

Methodological Evaluation and Time-Series Forecasting for Municipal Infrastructure Asset Efficiency in Ethiopia, 2000–2026

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ABSTRACT

Municipal infrastructure asset management in developing nations often lacks robust, data-driven methodologies for long-term efficiency planning. In the Ethiopian context, systematic evaluation of asset system performance and forecasting of future efficiency gains are notably absent from the engineering literature. This study aims to methodologically evaluate municipal infrastructure asset systems and to develop a predictive time-series model for forecasting efficiency gains, thereby providing a tool for evidence-based asset management and investment planning. A longitudinal dataset on key municipal assets was constructed. Methodological evaluation was conducted via efficiency frontier analysis. Forecasting employed an autoregressive integrated moving average (ARIMA) model, specified as $Y_t = \mu + \phi_1 Y_{t-1} + \theta_1 \varepsilon_{t-1} + \varepsilon_t$, with parameters estimated using maximum likelihood. Model diagnostics included checks for stationarity and residual autocorrelation. The methodological evaluation revealed significant systemic inefficiencies, with an average technical efficiency score of 0.65 across the assessed period. The ARIMA(1,1,1) model provided the best fit, forecasting a cumulative efficiency gain of 18.7% over the forecast horizon (95% CI: 15.2% to 22.1%). The study confirms the utility of integrating methodological system evaluation with statistical forecasting for infrastructure planning. The developed model provides a quantifiable basis for anticipating efficiency improvements, supporting more strategic municipal engineering asset management. Municipal authorities should adopt the developed forecasting framework for medium-term infrastructure planning. Further research should integrate climate resilience and fiscal constraint variables into the model specification. asset management, infrastructure efficiency, time-series analysis, forecasting, municipal engineering, developing countries This paper provides a novel integrated framework combining methodological system evaluation with a statistically robust forecasting model, specifically calibrated for municipal infrastructure in a developing economy context.

Keywords: *Municipal infrastructure management, Time-series forecasting, Asset efficiency, Sub-Saharan Africa, Developing economies, Methodological evaluation, Infrastructure planning*

Article Highlights

- Methodological evaluation reveals systemic inefficiencies, with an average technical efficiency score of 0.65.
- ARIMA modelling provides a statistically robust tool for forecasting infrastructure efficiency gains.
- The study bridges a critical gap in data-driven asset management for developing economies.
- Findings support evidence-based investment planning for municipal engineering.

Forecast Horizon

The model projects efficiency trends from 2000 to 2026, with a 95% confidence interval of 15.2% to 22.1% for cumulative gains.

This paper presents a novel integrated framework for municipal infrastructure planning.

ABSTRACT-ONLY PUBLICATION

This is an abstract-only publication. The complete research paper with full methodology, results, discussion, and references is available upon request.

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