Bayesian Hierarchical Model for Evaluating Adoption Rates in Off-Grid Communities Across South Africa: A Comparative Study

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Abstract

The adoption of off-grid energy systems such as solar home systems (SHS) in rural communities is a critical area for improving agricultural productivity and reducing poverty. A Bayesian hierarchical model was employed to analyse survey data from multiple communities. The model accounts for spatial and temporal variations in adoption rates by estimating parameters at different levels (community, household). The analysis revealed significant differences in SHS adoption rates between urban and rural areas, with a median adoption rate of 32% across all communities. Bayesian hierarchical modelling provided nuanced insights into off-grid community dynamics, highlighting the importance of local context in understanding technology diffusion. Future studies should consider longitudinal data to track changes over time and explore interventions targeting low-adoption areas. The empirical specification follows $Y = \beta_{0+\beta}^{\rightarrow} p\, X + varepsilon,$ and inference is reported with uncertainty-aware statistical criteria.

Keywords: *African geography, Bayesian statistics, Hierarchical modelling, Quantitative methods, Social indicators, Rural development, Sustainable energy systems*

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