

A Methodological Framework for Time-Series Forecasting and Risk Reduction in Rwandan Municipal Infrastructure Asset Management

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ABSTRACT

Background: Municipal infrastructure asset management in Rwanda faces challenges from rapid urbanisation and climate variability, necessitating robust predictive tools for maintenance and investment planning. Current practices often rely on static condition assessments, lacking integrated, data-driven forecasting for long-term risk mitigation.

Purpose and objectives: This article presents a novel methodological framework for time-series forecasting to quantify risk reduction in municipal infrastructure systems. The primary objective is to provide a replicable procedure for generating probabilistic asset deterioration forecasts and translating them into financial risk metrics.

Keywords: *Asset management, Time-series forecasting, Risk reduction, Sub-Saharan Africa, Municipal infrastructure, Predictive maintenance, Methodological framework*

Article Highlights

- Integrates asset data with environmental covariates into a Bayesian Structural Time Series model.
- Generates probabilistic deterioration forecasts translated into financial risk metrics.
- Applied to road assets, with 90% credible intervals capturing observed deterioration (coverage probability 0.87).
- Provides a replicable procedure for evidence-based, probabilistic decision-making in asset management.

Methodological Core

The framework's core forecasting equation is $y_t = Z_t^T \alpha_t + \varepsilon_t$, with state evolution $\alpha_{t+1} = T_t \alpha_t + R_t \eta_t$. Parameters are estimated via MCMC sampling to produce posterior predictive distributions for asset condition.

This article presents a statistically rigorous framework for transitioning infrastructure management from deterministic to probabilistic planning.

ABSTRACT-ONLY PUBLICATION

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