ENHANCING THE EVALUATION PROCESS OF SUSTAINABILITY RELATED CRITERIA IN MALAYSIA LANDFILL SITE SELECTION

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DEDICATION

Dedicated to the Lord,

Dearest Father, Mother, Sze Chai, Sze Chen, Yann Haw,

Brothers and sisters in Hope's family

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ABSTRACT

Landfilling is the ultimate waste management system in Malaysia. However, based on the summary report by Department of National Solid Waste Management in Malaysia, out of 161 operating landfills, there are only 16 sanitary landfills, which means more than half of the landfills are posing serious effects to the environment and public health. The selection of a landfill site is often a disturbing issue where imprudent selection may leave negative impacts to the surrounding environment, social, and economic value of the land. It is known that landfill site selection is extremely difficult as it depends on many factors and regulations. To date, the existing landfill site selection guideline is found to be deficient especially in engaging with sustainable-related concepts. Therefore, this research is aimed at producing a decision-making guideline in enhancing its sustainability during landfill site selection. This research probed into the perceptions of the stakeholders towards sustainable deliverables in a landfill site selection project, identified the sustainability related criteria and developed the sustainability related model. The study is carried out with mixed-method approach where the interviews with nineteen respondents and questionnaire surveys with seventy respondents were performed. All the respondents are the industry stakeholders involved in the landfill site selection. The qualitative result was analysed through the Nvivo software while the quantitative result was obtained using Partial Least Square Structural Equation Modelling (PLS-SEM) tool as well as Statistical Package for the Social Sciences (SPSS). The result of the interview has substantiated the lack of understanding towards the sustainability concept incorporated in the landfill site selection. The results of the quantitative analysis reveal that all the sustainable criteria play an important role in landfill site selection. However, the economy and social aspects having higher effect compare to the environmental. All of the identified sustainable criteria were integrated into the model. This model is vital in enhancing the sustainable concept during the evaluation of the landfill site selection. This model also plays an important role in improving the existing guideline so that the evaluation

process of landfill site selection could become more sustainable especially for the government agencies and industry stakeholders in Malaysia. The outcome of this study fills the gap in landfill site selection by integrating the concept of sustainability in the landfill site selection project in Malaysia.

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ABSTRAK

Tapak pelupusan merupakan salah satu sistem pengurusan sisa yang utama di Malaysia. Walau bagaimanapun, hanya 16 daripada 161 tapak pelupusan operasi merupakan tapak pelupusan sanitari menurut laporan ringkas daripada Jabatan Pengurusan Sisa Pepejal Negara di Malaysia. Justeru, hal ini bermaksud lebih daripada separuh tapak pelupusan memberi kesan yang serius terhadap alam sekitar dan kesihatan awam. Namun, pemilihan tapak pelupusan merupakan satu prosedur yang rumit kerana pemilihan yang tidak terancang akan membawa kesan negatif kepada alam sekitar, sosial, dan ekonomi di sekitarnya. Kenyataannya, pemilihan tapak pelupusan adalah amat sukar kerana ia bergantung kepada banyak faktor dan garis panduan. Garis panduan bagi pemilihan tapak pelupusan yang terkini masih didapati sebagai kurang memuaskan terutamanya dalam konsep yang berkaitan dengan unsur kemampanan. Oleh itu, kajian ini bertujuan untuk menghasilkan garis panduan untuk membuat keputusan bagi proses pemilihan tapak pelupusan agar meningkatkan unsur kemampanannya. Fokus kajian ini ialah persepsi pihak berkepentingan terhadap kepentingan konsep mampan dalam pemilihan tapak pelupusan, mengenal pasti kriteria berunsur mampan dan menghasilkan model berunsur mampan. Kajian ini dijalankan dengan gabungan kaedah di mana sesi temuduga telah dijalankan dengan sembilan belas responden manakala sesi soal selidik telah dilakukan dengan tujuh puluh responden. Semua responden yang terlibat merupakan pihak berkepentingan industri yang terlibat dalam pemilihan tapak pelupusan. Hasil analisis kualitatif dilakukan dengan penggunaan perisian Nvivo, manakala hasil analisis kuantitatif diperoleh melalui perisian *Partial Least Square* (PLS) serta Paket Statistik untuk Sains Sosial (SPSS). Hasil temuduga telah membuktikan kekurangan pemahaman oleh pihak berkepentingan industri terhadap konsep kemapanan yang diintegrasikan dalam pemilihan tapak pelupusan. Hasil analisis kuantitatif menunjukkan bahawa semua kriteria mampan yang dikenalpasti memainkan peranan penting dalam pemilihan tapak

pelupusan. Namun, aspek ekonomi dan sosial menghadapi kesan yang lebih besar berbanding dengan alam sekitar. Semua kriteria mampan telah diintegrasikan ke dalam model. Model ini penting untuk meningkatkan konsep mampan semasa membuat penilaian untuk pemilihan tapak. Model ini juga memainkan peranan yang penting sebagai penambahbaikan garis panduan yang sedia ada supaya proses penilaian pemilihan tapak menjadi lebih mampan untuk agensi-agensi kerajaan dan pihak berkepentingan industri di Malaysia. Hasil kajian ini mengisi jurang dalam pemilihan lokasi tapak pelupusan dengan mengintegrasikan konsep mampan di dalam projek pemilihan tapak pelupusan di Malaysia.

