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A Methodological Framework for Optimising Electric Fleet Routing in African Forestry: A Case Study of FSC-Certified Log Transport from SHARP Concession to Owendo, Gabon

J, e, a, n, -, B, a, p, t, i, s, t, e, M, o, u, s, s, a, v, o, u, ,, A, ï, c, h, a, B, o, u, s, s, a, m, b, a

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Abstract

The integration of electric vehicles into forestry logistics in Africa faces distinct challenges. These include sparse charging infrastructure, varied topography, and the necessity of upholding certified timber chain-of-custody protocols. Efficient routing is essential for operational viability. This article develops a methodological framework for optimising electric truck routing for log transport in an African setting. The primary objective is to create a model that minimises total trip duration while incorporating electric vehicle-specific constraints, demonstrated via a real-world case study. A mixed-integer linear programming model was formulated. It incorporated geospatial data on road networks, terrain, and projected charging station locations. Model constraints included vehicle range, payload capacity, mandatory driver rest periods, and FSC chain-of-custody rules. The model was applied to the specific route from the SHARP concession to the Owendo industrial zone. The model determined a primary optimal route necessitating one intermediate charging stop. This increased total journey time by approximately 18% compared to a diesel truck scenario. Sensitivity analysis indicated that positioning charging infrastructure in the final segment of the route was most crucial for minimising time penalties. The framework offers a structured and practicable approach for modelling electric fleet routing in forestry operations. It effectively balances logistical efficiency with the technical

limitations of electric vehicles within a context of limited infrastructure. Future work should integrate real-world energy consumption data and extend the model to consider fluctuating electricity tariffs and grid reliability. Practitioners are advised to undertake detailed terrain and energy analysis before deploying electric vehicle fleets. electric vehicle routing, forestry logistics, operations research, FSC certification, Gabon, sustainable transport, optimisation model This work provides the first dedicated methodological framework for optimising electric log truck routing in an African forestry context, addressing a critical gap in planning for sustainable forest operations.