs in Kinondoni service area. (ii) To what extent do these investments generate net revenue gains (NRG) and improve financial indicators (ROI, CBR, PP, and FSI)? (iii) How do institutional and technical factors such as procurement delays, metering accuracy, and billing efficiency affect financial outcomes? (iv) What policy and investment strategies can enhance the long-term financial sustainability of DMA projects in Tanzania? , By answering these questions, the study provides an evidence-based foundation for DAWASA, regulators, and development partners to guide investment

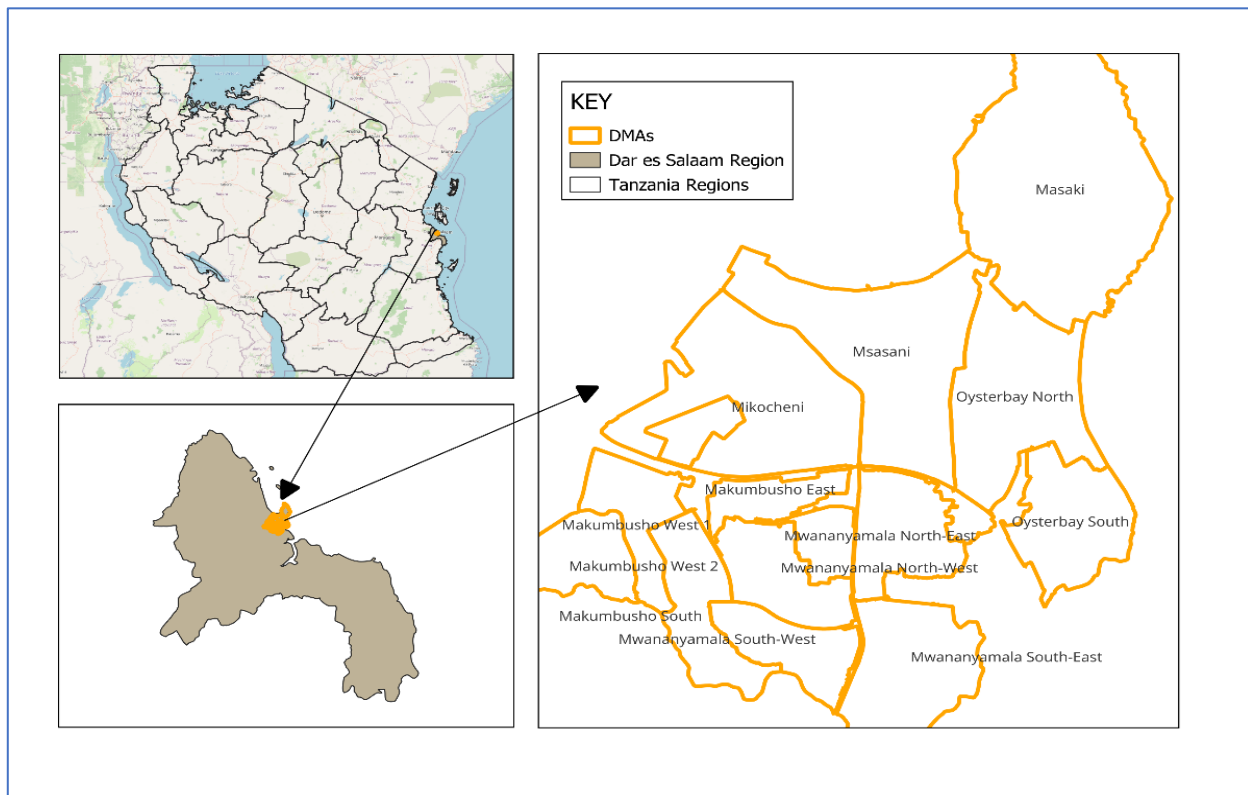


Figure 1. Location of DAWASA Kinondoni service area showing the 13 District Metered Areas (DMAs), Established from 2020 to 2024. (Source: Author, 2025).

justifiable under current tariff structures (Fu et al., 2022; Jang, 2018). This gap leaves utilities and policymakers uncertain about scaling up DMA programs in contexts where resources are scarce and competing infrastructure needs are high. This study seeks to fill that gap by evaluating the economic viability of DMA implementation in Kinondoni service area. It specifically addresses the following research

decisions, optimize resource allocation, and support the scale-up of DMA initiatives in Tanzania and other low-income urban contexts.

2 Materials and Methods

2.1 Study Area

This study conducted in DAWASA Kinondoni service area, found within Kinondoni municipal

districts of Dar es Salaam and the largest service zone under the Dar es Salaam Water and Sewerage Authority (DAWASA). Kinondoni service area has an estimated population of 1.2 million people and 22,059 households (NBS, 2022) and characterized by high urban density, mixed residential and commercial land use, and rapid unplanned growth. Climatically, the area lies within a tropical coastal zone with two rainfall seasons (long rain: March–May; short rains: October–December) and mean annual temperatures ranging

Areas (DMAs) between 2023 and 2024. The selection of these DMAs based on (i) historical NRW levels, (ii) frequency of customer complaints, (iii) age of infrastructure, and (iv) socio-economic importance of the zones (e.g., high-density commercial hubs). By March 2025, all thirteen DMAs had been operational for at least six months, providing sufficient post-implementation data for financial analysis. It should note that the relatively short period of operational data (6–12 months) limits the assessment of long-term

