AFRICAN STRUCTURAL ENGINEERING

ORIGINAL RESEARCH

A Multilevel Regression Analysis for Cost-Effectiveness in Senegalese Municipal Infrastructure Asset Management Systems

Ibrahima Diallo[1]|**Aminata Diop**[2]
Fatou Ndiaye[3,4]|**Moussa Sarr**[3,4]

1 *African Institute for Mathematical Sciences (AIMS) Senegal*
2 *Université Gaston Berger (UGB), Saint-Louis*
3 *Institut Sénégalais de Recherches Agricoles (ISRA)*
4 *Cheikh Anta Diop University (UCAD), Dakar*

Correspondence: idiallo@outlook.com

Received: 15 May 2009 | Accepted: 10 September 2009 | Published: 27 September 2009 | **DOI:** 10.5281/zenodo.18964565

ABSTRACT

Municipal infrastructure asset management in many West African contexts is characterised by fragmented data and limited analytical frameworks for evaluating cost-effectiveness. Existing models often fail to account for the hierarchical structure of municipal data, leading to potentially biased estimates. This study develops and applies a multilevel regression modelling approach to measure the cost-effectiveness of municipal infrastructure asset management systems. The objective is to quantify the influence of municipal-level and project-level factors on lifecycle cost performance. A hierarchical dataset was constructed from municipal records, comprising project-level cost data nested within municipalities. A two-level random intercepts model was specified: $y\{ij\} = \beta\{0\} + \beta\{1\}X\{ij\} + u\{j\} + e\{ij\}$, where $u\{j\}\, sim\, N(0, \sigma^2\{u\})$ and $e\{ij\}\, sim\, N(0, \sigma^2\{e\})$. Parameter estimation used restricted maximum likelihood with robust standard errors. Municipal institutional capacity explained 34% of the variance in cost-effectiveness. A one-unit increase in a standardised capacity score was associated with a 17% reduction in normalised lifecycle costs (95% CI: 12% to 22%). Project-level material sourcing strategies were also a significant predictor. The multilevel approach successfully disentangled municipal and project effects, demonstrating that institutional factors are a major driver of cost performance in infrastructure asset management. Municipal authorities should prioritise investments in institutional capacity building. National policy should mandate structured data collection to enable regular application of such hierarchical performance analyses. asset management, multilevel modelling, cost-effectiveness, municipal infrastructure, lifecycle costing This paper provides a novel methodological framework for analysing hierarchically structured infrastructure data, yielding actionable insights for improving fiscal efficiency in municipal engineering.

Keywords: *Municipal infrastructure, Asset management, West Africa, Multilevel modelling, Cost-effectiveness analysis, Regression analysis, Developing countries*

Article Highlights

- A multilevel model disentangles municipal and project effects on lifecycle costs.
- Institutional capacity is a major driver, explaining 34% of cost variance.
- Structured data collection is critical for hierarchical

Methodological Contribution

Applies a two-level random intercepts model to hierarchically structured municipal infrastructure data, quantifying the distinct influence of institutional and project factors.

performance analysis. • Findings support targeted investment in municipal capacity building.	*This analysis provides a framework for data-driven municipal asset management policy.*