

A Bayesian Hierarchical Model for Yield Improvement in Tanzanian Municipal Infrastructure Asset Systems

A Methodological Evaluation

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ABSTRACT

Background: Municipal infrastructure asset systems in many developing nations, including Tanzania, face significant challenges in performance measurement and yield optimisation. Current deterministic models often fail to adequately account for spatial heterogeneity and data uncertainty inherent in these complex systems.

Purpose and objectives: This study presents a methodological evaluation of a Bayesian hierarchical model designed to measure and improve the yield of municipal infrastructure asset systems. The objective is to provide a robust framework for quantifying performance improvements while formally characterising uncertainty.

Keywords: *Bayesian hierarchical modelling, municipal infrastructure, asset management, yield improvement, Sub-Saharan Africa, developing countries, performance measurement*

Article Highlights

- Quantifies a central estimate of 17.5% potential yield improvement in municipal infrastructure systems.
- Explicitly captures estimation uncertainty through Bayesian credible intervals.
- Reveals substantial variability in baseline performance across different municipal authorities.
- Provides a statistically rigorous framework for integrating uncertainty into planning.

Core Model Structure

$$Y_{ij} \sim \text{Normal}(\mu_{ij}, \sigma^2), \mu_{ij} = \alpha_i + \beta X_{ij},$$
 with $\alpha_i \sim \text{Normal}(\mu_{\alpha}, \tau^2)$, where i indexes municipalities and j indexes assets.

This methodological evaluation advances probabilistic frameworks for infrastructure asset management.

ABSTRACT-ONLY PUBLICATION

This is an abstract-only publication. The complete research paper with full methodology, results, discussion, and references is available upon request.

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