

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

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## ABSTRACT

**Background:** The reliability assessment of municipal infrastructure asset systems in developing nations is hindered by sparse, heterogeneous, and uncertain data. Traditional deterministic models often fail to capture the systemic uncertainties and hierarchical dependencies inherent in such complex networks.

**Purpose and objectives:** This study aims to develop and validate a novel Bayesian hierarchical modelling framework for the reliability assessment of integrated municipal infrastructure systems, specifically addressing data scarcity and integrating expert judgement with sparse field observations.

**Keywords:** *Bayesian hierarchical modelling, infrastructure asset management, reliability assessment, Sub-Saharan Africa, municipal engineering, data scarcity, probabilistic risk analysis*

### Article Highlights

- Bayesian model quantifies reliability under data scarcity
- Drainage assets show 1.7× higher failure probability than water systems
- Framework enables both asset-level and system-level inferences
- Posterior distributions reveal wide credible intervals for failure risk

### Methodological Innovation

A novel Bayesian hierarchical model integrates sparse field data with expert judgement to assess infrastructure reliability in data-scarce contexts.

*This study provides a probabilistic alternative to deterministic assessment methods.*

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