



Methodological Evaluation of Regional Monitoring Networks in South Africa: A Randomized Field Trial for Cost-Efficiency Assessment

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Abstract

In South Africa, regional monitoring networks are crucial for agricultural productivity and food security. These systems aim to detect and mitigate potential issues such as pests, diseases, and environmental changes promptly. A stratified random sampling method was employed to select regions for monitoring. A hybrid model combining logistic regression and fuzzy logic was used to predict anomaly occurrence probabilities across different zones. The analysis revealed a significant positive correlation ($p < 0.05$) between the number of anomalies detected and network operational costs, indicating an optimal balance at moderate investment levels. The study established that while increased monitoring resources do enhance anomaly detection rates, beyond a certain threshold, marginal returns diminish. Optimise resource allocation by focusing on regions with high anomaly risk identified through predictive models rather than expanding coverage indiscriminately. The empirical specification follows $Y = \beta_{0+\beta} X + \text{varepsilon}$, and inference is reported with uncertainty-aware statistical criteria.

Keywords: African, GIS, Randomization, Precision Agriculture, Cost-Benefit Analysis, Sampling Theory, Experimental Design

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