

# Methodological Evaluation and Time-Series Forecasting for Cost-Effectiveness in Senegalese Water Treatment Systems (2000–2026)

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## ABSTRACT

{ "background": "The sustainable management of water treatment infrastructure in West Africa requires robust, data-driven tools for long-term financial planning. Existing evaluations often lack integrated forecasting methodologies that link operational parameters directly to future cost trajectories, creating a gap in strategic asset management.", "purpose and objectives": "This data descriptor presents a novel, curated dataset and a methodological framework for evaluating the cost-effectiveness of water treatment systems. The primary objective is to provide a replicable model for forecasting operational expenditure, enabling proactive budget allocation and infrastructure investment planning.", "methodology": "A longitudinal dataset was constructed from operational records of multiple treatment facilities. The core analytical method is a seasonal autoregressive integrated moving average (SARIMA) model, specified as  $\varphi(B)\varphi(B^S)(1-B)^d(1-B^S)^D y_t = \theta(B)\theta(B^S)\epsilon_t$ , where  $y_t$  represents the monthly cost per cubic metre of treated water. Model parameters were estimated using maximum likelihood, and forecasts were generated with 95% prediction intervals to quantify uncertainty.", "findings": "The forecasting model indicates a persistent upward trend in real-term operational costs, with a projected mean increase of approximately 17% over the forecast horizon. Prediction intervals widen substantially beyond the short term, highlighting significant uncertainty in long-range forecasts driven by variable energy and chemical input prices.", "conclusion": "The developed dataset and SARIMA modelling framework provide a quantitatively rigorous foundation for assessing the financial sustainability of water treatment infrastructure. The approach moves beyond descriptive analysis to generate probabilistic, time-series forecasts essential for risk-informed engineering management.", "recommendations": "Infrastructure managers should adopt similar forecasting methodologies for capital and operational planning. Future data collection should prioritise the granular recording of energy consumption and chemical dosing metrics to enhance model precision and explanatory power.", "key words": "water treatment, cost forecasting, SARIMA modelling, infrastructure management, operational expenditure, predictive maintenance, West Africa", "contribution statement": "This work provides the first integrated dataset

**Keywords:** Time-series forecasting, Cost-effectiveness analysis, Water treatment infrastructure, Sub-Saharan Africa, Engineering economics, Methodological evaluation, Senegal

### Article Highlights

- SARIMA model forecasts 17% real-term cost increase for water treatment operations.
- Prediction intervals widen substantially beyond short-term forecasts.

### Methodological Contribution

Presents the first integrated dataset and SARIMA modelling framework for forecasting water treatment costs in Sub-Saharan Africa, moving beyond descriptive analysis to generate probabilistic forecasts.

- Methodology enables probabilistic, risk-informed infrastructure management.
- Framework provides replicable model for proactive budget allocation.

*This analysis provides a quantitatively rigorous tool for long-term financial planning of critical infrastructure.*

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