PAPER 8

# WHAT IS NOT MEASURED CANNOT BE IMPROVED – THE CASE FOR MUNICIPAL WATER AND SANITATION SERVICES EFFICIENCY QUANTIFICATION

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## ABSTRACT

As a water-scarce country, South Africa must efficiently manage its water to ensure the required service levels are delivered cost-effectively. However, there is a collective anecdotal perception that South African municipalities are inefficient in the use and management of water. This inefficiency manifests itself in poor delivery of water and sanitation services. The delivery of water and sanitation services is inextricably linked to the management of water and sanitation infrastructure, i.e. inadequate investment in infrastructure, deficient infrastructure operational procedures and insufficient infrastructure maintenance. Therefore, measuring water and sanitation infrastructure management efficiency will provide insight into the performance of municipalities in delivering water and sanitation services. Efficiency here relates to how well the service providers (municipalities) use the available resources to deliver services. Such a measure of efficiency must 1) be based on meaningful performance indicators and credible data, 2) be done transparently, 3) foster accountability, and 3) enable decision-makers to identify areas for improvement. Currently, there is no quantitative tool to objectively measure South African municipalities' efficiency in delivering water and sanitation services. It is not unreasonable to assume that the absence of such a model (quantitative tool for efficiency measurement) has contributed to our collective inability to measure, monitor and improve infrastructure management efficiency; after all, what is not measured cannot be improved. There is therefore a need to re-engineer and revolutionise our understanding and approach to municipal water services management efficiency. In this paper, the authors present a novel Data Envelopment Analysis (DEA) based tool for efficiency quantification in the form of the Municipal Water and Sanitation Services Infrastructure Management Efficiency (MWaSSIME) Index.

The MWaSSIME Index determines the relative efficiencies of the 144 Water Services Authority (WSA) municipalities from the 2015/16 to 2022/2023 financial years. The analysis covers all 144 WSAs by category (grouping) as follows (number analysed in each category): A (8), B1 (18), B2 (20), B3 (68), B4 (9) and C2 (21). This grouping allowed for meaningful comparison of WSAs in the same category and the observation of patterns and trends across their respective categories. The results are both surprising and expected, as it is clear that infrastructure management efficiency is not possible with very limited resources (as shown by B4 and C2), but resource availability does not automatically equate to efficiency (as shown by A and B1). These and other MWaSSIME Index findings provide an evidence-based foundation for the engineered revolution of efficiency in municipal water and sanitation services infrastructure management, through appropriate benchmarking tools and techniques.

## INTRODUCTION

Access to adequate water and sanitation services is a fundamental human right and a key driver for social and economic development. In South Africa, municipalities are constitutionally (The South African Constitution, 1996) mandated to provide water and sanitation services to communities (households and industries). To achieve this, the existing physical infrastructure must be competently operated and adequately maintained, with appropriate plans and funds for its future replacement and or upgrade. From basic infrastructure asset management (IAM) principles, it is understood that effective operation, maintenance, and management of infrastructure are prerequisites for realising the goal of providing adequate water and sanitation services to all.

This is even more important in South Africa as the country is water-scarce and cannot afford to waste this scarce resource through poor IAM practices. Furthermore, as a developing country with limited financial resources, South Africa must closely and *efficiently* manage the use of its limited resources. The South African constitution recognises access to sufficient water as a basic human right, this further emphasises the need for municipalities to *efficiently* manage this scarce resource. Furthermore, South African legislation emphasises the importance of transparency and *efficiency* in municipal operations (and all public goods funded through public funds). The South African government recognises that the regulation of public utilities, particularly those responsible for water and sanitation services, is of notable economic and social importance, as these utilities are essential to development and social wellbeing (Department of Water Affairs, 2013). It could however be argued that this regulation has not extended to the important subject of management *efficiency*, and that this ought to change.

The strategic importance of water and sanitation infrastructure to basic service delivery, necessitates the monitoring and assessment of the ability of municipalities to effectively and *efficiently* deliver these services and manage infrastructure. *Efficiency* generally refers to the measure of how well municipalities (or any other entity) manage their resources (input and output relationship), while effectiveness measures the appropriateness and quality of services. In the context of the management of municipal water and sanitation infrastructure, *efficiency* measures the levels (and quantity) of resources used (inputs) for infrastructure management, compared to infrastructure performance (output) (Luyaba *et al.*, 2024).

