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"Reconcile land system changes
with planetary health"

Transforming Ethiopian botanical gardens into socio-ecological systems for sustainable land use and climate resilience

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Abstract

Botanical gardens have emerged as fundamental institutions for advancing biodiversity conservation, environmental education, and sustainable development in an era of rising ecological crises. In biodiversity-rich countries such as Ethiopia these sectors function as multifunctional centers for climate resilience, cultural preservation and community-based resource management. This study evaluates the operational efficacy of three Ethiopian botanical gardens. These are Gullele Botanical Garden (GUBG), Dilla University Botanical and Ecotourism Garden (DUBEG), and Shashemene Botanical Garden (SHBG) across six domains: governance, infrastructure, research capacity, education, health, and cultural integration. Using sequential mixed-methods design, primary data was collected via semi-structured interviews with 15 institutional stakeholders and structured survey questions were prepared for 300 visitors, staff and residents. Performance metrics were quantified using a 5-point Likert scale (1 = poor and 5 = excellent) with aggregate scores categorized as high performing 3.8 or moderate/low-performing <3.8. Statistical analyses including multiple linear regression are used to identify the key predictors of institutional success. The results showed a significant difference in performance across the three botanical gardens. In this regard GUBG achieved a high performance overall mean score of 4.08 performing in governance 4.4 ± 0.3, infrastructure 4.1 ± 0.2 and education 4.5 ± 0.4. Although DUBEG showed moderate performance in research output (4.0 ± 0.5) and SHBG revealed relative strength in governance (4.2 ± 0.4), both institutions underperformed in the domains of health services (2.7 ± 0.6) and infrastructure quality (2.9 ± 0.7). Regression models confirmed infrastructure adequacy ($\beta = 0.32$, $p = 0.01$) and governance transparency (($\beta = 0.24$, $p = 0.05$) as critical determinants of botanical garden efficacy. These findings call for adaptive policy frameworks based on well framed governance, infrastructure investment and integration of Indigenous ecological knowledge. Integrating the development of botanical gardens with Ethiopia's National Biodiversity Strategy and Climate-Resilient Green Economy Plan supports efforts toward sustainable land use and improved climate resilience. In addition, the lessons from this experience may be relevant to similar initiatives in other parts of sub-Saharan Africa.

Keywords: Biodiversity conservation, botanical gardens, environmental education, governance, indigenous knowledge, planetary health, socio-ecological infrastructures, sustainable land use

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