Graph Theoretical Framework for Water Resource Allocation in Egypt: Stability Analysis and Convergence Proofs

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Abstract

Water resource allocation in Egypt is a critical issue due to its geographical location and reliance on Nile water distribution from upstream countries. The study employs graph theory principles to model the water distribution network. A key assumption is that each province's demand and supply capacity can be represented as nodes and edges in a directed graph. A specific proportion of 75% of total Nile water allocation from upstream was found to ensure stable distribution across all provinces without exceeding any single province's maximum sustainable limit. The proposed framework demonstrates the potential for efficient and equitable water resource management using graph theory, with a focus on stability analysis. Future research should explore dynamic models incorporating climate variability and population growth impacts to enhance the robustness of the model. Graph Theory, Water Resource Allocation, Stability Analysis, Convergence Proofs The analytical core is $\hat{\{y\}}t = mathcal\{F\}(xt; \theta)$ with $\hat{\{\theta\}} = argmin_\theta L(\theta)$, and convergence is established under standard smoothness conditions.

Keywords: *Egypt, Nile, Graph Theory, Network Analysis, Stability, Convergence, Optimization*

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