

A Multilevel Regression Analysis of Municipal Infrastructure System Reliability in South Africa

A Case Study (2000–2026)

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ABSTRACT

Background: The reliability of municipal infrastructure systems is a critical determinant of service delivery and economic development. In many regions, systemic failures in water, sanitation, and road networks are prevalent, yet quantitative, system-level reliability assessments remain methodologically underdeveloped, often relying on isolated asset condition reports.

Purpose and objectives: This case study aims to develop and apply a novel multilevel regression framework to quantitatively evaluate the reliability of integrated municipal infrastructure systems. The objective is to identify and quantify the key technical, financial, and institutional factors influencing system-wide performance.

Keywords: *Municipal infrastructure, System reliability, Multilevel regression, South Africa, Asset management, Service delivery, Water and sanitation*

Article Highlights

- Operational expenditure per capita had a stronger positive effect on reliability than capital expenditure alone.
- Institutional governance metrics were a dominant theme explaining variance between municipalities.
- The multilevel model successfully captured the nested structure of infrastructure system data.
- Sole focus on physical asset condition is insufficient for predicting system-wide performance.

Core Analytical Framework

A three-level hierarchical linear model analysed panel data from municipal asset registers, financial statements, and service delivery reports over a 26-year period.

This analysis provides a quantitative framework for rebalancing municipal infrastructure investment.

ABSTRACT-ONLY PUBLICATION

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