AFRICAN STRUCTURAL ENGINEERING

ORIGINAL RESEARCH

A Bayesian Hierarchical Model for Yield Improvement in Rwandan Transport Maintenance Depot Systems

A Methodological Evaluation

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ABSTRACT

Background: Transport maintenance depot systems in developing economies are critical infrastructure assets, yet their operational yield is often suboptimal due to complex, interacting factors. Current evaluation methods frequently lack the statistical rigour to quantify uncertainty and integrate multi-level data effectively.

Purpose and objectives: This study presents a methodological evaluation of a novel Bayesian hierarchical model designed to measure and diagnose yield improvement within depot systems. The objective is to provide a robust framework for identifying key performance drivers and quantifying their effects with explicit uncertainty.

Keywords: *Bayesian hierarchical modelling, yield improvement, transport maintenance depots, Sub-Saharan Africa, developing economies, operational research, infrastructure systems*

Article Highlights

- Bayesian hierarchical model quantifies uncertainty in depot yield analysis
- Identifies depot management as primary performance driver with >0.95 probability
- Substantial depot heterogeneity revealed beyond observed covariates
- Provides framework for multi-level performance diagnostics in developing economies

Core Model Structure

$y_{ij} \sim \text{Normal}(\alpha_j + \beta X_{ij}, \sigma^2)$, with $\alpha_j \sim \text{Normal}(\mu_{\alpha}, \tau^2)$, where y_{ij} is yield for observation i in depot j, X_{ij} are covariates, and α_j are depot-level random effects.

This methodological evaluation presents a probabilistically rigorous framework for infrastructure performance analysis.

ABSTRACT-ONLY PUBLICATION

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