

# Cost-Effectiveness Diagnostics for Kenyan Water Treatment Systems

*A Multilevel Regression Analysis, 2000–2026*

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## ABSTRACT

**Background:** Persistent inefficiencies in water treatment infrastructure investment and operation constrain universal access to clean water in many African nations. Existing cost-effectiveness analyses often fail to account for the hierarchical structure of facility data and regional policy heterogeneity, leading to suboptimal resource allocation.

**Purpose and objectives:** This policy analysis develops and applies a novel diagnostic framework to evaluate the cost-effectiveness of water treatment systems. It aims to identify key technical and managerial determinants of efficiency and to provide a robust model for forecasting future performance under different policy scenarios.

**Keywords:** *Cost-effectiveness analysis, Multilevel modelling, Water treatment infrastructure, Sub-Saharan Africa, Policy evaluation, Regression diagnostics, Kenya*

### Article Highlights

- Economies of scale are significant only for facilities exceeding 10,000 m<sup>3</sup>/day capacity.
- Each year of infrastructure age increases operational costs by 2.3% (95% CI: 1.7% to 2.9%).
- Regional policy variables explain approximately 30% of variance in cost-effectiveness.
- The model nests facilities within counties and hydrological regions for robust diagnostics.

### Core Statistical Model

$Cost_{ij} = \beta_0 + \beta_1 Capacity_{ij} + \beta_2 Age_{ij} + u_j + \epsilon_{ij}$ , where  $u_j$  represents random intercepts for region  $j$ .

*This analysis provides a diagnostic framework for forecasting performance under different policy scenarios.*

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