

# A Comparative Bayesian Hierarchical Model for Municipal Infrastructure Risk Reduction in Ethiopia: 2000–2026

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## ABSTRACT

**Background:** Municipal infrastructure systems in developing nations face significant challenges from ageing assets, population growth, and climate stressors. Traditional risk assessment methods often lack the flexibility to integrate sparse, multi-source data and quantify uncertainty for long-term planning.

**Purpose and objectives:** This study aims to develop and evaluate a novel comparative Bayesian hierarchical model for quantifying risk reduction across diverse municipal infrastructure asset systems. The objective is to provide a robust, probabilistic framework for prioritising interventions and forecasting future risk trajectories.

**Keywords:** *Bayesian hierarchical modelling, municipal infrastructure, risk reduction, Sub-Saharan Africa, comparative study, asset management, climate resilience*

### Article Highlights

- Bayesian hierarchical model enables comparative risk analysis across diverse infrastructure assets.
- Framework synthesizes sparse, heterogeneous data for robust probabilistic forecasting.
- Projected divergence in risk profiles informs strategic intervention prioritization.
- Method provides statistically rigorous uncertainty quantification for long-term planning.

### Methodological Innovation

A Bayesian hierarchical model with partial pooling across assets and temporal components, using Hamiltonian Monte Carlo for inference on risk trajectories.

*This study offers a transferable probabilistic framework for infrastructure risk management in data-scarce contexts.*

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