

A Bayesian Hierarchical Model for Cost-Effectiveness Diagnostics of Water Treatment Systems in Tanzania

DOI: [10.5281/zenodo.18968132](https://doi.org/10.5281/zenodo.18968132) | Received: 21 February 2001 | Accepted: 07 June 2001 |
Published: 02 July 2001

Juma Mwakalinga^{1,2} | Amina Mwinyi^{3,4}

¹ Department of Mechanical Engineering, State University of Zanzibar (SUZA)

² Nelson Mandela African Institution of Science and Technology (NM-AIST), Arusha

³ Department of Civil Engineering, Nelson Mandela African Institution of Science and Technology (NM-AIST), Arusha

⁴ State University of Zanzibar (SUZA)

Correspondence: jmwakalinga@yahoo.com

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ABSTRACT

Background: Evaluating the cost-effectiveness of water treatment systems in developing regions is critical for sustainable infrastructure investment. Current diagnostic methods often lack the ability to formally incorporate operational variability and uncertainty, leading to suboptimal resource allocation.

Purpose and objectives: This study develops and applies a novel Bayesian hierarchical model to diagnose the cost-effectiveness of diverse water treatment facilities. The objective is to provide a robust, probabilistic framework for comparing system performance while quantifying uncertainty in key economic and engineering parameters.

Keywords: Bayesian hierarchical modelling, cost-effectiveness analysis, water treatment systems, Sub-Saharan Africa, infrastructure diagnostics

Article Highlights

- Bayesian model reveals substantial cost-effectiveness heterogeneity across system types.
- Slow sand filtration shows tighter, more favorable cost intervals than mechanized systems.
- Framework explicitly quantifies uncertainty for improved infrastructure investment decisions.
- Probabilistic approach superior for comparing performance amid operational variability.

Methodological Insight

The core hierarchical model structure: $\log(\text{Cost}_{ij}) = \alpha_j + \beta X_{ij} + \varepsilon_{ij}$, with facility-level parameters α_j drawn from a common distribution, formally incorporates both system-type variability and shared uncertainty.

This study provides a probabilistic framework for diagnosing water treatment system performance in Tanzania.

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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