Bayesian Hierarchical Model for Evaluating Adoption Rates in Off-Grid Communities in Ethiopia: A Methodological Approach

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Abstract

Bayesian hierarchical models have become increasingly relevant for evaluating adoption rates in diverse settings, including off-grid communities in Ethiopia where access to modern energy solutions is crucial. A Bayesian hierarchical model will be employed, incorporating both fixed effects (community characteristics) and random effects (geographical variations). Uncertainty quantification will be achieved through credible intervals based on posterior distributions. The analysis revealed a significant proportion of communities adopting off-grid systems, with adoption rates varying by geographical region. For instance, in the northern highlands, adoption was notably higher than in the southern lowlands. This study demonstrates the effectiveness of Bayesian hierarchical models in accurately estimating and understanding community-level adoption dynamics in Ethiopia's off-grid energy sector. The findings suggest targeted interventions to increase adoption rates in underserved regions. Future research should consider incorporating additional covariates to refine model predictions. Model estimation used $\hat{\{\theta\}} = argmin\{\theta\} \, sumiell(yi, f\theta(\xi)) + \lambda lVert \theta rVert 2^2$, with performance evaluated using out-of-sample error.

Keywords: *Bayesian statistics, Hierarchical modelling, Markov Chain Monte Carlo, Spatial analysis, Quantile regression, Geographic Information Systems, Random effects models*

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