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# A Randomised Field Trial for Reliability Diagnostics in Kenyan Municipal Infrastructure Systems

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## ABSTRACT

Municipal infrastructure systems in many developing nations face chronic reliability challenges, yet diagnostic methods often rely on aggregated, non-experimental data, limiting causal inference for asset management. This case study evaluates a novel randomised field trial (RFT) methodology for generating robust reliability diagnostics of water distribution and solid waste collection systems within a municipal context. A stratified randomised controlled trial was implemented across 120 sampling units. Infrastructure performance was measured via direct observation and sensor data. Reliability was modelled using a Weibull survival function, $R(t) = exp^{-}(t/\eta)\hat{}\beta\}$, where $\eta$ is the scale parameter and $\beta$ the shape parameter. Inference was based on maximum likelihood estimation with robust standard errors. The RFT methodology proved feasible and yielded high-fidelity data. A key finding was a statistically significant 22% lower hazard of service failure in water systems with proactive maintenance regimes (95% CI: 15% to 29%). Diagnostic outputs identified valve malfunction as a predominant failure mode in specific network zones. The randomised field trial offers a rigorous, transferable methodological framework for isolating causal factors in infrastructure reliability, moving beyond descriptive analytics. Municipal engineers should adopt randomised sampling and controlled comparison designs for asset diagnostics. Funding bodies should prioritise trials that generate causal evidence for maintenance policy. Infrastructure reliability, randomised controlled trial, asset management, survival analysis, municipal engineering, maintenance diagnostics This paper provides the first documented application and validation of a full-scale randomised field trial for causal diagnostics of physical infrastructure reliability in a sub-Saharan African municipal setting.

**Keywords:** *Randomised controlled trial, Infrastructure reliability, Sub-Saharan Africa, Asset management, Causal inference, Municipal engineering, Developing countries*

### Article Highlights

- RFT methodology proved feasible and yielded high-fidelity diagnostic data.
- 22% lower hazard of service failure in water systems with proactive maintenance.
- Valve malfunction identified as a predominant failure mode in specific network zones.
- Provides a validated framework for causal inference in asset management.

### Key Statistical Model

Reliability was modelled using a Weibull survival function: $R(t) = \exp[-(t/\eta)^{\beta}]$, with inference based on maximum likelihood estimation and robust standard errors.

*This study presents the first full-scale application of an RFT for infrastructure diagnostics in sub-Saharan Africa.*