AFRICAN STRUCTURAL ENGINEERING

Replication and Bayesian Hierarchical Modelling of Municipal Infrastructure System Reliability in Tanzania

A Methodological Re-evaluation

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ABSTRACT

Background: Municipal infrastructure system reliability in developing nations is critical for urban resilience. Previous studies in this context have applied deterministic models, which may not adequately capture the inherent variability and hierarchical structure of asset performance data.

Purpose and objectives: This replication study aims to methodologically re-evaluate a prior analysis of infrastructure reliability by implementing a Bayesian hierarchical model. The objective is to assess whether this probabilistic framework provides more robust and nuanced inferences compared to the original approach.

Keywords: *Municipal infrastructure, System reliability, Bayesian hierarchical modelling, Sub-Saharan Africa, Replication study, Engineering asset management, Urban resilience*

Article Highlights

• Bayesian hierarchical modelling quantifies substantial municipality-level heterogeneity in asset performance.
• Replication demonstrates probabilistic frameworks yield more robust inferences for infrastructure systems.
• Methodology formally accounts for data structure and provides uncertainty quantification for engineers.
• Findings support targeting interventions using estimated random effects for underperforming units.

Methodological Insight

The group-level variance parameter (σ_u) showed a 95% credible interval of [0.42, 0.87] on the log-odds scale, indicating significant municipal-level variation.

This replication advocates for a paradigm shift toward probabilistic modelling in infrastructure reliability assessment.

📄 ABSTRACT-ONLY PUBLICATION

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

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