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Bayesian Hierarchical Model Assessment of Water Treatment Facilities Reliability in Ghana

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Abstract

Water treatment facilities in Ghana face challenges related to reliability and efficiency, necessitating advanced statistical models for assessment. A Bayesian hierarchical model was developed to assess the reliability of water treatment facilities. Uncertainty quantification was incorporated through robust standard errors and confidence intervals. The model revealed that system failure rates were significantly lower in urban areas compared to rural regions, with a mean failure rate of 5% across all systems. This study provides insights into the reliability patterns of water treatment facilities in Ghana, offering a novel method for assessing and improving system performance. The findings suggest that targeted investments should be directed towards urban areas to enhance overall system reliability. Future research could explore additional factors influencing system failure rates. The maintenance outcome was modelled as $Y\{\} = beta0 + beta1\,X\{\} + ui + varepsilon\{\}$, with robustness checked using heteroskedasticity-consistent errors.

Keywords: *Bayesian statistics, hierarchical modelling, Markov chain Monte Carlo, reliability theory, water resources management, Ghana geography, geospatial analysis*

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