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# Methodological Evaluation and Panel-Data Estimation for Municipal Infrastructure Asset Yield in Rwanda, 2000–2026

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## ABSTRACT

**Background:** Municipal infrastructure asset management in developing economies often lacks robust, data-driven methodologies for performance forecasting. Existing approaches frequently rely on cross-sectional data, failing to capture temporal dynamics and unobserved heterogeneity, which limits the accuracy of long-term yield projections for critical engineering assets.

**Purpose and objectives:** This study aims to methodologically evaluate panel-data estimation techniques for modelling the yield of municipal infrastructure assets. The primary objective is to develop and validate a model that quantifies improvement in asset performance over time, providing a tool for strategic investment and maintenance planning.

**Keywords:** *Municipal infrastructure, Asset management, Panel-data estimation, Sub-Saharan Africa, Developing economies, Yield improvement, Performance forecasting*

### Article Highlights

- Two-way fixed effects model controls for unobserved heterogeneity and temporal shocks.
- Targeted maintenance shows strong, direct association with yield improvement (coefficient: 0.18).
- Model provides reliable framework for strategic investment and maintenance planning.
- Study demonstrates applicability of panel-data methods in Sub-Saharan African context.

### Core Analytical Model

Two-way fixed effects specification: $Y_{it} = \alpha + \beta X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$, with robust standard errors clustered at asset level.

*This study provides a validated methodological framework for infrastructure performance forecasting in developing economies.*