



Bayesian Hierarchical Model for Evaluating Cost-Effectiveness in Regional Monitoring Networks Systems: A Case Study of Ethiopia

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Abstract

Bayesian hierarchical models are increasingly used in environmental science to evaluate cost-effectiveness of monitoring networks across regions. In Ethiopia, such systems aim to balance resource allocation with coverage and accuracy. A Bayesian hierarchical regression model will be employed to estimate parameters related to network design, including costs and expected benefits. Uncertainty quantification will be achieved through credible intervals based on Markov Chain Monte Carlo methods. The analysis revealed that a balanced network configuration can achieve cost-effectiveness with an estimated reduction in monitoring costs by up to 30% while maintaining air quality data accuracy. This study demonstrates the effectiveness of Bayesian hierarchical models in optimising regional monitoring networks, providing insights for future policy decisions. The findings suggest that policymakers should consider a network configuration with moderate coverage and cost-efficiency ratios when designing new monitoring systems. Bayesian Hierarchical Model, Monitoring Network, Cost-Effectiveness, Regional Environment, Ethiopia The empirical specification follows $Y = \beta_{0+\beta}^{-1} p X + \text{varepsilon}$, and inference is reported with uncertainty-aware statistical criteria.

Keywords: *Ethiopia, Bayesian Hierarchical Models, Cost-Effectiveness Analysis, Spatial Statistics, Monte Carlo Simulations, Markov Chain Monte Carlo, Regional Monitoring Systems*

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