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Randomised Field Trial for the Diagnostic Evaluation of Process-Control Systems and Yield Optimisation in Kenya

Wanjiku Mwangi[1]

University of Nairobi

Correspondence: wmwangi@aol.com

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ABSTRACT

Process-control systems in industrial and agricultural production are critical for efficiency and yield, yet rigorous field-based diagnostic methodologies for their evaluation in resource-constrained settings are underdeveloped. This article presents a methodological framework for conducting a randomised field trial to diagnostically evaluate process-control systems and quantify their causal impact on production yield. The methodology employs a cluster-randomised design, assigning operational units to intervention (upgraded control systems) or control (existing systems) groups. Yield data are collected longitudinally. The core analysis uses a linear mixed model: $Y\{ij\} = beta0 + beta1\,T\{ij\} + uj + \varepsilon\{ij\}$, where $Y\{ij\}$ is yield for unit i in cluster j, $T\{ij\}$ is the treatment indicator, uj is a cluster random effect, and $\varepsilon\{ij\}$ is the error term. Inference is based on cluster-robust standard errors. As a methodology article, this paper presents no empirical results from a completed trial. However, the framework is designed to detect a minimum detectable effect of a 15% relative increase in mean yield with 80% power at the 5% significance level, based on pre-trial simulations. The proposed randomised field trial methodology provides a robust, evidence-based approach for the causal diagnostic evaluation of process-control systems in real-world settings. Researchers and engineers are encouraged to adopt this experimental framework to generate high-quality evidence for technology investment decisions, ensuring trials are adequately powered and account for operational clustering. randomised controlled trial, process control, diagnostic evaluation, yield optimisation, experimental design, industrial engineering This paper provides a novel, generalisable methodological protocol for the causal evaluation of engineering systems in field settings, specifically addressing clustering and inference challenges common in industrial applications.

Keywords: *Randomised controlled trial, Process control, Yield optimisation, Sub-Saharan Africa, Field diagnostics, Engineering methodology*

Article Highlights

- Presents a cluster-randomised design for evaluating process-control systems in field settings.
- Employs a linear mixed model with cluster-robust inference for causal analysis.
- Framework designed to detect a 15% relative yield increase with 80% statistical power.
- Addresses methodological challenges of clustering and inference in industrial applications.

Methodological Core

The analysis uses a linear mixed model: $Y_{ij} = \beta_0 + \beta_1 T_{ij} + u_j + \varepsilon_{ij}$, with inference based on cluster-robust standard errors to account for operational grouping.

This is a methodology paper; no empirical results from a completed trial are presented.