MULTI-OBJECTIVE OPTIMIZATION OF POST-DISASTER RELIEF LOGISTICS WİTH STRATEGIC DEPOT LOCATION AND GREEN VEHICLE ROUTING UNDER OPERATIONAL CONSTRAINTS

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Abstract

This study formulates and solves a mixed-integer programming model addressing the post-disaster relief distribution problem by integrating capacitated facility location and heterogeneous vehicle routing with environmental considerations. The proposed framework accommodates both electric and internal combustion engine vehicles, subject to heterogeneous capacity constraints, driving range limitations, and the spatial availability of charging infrastructure. Delivery nodes are associated with priority-based time windows, and road segments are penalized using risk coefficients. As a multi-criteria decision-making technique, the Analytic Hierarchy Process (AHP) is employed to evaluate and prioritize depot locations based on multiple qualitative and quantitative criteria such as cost, distance, road risk, and environmental sustainability. The resulting AHP-derived weights are embedded directly into the optimization model, influencing depot selection decisions within the mathematical framework. The objective function aggregates multiple conflicting objectives in a weighted form, including: total transportation distance adjusted by road risk, total CO_2 emissions, fixed vehicle usage costs, the number of charging operations, renewable energy scores of charging stations, and depot establishment costs. The model enforces compatibility between depot activation and routing feasibility, incorporates range-dependent charging decisions for electric vehicles, and respects capacity limitations of charging infrastructure. A systematic Pareto frontier exploration is conducted through enumeration of normalized weight vectors across the multi-objective space. Each scenario is evaluated via a GAMS-based solver integrated with Python, automating scenario generation, execution, and solution extraction. This computational framework yields a diverse set of non-dominated solutions that illuminate the trade-offs among sustainability, cost-efficiency, and operational feasibility. The results provide actionable insights for emergency logistics planners seeking environmentally responsible routing and infrastructure decisions under uncertainty and time pressure.

Keywords: Disaster logistics,Vehicle routing, AHP, Carbon emissions.