The obvious potential consequences of inappropriately (ineffectively and *inefficiently*) managed water and sanitation infrastructure highlight the importance of prioritising robust and comprehensive infrastructure management strategies. In South Africa, providing basic infrastructure services, particularly water and sanitation services, remains a challenge, especially for lower income communities (Luyaba *et al., 2024)*.

Therefore, it is reasonable to argue that the absence of an objective and deterministic tool for measuring efficiency does not assist the South African state in achieving its socio-economic goals that include access to sufficient water for all in South Africa. To this end, the development of the Municipal Water and Sanitation Services Infrastructure Management *Efficiency* (MWaSSIME) Index would benefit South Africa.

## METHODOLGY

There is a total of 257 municipalities in South Africa, out of which 144 are Water Services Authorities (WSAs). The WSA status is currently (2024) allocated as follows: all 8 Metropolitan Municipalities, 21 authorised District Municipalities and 115 authorised Local Municipalities. A municipality that is allocated (authorised in terms of the Municipal Structures Act) the WSA status has the Constitutional responsibility to ensure the provision of water and sanitation services within its area of jurisdiction (National Treasury, 2014). These WSAs fall into one of three defined categories: Metropolitan (referred to as category A), Local (category B), and District (category C). Table 1 below provides municipal categorisations along with their corresponding descriptions as defined by the Department of Cooperative Governance and Traditional Affairs - CoGTA (2009) and the Municipal Demarcation Board - MDB (2018).

**TABLE 1:** *Municipal categorisation and their description (CoGTA, 2009; MDB, 2018).*

| Category | Number of WSAs | Description |
|---|---|---|
| A | 8 | **Metropolitan municipalities**: large urban complexes with populations over one million and accounting for 56% of all municipal expenditure in the country. |
| B1 | 18 | **Local municipalities** with **large budgets** and **containing secondary cities**. |
| B2 | 20 | **Local municipalities** with a **large town** as a core. |
| B3 | 68 | **Local municipalities** with **small towns** as a core. |
| B4 | 9 | **Local municipalities** that are **mainly rural with communal tenure** and with, at most, one or two small towns in their area. |
| C2 | 21 | **District municipalities** that are water services authorities. |

In South African, there is a notable lack of models and tools to quantify and assess the overall efficiency of municipal infrastructure management. Several efficiency evaluation techniques were considered for the development of the MWaSSIME Index. The techniques considered, were those that are most commonly utilised for assessing the management efficiency of public infrastructure utilities, encompassing non-parametric methods, such as the Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH), as well as parametric approaches, including the Stochastic Frontier Approach (SFA) and Ordinary Least Squares (OLS). In the development of the MWaSSIME index, a rigorous sensitivity analysis was undertaken where the results lead to the selection of Data Envelopment Analysis for the MWaSSIME Index, as more comprehensively detailed in Mbhele (2024). The DEA assesses the efficiency of decision-making units (DMUs) by analysing their input-output relationships (Ramanathan, 2003).

Ideally, infrastructure management efficiency levels should be determined using direct measures of resources (inputs) and performance (outputs). However, in the absence of credible data on direct measures for all WSAs, indicators can be used. The MWaSSIME index uses a combination of direct (explicitly related to the physical infrastructure) and indirect (proxy) parameters as inputs and outputs, respectively. These parameters encompass municipal water and sanitation infrastructure considerations, and general municipal financial management ratios and norms (National Treasury, 2014). This mixed approach is used as some direct data is not available and, in many instances, municipalities have shared management and support services (finance, human capital etc). The approach also recognises the scarcity of municipal finances and cross-subsidisation between services, from this it is evident that inefficiency in one area affects the efficiency of another area.

The DEA is a sensitive model, with the validity of its results largely influenced by data quality. In parameter selection the authors carefully considered the South African context with respect to municipal operating models and data (availability, completeness and accuracy). To mitigate these data quality and availability risks, the selected parameters (inputs and outputs) use data that is: sourced from independent (reliable and credible) and audited (when from the municipality directly) datasets. Table 2 below shows the list of parameters used in the MWaSSIME index.

