

UNIVERSITI TEKNOLOGI MARA

**A FACILITY LOCATION MODEL
WITH FIXED CAPACITIES FOR
RECYCLING FACILITIES'
LOCATIONS – A CASE STUDY IN
SEREMBAN, MALAYSIA**

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ABSTRACT

Malaysia encounters considerable challenges in waste management and recycling, driven by population growth, urbanization, and evolving lifestyles. Despite the government's goal of a 40% recycling rate by 2025, over 80% of recyclable waste continues to be disposed of in landfills. This is largely due to low public participation in source separation activities, especially among households, which is a critical step in promoting recycling practices. A key obstacle to enhance recycling rates is the insufficient accessibility and availability of recycling infrastructure, including collection points and appropriately sized containers. To address this, optimal location of recycling facilities is critical to encourage public participation and efficiently managing recyclable waste. Hence, this research focuses on a variant of the Facility Location Problem (FLP) model, utilizing the set covering problem to guarantee that areas generating recyclable waste have access to at least one operational facility within an acceptable travel time. Moreover, the uncapacitated model of Maximal Expected Coverage Location Problem is unrealistic for real-world applications, as it fails to account for varying container sizes and demand constraints. Therefore, the proposed model of Maximal Covering Location Problem incorporates capacity considerations to ensure more practical and effective coverage in real-life scenarios. The proposed methodology was validated using both randomly generated datasets and small-scale real-world data to demonstrate its applicability and practical relevance. The model was then applied to Seremban, which comprises approximately 315 household areas with a population of 422,710 in 2024. These figures indicate a growing volume of recyclable waste, highlighting the need for a strategic approach to locating recycling facilities with optimal capacity level to support a better waste management system of the city. Using the proposed methodology, nine recycling facility locations were identified to serve selected areas in Seremban. Of these, six are the existing facility locations, while the remaining three are newly proposed locations. Scenario testing was also carried out by imposing limitations on the authorities' capacity to serve users. The analysis indicates that operating a single facility, which serves only 10% of total demand, results in significantly lower coverage efficiency compared to operating eight facilities, which serve 90% of demand. The findings emphasize that the commitment of both users and authorities plays a vital role in the success of recycling efforts. This reflects the strength of proposed methodology in accounting for stakeholder perspectives and operational capacities in the process of identifying optimal locations for recycling facilities. To conclude, the proposed mathematical model for the FLP shows significant potential to improve the current Malaysia's recycling system. By optimizing facility locations, it enhances service coverage, reduces infrastructure costs, and supports user engagement while accounting for authority constraints. For future research, it is recommended to apply the proposed model to other urban settings across Malaysia to assess its scalability and adaptability. Further research could also explore dynamic demand patterns, integration with smart waste technologies, and multi-objective optimization to enhance decision-making in sustainable waste management.

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TABLE OF CONTENTS

	Page
CONFIRMATION BY PANEL OF EXAMINERS	ii
AUTHOR'S DECLARATION	iii
ABSTRACT	iv
ACKNOWLEDGEMENT	v
TABLE OF CONTENTS	vi
LIST OF TABLES	ix
LIST OF FIGURES	xi
LIST OF SYMBOLS	xii
LIST OF ABBREVIATIONS	xiv
CHAPTER 1 INTRODUCTION	1
1.1 Research Background	1
1.2 Motivation for This Research	3
1.3 Problem Statement	4
1.4 Research Question	5
1.5 Research Objectives	5
1.6 Summary of Research Work	7
1.7 Significant of the Research	8
1.8 Scope and Limitation	9
1.9 Definition of Terms	10
1.10 Organisation of Research	11
CHAPTER 2 LITERATURE REVIEW	12
2.1 Introduction	12
2.2 Previous Facility Location Problem (FLPs)	12
2.3 Covering Models Applications	18
2.4 Recycling Facility Location Model	24
2.5 Gap Analysis on Selected Mathematical Models and Methods	28
2.5.1 Objective Function	28

CHAPTER 1

INTRODUCTION

1.1 Research Background

The world is increasingly facing challenges in health, social, economic, and environmental areas (Marchesini, 2025), which have a direct impact on the performance of waste management and recycling systems. These issues are apparent in many countries, including Malaysia. Malaysia encounters numerous obstacles in the fields of waste management and recycling. For example, household waste (65%), commercial and institutional refuse (28%), and industrial waste (7%) are all components of municipal solid waste (MSW) (Shakil et al., 2023). In 2021, the per capita generation rate was 1.17 kilograms/capita/day, and an estimated 14 million tonnes of MSW were produced (Ng et al., 2023). The increase in solid waste in Malaysia is attributed to population growth, lifestyle changes, and the rapid urbanization and development process (International Trade Administration, 2024). Nevertheless, excessive landfilling, inadequate infrastructure, and methane emissions continue to pose environmental hazards. The government's objective is to ensure that waste management enhancements align with climate action objectives, which include achieving a 40% recycling rate by 2025 (New Straits Times, 2022). In order to resolve existing obstacles, strategic enhancements such as optimizing the locations of recycling facilities can be implemented.

Facility location studies are not a new concept. They have been conducted in both the public and private sectors for decades. The facility location problem (FLP) is a well-known optimization problem that involves determining the optimal sites for facilities to meet the demand of identified locations, at the minimum possible cost (Markarian et al., 2022). In other words, it concerns the optimal placement of facilities, achieved by minimizing the associated costs and/or maximizing the desirability gained through the selected locations. In general, facility location challenges involve placing facilities on a network to meet a set of demands while adhering to specific constraints to ensure the facilities' availability and accessibility (Marín et al., 2010; Štádlarová et al., 2024). Notably, choosing the most suitable location for a facility can enhance service quality and reduce risk. However, making these decisions is not a simple task,