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Multilevel Regression Analysis for Reliability Assessment of Municipal Infrastructure Asset Systems in Rwanda

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ABSTRACT

Background: Municipal infrastructure asset systems in Rwanda face challenges from rapid urbanisation and constrained maintenance resources. Current reliability assessments often fail to account for the hierarchical nature of asset data, where individual components are nested within larger systems and geographical units.

Purpose and objectives: This study aimed to develop and apply a multilevel regression modelling framework to assess the reliability of municipal infrastructure systems, explicitly accounting for data hierarchy to provide more accurate and actionable insights for asset management.

Keywords: *Municipal infrastructure, Asset management, Reliability assessment, Multilevel regression, Sub-Saharan Africa, Urbanisation, Systems engineering*

Article Highlights

- Multilevel regression reveals 31% of asset reliability variance stems from district-level effects.
- Increased maintenance frequency raises odds of full functionality by 2.4 times.
- Hierarchical data analysis is essential for accurate municipal asset management.
- Framework provides actionable insights for resource allocation in Sub-Saharan Africa.

Methodological Insight

A two-level random intercept logistic model was specified to analyse hierarchical asset data, with parameters estimated via restricted maximum likelihood.

This study demonstrates the critical advantage of hierarchical modelling for infrastructure systems in rapidly urbanizing contexts.