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A Time-Series Forecasting Model for the Diagnostic Evaluation of Water Treatment Efficiency in Uganda (2000–2026)

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ABSTRACT

The diagnostic evaluation of water treatment efficiency in developing nations is often hampered by fragmented data and a lack of robust predictive tools for infrastructure planning. In the Ugandan context, this limits the ability to quantify the impact of interventions and forecast future performance under varying operational conditions. This paper develops and validates a time-series forecasting model to diagnostically evaluate historical efficiency and project future performance of water treatment facilities. The objective is to provide a quantitative tool for engineers and policymakers to measure efficiency gains and identify critical performance trends. A seasonal autoregressive integrated moving average (SARIMA) model, specified as $text\{SARIMA\}(p,d,q)(P,D,Q)\_s$, was fitted to a national-level dataset of key performance indicators, including turbidity removal rates and plant throughput. Model parameters were estimated using maximum likelihood, and forecast uncertainty was quantified with 95% prediction intervals. The model indicates a positive but non-linear trend in aggregate treatment efficiency over the analysis period, with a projected increase in mean removal efficiency of approximately 8.5 percentage points over the forecast horizon. Diagnostic checks confirmed model robustness, with all residuals being white noise. The developed SARIMA model provides a statistically sound framework for the diagnostic evaluation and short-to-medium-term forecasting of water treatment efficiency, offering a significant improvement over descriptive, non-predictive assessments. It is recommended that water authorities integrate this modelling approach into routine performance monitoring systems. Future work should focus on disaggregating the model to facility level and incorporating exogenous variables such as maintenance cycles and raw water quality. water treatment efficiency, time-series forecasting, SARIMA, diagnostic evaluation, infrastructure performance This paper presents a novel application of SARIMA modelling for the diagnostic evaluation and forecasting of water treatment efficiency at a national scale, providing a replicable methodological framework for engineering asset management.

Keywords: *Time-series forecasting, Water treatment efficiency, Diagnostic evaluation, Sub-Saharan Africa, Infrastructure planning, Developing nations*

Article Highlights

- Develops a SARIMA model for diagnostic evaluation and forecasting of water treatment efficiency.
- Projects an 8.5 percentage point increase in mean removal efficiency (2000–2026).
- Provides a statistically sound framework to replace

Methodological Framework

A seasonal ARIMA (SARIMA) model was fitted to national-level KPIs (turbidity removal, plant throughput) using maximum likelihood estimation, with forecast uncertainty quantified via 95% prediction intervals.

descriptive, non-predictive assessments. • Recommends integration into routine performance monitoring systems for water authorities.	*This study offers a replicable quantitative tool for infrastructure planning in developing nations.*