AFRICAN CIVIL ENGINEERING JOURNAL
Vol. 1 | No. 1 | 2024 | 10.5281/zenodo.18971793

A Bayesian Hierarchical Model for Yield Improvement in Ghana's Industrial Machinery Fleets

A Methodological Evaluation

Kwame Asante[1]

Department of Mechanical Engineering, Noguchi Memorial Institute for Medical Research

Correspondence: kasante@yahoo.com

Received: 30 September 2023 | Accepted: 28 November 2023 | Published: 07 January 2024 | **DOI:** 10.5281/zenodo.18971793

ABSTRACT

Background: Industrial machinery fleets in developing economies are critical for infrastructure development, yet systematic methodologies for quantifying and improving their operational yield are lacking. Existing approaches often fail to account for heterogeneous machine types, site-specific conditions, and the inherent uncertainty in performance data.

Purpose and objectives: This study presents a methodological evaluation of a Bayesian hierarchical model designed to measure and diagnose yield improvement within industrial machinery fleets. The objective is to provide a robust statistical framework that integrates multi-level operational data to inform maintenance and deployment strategies.

Keywords: *Bayesian hierarchical modelling, yield improvement, industrial machinery fleets, Sub-Saharan Africa, operational research, developing economies, maintenance optimisation*

Article Highlights

- Bayesian hierarchical model quantifies yield improvement while characterizing uncertainty.
- Identifies significant heterogeneity in baseline performance across individual machine units.
- Provides operationally actionable framework superior to aggregate fleet-level metrics.
- Enables data-driven maintenance strategies tailored to specific machine performance.

Core Statistical Framework

The model structure $y_{ij} \sim \text{Normal}(\alpha_i + \beta X_{ij}, \sigma^2)$, with $\alpha_i \sim \text{Normal}(\mu_{\alpha}, \tau^2)$, captures machine-level heterogeneity and project covariates to inform maintenance decisions.

This methodological evaluation offers a statistically rigorous alternative to conventional fleet management approaches.