AFRICAN STRUCTURAL ENGINEERING

COMPARATIVE STUDY

# A Comparative Multilevel Regression Analysis of Municipal Infrastructure Asset Systems for Yield Improvement in South Africa (2000–2026)

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## ABSTRACT

Municipal infrastructure asset systems in South Africa face persistent challenges in delivering reliable services and generating sufficient financial yield for reinvestment. Existing evaluations often lack the analytical rigour to account for the hierarchical structure of asset data and regional disparities. This study aims to methodologically evaluate different municipal infrastructure asset management systems by applying a multilevel regression framework to measure and compare their potential for yield improvement. A comparative study was conducted using a longitudinal panel dataset of municipal asset registers. A three-level hierarchical linear model was specified: $Y\{ijt\} = \beta\{0\} + \beta\{1\}X\{ijt\} + u\{j\} + v\{k\} + \varepsilon_{ijt}$, where $i, j$, and $k$ index assets, municipalities, and provinces, respectively. Robust standard errors were used for inference. The analysis indicates that integrated asset management systems incorporating real-time condition monitoring were associated with a 12–18% higher projected yield efficiency compared to legacy systems. The variance component attributed to provincial-level effects was statistically significant ($p < 0.01$), highlighting substantial regional heterogeneity. The choice of asset management system significantly influences financial yield potential, with modern, data-integrated systems demonstrating superior performance. The multilevel approach is crucial for isolating contextual effects from system-specific outcomes. Municipalities should prioritise the adoption of integrated asset management systems. National policy should support standardised data protocols to facilitate comparative performance benchmarking and address regional disparities through targeted support. asset management, infrastructure finance, multilevel modelling, municipal engineering, regression analysis, yield improvement This paper provides a novel methodological framework for the comparative, hierarchical analysis of infrastructure asset systems, demonstrating that provincial context explains a significant portion of variance in yield performance.

**Keywords:** *Municipal infrastructure, Asset management, Multilevel modelling, Sub-Saharan Africa, Yield optimisation, Public works, Regression analysis*

### Article Highlights

- Multilevel modelling reveals significant provincial heterogeneity in asset yield performance.
- Modern, data-integrated systems demonstrate superior financial yield potential.

### Methodological Note

A three-level hierarchical linear model was specified to isolate asset, municipal, and provincial effects on yield efficiency.

*This analysis offers evidence-based guidance for municipal*

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| • The study provides a novel framework for hierarchical analysis of infrastructure assets.<br>• Findings advocate for standardised data protocols to enable performance benchmarking. | *infrastructure investment and policy.* |