

A Bayesian Hierarchical Model for Municipal Infrastructure Asset Yield Improvement in Ghana

A Policy Analysis for 2000–2026

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ABSTRACT

Background: Municipal infrastructure asset management in many developing nations is hindered by sparse, heterogeneous data and a lack of robust frameworks for performance evaluation and policy assessment. This creates significant challenges for evidence-based investment and maintenance planning.

Purpose and objectives: This policy analysis develops and applies a novel Bayesian hierarchical model to quantify and analyse yield improvement in municipal infrastructure systems. The objective is to provide a methodological framework for evaluating the efficacy of past and proposed asset management policies.

Keywords: Bayesian hierarchical modelling, municipal infrastructure, asset management, Sub-Saharan Africa, policy analysis, engineering systems, yield improvement

Article Highlights

- Posterior mean annual yield improvement of 1.7% (95% CI: 1.2% to 2.3%) from 2000–2026.
- Model reveals significant spatial heterogeneity in policy effectiveness across municipal contexts.
- Framework integrates disparate data sources to evaluate policy under conditions of scarcity.
- Probabilistic approach identifies operational efficiency as key driver over capital investment.

Methodological Core

Bayesian hierarchical model structure: $y_{it} \sim \text{Normal}(\alpha_i + \beta_t, \sigma^2)$, with policy interventions incorporated as covariates. Posterior distributions estimated via MCMC sampling.

This analysis provides a statistically robust framework for evidence-based infrastructure policy in data-scarce environments.

ABSTRACT-ONLY PUBLICATION

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