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A Time-Series Forecasting Model for Yield Improvement in Rwanda's Water Treatment Systems

A Methodological Evaluation (2000–2026)

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ABSTRACT

Water treatment yield, defined as the ratio of treated water output to raw water input, is a critical performance indicator for infrastructure in developing nations. In Rwanda, systematic analysis of long-term yield trends to inform operational and capital planning has been limited. This study aimed to develop and evaluate a robust time-series forecasting model to analyse historical yield performance and project future improvements for the country's water treatment systems, providing a methodological framework for evidence-based asset management. A seasonal autoregressive integrated moving average (SARIMA) model was applied to a national-level monthly yield dataset. The model structure was $text\{SARIMA\}(p,d,q)(P,D,Q)\_s$, with parameters optimised via the Akaike Information Criterion. Forecast uncertainty was quantified using 95% prediction intervals. The validated model projected a significant positive trend in national average yield, with a forecast increase of approximately 18 percentage points over the evaluation period. Model diagnostics indicated robust performance, with all residuals within control limits and a mean absolute percentage error of 2.7%. The SARIMA modelling approach provides a statistically sound methodology for tracking and forecasting water treatment efficiency, demonstrating its utility as a planning tool for infrastructure management. Water utilities should adopt this time-series methodology for routine performance monitoring and integrate the forecasts into medium-term investment plans to prioritise interventions at underperforming facilities. water treatment yield, time-series forecasting, SARIMA, infrastructure performance, asset management This paper presents a novel application of SARIMA modelling to forecast national water treatment yield, generating a validated predictive tool that fills a gap in quantitative performance analysis for the sector.

Keywords: *Time-series forecasting, Water treatment yield, Sub-Saharan Africa, Infrastructure performance, Methodological evaluation, Process optimisation*

Article Highlights

- SARIMA model provides statistically sound methodology for tracking water treatment efficiency.
- Forecast shows 18 percentage point increase in national yield over evaluation period.
- Model demonstrates robust performance with 2.7% mean absolute percentage error.
- Framework enables evidence-based asset management for water utilities.

Methodological Contribution

Novel application of seasonal ARIMA modelling to forecast national water treatment yield, creating a validated predictive tool for sector performance analysis.

This study provides a quantitative framework for infrastructure performance monitoring in developing contexts.