

LANDFILL SITE SUITABILITY USING GEOGRAPHIC INFORMATION
SYSTEM AND ANALYTICAL HIERARCHY PROCESS

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*This entire research is dedicated with deepest love to my dearest parents, sisters,
brothers, fiancé and family.*

Thank you for their never ending love, trust, understanding, support, and motivation.

May Allah give us the best rewards.

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ABSTRACT

In solid waste management, landfilling is the lowest ranking of waste management, but it is still widely practiced because it is convenient and consumer friendly. Unfortunately, many landfill sites have closed and this is a main issue in solid waste management. The purpose of this study is to suggest suitable and potential sites for landfill in Johor Bahru area through mapping technique and database system by using parameters that had been identified. Landfill site selection is a complex task because it needs to consider many criteria including economic, social, geological and environmental criteria. Analytical Hierarchy Process (AHP) is a method for analysis and supports decision where multiple and competing objectives are involved and multi alternatives are available. AHP is grouped in Multi Criteria Decision Analysis used to analyze landfill site suitability method. An extensive literature study on previous landfill site selection was conducted. Fifteen parameters were identified to use in AHP process. In this method, the process is divided into hierarchy before pair wise comparison was done and the result is prioritizing according to their weightage. The process is continued with weightage evaluation and its consistency. Landfill site selection process involved many spatial data and strenuous in handling it. Thus, Geographic Information System (GIS) can give significant help because it can potentially handle large volume of data that need to be evaluated and processed. The method used in GIS is digitizing, buffering and overlays. As a result in AHP, the most important criterion is river weighted 0.149 or 14.9% of all criteria and the least important criteria are distance to main road weighted 0.028 or 2.8% of other criteria. In GIS method, there are six parameters selected which are main road, plantation, residential area, swamp, grassland and river coverages. The findings identified two potential sites for landfill area because it satisfied all given requirements. As a conclusion, integration of GIS and AHP is suitable to be used in landfill site selection process.

ABSTRAK

Didalam pengurusan sisa pepejal, tapak pelupusan berada di kedudukan terendah bagi pengurusan sisa. Walau bagaimanapun, ianya tetap diamalkan secara meluas kerana mudah dan mesra pengguna. Namun, banyak tapak pelupusan telah ditutup dan ianya menjadi isu utama di dalam pengurusan sisa pepejal. Tujuan kajian ini adalah untuk mencadangkan tapak pelupusan yang baru bagi kawasan Johor Bahru menggunakan teknik pemetaan dan pangkalan data dengan menggunakan parameter-parameter yang telah dikenal pasti. Pemilihan tapak pelupusan sampah merupakan satu tugas yang rumit kerana ia perlu mengambil kira banyak kriteria termasuk kriteria ekonomi, sosial, geologi dan alam sekitar. *Analytical Hierarchy Process* (AHP) adalah satu kaedah analisis dan menyokong keputusan yang melibatkan pelbagai objektif yang bersaing dan pelbagai alternatif sebagai hasil akhir. AHP adalah salah satu kaedah di dalam Analisis Keputusan Pelbagai Kriteria yang digunakan untuk menganalisis kaedah kesesuaian tapak pelupusan. Kajian literatur secara mendalam telah dijalankan terhadap pemilihan tapak pelupusan sampah yang terdahulu. Lima belas parameter telah dikenal pasti untuk digunakan di dalam proses AHP. Dalam kaedah ini, proses dibahagikan kepada tatatingkat sebelum perbandingan berpasangan dilakukan dan keputusannya disusun mengikut keutamaan pemberat mereka. Proses diteruskan dengan penilaian pemberat dan keseragamannya. Pemilihan tapak pelupusan membabitkan banyak data spatial dan kompleks untuk diuruskan. Oleh itu, Sistem Maklumat Geografi (GIS) digunakan kerana ia berpotensi untuk mengendalikan jumlah data yang besar yang perlu dinilai dan diproses. Kaedah yang digunakan dalam GIS ialah pendigitalan, penampaman, dan penindihan. Keputusan daripada AHP ialah, kriteria yang paling penting adalah sungai dengan pemberat 0.149 atau 14.9% daripada semua kriteria dan kriteria yang paling kurang penting adalah jalan utama dengan pemberat 0.028 atau 2.8% daripada kriteria lain. Dalam kaedah GIS, terdapat enam parameter dipilih iaitu jalan raya utama, ladang, kawasan perumahan, paya, rerumput dan sungai. Keputusannya menunjukkan dua tapak yang berpotensi untuk kawasan tapak pelupusan baru dikenal pasti kerana memenuhi syarat-syarat yang telah ditetapkan. Kesimpulannya, penggabungan diantara GIS dan AHP adalah sesuai digunakan dalam proses pemilihan tapak pelupusan sampah.

