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A Time-Series Forecasting Model for Efficiency Diagnostics in Rwanda's Water Treatment Systems

A Policy Analysis, 2000–2026

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ABSTRACT

The operational efficiency of water treatment infrastructure is a critical determinant of public health and economic development. In Rwanda, despite significant investment, systematic, data-driven diagnostics for evaluating long-term efficiency trends in treatment facilities have been lacking, hindering targeted policy interventions. This policy analysis aims to develop and validate a novel time-series forecasting model to measure and diagnose efficiency gains within the nation's water treatment systems, providing a quantitative tool for infrastructure policy assessment. A seasonal autoregressive integrated moving average (SARIMA) model, specified as $\varphi(B)\varphi(B^s)nabla^{dnablas}\hat{}D\ yt\ =\ \theta(B)\theta(B^s)\varepsilon_t$, was fitted to historical performance data. Model parameters were estimated using maximum likelihood, with diagnostic checks for residual autocorrelation and heteroskedasticity to ensure robust inference. The model forecasts indicate a positive but decelerating trend in system-wide efficiency, with a projected gain of approximately 15 percentage points over the forecast horizon. However, confidence intervals for provincial-level forecasts widen considerably, suggesting significant regional disparities in performance and data reliability. The forecasting model provides a rigorous, evidence-based diagnostic tool that reveals both aggregate progress and underlying instability in treatment efficiency, challenging assumptions of uniform system improvement. Policy should prioritise standardised data collection protocols and invest in capacity building for regional maintenance units. Infrastructure funding allocations should be informed by model-derived efficiency diagnostics to target underperforming subsystems. infrastructure diagnostics, SARIMA modelling, water treatment efficiency, public utility policy, predictive analytics This article introduces a novel application of SARIMA time-series forecasting for engineering policy analysis, providing the first longitudinal, quantitative diagnostic framework for evaluating efficiency in the country's water treatment sector.

Keywords: *Time-series forecasting, Water treatment efficiency, Policy analysis, Sub-Saharan Africa, Infrastructure diagnostics, Operational performance, Data-driven evaluation*

Article Highlights

- SARIMA model forecasts a 15-percentage-point efficiency

Policy Implication

Infrastructure funding should be informed by model-derived

gain by 2026, but with decelerating trend. • Widening provincial forecast confidence intervals signal regional performance instability. • Model provides first longitudinal diagnostic tool for Rwanda's water treatment sector. • Findings challenge assumptions of uniform system improvement across regions.	efficiency diagnostics to target underperforming subsystems, paired with investment in regional data capacity. *This analysis provides a quantitative framework for moving beyond aggregate efficiency metrics.*