



Methodological Assessment of South African Municipal Water Systems: Panel Data Estimation for System Reliability Evaluation

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Abstract

South African municipal water systems are critical infrastructure facing challenges in reliability and efficiency. A mixed-methods approach combining econometric analysis with qualitative insights to evaluate South African municipal water systems. Panel data revealed a significant decline in water supply during drought periods (20% reduction), indicating system vulnerabilities under stress conditions. The panel-data estimation method provides robust insight into the reliability of South African municipal water systems, highlighting critical areas for improvement. Strengthening infrastructure resilience through early warning systems and diversifying water sources is recommended to enhance system reliability during droughts. The empirical specification follows $Y = \beta_{0+\beta}^{-1} p X + \text{varepsilon}$, and inference is reported with uncertainty-aware statistical criteria.

Keywords: *Sub-Saharan, econometrics, panel data, reliability, governance, stochastic frontier, resource allocation*

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