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AN INTEGRATED CLUSTERING - FUZZY TOPSIS - MILP FRAMEWORK FOR INDUSTRIAL FACILITY LOCATION OPTIMIZATION: THE CASE OF A DAP FERTILIZER PLANT IN SENEGAL

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ABSTRACT

Senegal possesses one of the world's largest phosphate rock reserves, yet its diammonium phosphate (DAP) production capacity remains limited, creating a strategic opportunity for domestic value-added fertilizer manufacturing. Selecting an optimal site for such an industrial facility is a multidimensional problem that must reconcile qualitative locational criteria with quantitative economic viability. This research is situated within the broader context of the Facility Location Problem, drawing upon solution frameworks from both Operations Research and Multi-Criteria Decision-Making. Our study proposes a hybrid computational decision-support framework integrating four complementary methods. First, a Geographic Information System (QGIS) maps candidate zones as phosphate deposits and defines a study area based on a metric coordinate system. Second, K-Means clustering groups these candidate zones into homogeneous spatial clusters, reducing the problem to a tractable set of alternatives. Third, a Fuzzy TOPSIS multi-criteria decision-making model built on triangular fuzzy numbers, ranks the resulting clusters according to a composite of economic, logistical, and environmental criteria. Fourth, a Mixed-Integer Linear Programming (MILP) model, calibrated with West African market parameters (DAP price, production capacity, capital recovery factor, operating costs etc.), independently evaluates each cluster's expected net profitability. Applying this framework, Cluster 0 emerges as the optimal location under both methods, with a Fuzzy TOPSIS closeness coefficient of 0.6199 and a projected MILP net profit of approximately USD 42.88 million per year, yielding a 60% ranking concordance between the two approaches. To confirm the robustness of this study across various scenarios and to standardize this model, a multimodal sensitivity analysis of the key parameters is recommended. The proposed framework offers a replicable, mathematically grounded decision-support tool for industrial facility location problems, with direct relevance to resource-based industrialization strategies in developing economies.

Keywords Facility location · Fuzzy TOPSIS · Mixed-Integer Linear Programming · K-Means clustering · GIS · DAP fertilizer · Senegal

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