

# Methodological Evaluation and Panel-Data Efficiency Diagnostics for Ethiopian Water Treatment Facilities, 2000–2026

Selamawit Tesfaye<sup>1,2</sup>, Meklit Abebe<sup>3</sup>, Tewodros Getachew<sup>4</sup>

Ethiopian Institute of Agricultural Research (EIAR) | Department of Electrical Engineering, Mekelle University |

Department of Mechanical Engineering, Debre Markos University | Mekelle University

Correspondence: [stesfaye@gmail.com](mailto:stesfaye@gmail.com)

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## ABSTRACT

Efficiency analysis of water treatment infrastructure in developing nations is critical for resource optimisation and service delivery. Existing studies often rely on cross-sectional data, which fails to capture temporal dynamics and unobserved heterogeneity across facilities. This Data Descriptor presents a methodological framework and a novel panel dataset designed to enable robust longitudinal efficiency analysis of water treatment facilities. The objective is to provide a resource for evaluating technical efficiency trends and the impact of operational interventions over time. The dataset was constructed from annual operational reports, regulatory filings, and targeted field surveys. Efficiency is estimated using a true fixed-effects stochastic frontier model, specified as  $\ln y_{it} = \alpha_i + \beta^{prime} x_{it} + v_{it} - u_{it}$ , where  $u_{it} \sim N^+(\mu, \sigma_u^2)$ . Robust standard errors are clustered at the facility level to account for serial correlation. The diagnostic analysis of the panel structure confirms its suitability for efficiency estimation, rejecting the pooled model in favour of the panel specification at the 1% significance level. A preliminary application indicates a central tendency for technical efficiency scores to cluster between 0.65 and 0.80, with significant inter-facility variation. The constructed panel dataset and the advocated methodological approach provide a superior foundation for analysing efficiency dynamics compared to cross-sectional alternatives, effectively controlling for time-invariant unobserved heterogeneity. Researchers and policymakers should adopt panel-data methods for infrastructure performance assessment. Future data collection should prioritise the variables identified here to maintain consistency and enable comparative longitudinal studies. stochastic frontier analysis; panel data; technical efficiency; water treatment; infrastructure management This work provides the first publicly available longitudinal dataset compiled for efficiency analysis of water treatment facilities in the region, coupled with a diagnostic framework for model specification.

**Keywords:** Panel data, Efficiency analysis, Water treatment infrastructure, Sub-Saharan Africa, Stochastic frontier analysis, Technical efficiency, Resource optimisation

### Article Highlights

- Novel panel dataset enables robust longitudinal efficiency analysis of water treatment facilities.
- Diagnostics confirm panel structure suitability, rejecting pooled model at 1% significance.
- Preliminary application shows technical efficiency scores cluster between 0.65 and 0.80.
- Advocates for panel-data methods to control for unobserved facility-level heterogeneity.

### Methodological Note

Efficiency is estimated using a true fixed-effects stochastic frontier model with robust standard errors clustered at the facility level.

*This work provides the first publicly available longitudinal dataset for efficiency analysis of water treatment facilities in the region.*



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