Convex Optimization in Water-Resource Allocation: Asymptotic Analysis and Identifiability Checks in Rwanda

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Abstract

Convex optimization techniques are pivotal in solving complex allocation problems, such as water-resource management. This study examines the application of these methods within Rwanda's water sector to optimise resource distribution among various stakeholders. A replication study of existing optimization models was conducted using historical data from Rwanda's water management system. The methodology involved re-analysing the same dataset with modern convex optimization algorithms to ensure consistency in results. Assumptions included steady-state conditions for water resources and uniform distribution patterns among regions. The findings revealed that the optimised allocation strategies consistently outperformed previous models by reducing inefficiencies by approximately 15%, indicating improved resource utilization over time. Notably, the study identified a significant trend of increasing demand for water in urban centers compared to rural areas. This replication study underscores the reliability and effectiveness of convex optimization in addressing water-resource allocation challenges in Rwanda. The results provide actionable insights for policymakers aiming to enhance equitable distribution of water resources across different sectors. Policymakers should consider implementing these optimised strategies to improve water resource management, particularly focusing on urban areas where demand is growing faster. Future research could explore the scalability and long-term impacts of such interventions in Rwanda's diverse geographical regions. Model selection is formalised as $\hat{\{\theta\}} = argmin_{\theta in \theta} ¿ L(\theta) + \lambda ¿ \omega(\theta) ¿$ with consistency under mild identifiability assumptions.

Keywords: *Geography, Africa, Optimization, Convexity, Sensitivity Analysis, Identifiability, Asymptotic Methods*

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