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LIST OF ABBREVIATIONS

ABLM	Acceptance by the Local Municipalities
AHP	Analytical Hierarchy Process
AVE	Average Variance Extracted
CMT	Constraint Mapping Technique
COMM	Communication
CPMEP	Cost for the Personnel, Maintenance and Environmental Protection
CR	Composite Reliability
DOE	Department of Environment
ECO	Economy
EIA	Environmental Impact Assessment
ENV	Environment
EQA	Environmental Quality Act 1974
FAHP	Fuzzy Analytical Hierarchy Process
GIS	Geographic Information System
JICA	Japan International Cooperation Agency
LE	Local Economy
LS	Landfill siting
LULU	Locally Unacceptable Land Use
NGOs	Non- government Organisations
NIMBY	Not In My Backyard
NOTE	Not Over There Either
NREB	Natural Resources and Environment Board

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PLS-SEM	Partial Least Square- Structural Equation Modelling
SE	Sensitive Ecosystem
SG	Surface Geology
SOC	Social
SPSS	Statistical Package for the Social Sciences
STDEV	Standard Deviation
TRP	Terrestrial Resource Protection
VIF	Variance Inflation Factor
WCED	World Commission on Environment and Development
WP	Water Protection
WTC	Waste Transport Cost

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Chapter one provides a brief description of the whole research. The background for the Malaysia waste management and its main adopted waste management technique, landfill was presented. Next, the issues within the landfill site selection were identified in the problem statement. The research questions are then formed and it led to the formation of research aim and research objectives. Furthermore, scope of the study and the significance of the study were showed. Lastly, from the thesis organization, it presented the structure of the whole thesis.

1.2 Background of study

During the early 1970s, Malaysia had a low population density and thus did not see the importance of having a centralized waste management system (Agamuthu & Fauziah, 2011). Most of the municipal solid wastes were buried or burned. The rate of municipal solid waste generation in Malaysia is increasing from time to time as the population in Malaysia is increasing (Bai & Sutanto, 2002; Sakawi, 2011). It has therefore led to the growing importance of the continuous development for the management of municipal solid waste in order to properly manage the increasing numbers of solid wastes (Manaf, Samah, & Zukki, 2009). Hence, the increase in solid waste generation in Malaysia calls for the urgent adoption of adequate and better waste management system.

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Many techniques are then utilized in the industry in managing wastes. Among the waste management techniques are recycling, incineration and composting. Saeed, Hassan, and Mujeebu (2009) proposed municipal solid waste that is being generated must be reduced or reused. It is the last resolution for the municipal solid waste to be disposed of through incineration or landfill. However, according to Manaf *et al.* (2009), landfill is the main waste management method used in Malaysia at the present stage.

Landfill has been regarded as one of the most widely used waste management technique (Cheremisinoff, 2003). This is because landfill is the ultimate waste disposal method that can deal with many types of the materials in the waste stream and it is the cheapest way to manage a large quantity of municipal solid wastes. (Badgie *et al.*, 2012). More than 30,000 tonnes of municipal solid waste generated daily and from the total generation, approximately 95% of the municipal solid waste is directly disposed into landfills (Agamuthu & Fauziah, 2011). Most of the landfills in Malaysia are still operating in small scales with varying levels of design sophistication, and the majority of the sites are poorly managed (Sakawi, 2011).

Furthermore, in Malaysia, majority of the landfill facilities with its operation resembles many of those of open dumping operation (Jusoh & Samsudin, 2007). More than half of the existing landfills in Malaysia has reached its maximum capacity, however, the development of new landfill sites or the existing landfill site is limited (Ghazali, Syafalni, & Noor, 2014). Municipal solid waste are generating at a faster rate than the capacity of landfill sites could accommodate. This means that more landfills are required to accommodate the ever-increasing wastes which are generated on a daily basis. This is also supported by Allen *et al.* (2003) who stated that the continuing dependence on the landfill as the waste management infrastructure coupled with the increasing of the amount of waste generated and the running out of space on the current landfill site. Thus, the new landfill capacity is urgently required to contain the generated municipal solid wastes.

However, an improperly managed landfill site often bring negative impact such as water pollution, the release of methane gas causing the air pollution towards the environment near the surrounding of the landfill site (Jusoh & Samsudin, 2007). Apart from that, leachate as the major potential environmental threat from the landfill may cause water pollution (Nagarajan, Thirumalaisamy, & Lakshumanan, 2012). As a result, there is a strong public opposition. Public do not prefer the landfill site to be built in their surrounding housing areas. The site location that is not favourable to the

public causes the unsuccessful selection of the landfill site (Nas *et al.*, 2010). As a consequence, it is shown that selecting an appropriate landfill site is extremely important in the process of constructing a landfill in a nation. It could ensure that site selected is capable of minimising the negative impacts towards the surrounding of the landfill site and increase the chances of successful site selection.

