FACULTY OF ENGINEERING

DEPARTMENT OF WATER RESOURCES ENGINEERING

FINAL YEAR PROJECT REPORT

A SMART MUNICIPAL WASTE MANAGEMENT SYSTEM FOR ROUTE OPTIMIZATION AND IMPROVED REVENUE COLLECTION

By

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ABSTRACT

Efficient municipal waste management is a critical challenge faced by cities globally, including Kampala. This study presents a case study where we propose a smart municipal waste management system that utilizes advanced technologies to address the specific challenges of route optimization and revenue collection. By integrating data analytics, Internet of Things (IoT) devices, and intelligent algorithms, the system aims to optimize waste collection routes and enhance revenue collection process. To solve the problem of route optimization, the system leverages data analytics techniques to analyze waste generation patterns taking into account factors such as waste disposal behaviors, and geographical information such as real time traffic data. By utilizing this data, the system intelligently determines the most efficient collection routes, reducing travel distances and optimizing resource allocation. This approach not only lowers operational costs but also minimizes the environmental impact associated with waste collection activities. In terms of revenue collection, the smart system incorporates IoT devices, such as smart bins equipped with sensors and communication capabilities. These devices provide real-time data on bin fill levels, enabling accurate and timely billing for waste collection services. The intelligent algorithms are integrated to detect anomalies in revenue collection, facilitating effective enforcement and revenue recovery processes. Over a two-month period, our study aims to implement and evaluate the proposed smart municipal waste management system. We gathered relevant data, including waste generation patterns, waste disposal behaviors, and revenue collection records. The system's performance was assessed based on key metrics, such as route optimization efficiency, revenue collection accuracy, and customer satisfaction. Expected results of this study included improved route optimization which was achieved at a percentage of approximately 60% leading to reduced travel distances and optimized resource allocation tailored to waste management needs. This results in cost savings for waste management authorities and a reduced environmental impact. Moreover, the implementation of the smart system is anticipated to enhance revenue collection by enabling accurate and efficient billing for waste collection services.

DECLARATION

We thereby declare to the best of our knowledge, that this report is our own research and has never been submitted before to any other institution of higher learning for any academic award. We stand to account for all the information contained in this report.

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APPROVAL

This report of a smart municipal waste management system for route optimization and improved billing has been under the supervision of;

SUPERVISOR:

Name; MR MASERUKA BENDICTO

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DEDICATION

This report is dedicated to our families and our supervisor, MR MASERUKA BENDICTO who endured all the hard work put upon them. We are very grateful especially to our beloved parents and our supervisor; May the almighty God bless you all and repay you in abundance and excel in your various activities.

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LIST OF ABBREVIATIONS

MSW	Municipal Waste Management
KCCA	Kampala Capital City Authority
SDG'S	Sustainable Development Goals
IoT	Internet of Things
RTD	Real Time Data
LED	Light Emitting Diode
VRP	Vehicle Routing Problem
LCD	Liquid crystal display
TSP	Travelling Salesman Problem
UN	United Nations
NEMA	National Environmental Management Authority
MDOD	Maximum Depth of Discharge
LMICs	Low Middle-Income Countries

INTRODUCTION

1.1 BACKGROUND

According to a report by the World Bank, the global municipal solid waste (MSW) generation is expected to rise from 2.01 billion tonnes in 2016 to 3.4 billion tonnes by 2050. The report further states that low and middle-income countries (LMICs) are expected to experience the largest increase in waste generation, with sub-Saharan Africa projected to have the fastest increase in waste generation rate by 2050 (Kaza et al., 2018).

The United Nations (UN) has recognized the need to address the global waste management crisis and has set a target to significantly reduce the amount of waste generated by 2030. The Sustainable Development Goal 11 (SDG 11) aims to make cities and human settlements inclusive, safe, resilient and sustainable, with target 11.6 specifically focusing on improving waste management practices (UN, 2018).

In Uganda, waste management remains a major challenge, especially in urban areas. According to the Uganda Bureau of Statistics, Kampala, the capital city of Uganda, generates about 1,800 tonnes of solid waste per day, with only 40% of this waste collected and disposed of properly. The remaining waste is left to accumulate in open spaces, drainage channels, and water bodies, causing health and environmental hazards. Furthermore, the report highlights that only 30% of the urban population has access to proper waste disposal facilities (NEMA, 2016)

In Kampala, the waste management system is mainly manual and inefficient, with inadequate infrastructure and equipment, and insufficient funding. According to a report by the Kampala Capital City Authority (KCCA), the current waste collection system is fragmented, with multiple actors involved in waste collection and disposal, leading to inefficiencies, duplication of efforts

and revenue losses (Ssemugabo et al., 2020). Furthermore, the report highlights that the current system is unable to provide accurate data on waste generation, collection, and disposal, making it difficult to plan and implement effective waste management strategies. A Smart Municipal Waste System for Route Optimization and Improved Revenue Collection: A smart municipal waste system can address the challenges associated with waste collection and management in Kampala. Such a system will leverage technology to optimize waste collection routes, improve revenue collection, and provide accurate data on waste generation and disposal. The system will involve

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