ROUTE OPTIMIZATION MODEL FOR SOLID WASTE COLLECTION USING MACHINE LEARNING AND GIS TECHNIQUES

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DECLARATION

This thesis is my original work and has not been presented for a degree award in any other university.

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DEDICATION

I would like to dedicate this work to my family, whose unwavering support, love, and encouragement have been instrumental throughout my academic journey. Your belief in me and your constant motivation have fueled my determination to pursue excellence and overcome challenges. This achievement would not have been possible without your understanding, patience, and sacrifices. I am forever grateful for your presence in my life and the inspiration you provide. This work is a tribute to your boundless love and the values you have instilled in me. Thank you for always being my pillar of strength.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACO – Ant-Colony Algorithm

AI - Artificial Intelligence

CBO – Community Based Organization

CGM - County Government of Mombasa

CO_2 – Carbon Dioxide

DEM – Digital Elevation Model

DSR - Design Science Research

DSS - Decision Support System

GCP – Ground Control Point

GDP - Gross domestic product

GIS - Geographical Information Systems

GPS – Geographical Positioning System

ILP - Integer Linear Programming

IoT - Internet of Things

ISWM - Integrated Solid Waste Management

JOM - Java Optimization Modular

ML – Machine Learning

MSW - Municipal Solid Waste

NA – Network Analyst

QGIS – Quantum Geographical Information System

RL – Reduced Level

ROMWC - Route Optimization Model for Waste Collection

RQ – Research Question

RS – Remote Sensing

SWM - Solid Waste Management

TS – Transfer Station

UNEP - United Nations Environmental Program

DEFINITION OF KEY TERMS

Algorithm - a sequence of instructions or a set of logical steps that a computer or any problem-solving system follows to accomplish a specific task or calculation.

Arc - often called an edge.

Distance - the length of the space between two points.

Dumpsite - a piece of land where waste materials are dumped.

Model - represents what was learned by a machine learning algorithm.

Node - are collection points represented by circle.

NP Hard problem - is a problem that is at least as hard as the hardest problems in NP (nondeterministic polynomial time)

Optimization - to utilize a situation or resource in the most efficient or effective way possible.

Optimization technique - refers to the mathematical method or algorithm used to determine the most efficient routes for waste collection vehicles to follow.

Performance metrics - are measurements used to evaluate the performance of a model.

Route - a path or course that is followed in order to travel from a starting location to a particular destination

Shapefile - a digital format that stores geographical location and its related attributes using vector storage.

Solid Waste Management - refers to the collection, transportation, processing, and disposal of solid waste in an environmentally sound and sustainable manner.

Spatial - relating to or occupying space.

Transfer Station - facilities where solid waste, mainly municipal solid waste (MSW), is unloaded from collection vehicles or containers for reloading into larger, long-distance vehicles for transport to landfills/dumpsite.

ABSTRACT

The County Government of Mombasa (CGM) faces a major challenge in solid waste management (SWM), which involves collecting and removing waste. The study aimed to improve the waste transportation and logistics operations from collection points to final disposal by computing an algorithm for the optimal waste collection route in Mombasa. The ultimate goal of this study is to develop a model that optimizes the waste collection system using machine learning and geographical information system (GIS) technologies. The study aimed to determine the optimal waste collection route using ant colony, integer linear programming, and simulated annealing algorithms. These algorithms were used to analyze the data collected on the waste collection process, which included locations of transfer stations, time taken, distance, and cost for fuel. The data was first cleaned and tested for distribution, and the optimal factors were then identified. The supervised machine learning process was then applied to identify the relationships between the variables, make predictions, and find the optimization route. Finally, the integration of geographical information system (GIS) process was used to determine the final optimal route for the waste collection process. The results showed that the use of ant colony, integer linear programming, and simulated annealing algorithms was effective in finding the optimal waste collection route, resulting in a more efficient, cost-effective, and sustainable waste management system. This study is crucial and greatly benefit the department responsible for SWM in the CGM by improving the efficiency and effectiveness of waste collection. It primarily use quantitative research methods and intended to evaluate the current waste collection network. The study developed a map of the existing waste collection network using quantum geographical information system (QGIS) software and use a supervised machine learning model to find the best solution to the route optimization problem, determining the shortest path with the minimum cost.