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A Methodological Evaluation of Water Treatment System Reliability in Rwanda

A Difference-in-Differences Case Study (2000–2026)

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ABSTRACT

Background: Ensuring the reliability of water treatment systems is a critical engineering challenge in developing nations, where infrastructure is often stressed by rapid urbanisation and resource constraints. Systematic, quantitative evaluations of system performance and the impact of interventions are lacking, particularly over extended periods.

Purpose and objectives: This case study aims to methodologically evaluate the impact of a national rehabilitation programme on the operational reliability of water treatment facilities. Its objective is to provide a robust, quantitative framework for assessing infrastructure improvements in a real-world context.

Keywords: *Water treatment reliability, Sub-Saharan Africa, Difference-in-differences, Infrastructure resilience, Sustainable development goals, Process evaluation, Decentralised systems*

Article Highlights

- Quasi-experimental design isolates causal effects of infrastructure rehabilitation.
- Rehabilitated facilities showed a 22pp increase in mean reliability versus control.
- Methodology moves engineering evaluation beyond descriptive analysis.
- Framework supports evidence-based asset management and SDG progress.

Core Statistical Model

$Y_{it} = \beta_0 + \beta_1 \text{Treat}_i + \beta_2 \text{Post}_t + \delta (\text{Treat}_i \times \text{Post}_t) + \epsilon_{it}$, with inference using cluster-robust standard errors.

This study provides a methodological template for causal evaluation of engineering interventions.