**TABLE 2:** *Overview of the MWaSSIME Index selected performance indicators (Mbhele, 2024).*

| Parameter (Ideal WSA) | Parameter type | Data Source |
|---|---|---|
| Water Losses (5%) | Input | Audited Annual Financial Statements |
| Electricity Losses (5%) | Input | Audited Annual Financial Statements |
| Blue Drop Score (99%) | Output | DWS Blue Drop Reports |
| Green Drop Score (99%) | Output | DWS Green Drop Reports |
| Repairs and Maintenance (8%) | Output | Audited Annual Financial Statements |

The infrastructure management efficiency of similar Water Services Authorities was assessed separately (by category and individually) where the level of infrastructure management efficiency of each municipality was compared to an ideal municipality. An efficient municipality is one that performs close to ideal performance levels for each parameter shown in Table 2. The setting of ideal performance targets for each parameter was based on achievable targets (as such some municipalities were ideal on certain indicators). The municipalities were in turn compared to each other to measure the relative efficiency level for infrastructure management. This approach also enabled the authors to compare similar (in terms of mandate, financial strength, functions, size etc) municipalities. Electricity losses appear misplaced in a water services analysis. However, electricity losses were included considering the importance of electricity revenue in financial sustainability and the cost of electricity as an input in providing water and sanitation services. Electricity is therefore a practical indirect measure that directly impacts water services.

Mbhele (2024) undertook an extensive sensitivity analysis and the DEA Charnes, Cooper and Rhodes (CCR) input-oriented model was selected for use in the MWaSSIME Index. The CCR-I measures how efficiently inputs are being used to the generated outputs, i.e. each DMU (municipality) seeks to minimise its input levels while maintaining the same output levels as a benchmark DMU (the ideal municipality). The efficiency score measures the extent to which a DMU can reduce its inputs while staying as efficient as the benchmark DMU (Charnes, Cooper & Rhodes, 1978), this is crucial for evaluating infrastructure management efficiency in municipalities. The DEA input-oriented model (CCR-I) can be represented mathematically as follows.

$$\min E_m = \sum_{i=1}^{I} u'_{im}\, x_{im} \qquad (1)$$

Subject to:

$$\sum_{i=1}^{I} u_{im}\, x_{in} = 1; \quad n = 1,2,K,N$$

Where:

$$u_{im} \geq 0; \quad i = 1,2,K,I; \quad j = 1,2,K,J$$

**TABLE 3:** *DEA equation symbols and their meaning (Ramanathan, 2003).*

| Symbol | Meaning |
|---|---|
| $E_m$ | The efficiency of the $m^{th}$ Decision Making Unit (DMU) |
| $y_{jm}$ | The $j^{th}$ output for the m$^{th}$ DMU |
| $v_{jm}$ | The weight of that output |
| $x_{im}$ | The $i^{th}$ input for the m$^{th}$ DMU |
| $u_{im}$ | The weight of that input |
| $\varepsilon$ | $10^{-6}$ |
| $y_{jn}$ and $x_{in}$ | The $j^{th}$ output and $i^{th}$ input for the n$^{th}$ DMU, n=1,2, N. |

## RESULTS AND DISCUSSION

With the suitable parameters and model selected, the next step was defining management efficiency bands. Table 4 presents a breakdown of extremely inefficient to highly efficient municipal score categorisation (Mbhele, 2024). With Figure 1 and Figure 2 presenting the management efficiency analysis results. As step-by-step guide on how efficiency was calculated is provided by Mbhele (2024).

**TABLE 4:** *Overview of efficiency categorisation for the MWaSSIME Index (Mbhele, 2024).*

| Municipal Infrastructure Management Efficiency Categorisation | | | | |
|---|---|---|---|---|
| Extremely Inefficient | Highly Inefficient | Fairly Inefficient | Moderately Efficient | Highly Efficient |
| 0% – 29% | 30% – 49% | 50% – 59% | 60% – 79% | 80% – 100% |

Figure 1 shows a comparison of the 144 South African WSAs infrastructure management efficiency over eight financial years (2015/16 to 2022/23). Figure 2 provides a visual overview of performance for one financial year (2019/20). The results show that all WSAs over this eight-year period were extremely and highly inefficient (raging between 0% and 49%). Category A municipalities (Metros), demonstrate an average highly inefficient performance.

