

## CASE STUDY

# Cost-Effectiveness Analysis of Water Treatment Systems in Ethiopia

*A Multilevel Regression Modelling Case Study*

Dawit Tesfaye<sup>1</sup>|Selamawit Assefa<sup>2</sup>  
Betelhem Mekonnen<sup>3</sup>|Alemayehu Tadesse<sup>4</sup>

<sup>1</sup> Department of Sustainable Systems, Ethiopian Public Health Institute (EPHI)

<sup>2</sup> Debre Markos University

<sup>3</sup> Hawassa University

<sup>4</sup> Department of Sustainable Systems, Debre Markos University

Correspondence: [dtesfaye@aol.com](mailto:dtesfaye@aol.com)

Received: 22 March 2002 | Accepted: 12 May 2002 | Published: 08 July 2002 | DOI: [10.5281/zenodo.18969348](https://doi.org/10.5281/zenodo.18969348)

## ABSTRACT

Evaluating the cost-effectiveness of water treatment infrastructure in low-resource settings is critical for sustainable development. Existing analyses often fail to account for the hierarchical nature of cost data, which is clustered by geographical region and facility type, leading to potentially biased estimates. This case study aims to demonstrate a robust methodological framework for assessing the cost-effectiveness of diverse water treatment systems. Its objective is to quantify the influence of facility-level and regional-level factors on unit treatment costs. A multilevel regression model was applied to operational cost data from a sample of treatment facilities. The core statistical model is specified as  $Cost_{ij} = \beta_0 + \beta_1 X_{ij} + u_j + e_{ij}$ , where  $i$  denotes facilities and  $j$  denotes regions, with  $u_j$  as the region-level random effect. Inference was based on robust standard errors. The analysis revealed that membrane-based systems were, on average, 34% more cost-effective per cubic metre treated than conventional coagulation plants, after controlling for capacity and energy source. The regional random effects were significant, indicating that unobserved geographical factors account for a substantial portion of cost variation. Multilevel modelling provides a superior analytical approach for infrastructure cost-effectiveness studies where data has a nested structure, yielding more reliable and actionable insights for engineers and policymakers. Future project appraisals should adopt hierarchical modelling techniques. Investment should be prioritised towards membrane technologies in settings with reliable power, while also funding region-specific cost-driver analyses. cost-effectiveness analysis, multilevel modelling, water treatment infrastructure, random effects, sustainable engineering This study provides a novel application of multilevel regression to civil engineering economic analysis, demonstrating that accounting for data hierarchy significantly alters cost-effectiveness rankings for water treatment technologies.

**Keywords:** *Cost-effectiveness analysis, Multilevel modelling, Water treatment systems, Sub-Saharan Africa, Sustainable development, Infrastructure evaluation, Hierarchical data*

### Article Highlights

- Multilevel modelling corrects for bias in hierarchical cost data from clustered regions and facilities.
- Regional random effects were significant, revealing unobserved geographical drivers of cost variation.
- The study provides a robust framework for infrastructure

### Methodological Insight

The core model,  $Cost_{ij} = \beta_0 + \beta_1 X_{ij} + u_j + e_{ij}$ , incorporates region-level random effects ( $u_j$ ) to account for nested data structure.

*This analysis demonstrates how statistical rigour alters technology*

<p>appraisal in low-resource settings.</p> <ul style="list-style-type: none"><li>• Findings support prioritising membrane technologies where reliable power exists.</li></ul>	<p><i>rankings in engineering economics.</i></p>
---	--

## **ABSTRACT-ONLY PUBLICATION**

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

## **REQUEST FULL PAPER**

 **Email:** [info@parj.africa](mailto:info@parj.africa)

Request your copy of the full paper today!

## **SUBMIT YOUR RESEARCH**

**Are you a researcher in Africa? We  
welcome your submissions!**

Join our community of African scholars and share  
your groundbreaking work.

 **Submit at:** [app.parj.africa](http://app.parj.africa)



Scan to visit [app.parj.africa](http://app.parj.africa)

### **Open Access Scholarship from PARJ**

Empowering African Research | Advancing Global  
Knowledge