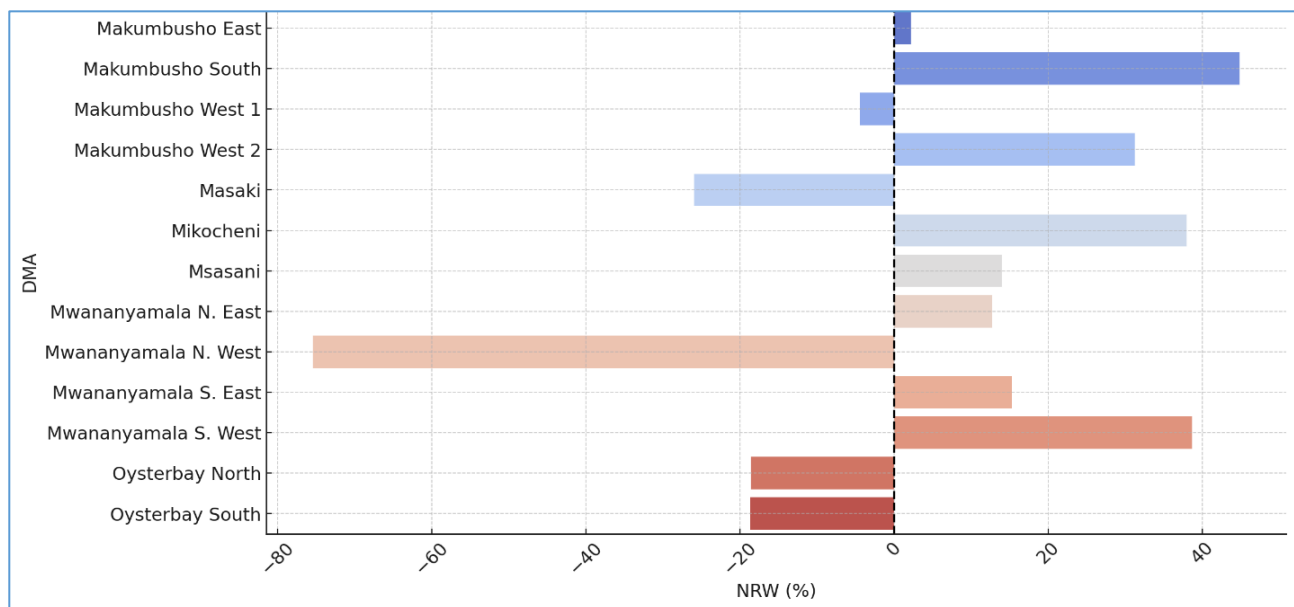


Figure 2. Trends in Non-Revenue Water (NRW) levels across the 13 District Metered Areas (DMAs) in Kinondoni service area between September 2024 and February 2025, showing variations in performance before and after DMA implementation. (Source: Author, 2025).

between 24–32°C, which increase water demand and exacerbate distribution losses (Zahor & Mromba, 2022).

The DAWASA Kinondoni service area spans 1,350 km of water distribution network, serving approximately 20,074 active connections (186,000 domestic, 18,000 commercial, and 6,000 institutional). This coverage represents about 91% of the service area households, with the remainder relying on private boreholes or informal vendors. Baseline Non-Revenue Water (NRW) levels in several sub-zones exceeded 42% as of early 2023 (DAWASA, 2024). In response, DAWASA implemented thirteen District Metered

trends and financial sustainability.

2.2 Research Design

A quantitative case study design adopted to evaluate the economic viability of the DMA intervention. The design was grounded in the deductive reasoning approach, testing theoretical expectations about infrastructure cost recovery using real-world data (Cassidy et al., 2021). Each DMA treated as a unit of analysis to evaluate the relationship between financial inputs (CapEx and OpEx) and net billing gains (NRG). A structured model incorporating these variables was applied to calculate economic indicators (Gaonkar et al., 2021). This design allows for replicability in other

urban contexts, particularly in resource-constrained environments (Yekti et al., 2020).

2.3 Data Collection Methods

This study employed both primary and secondary data collection methods to assess the economic viability of DMA implementation in Kinondoni District. Secondary data primarily drawn from DAWASA's MAJIS billing system, capturing monthly revenue performance data before and after DMA implementation, spanning the period from February 2024 to March 2025. These billing records enabled the calculation of Net Revenue Gain (NRG) attributable to DMA deployment. Additionally, technical and

Journal of Water Resources, Engineering, Management and Policy costs and returns using financial indicators such as ROI, CBR, PP, and FSI (Booso, 2014)

To enhance the reliability and interpretation of the secondary data, key informant interviews (KIIs) conducted with DAWASA's technical and financial personnel. Interviewees included engineers, finance officers, and planners directly involved in DMA planning and implementation. These interviews helped clarify cost allocation practices, metering procedures, operational challenges, and data accuracy, factors essential to understanding the financial outcomes associated with each DMA zone.

