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A Time-Series Forecasting Model for Efficiency Diagnostics in Kenyan Water Treatment Systems

A Case Study (2000–2026)

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ABSTRACT

Background: Water treatment systems in many regions face persistent challenges in operational efficiency, leading to resource wastage and service shortfalls. Diagnostic tools for long-term performance evaluation are often lacking, particularly for infrastructure with limited historical monitoring data.

Purpose and objectives: This case study develops and validates a time-series forecasting model to diagnose efficiency trends in water treatment facilities. The objective is to provide a replicable methodological framework for quantifying efficiency gains or losses over extended operational periods.

Keywords: *Time-series forecasting, Efficiency diagnostics, Water treatment systems, Sub-Saharan Africa, Operational research, Predictive maintenance, Resource optimisation*

Article Highlights

- ARIMA model translates complex operational data into clear long-term performance trajectories.
- Forecasts indicate a high likelihood of continued positive efficiency trajectory under current practices.
- Provides quantitative basis for distinguishing random fluctuation from systemic change.
- Methodological framework designed for replication in infrastructure with limited historical data.

Methodological Note

Core analytical tool was an ARIMA model specified as $\Delta^d y_t = c + \varphi_1 \Delta^d y_{t-1} + ... + \varphi_p \Delta^d y_{t-p} + \theta_1 \varepsilon_{t-1} + ... + \theta q \varepsilon_t - q + \varepsilon_t$, with parameters estimated via maximum likelihood.

This case study provides a replicable framework for long-term efficiency diagnostics in water treatment systems.