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# A Difference-in-Differences Framework for Reliability Diagnostics in Senegalese Water Treatment Systems (2000–2026)

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## ABSTRACT

**Background:** The reliability of water treatment infrastructure in sub-Saharan Africa is a critical engineering challenge, yet robust quantitative frameworks for its longitudinal assessment are lacking. Existing evaluations often rely on cross-sectional data or descriptive statistics, which fail to isolate the causal impact of specific interventions or stressors on system performance.

**Purpose and objectives:** This article presents a novel methodological framework for diagnosing the reliability of water treatment systems. Its objective is to provide engineers and planners with a rigorous, quasi-experimental tool to quantify the effect of maintenance programmes, upgrades, or external shocks on key performance indicators.

**Keywords:** *Difference-in-differences, Reliability engineering, Water treatment systems, Sub-Saharan Africa, Infrastructure diagnostics, Longitudinal analysis, Senegal*

### Article Highlights

- Adapts econometric difference-in-differences model for engineering reliability diagnostics.
- Provides a quasi-experimental tool to isolate causal impacts of interventions or stressors.
- Controls for seasonal variations and regional baseline differences in performance.
- Enables rigorous evaluation of maintenance programmes, upgrades, and external shocks.

### Core Model

$Y_{it} = \alpha + \beta (\text{Treatment}_i \times \text{Post}_t) + \gamma_i + \delta_t + \epsilon_{it}$, where $\beta$ captures the causal effect on reliability metric $Y$.

*A pilot application indicated a measurable positive effect of a targeted maintenance protocol.*