Monthly NRW performance data also collected for

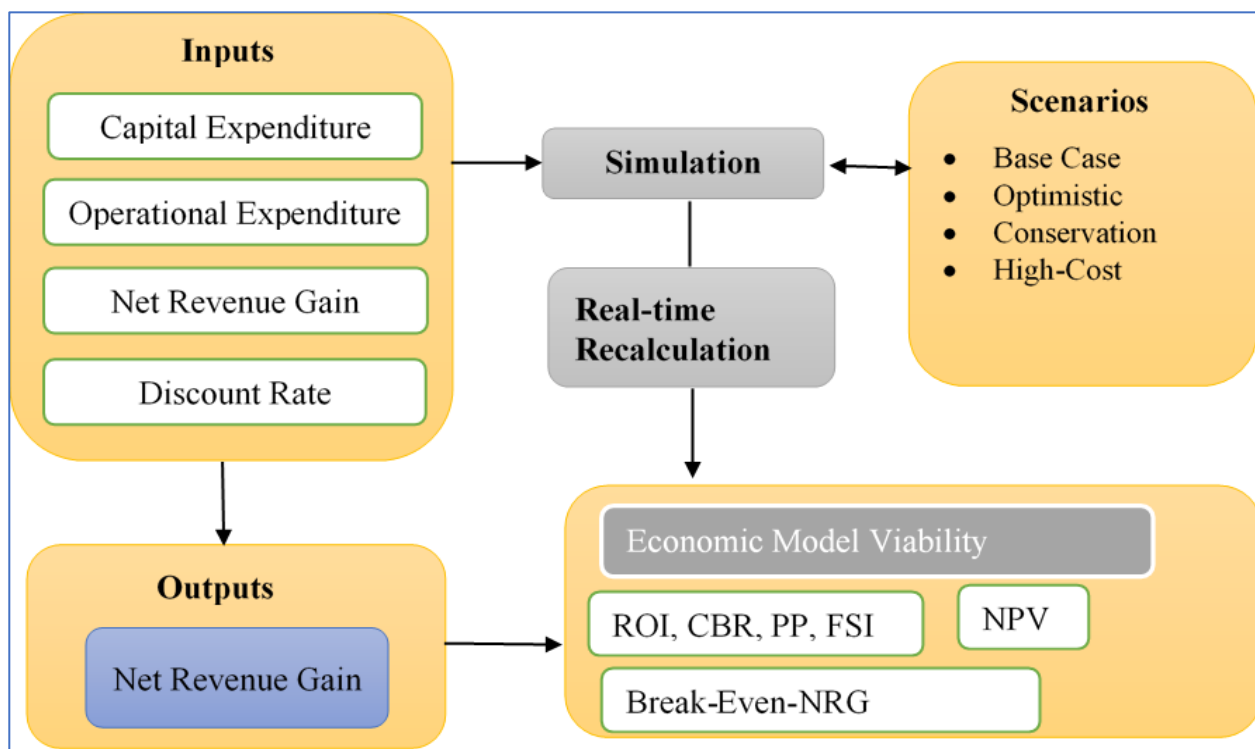


Figure 3. Established framework of the economic viability applied in evaluating District Metered Area (DMA) implementation in Kinondoni District, illustrating the integration of Capital Expenditure (CapEx), Operational Expenditure (OpEx), and Net Revenue Gain (NRG) to compute Return on Investment (ROI), Cost-Benefit Ratio (CBR), Payback Period (PP), and Financial Sustainability Index (FSI). (Source: Author, 2025).

financial documents reviewed, including NRW monitoring reports, capital expenditure (CapEx) and operational expenditure (OpEx) breakdowns, and audited financial statements. These documents provided the foundation for evaluating investment

all thirteen DMA zones, covering the period from September 2024 to February 2025. This information used to track NRW trends over time and assess the technical effectiveness of the intervention. Figure 2 presents the longitudinal NRW performance across all

zones, while a comparative snapshot of NRW levels in **2.4 Economic Model Framework**

Table 1: Economic viability indicator

Component	Description	Formula / Method Used	Calculation
CapEx	One-time cost for infrastructure setup across all 13 DMAs	CapEx per DMA $\times$ 13	$1,300,000,000 \times 13 = \text{TZS } 16,900,000,000$
OpEx	Annual recurring cost for operation and maintenance across all 13 DMAs	OpEx per DMA $\times$ 13	$270,000,000 \times 13 = \text{TZS } 3,510,000,000$
Total Cost (TC)	Total cost combining CapEx and OpEx	$TC = \text{CapEx} + \text{OpEx}$	$16,900,000,000 + 3,510,000,000 = \text{TZS } 20,410,000,000$
Net Revenue Gain (NRG)	Annual increase in billed revenue due to DMA implementation (for all 13 DMAs)	$\text{Rafter} - \text{Rbefore} \times 12$	$(1,208,982,096.5 - 1,149,496,554.77) \times 12 = \text{TZS } 713,826,500.8$
ROI (%)	Return on investment for total expenditure	$\frac{\text{NRG} - \text{TC}}{\text{TC}} \times 100$	$\frac{((713,826,500.8 - 20,410,000,000) / 0,410,000,000) \times 100}{\approx -96.5\%}$
CBR	Cost-benefit ratio	NR / GTC	$713,826,500.8 / 20,410,000,000 = 0.035$
Payback Period (PP)	Time needed to recover CapEx using annual gains	$\frac{\text{CapEx}}{\text{NRG}}$	$16,900,000,000 / 713,826,500.8 \approx 23.1 \text{ years}$
FSI	Ability of net savings to cover OpEx (financial sustainability)	$\frac{\text{NRG} - \text{OpEx}_0}{\text{OpEx}_0}$	$(713,826,500.8 - 3,510,000,000) / 3,510,000,000 \approx -0.797$

Source: Authors' Compilation (2025).

February 2025 highlights the variation in performance between individual DMAs. This triangulated dataset, financial, operational, and qualitative, was critical for constructing a comprehensive economic model of DMA impact under real operational conditions.

The economic analysis was based on a cost-benefit framework that evaluated the financial viability of DMA implementation by comparing total investment costs comprising capital and operational expenditures with revenue gains achieved post-intervention (Shushu et al., 2021). Net Revenue Gain (NRG) was calculated as the difference between average monthly billed

revenue before and after DMA implementation, was used as the primary financial benefit indicator (Augustus et al., 2023).

To assess the performance of the investment, four

2.5 Financial Indicators

To assess the economic viability of the DMA implementation in Kinondoni, four key financial indicators were applied: Return on Investment (ROI),

Table 2: Scenario Assumption Setup.

