



Bayesian Hierarchical Model for Evaluating Yield Improvement in Municipal Water Systems Across Nigeria

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Abstract

Municipal water systems in Nigeria face significant challenges related to yield improvement, which can be attributed to factors such as inadequate infrastructure, frequent breakdowns, and inconsistent maintenance practices. A Bayesian hierarchical model was developed to analyse yield data from multiple municipalities across Nigeria. The model accounts for spatial heterogeneity by incorporating random effects at the local government area level and uses shrinkage priors to stabilise estimates where data are sparse. The analysis revealed a significant improvement in yield under certain interventions, with an estimated effect size of approximately 10% in favour of well-maintained systems compared to those without regular maintenance checks. This study provides evidence that targeted interventions can substantially enhance municipal water system yields, contributing to more reliable and sustainable water supply services in Nigeria. Public health authorities should prioritise the implementation of consistent maintenance schedules and infrastructure upgrades to achieve meaningful yield improvements across Nigerian municipalities. Municipal Water Systems, Yield Improvement, Bayesian Hierarchical Model, Spatial Analysis, Intervention Effectiveness Model estimation used $\hat{\theta} = \operatorname{argmin} \{ \theta \} \sum_i \ell(y_i, f_{\theta}(\xi)) + \lambda \|\theta\|_2^2$, with performance evaluated using out-of-sample error.

Keywords: Nigerian, Bayesian, Hierarchical, Markov, Chain, Monte, Carlo

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