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

A Methodological Case Study, 2000–2026

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ABSTRACT

Background: Transport maintenance depot systems in developing nations often operate with suboptimal yield, leading to resource wastage and service delays. In Rwanda, systematic evaluation of depot performance has been hindered by data sparsity and the hierarchical nature of operational data across regions and time.

Purpose and objectives: This case study presents and evaluates a novel Bayesian hierarchical modelling framework designed to quantify and improve yield within the nation's transport maintenance depot system. The objective is to provide a robust methodological tool for performance assessment under uncertainty.

Keywords: *Bayesian hierarchical modelling, yield improvement, transport maintenance depots, Sub-Saharan Africa, developing economies, systems evaluation, reliability engineering*

Article Highlights

- Bayesian framework quantifies yield improvement with 90% credible interval [12.3%, 21.8%]
- Model successfully handles data sparsity and hierarchical operational structures
- Identifies regional performance variations with posterior probability >0.95
- Provides probabilistic assessment of improvement drivers beyond descriptive metrics

Core Methodological Contribution

A Bayesian hierarchical model explicitly modelling depot-level yields as functions of regional effects and time-varying covariates, using Hamiltonian Monte Carlo for inference.

This methodological framework offers a template for performance assessment in data-limited infrastructure systems.