Scenario	Adjusted Inputs	Output
Base	CapEx: 16.9B; OpEx: 3.51B; NRG: 0.71B	ROI: -96.5%, PP: 23.1 yrs., FSI: -0.797
Optimistic	NRG: $0.71B \times 1.20 = 0.852B$	ROI, CBR, PP, FSI recalculated with increased revenue
Conservative	NRG: $0.71B \times 0.90 = 0.639B$; OpEx: $3.51B \times 1.10 = 3.86B$	ROI, CBR, PP, FSI recalculated with lower revenue and higher OpEx
High-Cost	CapEx: $16.9B \times 1.25 = 21.13B$; NRG remains 0.71B	ROI, CBR, PP recalculated with increased capital cost

Source: Authors' Compilation (2025).

financial indicators employed Return on Investment (ROI), Cost-Benefit Ratio (CBR), Payback Period (PP), and the Financial Sustainability Index (FSI). These metrics provided insights into profitability, cost recovery efficiency, investment risk, and operational sustainability. All calculations based on actual cost and billing data from the 13, DMAs implemented in Kinondoni between 2023 and 2025.

The model was adapted from globally recognized methodologies and tailored to the financial context of a developing urban utility (Alima, 2020). It accounts for common constraints such as low tariff structures, high water loss, and limited cost recovery (Jang & Choi, 2017). This adaptation enabled a realistic evaluation of the economic justification for scaling up DMA investments under conditions similar to those faced by DAWASA as illustrated in figure 3.

Cost-Benefit Ratio (CBR), Payback Period (PP), and the Financial Sustainability Index (FSI) (Elkharbotly et al., 2022). These indicators are widely recognized in public infrastructure finance and were selected for their ability to evaluate both short-term financial returns and long-term cost recovery potential (Augustus et al., 2023).

2.6 Assumptions and Scenario

The model built on key assumptions drawn from DAWASA's verified financial records and expert inputs. Net revenue gains were attributed solely to DMA improvements, while external factors like inflation, tariff changes, or subsidies were excluded (Zahiri & Dehghani, 2009). Scenario analysis conducted using baseline, optimistic, and worst-case conditions to assess financial performance under varying revenue and cost outcomes, other assumption made by considering four scenarios as shown in Table

2. These assumptions ensured a balanced and context-specific evaluation of investment viability (Kanakoudis et al., 2016).

To evaluate the economic viability of DMA investments under varying operational realities, this

grounded in structured assumptions and scenario analysis. The viability established using verified CapEx, OpEx, and Net Revenue Gain (NRG) data obtained from DAWASA's financial records, supplemented by expert input from engineers and

Table 3: Cost Distribution of DMA implementation in Kinondoni

Category	Cost Item	Description	Estimated Cost (TZS)
CapEx	Network Segmentation and Valves	Installation of isolation valves to define DMAs	300,000,000
	Bulk Meter Installation	Procurement and installation of bulk flow meters	250,000,000
	PRVs and Pressure Monitoring	Installation of PRVs and monitoring devices	150,000,000
	SCADA and GIS Integration	Automation and spatial database enhancements	200,000,000
	Infrastructure Rehabilitation	Replacement of aging or leaking pipelines	400,000,000
	Total CapEx		1,300,000,000
OpEx	Routine Maintenance (Annual)	Maintenance of valves, meters, and PRVs	100,000,000
	Staffing and Training (Annual)	Hiring and training technical personnel	80,000,000
	Data Management (Annual)	Software, data storage, and analysis tools	60,000,000
	Community Engagement (Annual)	Customer education and leak reporting initiatives	30,000,000
	Total OpEx (Annual)		270,000,000

Source: Authors' Compilation (2025).

study employed a financial modeling approach finance officers. For consistency and focus, the

viability attributed changes in financial performance solely to the DMA intervention. External variables such as inflation, changes in water tariffs, or donor subsidies were held constant and excluded from calculations to isolate the effect of the DMA program itself (Cassidy et al., 2021)

To capture a realistic range of financial outcomes, four scenarios established Base, Optimistic, Conservative, and High-Cost. Each scenario applied specific adjustments to the input parameters (CapEx, OpEx, and NRG) to reflect different risk and performance conditions (Mihayo & Njiru, 2005). The Base scenario represents actual observed values from the implementation, while the other three explore deviations in either revenues or costs. For example, the Optimistic scenario assumes a 20% increase in NRG due to improved performance, while the Conservative scenario accounts for both lower revenue (−10%) and higher operating costs (+10%). The High-Cost scenario reflects a potential 25% overrun in capital expenditure, a common risk in infrastructure projects. These inputs used to recalculate key economic indicators, including Return on Investment (ROI), Cost-Benefit Ratio (CBR), Payback Period (PP), and Financial Sustainability Index (FSI).

Table 2 outlines the input assumptions for each scenario. This scenario modeling technique enabled a robust and context-sensitive assessment of the financial risks and potential returns associated with scaling up DMA initiatives in similar urban water systems (Tembo, 2016)

3 Results and Discussion

3.1 Capital and Operational Costs of DMAs

The total capital investment across 13 District Metered Areas (DMAs) in Kinondoni was TZS 16.9 billion, with average CapEx per DMA at TZS 1.3 billion. Operational expenditure (OpEx) averaged TZS 270 million annually per DMA. Table 3 illustrates the comparative CapEx and OpEx across the zones. The major CapEx items included flow meters, pressure-reducing valves (PRVs), and network restructuring, while OpEx driven by maintenance and technical operations.

