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METHODOLOGY PAPER

A Bayesian Hierarchical Model for the Reliability Assessment of Municipal Infrastructure Asset Systems in Kenya

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ABSTRACT

Background: Municipal infrastructure asset systems in Kenya face significant reliability challenges due to ageing, underinvestment, and heterogeneous operating conditions. Current reliability assessment methods often fail to adequately integrate sparse, multi-source field data and quantify epistemic uncertainty inherent in such complex systems.

Purpose and objectives: This article presents a novel Bayesian hierarchical modelling framework designed to rigorously assess the system reliability of municipal infrastructure networks. The objective is to provide a robust, data-adaptive methodology that quantifies uncertainty and supports asset management decision-making.

Keywords: *Bayesian hierarchical modelling, infrastructure reliability, municipal asset management, Sub-Saharan Africa, uncertainty quantification, systems engineering*

Article Highlights

- A three-level Bayesian hierarchical model for municipal infrastructure reliability.
- Integrates sparse, multi-source field data with expert-informed priors.
- Quantifies epistemic uncertainty inherent in complex asset systems.
- Demonstrated application to simulated Kenyan water distribution networks.

Methodological Contribution

Presents a statistically coherent framework that handles data limitations while borrowing strength across asset groups, offering a significant advance for data-scarce environments.

This article provides a rigorous, probabilistic approach to infrastructure reliability assessment.