African Water Security Studies (Environmental/Cross-disciplinary)

Time-Series Forecasting Model Evaluation in Off-Grid Communities of Senegal: A Methodological Approach to Risk Reduction Analysis

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Abstract

Off-grid communities in Senegal face significant challenges in energy access and reliability, particularly due to erratic power supply from solar panels. This study aims to evaluate the effectiveness of time-series forecasting models in predicting and managing energy risks within these communities. A comprehensive literature review informed the selection of appropriate statistical models. The study employed an ARIMA (AutoRegressive Integrated Moving Average) model to forecast daily solar power generation data from off-grid Senegalese communities. Model performance was evaluated using Mean Absolute Error (MAE) and robust standard errors, providing a basis for understanding prediction uncertainties. The ARIMA model demonstrated a MAE of 15% in predicting daily solar energy output, indicating room for improvement, particularly during periods with high variability in sunlight intensity. Analysis revealed that community size had the strongest impact on forecasting accuracy, necessitating adjustments to account for varying energy demands and resource availability. The ARIMA model offers a robust framework for risk reduction analysis in off-grid Senegalese communities, though further research is required to refine its application under diverse operating conditions. Recommendations include developing localized models tailored to specific community needs. Develop localized time-series forecasting models for off-grid communities based on community-specific data and feedback. Incorporate additional factors such as maintenance schedules and energy storage solutions into model inputs. 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: *Sub-Saharan, Geospatial Analysis, Ensemble Forecasting, SARIMA, Monte Carlo Simulation, Social Impact Assessment, Data Envelopment Analysis*