

# A Time-Series Forecasting Model for the Reliability Assessment of Municipal Infrastructure Asset Systems in Uganda (2000–2026)

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## ABSTRACT

The reliability of municipal infrastructure asset systems in many developing nations is poorly quantified, hindering effective maintenance planning and investment. Existing assessment methods often lack the temporal forecasting capability needed for proactive asset management. This study aimed to develop and validate a time-series forecasting model to assess the reliability of integrated municipal infrastructure systems, specifically targeting water supply, road networks, and drainage assets. A methodological framework was constructed using historical performance data. The core forecasting model employs an autoregressive integrated moving average (ARIMA) formulation, expressed as  $\phi(B)(1-B)^d R_t = \theta(B) \epsilon_t$ , where  $R_t$  is the composite reliability index at time  $t$ . Model parameters were estimated using maximum likelihood, and forecasts were generated with 95% confidence intervals to quantify uncertainty. The model forecasts a statistically significant decline in the composite system reliability index, projecting a decrease of approximately 22% over the forecast horizon. Uncertainty analysis indicated that the confidence intervals for the road network subsystem were widest, reflecting greater volatility in its performance data. The developed model provides a robust, quantitative tool for forecasting infrastructure system reliability, revealing a concerning downward trajectory that necessitates urgent intervention. Municipal engineers and planners should adopt similar predictive modelling for capital works programming. National policy should mandate the routine collection and analysis of standardised asset performance data to feed such models. asset management, infrastructure reliability, forecasting, ARIMA, municipal engineering, developing countries This paper presents a novel application of a composite ARIMA model for forecasting the reliability of integrated municipal infrastructure systems, validated with a unique longitudinal dataset.

**Keywords:** *Municipal infrastructure, Asset management, Reliability assessment, Time-series forecasting, Sub-Saharan Africa, Developing countries, Maintenance planning*

### Article Highlights

- ARIMA model forecasts a 22% decline in municipal infrastructure reliability by 2026.
- Road network subsystem forecasts exhibit the widest confidence intervals.
- Provides a quantitative tool for proactive capital works programming.
- Validated using a longitudinal dataset from Ugandan municipal assets.

### Methodological Note

Core model employs an ARIMA formulation:  $\phi(B)(1-B)^d R_t = \theta(B) \epsilon_t$ , where  $R_t$  is the composite reliability index at time  $t$ . Parameters estimated via maximum likelihood.

*This study provides a validated forecasting tool for infrastructure asset management in developing contexts.*



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