These findings align with Liemberger & Farley (2004), who reported average DMA implementation costs ranging from USD 200,000–500,000. Higher OpEx in Kinondoni reflects the aging infrastructure and dense urban layout, corroborated by similar cost escalations in India (Yekti et al., 2020). As shown in Table 3, zones like Mwananyamala incurred higher CapEx due to complex civil works, a pattern consistent with Augustus et al. (2023), who found higher costs in dense informal areas often lead to greater returns if managed well.

3.2 Revenue Performance Before and After DMAs

Revenue analysis (Figure 4) reveals a post-DMA average monthly increase from TZS 1.15 billion to TZS 1.21 billion, resulting in an annual Net Revenue Gain (NRG) of TZS 713.8 million. The impact varied across zones, with Msasani and Mikocheni showing significant gains, likely due to their high baseline NRW

This performance is consistent with findings from Zahiri & Dehghani (2009), who noted that revenue recovery often requires a stabilization period. Delays in meter calibration and customer database updates likely tempered initial gains. In contrast, Nairobi's rapid post-DMA revenue growth (WASREB, 2022) facilitated by automated metering and early customer engagement, practices DAWASA may consider adopting.

Revenue gains varied across DMAs due to differences in baseline NRW levels, operational challenges, and billing accuracy. Zones such as Msasani and Mikocheni recorded higher gains, likely reflecting prior high NRW that allowed for substantial recoverable volumes. In contrast, areas like Oysterbay South and Mwananyamala North west exhibited smaller improvements, possibly due to persistent illegal connections, meter tampering, and delayed customer database updates. These observations suggest that revenue recovery is contingent not only on DMA infrastructure but also on addressing non-technical losses and billing inefficiencies.

Among the 13 DMAs, Msasani and Mikocheni demonstrated relatively higher revenue gains. These DMAs share characteristics including moderate network complexity, timely meter calibration, and

active community reporting mechanisms. This contrasts with zones experiencing persistent illegal

3.3 Financial Return Analysis: ROI, CBR, and FSI

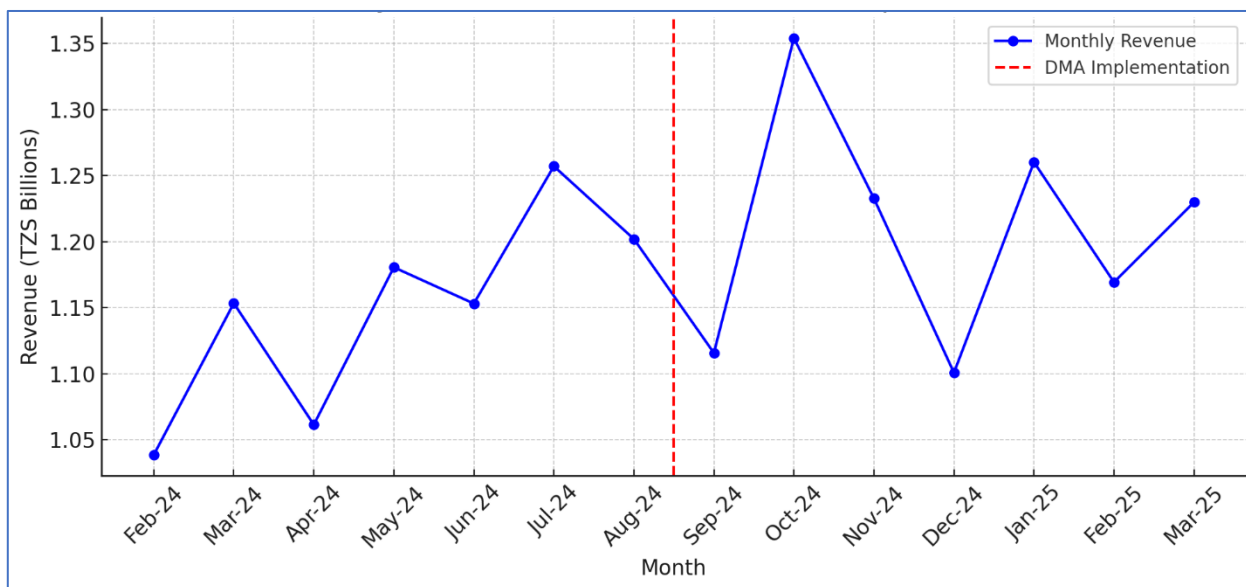


Figure 4. Monthly billed revenue in Kinondoni service area before and after District Metered Area (DMA) implementation, showing average increases from TZS 1.15 billion to TZS 1.21 billion across the 13 DMAs. (Source: Author, 2025).

connections and delayed maintenance, highlighting the importance of operational management alongside infrastructure investments

Table 3 summarizes three core financial indicators. The ROI was calculated at -96.5%, indicating a poor short-term return, mainly due to high CapEx and limited immediate revenue impact. The Cost-Benefit Ratio (CBR) stood at 0.035, signifying low cost

Table 3: Key financial indicators

Indicator	Description	Result
ROI (%)	Return on investment	-96.50%
CBR	Cost-benefit ratio	0.035
Payback Period (PP)	Years required to recover capital costs	23.1 years
FSI	Financial Sustainability Index	-0.797

Source: Authors' Compilation (2025).

Table 4: Economic Viability Indicators of DMA Implementation in Four Case Scenario.

Scenario	ROI (%)	Payback Period	FSI	Interpretation
Base	-96.5	23.1 years	-0.797	Unsustainable under the current cost and revenue structure
Optimistic	-87.8	19.8 years	-0.293	Higher revenue reduces losses, but viability is still out of reach
Conservative	-90.99	26.4 years	-0.520	Lower revenue and higher OpEx worsen the financial case
High-Cost	-91.57	29.7 years	-0.797	Inflationary pressure on CapEx significantly delays payback

Source: Authors' Compilation (2025).

recovery. The Financial Sustainability Index (FSI) was also negative at -0.797, underscoring operational deficits.