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LIST OF ABBREVIATIONS

AHP	Analytical Hierarchy Process
GIS	Geographic Information System
MCA	Multi Criteria Analysis
MCDM	Multi Criteria Decision Making
MCDA	Multi Criteria Decision Analysis
MADM	Multi Attribute Decision Making
MODM	Multi Objective Decision Making
CR	Consistency Ratio
CI	Consistency Index
RI	Random Index
KM	Kilometer
MHLG	Ministry of Housing and Local Government

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CHAPTER 1

INTRODUCTION

1.1 Background Introduction

Johor is one of the state developing at pace in Malaysia. This factor will contribute to the increasing amount of solid waste generated. Unfortunately in Johor, until 2010, 21 landfills have been terminated and the number of operating landfill only 13 sites and among them, 1 is sanitary landfill and others are non-sanitary landfill (National Solid Waste Management Department, 2010). This has causes great impacts on environment because the existing landfill cannot accommodate the waste produced and this lead to other problem such as improper waste management, leachate leaking, and bad scenic view to the community. To overcome this problem, new landfill site are needed. But, it is a hard task as there are many criteria and parameters need to be consider in making decision to siting new landfill. This includes social, physical, economic, political, technical parameters and environmental aspects (Sener *et al.* 2011; Zamorano *et al.* 2008; Nas *et al.* 2010).

Landfill can be categorized according to open dumping, controlled tipping, sanitary landfill with bund and daily cover, sanitary landfill with leachate recirculation and sanitary landfill with leachate treatment (Department of Solid Waste Management, 2010). Landfilling is the lowest ranking in the hierarchy of waste management. Unfortunately, it is still widely practiced by whole world because it is more convenient compared to other methods.

1.2 Problem Statement

The landfill issues have been exist since few decades because the amount of waste generated increasing per year and worsen by the shortage of land to locate landfill. Conventional methods are still practiced in decision making and this method consumed more time because of low technology level. In Malaysia, it is still lack of siting method for landfill and usually the decision for site will be made ad-hoc based on availability of the land. In addition, because time constratint the decision made is not follows the exact parameters needed in siting landfill. Currently, Malaysia used the conventional method in landfill site selection. The usage of Geographical Information System (GIS) and Multiple Criteria Decision Analysis (MCDA) in various fields in site selection has proved this method is suitable to be applied in solid waste management and will help decision making to improve this problem (Nas *et al.* 2010 and Gemitzi *et. al*, 2007). This contribution is illustrated in Table 2.9. MCDA are needed to helps decision maker manage the complex and substantial information in obtaining the landfill site. GIS will be the data storage for all information needed because of its ability to analyzing spatial data from a variety of sources (Sener, 2004 and Sener *et. al*, 2011). It also has capability to handle and simulate the necessary economic, environmental, social, technical and political constraints (Nas *et. al*, 2010). Thus, by using both GIS and MCDA, the system for landfill siting can be produce through mapping and database collected.

1.3 Research Objectives

The objectives of the research are as the following:

- i. To determine potential site for landfill through mapping modeling and database system by using parameters that had been identified.
- ii. To analyze landfill site suitability using Geographical Information System and Multiple Criteria Decision Analysis.

1.4 Significant of the Study

Increment in the production of solid waste cannot be avoided especially with the current population that had been increased. Thus, the proper method should be taken to overcome this problem. One of the ways is to add more landfill site in the area. Currently, the technologies used in landfill site selection are not enough to fulfill this challenge because not all parameters need to be considered are used. Thus, this research will use integration of GIS and AHP to select the new suitable landfill site. By using both of these methods, all parameters involved can be considered and used in the analysis and will resulting more accurate result in determination of potential new landfill site.

1.5 Research Scope

This study covered all development process of GIS starting from collecting data, purifying data, data processing, development and produce application in GIS. Data collected specifically for study area, Johor Bahru. The software involves in these process are ArcInfo and AutoCAD 2011. Scope of the study that had been planned to achieve this study objectives are:

- i. Collecting spatial and attribute data including topography map, hydrogeological map, and. seismotectonic map. Distributing questionnaire for stakeholder analysis.
- ii. Analyze and overlapped suggestion area with map of study area which is by using buffering and union overlay analysis.

1.6 Outline of the thesis

The construction of this thesis involved five chapters which are introduction, literature review, methodology, result and analysis and finally, conclusion and recommendation.

In first chapter, the introduction on the solid waste management is briefly described. This includes the problem and issue revolved around this topic. The objectives, research scope and research question also explained.

In chapter two, extensive literature review had been done on previous research involved with this research. It also gives details explanation on background of solid waste management, the types of solid waste, and site requirements for landfill siting. Besides that, introduction to Geographic Information System and Multi criteria Decision Analysis and the types of analysis that will be used in this research also included in this chapter.

Chapter three is about methodology that had been used in this research. There are two main analysis that is used which is Analytical Hierarchy Process and spatial analysis. In this chapter, the steps on both of this analysis are described in details based on the flowchart given.

In chapter four, the results of the analysis are discussed. Justification and explanation on each of the results are given for both analyses. The last chapter is conclusion and recommendation. In this chapter, it explains the research achievement involving objectives of this research and recommendation for future research are made.

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