A Time-Series Forecasting Model for Risk Reduction in Tanzanian Municipal Infrastructure Asset Management Systems (2000–2026)

Amina Mwinyi[1,2]|**Baraka Mwakalukwa**[1,3]|**Juma Kavishe**[4,5]
Neema Mfinanga[4,6]

Tanzania Commission for Science and Technology (COSTECH) • *Catholic University of Health and Allied Sciences (CUHAS)* • *Tanzania Wildlife Research Institute (TAWIRI)* • *National Institute for Medical Research (NIMR)* • *Department of Electrical Engineering, Catholic University of Health and Allied Sciences (CUHAS)* • *Department of Civil Engineering, Tanzania Wildlife Research Institute (TAWIRI)*

Correspondence: amwinyi@gmail.com

ABSTRACT

Municipal infrastructure asset management in many developing nations is hindered by reactive, data-poor strategies, leading to inefficient resource allocation and heightened vulnerability to asset failure. This is particularly acute in sub-Saharan Africa, where systematic, forward-looking risk assessment frameworks are scarce. This study aimed to develop and validate a quantitative forecasting model to measure potential risk reduction in municipal infrastructure systems, providing a decision-support tool for proactive asset management. A time-series model was constructed using historical municipal asset condition and failure data. The core forecasting equation is $yt = \alpha + beta1\, y\{t-1\} + beta2\, Xt + epsilont$, where X_t represents a vector of environmental and usage covariates. Model parameters were estimated using maximum likelihood, with robust standard errors to account for heteroskedasticity. Forecast accuracy was evaluated against a holdout sample. The model demonstrated a statistically significant forecasting capability, with a 95% confidence interval for the one-step-ahead prediction error of ±7.2%. Application of the model indicated that adopting its forecasts for maintenance scheduling could reduce the projected risk of critical asset failure by an estimated 18–25% over a medium-term horizon, compared to current practice. The proposed time-series model provides a technically robust and empirically validated framework for quantifying risk reduction in infrastructure asset management, moving beyond qualitative assessment. Municipal engineers and planners should integrate quantitative forecasting models into asset management systems to enable data-driven, preventative maintenance strategies. Further research should focus on integrating climate stressor projections into the model covariates. asset management, infrastructure risk, time-series analysis, predictive maintenance, municipal engineering, forecasting This paper presents a novel methodological framework that quantifies the efficacy of risk reduction strategies for municipal infrastructure, a significant advancement from descriptive, condition-based assessments.

Keywords: *Municipal infrastructure, asset management, time-series forecasting, Sub-Saharan Africa, risk reduction, developing countries, predictive maintenance*

Article Highlights	Methodological Core
• Model forecasts reduced critical asset failure risk by 18–25% compared to current practice. • Quantitative framework validated with 95% confidence	Time-series model constructed using historical asset condition and failure data, with parameters estimated via maximum likelihood and robust standard errors.

interval for prediction error of ±7.2%.
• Shifts asset management from reactive to proactive, data-driven strategies.
• Provides decision-support tool for municipal engineers in developing contexts.

This study presents a validated forecasting model for proactive infrastructure management.

📄 ABSTRACT-ONLY PUBLICATION

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

✉ REQUEST FULL PAPER

✉ Email: info@parj.africa

Request your copy of the full paper today!

🚀 SUBMIT YOUR RESEARCH

Are you a researcher in Africa? We welcome your submissions!

Join our community of African scholars and share your groundbreaking work.

🌐 Submit at: app.parj.africa

Scan to visit app.parj.africa

Open Access Scholarship from PARJ

Empowering African Research | Advancing Global Knowledge