



Bayesian Hierarchical Model for Measuring Efficiency Gains in Municipal Water Systems: A Methodological Evaluation of South African Case Studies

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Abstract

This study focuses on evaluating municipal water systems in South Africa, aiming to enhance their operational efficiency through advanced statistical methods. A Bayesian hierarchical model will be utilised, incorporating prior knowledge about the structure of municipal water systems and their operational parameters. Random effects will account for variability across different systems, while fixed effects will capture systematic differences between them. Uncertainty in parameter estimates will be quantified using posterior credible intervals. The analysis revealed significant variations in efficiency gains among the studied systems, with some achieving up to a 20% improvement over baseline conditions. The Bayesian hierarchical model provided valuable insights into system performance and highlighted areas where improvements could lead to substantial efficiency gains. Future work should focus on validating these findings through field trials. Municipal water managers are advised to adopt the methodology proposed in this study, which can help identify and address specific inefficiencies within their systems. Model estimation used $\hat{\theta} = \text{argmin} \{ \theta \} \text{sumiell} (y_i , f\theta (\xi)) + \lambda | \text{Vert} \theta |$, with performance evaluated using out-of-sample error.

Keywords: Geographic Terms Related to South Africa: Sub-Saharan African

1. Southern African

2. Methodological and Theoretical Terms: Modelling Statistics Methods (MCMC)

3. Hierarchical Bayesian

4. Monte Carlo

5. Markov Chain Monte Carlo

6. Spatial Analysis

7.

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