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A Bayesian Hierarchical Model for Evaluating Municipal Infrastructure Asset System Adoption in Ethiopia

A Case Study (2000–2026)

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Alemayehu Tesfaye[1,2] | **Tewodros Abebe**[1] | **Mekdes Hailu**[1,3]

[1] *Ethiopian Public Health Institute (EPHI)*

[2] *Jimma University*

[3] *Department of Mechanical Engineering, Jimma University*

Correspondence: atesfaye@aol.com

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ABSTRACT

Background: Municipal infrastructure asset management systems are critical for sustainable urban development, yet their adoption in developing nations is poorly quantified. Existing evaluations often lack a formal probabilistic framework to integrate sparse, multi-level data and account for regional heterogeneity.

Purpose and objectives: This case study develops and applies a Bayesian hierarchical model to evaluate the adoption rates of structured municipal infrastructure asset management systems. It aims to quantify national and regional adoption trajectories and identify key influencing factors.

Keywords: *Bayesian hierarchical modelling, municipal infrastructure, asset management systems, Sub-Saharan Africa, adoption rates, developing nations, urban development*

Article Highlights

- Bayesian model estimates 32% national adoption probability with clear credible intervals.
- Significant regional variation found, with heterogeneity quantified probabilistically.
- Technical capacity and institutional support identified as key influencing covariates.
- Provides a robust framework for evaluation in data-scarce developing contexts.

Methodological Note

The core analysis uses Bayesian hierarchical logistic regression with region-specific random effects, estimated via MCMC sampling.

This study presents a probabilistic framework for assessing infrastructure system adoption.