The efficiency values fluctuate between 26.2% and 34.8%. The highest efficiency was recorded in FY2016/17 (34.8%), while the lowest efficiency was recorded in FY2022/23 (26.2%). Overall, the metros fall mostly in the "Highly Inefficient" category throughout the years and appear to be deteriorating

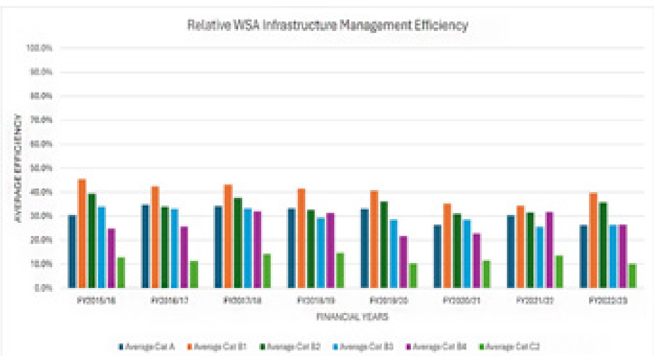



**FIGURE 1:** *Relative Infrastructure Management Efficiency of the 144 WSAs over an 8-Year Period.*

over time. The Metros had one of their lowest infrastructure management efficiencies during the 2020/21 financial year, this corresponded with increased water losses (non-revenue water), minimal to no repairs and maintenance expenditure.

This poor performance can be attributed to the Covid-19 pandemic (2019/20 to 2020/21), which saw revenue collection fall and limited investment in infrastructure upkeep (repairs and maintenance) being possible.

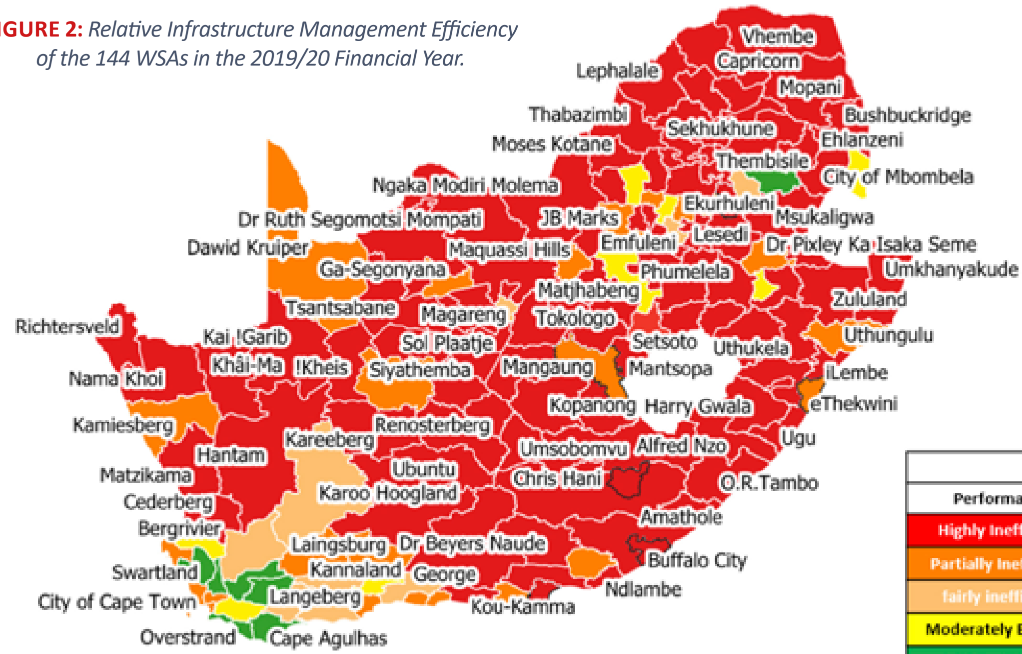
It was notable that Secondary Cities (B1) consistently outperformed Metros (A) in every year but were still Highly Inefficient in every year and also trending negatively (decreasing efficiency year-to-year). B1's (Secondary Cities) were closely followed by Large Towns (B2's), who also outperformed the Metros, but were also Highly Inefficient in every year and showing no improvement. The highest efficiency scores for all categories across the eight years was achieved by Secondary Cities (45.3% in the 2015/16 FY), followed by Large Towns (39,4%) in the 2015/16 FY. This suggests that scale (municipal size) does not automatically equate to (infrastructure) management efficiency. This is deducted from the fact that Metros (category A) which, despite having the most resources and the largest budgets, are not the most efficient.