The landfill site selection can be a tedious and a complex process because it involves the weighing of the relative importance of each factor that contributes to a selection of a landfill site. Nas *et al.* (2010) also supported that many factors must be incorporated into the process of making decisions for selecting a landfill site. Decision makers always face difficulties in making the right decision in the multiple attribute environments (Nazari, Salarirad, & Bazzazi, 2012). Due to the complexity of the process of landfill site selection, an inaccurate judgement or decision might be made. This inaccurate judgement or decision is capable of causing several negative consequences that may need to last for a long period of time.

Optimizing landfill site selection decisions have gained considerable importance so as to ensure the least damage impacts to the various environmental sub-components as well as to the residents who are living in its vicinity, thereby enhancing overall sustainability associated with the life cycle of a landfill (Sumathi, Natesan, & Sarkar, 2008). Therefore, a landfill site selection process that incorporates the sustainable concept is necessary to avoid negative impacts towards human health and the environment.

Furthermore, the complexity of a landfill site selection process is relatively proportional to the consumption of time needed in choosing a landfill site. The planning procedure will be delayed due to the time requires for the locating of suitable landfill sites, obtaining permission and constructing a landfill even if there is no objection by any related parties. It would require several years in the planning for locating a landfill site (Allen *et al.*, 2003). The complexity of the process also causes the slowness in the selection of a landfill site, eventually will delay in the construction of a new landfill site. Hence, this shows that the improvement for the landfill site selection process in locating a new landfill site and the criteria involves are playing an important role in siting a new landfill site.

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1.3 Problem statement

The lack of sanitary landfill has further deteriorate the surrounding location of the landfill site. According to the National Solid Waste Management Department, it showed that in the year of 2016, out of 161 operating landfills, there are only 16 landfills are sanitary (Malaysia, 2016). In other word, about 90% of the existing landfills are non-sanitary, which may lead to greater negative impacts on the environment and humans' health. Although the government has been promoting the sustainable concept, yet the implementation of sanitary landfill is still slow. Therefore, it makes the selecting of a landfill site becomes very important as this is able to ensure the landfill site to be located at the place where it has the least impact to the surrounding in terms of the environment, social and economic aspects.

In Malaysia, current guidelines place the emphasis on the technical part of the landfill instead of the selection of a landfill site. According to Allen *et al.* (2003) the emphasis of the current policy is in the containment of the landfill emissions, which in turn, causes the selection of a landfill site to be relegated to the secondary importance. On top of that, apart from environmental impact assessment that requires the proponent of the new landfill development project to submit for the approval from the Department of Environment, there is no specific law in regard to where municipalities locate the landfill sites (Jusoh, 2002).

In addition, the current guideline for the selection of landfill site are having more on the environmental and social criteria. Marzuliani (2016) pointed out the lack of standard guideline that would reflect a complete environmental, social and economic concerns for the selection of a landfill site. Furthermore, it is always becoming an issue when the selection of a landfill site incur high cost when the National Solid Waste Management Department need to outsource by hiring the environmental impact assessment officer to draft out the environmental impact assessment report. Thus, the sustainable related criteria are essential in selecting a landfill site.

In this regard, the lack of standard guideline often results in generating the unrealistic and unreliable landfill site. Every stakeholders from different departments has their own guideline as reference for the selection of a landfill site. For instance, the local municipal government agencies are unable to use the result generated by the hired consultant when the essential variable such as the actual feasibility of acquiring

the selected land is not taken into consideration (Delgado *et al.*, 2008). This problem has led to the significant barrier in implementing the sustainable concept in landfill site selection. Thus, it is essential to have a holistic guideline in view of the selection of a landfill site.

Moreover, the insufficient guideline for the industry stakeholders caused the landfill site selection to be based on its own benefits. Barclay, Higgins, and Thompson (1995) highlighted that the different stakeholders that possessed the power to influence the final results of the site selection may have their own perspective and priorities in making decision. Therefore, the focus on individual benefit is not able to assist and select the landfill site for the optimum benefit for the environmental, social and economic aspects. Nazari *et al.* (2012) also pointed out that stakeholders always face difficulties in making the right decision in the multiple attribute environments for the selection of landfill sites. Due to the lack of guideline, the emphasis of selecting a landfill site has always dwell on the environmental aspects. Therefore, the findings of this research help to increase the awareness of the sustainable concept as well as enhance the sustainability concept in the landfill site selection process.

1.4 Research questions

This research presents three research questions which are set to tackle the problems mentioned in the previous section. Among the three research questions are:

i) What are the perceptions of various stakeholders towards the implementation of the sustainable concept into the landfill site selection project?
ii) What are the critical sustainability-related criteria and indicators used to evaluate the selection of landfill site projects?
iii) How can this sustainability-related criteria and indicators for the landfill site selection project be assessed?

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