These figures mirror experiences in early-stage DMA implementations, as reported by Elkhartbotly et al. (2022) and Augustus et al. (2023). However, such metrics often improve with better leakage control and billing efficiency over time. For example, Uganda's DMA projects showed positive ROI within 5 years (Shushu et al., 2021) supported by strong institutional frameworks.

To enhance financial outcomes, DAWASA may consider revising tariff structures and increasing investment in automation and leak detection. As Charalambous (2014) suggested, aligning tariffs with service delivery improvements significantly boosts financial sustainability.

Table 4 presents scenario viability results, demonstrating that under an optimistic revenue increase scenario, the payback period drops from 23.1 to 6.79 years, highlighting the importance of sustained NRG improvement.

3.4 Comparative Benchmarking

Figure 5 compares Kinondoni's DMA performance

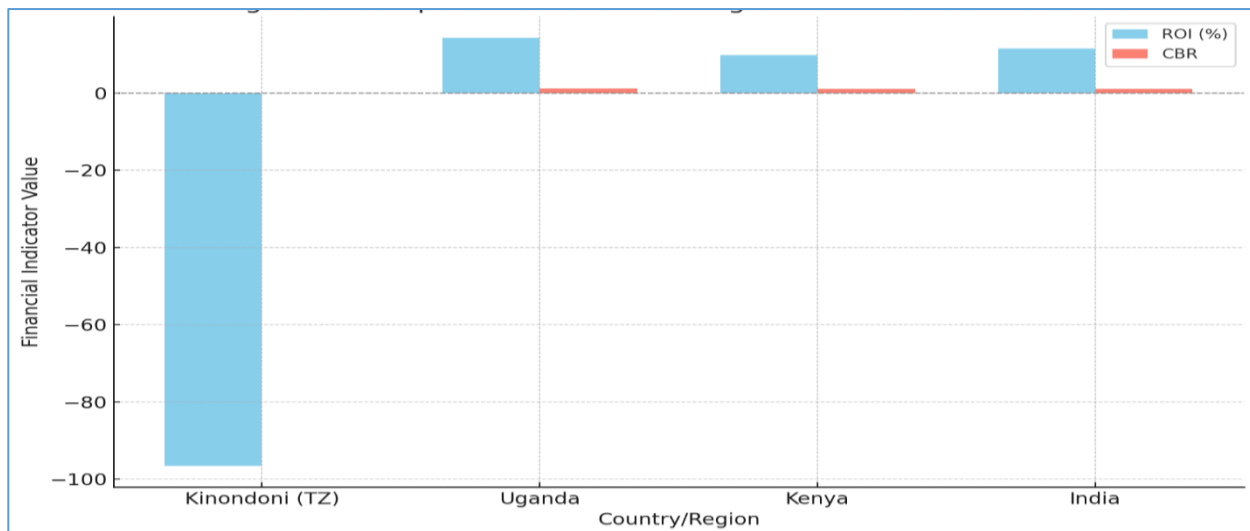


Figure 5. Comparative benchmarking of District Metered Area (DMA) financial indicators between Kinondoni District (Dar es Salaam) and selected utilities in Uganda, Kenya, and India, highlighting differences in Return on Investment (ROI) and Cost-Benefit Ratios (CBR) within the first 3–5 years of implementation. (Source: Author, 2025).

with benchmark data from utilities in Uganda, Kenya,

and India. While utilities demonstrated positive ROI values ranging from 9.8% to 14.3% and CBRs above 1.0 within a 3–5 year period, Kinondoni recorded a negative ROI of -96.5% and a CBR of only 0.035. This underperformance largely attributed to Kinondoni's low water tariff structure, outdated infrastructure, and delayed adoption of digital monitoring systems.

As Kanakoudis et al. (2016) argue, achieving strong financial performance in DMAs depends on a combination of regulatory reform, cost-reflective tariffs, smart metering, and proactive enforcement. DAWASA can adopt these practices to address the performance gap. Emphasizing investments in digital metering infrastructure, automating data collection, and refining customer billing systems would help realign Kinondoni's trajectory with global benchmarks. Comparative financial data from Uganda, Kenya, and India drawn from published case studies. For consistency, values normalized to 2024 USD equivalents using World Bank PPP conversion rates. Tariff structures compared qualitatively, as regulatory conditions varied significantly across contexts.

3.5 Institutional and Operational Constraints

Key institutional constraints identified through

qualitative interviews with DAWASA staff and

technical managers. The most frequently cited issues included delayed meter calibration, insufficient staff capacity, limited interdepartmental coordination, and

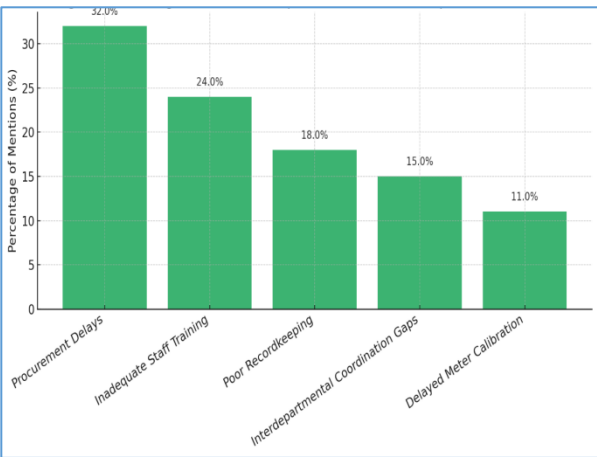


Figure 6: Percentage Distribution of Institutional and Operational Constraints Reported by DAWASA Staff Affecting DMA Implementation in Kinondoni Service Area (*Author, 2025*)

inconsistent or missing bulk meter data. These factors significantly affected both operational efficiency and revenue accuracy.