On the other hand, an extreme lack of resources does contribute to inefficiency, as evidenced by the performance of category B4 (small rural towns) and C2 (rural districts) WSA's, being consistently extremely inefficient (Luyaba *et al.*, 2024). The lowest efficiency score for category C2 (10.1%) was observed in the 2022/23 financial year. Not only did the results show that they are extremely inefficient, but their performance also suggests that they are completely failing post the Covid-19 pandemic and require targeted attention and intervention. The extremely low efficiency scores for category B3 and B4 (small and rural local municipalities) and C2 (districts) WSAs inevitably raises the issue of whether these functions should be handled at the district or local level. Luyaba *et al.* (2020) argue for a progressive consolidation of WSAs as less could be more, through the unlocking of economies of scale and other benefits envisaged by the South African government through the District Development Model (DDM). While this may be the case, if financial resourcing is not increased, rural municipalities will be unable to efficiently manage water services regardless of which municipal category is authorised (Local or District).

Financial resourcing constraining water services delivery (measured through ability to undertake repairs and maintenance) is more explicitly examined by Luyaba *et al.* (2024), where rural municipalities (B3, B4 and C2) are shown to not have the requisite financing to undertake adequate repairs and maintenance of their existing infrastructure. It can therefore be argued that finding solutions for municipal financial sustainability is more urgent and pressing than deciding who should have the WSA function. A pragmatic solution from infrastructure asset management fundamentals is increasing tariffing (not feasible due to affordability considerations in rural areas) or lowering the level of service (not the quality e.g. moving from a household connection to communal standpipes). Lowering the level of service may also not be socially acceptable, leaving engineering revolution for innovation as the only option that can lead to acceptable (socially), sustainable (financially) and appropriate (technically) solutions.

Most of the WSAs show fluctuations in efficiency but generally stay within the "Highly Inefficient" to "Extremely Inefficient" range. There is no significant upward trend, but there is a subtle gradual downward trend, indicating persistent inefficiency issues across all categories over the years and a deteriorating state. Category B1 shows relatively better efficiency compared to other categories but still remains in the "Highly Inefficient" range. Category C2 shows the lowest efficiency, consistently falling deeper into the "Extremely Inefficient" range with its efficiency score ranging between 10.1% and 14.7%.

**FIGURE 2:** *Relative Infrastructure Management Efficiency of the 144 WSAs in the 2019/20 Financial Year.*




| LEGEND | |
|---|---|
| Performance | Score |
| Highly Inefficient | 0% – 29% |
| Partially Inefficient | 30% - 49% |
| fairly inefficient | 50% – 59% |
| Moderately Efficient | 60% - 79% |
| Highly Efficient | 80% - 100% |

Following this methodology (MWaSSIME) the WSAs can be ranked as follows (average score over the eight financial years): 1 – Secondary Cities (B1 – 40,3%), 2 - Large Towns (B2 – 34,7%), 3 – Metros (A – 31,1%), 4 - Small Towns (B3 – 29,8%), 5 - Rural Small Towns (B4 – 27%) and 6 - Rural Districts (C2 – 12,3%). The persistent inefficiency suggests an urgent need for significant improvements in the use, management and allocation of resources. The fact that no WSA category attained a "Fairly Inefficient" outcome highlights systemic issues that require comprehensive strategies for improvement. Addressing these inefficiencies is crucial for improving the delivery, operation and maintenance of municipal infrastructure services, particularly in water and sanitation.

## CONCLUSIONS

This study highlighted the need for a tool to measure municipal water and sanitation infrastructure management efficiency and then proceeded to develop such a tool. Various models were considered and tested, with the Data Envelopment Analysis (DEA) CCR-I model being selected as the most appropriate for assessing municipal water and sanitation services infrastructure management efficiency (MWaSSIME).

The infrastructure management efficiency analysis over the eight financial years (FY2015/16 to FY2022/23) uncovers and quantifies persistent gross inefficiencies across various categories of WSAs. Efficiency levels for most categories fluctuate but remain predominantly in the "Highly Inefficient" or "Extremely Inefficient" range. Rural municipalities exhibit extreme inefficiency, specifically in categories B4 and C2, highlighting their severe financial resource constraints. These findings highlight the need for a differentiated support and intervention approach for these municipalities.

The findings highlight a critical need for an engineering revolution in public utility performance monitoring and measurement. As demonstrated through the MWaSSIME Index, this would generate new insights that enable evidence-based decision-making to address systemic issues in resource allocation and utilisation. The development and application of the MWaSSIME Index serves as a valuable tool for benchmarking efficiency in water and sanitation services and should be extended to all public infrastructure. This work also enables critical continuous improvement (and basic service delivery) in a context where more must be done with less resources, as substantial economic growth has been elusive for South Africa. This approach not only guides municipalities in identifying areas for improvement but also enables the other spheres of government to better support municipalities and monitor the impact of their support.

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