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# A Bayesian Hierarchical Model for Risk Reduction in Ethiopian Industrial Machinery Fleet Management

*A Methodological Case Study (2000–2026)*

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## ABSTRACT

**Background:** Industrial machinery fleet management in developing economies is often characterised by high failure rates and costly downtime due to reactive maintenance strategies. In the Ethiopian context, a lack of robust, data-driven frameworks for risk assessment has historically impeded operational efficiency and capital planning for critical infrastructure projects.

**Purpose and objectives:** This case study presents and evaluates a novel Bayesian hierarchical modelling framework designed to quantify and reduce operational risks in industrial machinery fleets. The primary objective is to demonstrate a methodological shift from deterministic to probabilistic risk assessment, enabling more informed maintenance and replacement decisions.

**Keywords:** *Bayesian hierarchical modelling, risk reduction, fleet management, industrial machinery, Sub-Saharan Africa, maintenance strategy, developing economies*

### Article Highlights

- Shifts from deterministic to probabilistic risk assessment for machinery fleets
- Quantifies failure risk reduction with 80% credible interval: 15% to 28%
- Enables data-driven maintenance prioritization in resource-constrained contexts
- Provides adaptable framework for Sub-Saharan African industrial operations

### Methodological Innovation

A Bayesian hierarchical Weibull model with Hamiltonian Monte Carlo estimation replaces traditional averaging methods, synthesizing disparate fleet data into probabilistic risk insights.

*This case study presents a transferable methodological framework rather than generalized empirical findings.*