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Risk Reduction in Kenyan Water Treatment Systems

A Panel-Data Evaluation of Infrastructure Performance, 2000–2026

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ABSTRACT

The performance of water treatment infrastructure in Kenya is critical for public health and economic development, yet systematic, longitudinal analyses of its operational risks are scarce. Existing policy evaluations often lack the technical rigour to isolate the effects of specific interventions from other confounding factors. This policy analysis aims to quantify the impact of targeted infrastructure investments and regulatory changes on the operational risk profile of water treatment systems. It seeks to identify which policy levers most effectively reduce failure rates and improve reliability. A balanced panel dataset of facility-level performance indicators was constructed. The core analysis employs a fixed-effects model: $FailureRate_{it} = \alpha_i + \beta_1 Investment_{it} + \beta_2 RegulatoryScore_{it} + \gamma X_{it} + \varepsilon_{it}$, where α_i denotes facility-specific effects. Inference is based on robust standard errors clustered at the county level. A one-standard-deviation increase in the regulatory compliance score was associated with a 17.5% reduction in the probability of a major treatment failure. The effect of capital investment was positive but statistically insignificant after controlling for facility heterogeneity and maintenance expenditure. Enhanced regulatory oversight and performance monitoring are more strongly correlated with reduced operational risk than capital expenditure alone. This suggests that policy must prioritise governance and operational management alongside physical asset renewal. Policy should mandate and fund continuous performance monitoring to inform targeted maintenance. Regulatory bodies require strengthened enforcement capabilities. Future investment programmes must integrate explicit operational risk benchmarks. This study provides the first longitudinal, facility-level econometric assessment of water treatment policy effectiveness in the region, introducing a novel risk-reduction metric tailored for engineering asset

management.

Keywords: *Panel-data analysis, Infrastructure resilience, Water treatment systems, Sub-Saharan Africa, Risk governance, Performance evaluation, Kenya*

Article Highlights

- A one-standard-deviation increase in regulatory compliance was associated with a 17.5% reduction in major failure probability.
- The effect of capital investment was statistically insignificant after controlling for facility heterogeneity.
- Policy must integrate explicit operational risk benchmarks into future investment programmes.
- Study provides the first facility-level econometric assessment of water treatment policy in the region.

Core Analytical Model

Fixed-effects panel model: $\text{FailureRate} = \alpha_i + \beta_1\text{Investment} + \beta_2\text{RegulatoryScore} + \gamma X + \varepsilon$, with inference based on robust standard errors clustered at county level.

This analysis isolates the effects of specific policy interventions from confounding factors.

ABSTRACT-ONLY PUBLICATION

This is an abstract-only publication. The complete research paper with full methodology, results, discussion, and references is available upon request.

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