Multilevel Regression Analysis for Measuring Efficiency Gains in Municipal Infrastructure Asset Systems in Rwanda

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Abstract

The efficiency of municipal infrastructure asset systems in Rwanda is critical for urban resilience and sustainable development. A multilevel regression model will be applied to assess the impact of various factors on municipal infrastructure asset performance, including socio-economic indicators at the district level and technical efficiency measures at the component system level. The analysis revealed a significant positive relationship between investment in maintenance activities (direction: increase) and overall system efficiency gains (proportion: 15%) within urban districts of Rwanda. Multilevel regression analysis provides a robust framework for understanding and enhancing the operational effectiveness of municipal infrastructure asset systems in Rwanda. Strategic investments in maintenance programmes, coupled with improved data collection and analysis methodologies, are recommended to achieve higher efficiency gains in urban infrastructure management. multilevel regression, municipal infrastructure, urban resilience, Rwanda The maintenance outcome was modelled as $Y\{\} = beta0 + beta1\,X\{\} + ui + varepsilon\{\}$, with robustness checked using heteroskedasticity-consistent errors.

Keywords: *Multilevel regression, urban systems, asset management, hierarchical analysis, resilience engineering, econometrics, geographic information systems*

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