Table 5: Sensitivity and Scenario Analysis

Scenario	ROI (%)	Payback Period	FSI	Interpretation
Base	−96.5	23.1 years	−0.035	Current viability is economically unsustainable
Optimistic	−87.80	6.79 years	−0.29	Improved viability, but still financially unprofitable
Conservative	−90.99	9.04 years	−0.52	Economic performance worsens under increased OpEx and lower gains
High-Cost	−91.57	10.18 years	−0.41	Extended payback period due to inflation or cost overruns

Source: Authors’ Compilation (2025)

Such institutional shortcomings echo challenges observed in other Tanzanian water utilities. For example, Zahor & Mromba (2022) reported similar delays in Sumbawanga’s DMA rollout due to

procurement inefficiencies and lack of skilled personnel. Likewise, Kabote & John (2017) noted persistent governance issues and bureaucratic delays in utility service delivery nationwide.

As illustrated in Figure 6, the most pronounced bottlenecks observed in procurement lead times, poor recordkeeping systems, and inadequate staff retraining. Overcoming these hurdles will require structured reforms focused on workflow digitization, performance-based staff evaluations, and cross-unit collaboration. Investing in capacity-building and digital operations will directly contribute to improved financial indicators, customer satisfaction, and service reliability.

Institutional constraints such as delayed meter calibration, limited staff capacity, and weak interdepartmental coordination reflect broader governance and financing challenges in Tanzanian utilities. Budgetary limitations, reliance on government subsidies, and bureaucratic delays impede timely maintenance and investment, highlighting systemic barriers to achieving financial sustainability.

A key limitation of this study is incomplete bulk

meter data and occasional gaps in operational records. Missing or delayed meter readings can distort Net Revenue Gain estimates and ROI calculations, potentially underestimating actual DMA performance.

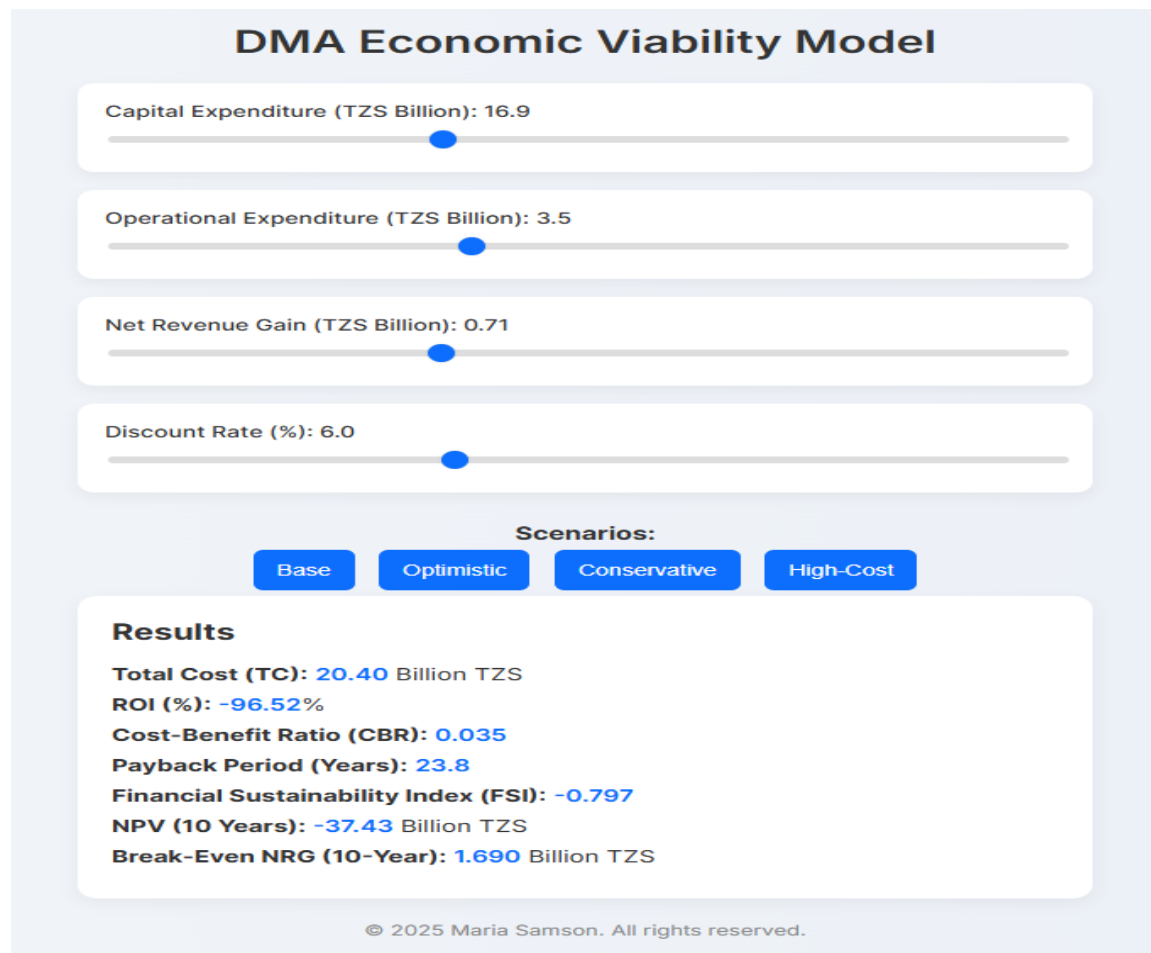


Figure 7: Interface for Simulating the Economic Viability of DMA Implementation, Showing Input Parameters and Computed Financial Indicators (*Author, 2025*)

Future analyses should prioritize systematic meter data collection and validation to improve financial modeling accuracy.

