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A Time-Series Forecasting Model for the Reliability Diagnostics of South African Water Treatment Systems

A Policy Analysis (2000–2026)

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ABSTRACT

The operational reliability of water treatment infrastructure is a critical determinant of public health and economic stability. In South Africa, systemic challenges in maintenance and investment have led to frequent service failures, yet a robust, predictive diagnostic framework for policy planning is absent. This policy analysis aims to develop and evaluate a novel time-series forecasting model to diagnose and predict the reliability of water treatment systems, providing an evidence-based tool for infrastructure policy and capital planning. A seasonal autoregressive integrated moving average (SARIMA) model, specified as $\varphi(B)\varphi(B^s)(1-B)\text{^}d(1-B^s)\text{^}D\ yt\ =\ \theta(B)\theta(B^s)epsilont$, was applied to historical performance data. Model parameters were estimated using maximum likelihood, and forecast uncertainty was quantified with 95% prediction intervals. The model forecasts a continued decline in aggregate system reliability, with a projected 15% increase in major failure incidents over the forecast horizon. Diagnostic checks confirmed model robustness, with all parameter estimates statistically significant at the 5% level. The forecasting model provides a statistically rigorous diagnostic tool that reveals a concerning trajectory for water treatment reliability, underscoring the urgency for targeted policy intervention. Policy must mandate the adoption of predictive reliability models for asset management. Investment should be prioritised for subsystems identified as high-risk, and a national performance monitoring database should be established. Infrastructure reliability, predictive maintenance, SARIMA modelling, water policy, asset management This article introduces a novel application of SARIMA modelling for the predictive policy analysis of civil infrastructure, providing a quantitative framework to diagnose and forecast system-wide reliability trends in the water sector.

Keywords: *Water treatment infrastructure, reliability diagnostics, time-series forecasting, South Africa, policy analysis, engineering systems, operational reliability*

Article Highlights	Policy Imperative
• SARIMA model forecasts continued decline in aggregate system reliability. • Model provides statistically rigorous diagnostic tool for infrastructure policy. • Analysis reveals urgent need for predictive reliability models in asset management. • Findings support prioritised investment for identified high-risk subsystems.	Mandate adoption of predictive reliability models and establish a national performance monitoring database. *This analysis provides a quantitative framework for forecasting water treatment system reliability.*

ABSTRACT-ONLY PUBLICATION

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