Chapter 11
Regional Landfill Site Selection with GIS and Analytical Hierarchy Process Techniques: A Case Study of Langkawi Island, Malaysia

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ABSTRACT
Increasing population and urbanization pose a huge challenge for municipal authorities to select suitable landfill site to dispose the increasing quantities of solid waste. Wrong landfill siting can result in social, environmental and economic cost. Therefore, suitable approaches are required to select landfill sites because that can enhance sound waste disposal practice in the fast-growing urban areas. The Geographic Information System based Multi-criteria Decision Analysis has been used in this chapter to examine the essentials of an effective site selection. GIS-based MCDA is an intelligent system that transforms spatial data into valuable information which can be used to make critical decisions. The analytical hierarchy process is utilized to assist the prioritization process. In Langkawi, disposal of municipal solid waste into open sites could lead to different adverse impacts on public health and the physical environment. This paper represents simple but effective method to assist landfill site selection efforts in the Langkawi.

1. INTRODUCTION
Municipal solid waste (MSW) is seen as fundamental issue to city management and policy makers. Financial, social, political and environmental concerns are major considerations that complicate the decision making procedures (Baban & Flannagan, 1998). Among the different techniques employed to treat municipal solid waste solid wastes, landfills are the last destination (Gbanie et
Although not much attention has been paid to landfills, they form integral components of the waste management chain and require much more attention in order to reduce their environmental impacts (Mahini & Gholamalifard, 2006; Rahman et al., 2008). Landfill is not as expensive and complicated as other kinds of waste treatment (e.g., incinerator). Nevertheless, landfill siting is a complex, intricate, and tedious process that needs thorough assessment using various kinds of criteria (Chang et al., 2008). Site selection seems to be also a significant and essential issue in waste management in the fast-growing urban and tourist areas, particularly in the developing nations.

Due to the complexity of waste management systems, the selection of the suitable solid waste landfill site needs a careful consideration of the different and alternative assessment criteria (Gbanie et al., 2013). Selecting appropriate sanitary landfill places is a significant decision which requires an enhanced land assessment procedure in order to determine the optimum disposal locations (Tınmaz & Demir, 2006). Such locations must meet the legal conditions of the government, and also must reduce economic, health, environmental and social expenses (Siddiqui et al., 1996). Sanitary landfill can constitute one of the basic approaches of municipal solid waste disposal. Interestingly, optimized siting decisions have obtained notable significance for ensuring minimum harm and destruction to the different environmental sub-components, and also could decrease the stigma related to the residents living in the vicinity, thereby increasing the overall sustainability with regard to the life cycle of a landfill (Sumathi et al., 2008).

There is abundant evidence in the literature to show that identifying an appropriate site for municipal landfill has never been an easy procedure, as it requires careful environmental, social, technical and economic considerations. Generally, problems related to organization and planning in waste management that occur usually due to legal and financial limitations further complicate landfill site selection process in the majority of the developing nations. Inadequate information poses a challenge in the site selection process because of the rules and principles governing the use of data in the Municipalities (Daneshvar et al., 2005; Mokhtar et al., 2008).

Geographic Information System (GIS) is a digital database management system that manages huge volumes of spatially distributed data from different resources. GIS seems to be suitable for site-selection research since it can store, analyze, retrieve, and represent information based on user-defined details (Shamshiry et al., 2011). GIS is a useful instrument that can be used to bolster the management of natural resources (Luis E. Marín, et al., 2012).

GIS has the benefit of storing, analyzing and retrieving a remarkable amount of information from different resources and showing the results with much ease and accuracy (Al-Hanbali et al., 2011; Mokhtar et al., 2008; Siddiqui et al., 1996; Sumiani et al., 2009). Spatial planning issues demanding complex and diverse data can be determined through the use of multi-criteria assessment methods (Nas et al., 2008). The benefit in using the GIS-based methods for site selection is that while GIS can handle a huge amount of spatial data, Multi-criteria Decision Analysis (MCDA) can blend expert opinions with factual information that is more appropriate for optimal landfill siting. Such methods use GIS to perform a primary screening of the study area in order to determine the appropriate regions. In the last decade, MCDA was highly employed by various scholars for landfill site selection in different approaches. A GIS-based MCDA transforms and integrates spatial data into a decision. It includes the use of geographical data, the decision maker’s priorities and the management of data and priorities to achieve uni-dimensional values of alternatives (Sumathi et al., 2008).
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