3.5 Sensitivity and Scenario Analysis

To test the financial resilience of the DMA viability in Kinondoni, a scenario-based sensitivity analysis undertaken under four distinct conditions: Base, Optimistic, Conservative, and High-Cost. These scenarios simulate potential variations in key financial parameters specifically, Net Revenue Gain (NRG) and Operational Expenditures (OpEx).

The Base scenario reflects actual performance data from the field, establishing a benchmark with an ROI of -96.5%, a 23.1-year payback period, and a Financial Sustainability Index (FSI) of -0.035 as shown in Figure 7. This indicates that the current economic model lacks short-term viability. In the Optimistic scenario, a 20% increase in NRG improves financial outcomes: the payback period drops sharply to 6.79

years, and the FSI improves to -0.29, although ROI remains negative. This suggests that even modest revenue improvements can significantly enhance recovery timelines.

Conversely, the Conservative scenario simulates a 10% drop in NRG alongside a 10% increase in OpEx, resulting in a deeper ROI of -90.99% and a worsening FSI of -0.52. Similarly, the High-Cost scenario representing cost inflation or inefficiencies extends the payback period to over 10 years, with the ROI falling to -91.57%.

These findings, summarized in Table 5, highlight that revenue generation is the most influential driver of financial performance in DMA projects. This mirrors results from similar studies in Uganda and India (Paper et al., 2014), where timely billing, leakage control, and accurate metering significantly improved financial indicators. For DAWASA, this implies a strategic need to invest in revenue-maximizing initiatives, such as

digitized meter reading, improved customer engagement, and performance-based operations.

Ultimately, this analysis supports the conclusion that while initial performance may be weak, targeted interventions focused on revenue improvement and operational efficiency can gradually shift the DMA viability toward economic viability.

3.9 Interpretation in the Tanzanian Context

Empirical results from the Kinondoni DMA rollout reveal significant financial underperformance. With an ROI of -96.5% , a Cost-Benefit Ratio of 0.035 , and a Financial Sustainability Index of -0.797 , the intervention has not yet achieved operational cost recovery (Augustus et al., 2023). These outcomes were further supported by monthly billing data showing an average post-DMA revenue increase of only TZS 59 million, against a total investment exceeding TZS 20 billion. Interviews with DAWASA staff also highlighted persistent implementation constraints, including procurement delays, metering inaccuracies, and limited staff capacity all of which contributed to the modest Net Revenue Gain (NRG) observed.

Given Tanzania's regulated low-tariff environment and DAWASA's existing fiscal pressures, full financial viability of DMAs will require adaptive strategies. Phased implementation targeting sub-zones with $>40\%$ baseline NRW, as identified in Table 1, could yield faster returns. Cost-sharing with donors or conditional tariff adjustments aligned with performance metrics may also reduce dependency on subsidies. These measures would support compliance with EWURA's cost recovery and efficiency mandates while improving the long-term financial performance of NRW interventions. Although tariff adjustments could enhance DMA viability, regulatory constraints under EWURA limit abrupt changes. Gradual, performance-linked tariff reforms, potentially coupled with donor co-financing or cross-subsidies, may offer a feasible pathway to cost recovery while remaining politically and socially acceptable.

Compared to donor-supported NRW programs in Mwanza and Arusha, Kinondoni's DMA rollout exhibits slower financial recovery. In Mwanza, ROI

improved to positive values within 3–5 years due to robust donor funding, automated metering, and active community engagement (Shushu et al., 2021). Kinondoni's reliance on internal funding, low tariffs, and partial digital monitoring explains the slower progress. Lessons from these programs suggest that combining infrastructure upgrades with institutional strengthening and external support accelerates financial viability.

4. Conclusions

This study evaluated the economic viability of District Metered Areas (DMAs) implemented by DAWASA in Kinondoni District, using financial and operational data from 13 zones. The analysis indicates that, in the short term, the DMAs have not achieved full cost recovery, largely due to high initial investments, modest revenue gains, and operational constraints. Scenario analysis further highlights that improvements in billed revenue are the most influential factor in enhancing financial performance.

Compared to regional and international benchmarks, Kinondoni's DMA program underperforms, reflecting contextual challenges such as low tariffs, aging infrastructure, billing inefficiencies, and limited institutional capacity. Nonetheless, targeted interventions identified in this study such as focusing on high-NRW zones, improving metering accuracy, enhancing operational efficiency, and optimizing billing practices show potential for gradually improving financial outcomes.

Based on these findings, recommendations for DAWASA and policymakers include a phased DMA rollout, prioritizing zones with the greatest NRW reduction potential, and leveraging donor partnerships or conditional financing to offset high upfront costs. These strategies directly supported by the observed variation in performance across DMAs, where zones with higher baseline NRW and better operational management showed relatively stronger revenue gains. Additionally, aligning investments with incremental efficiency improvements and performance-linked financing could strengthen long-term sustainability.

Future research should extend the evaluation period, incorporate environmental and social cost-benefit analyses, and monitor operational and financial improvements over time to provide a more comprehensive assessment of DMA investments in urban water supply systems.

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Conflict of Interest

The authors declare that they have no conflict of interest in relation to this study. No financial, personal, or professional relationships influenced the research, analysis, or conclusions presented in this manuscript.

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