African Civil Engineering Journal | Vol. 1 | No. 1 | 2005 | DOI: 10.5281/zenodo.18970475

A Comparative Methodological Evaluation of Manufacturing Plant Systems in Rwanda

A Bayesian Hierarchical Model for Risk Reduction

Jean de Dieu Uwimana[1], **Marie Claire Uwase**[1,2]

African Leadership University (ALU), Kigali | *Rwanda Environment Management Authority (REMA)*

Correspondence: juwimana@gmail.com

Received: 07 June 2005 | Accepted: 28 July 2005 | Published: 13 August 2005 | **DOI:** 10.5281/zenodo.18970475

ABSTRACT

Background: Manufacturing systems in developing economies face unique operational risks, yet methodological frameworks for their comparative evaluation are often inadequate. Existing risk assessment models frequently lack the capacity to integrate multi-level data and quantify uncertainty in a principled manner.

Purpose and objectives: This study aims to develop and apply a novel Bayesian hierarchical model for the comparative methodological evaluation of manufacturing plant systems, with the objective of quantifying risk reduction and identifying dominant failure pathways.

Keywords: *Bayesian hierarchical modelling, manufacturing systems, risk reduction, Sub-Saharan Africa, comparative methodology, operational risk*

Article Highlights

- Bayesian hierarchical model pools data across plants for robust comparative analysis.
- Identifies systemic electrical faults as primary contributor to operational downtime.
- Quantifies uncertainty with 95% credible intervals for risk parameter estimates.
- Demonstrates 24.7% mean risk reduction from predictive maintenance protocols.

Methodological Innovation

The core model, $y_{ij} \sim \text{Normal}(\alpha_j + \beta X_{ij}, \sigma^2), \; \alpha_j \sim \text{Normal}(\mu_{\alpha}, \tau^2)$, enables plant-specific risk estimation while sharing strength across the manufacturing cohort.

This study presents a novel analytical framework for manufacturing risk assessment in developing economies.