

A Bayesian Hierarchical Model for Reliability Diagnostics and Maintenance Policy in Rwandan Water Treatment Systems

Samuel Habimana^{1,2} | Marie Claire Uwase^{3,4}
Jean de Dieu Uwimana⁵ | Valérie Mukamana^{6,7}

Department of Mechanical Engineering, African Leadership University (ALU), Kigali • *Department of Sustainable Systems, University of Rwanda* • *Department of Civil Engineering, University of Rwanda* • *Rwanda Environment Management Authority (REMA)* • *Department of Electrical Engineering, African Leadership University (ALU), Kigali* • *Department of Sustainable Systems, Rwanda Environment Management Authority (REMA)* • *African Leadership University (ALU), Kigali*

Correspondence: shabimana@hotmail.com

Received: 16 August 2014 | Accepted: 19 September 2014 | Published: 28 October 2014 | DOI:

[10.5281/zenodo.18974023](https://doi.org/10.5281/zenodo.18974023)

ABSTRACT

Background: The reliability of water treatment infrastructure is a critical determinant of public health and economic development. In many developing nations, maintenance policies are often reactive, leading to inefficient resource allocation and service disruption. A systematic, data-driven approach to reliability assessment is therefore essential for effective infrastructure management.

Purpose and objectives: This policy analysis article develops and evaluates a novel Bayesian hierarchical model to diagnose reliability and inform maintenance strategies for water treatment systems. The primary objective is to provide a robust methodological framework for quantifying system failure risks and optimising intervention schedules.

Keywords: *Bayesian hierarchical modelling, infrastructure reliability, maintenance policy, water treatment systems, Sub-Saharan Africa*

Article Highlights

- Bayesian hierarchical model quantifies failure risks across water treatment components.
- Reveals substantial reliability heterogeneity, with filtration units at higher risk.
- Provides statistically rigorous tool for condition-based maintenance policy.
- Enables data-driven allocation of maintenance budgets based on posterior risk.

Policy Implication

Investment and maintenance budgets should be informed by probabilistic reliability assessments, not just historical expenditure.

This analysis provides a framework for data-driven infrastructure management in developing contexts.

ABSTRACT-ONLY PUBLICATION

This is an abstract-only publication. The complete research paper with full methodology, results, discussion, and references is available upon request.

REQUEST FULL PAPER

 **Email:** info@parj.africa

Request your copy of the full paper today!

SUBMIT YOUR RESEARCH

**Are you a researcher in Africa? We
welcome your submissions!**

Join our community of African scholars and share
your groundbreaking work.

 **Submit at:** app.parj.africa



Scan to visit app.parj.africa

Open Access Scholarship from PARJ

Empowering African Research | Advancing Global
Knowledge