ORIGINAL ARTICLE

FEASIBILITY OF LANDFILL ESTABLISHMENT IN KHOMEYNISHAHR CITY OF ISFAHAN USING GIS, MCE AND BOOLEAN LOGIC

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ABSTRACT

Land filling is the most common disposal method in most parts of the world and landfill site has always been the final destination in solid waste management hierarchy. Thus, the selection of landfill site is always an essential part in the management of solid waste. Selecting an appropriate site for landfill minimizes any unwarranted ecological and socio-economic effects. Hence, landfill site selection requires a detailed analysis of the area that must be able to meet the local authority requirement and criteria. The present study presents a feasibility assessment of landfill establishment for Khomeynishahr city in Isfahan, applying a multi criteria evaluation (MCE) method using GIS technique. Information layers related to topography, soil, water table, sensitive habitats, land use and geology maps were prepared and superposed using Boolean logic in GIS environment. Essential analysis and regulation, criteria and site selection assessment showed that because of many limitations khomeynishahr city doesn't have adequate conditions for landfill site establishment. Khomeynishahr city has a dense population and limited area and is not suitable for landfill establishment. In this case consideration of adjacent cities and finding a common landfill site between two or more cities could be a viable solution of solving this problem.

Keywords: *Landfill, solid waste, GIS, MCE, Boolean Logic*

INTRODUCTION

Integrated solid waste management, landfill is considered as the last strategy in the solid waste disposal hierarchy. This is mainly because the cost of landfill is lower than any other disposal options and is appropriate for a wide range of wastes. An unsuitable landfill site selection may cause the inappropriate environmental and socio economic effects[1]. Landfilling is consists of loading, scattering on the surface, compacting and fast covering of municipal solid waste with the covered matters such as soil with the aim of preventing sanitary problems and environmental pollution. The proposed landfill site should minimize the risks on environment and costs[2]. Thus, landfill site selection requires the analysis of spatial data, regulations and accepted criteria[3].

The role of various criteria in landfill site selection has guided decision makers to have more accurate and simple system. High efficiency of geographic information system in layer analysis and management has made it possible to be used for the optimum municipal solid waste management. Furthermore as many criteria should be incorporated in landfill site selection, this matter is considered as a multi criteria evaluation (MCE) problem. MCE helps decision makers in the management of large amounts of information. This method divides the problem into smaller parts, analyzes each part and then combines them in a logic trend[4]. Boolean logic is one method of MCE, which divides the study area into two classes of suitable and unsuitable and defines the appropriate sites for landfill[5].

The GIS has been used in the landfill site selection management. Vatalis and Manoliadis (2002) and Kontos et al., (2005) studied on the landfill site selection in Macedonia in Northwestern Greece, and the island of Lemnos in the North Aegean Sea (Greece), respectively[6-7]. Farhoodi et al., (2005) investigated the existing and previous landfill site of Sanandaj city in Iran by use of GIS. They considered the existing landfill site unsuitable because of not being compatible with the criteria of site selection[8]. This paper is an attempt to investigate the feasibility of suitable landfill site for Khomeynishahr city by use of GIS, MCE and Boolean logic.

METHODS

Study Area

Khomeynishahr city (N33° 27′, E51° 31′) is located in the northwest of Isfahan province in Iran (**Figure 1**). This city is limited to Natanz from north, Isfahan from south and Najafabad from west. It is consisted of Kooshk, Dorche and central villages with the population of *ca* 319000 people. The population density of the area is so high and according to the existing information is the second most populated area after Tehran city in the country. The amount of waste generated is *ca* 194 tons per day with its composition as indicated in **Table 1**. The existing landfill site of Khomeynishahr city covered an

area of 108885m^2, located in the northwest of the city and situated in a valley of 80 meters depth between two mountains. The landfilling process consisting of filling and covering the waste with soil.

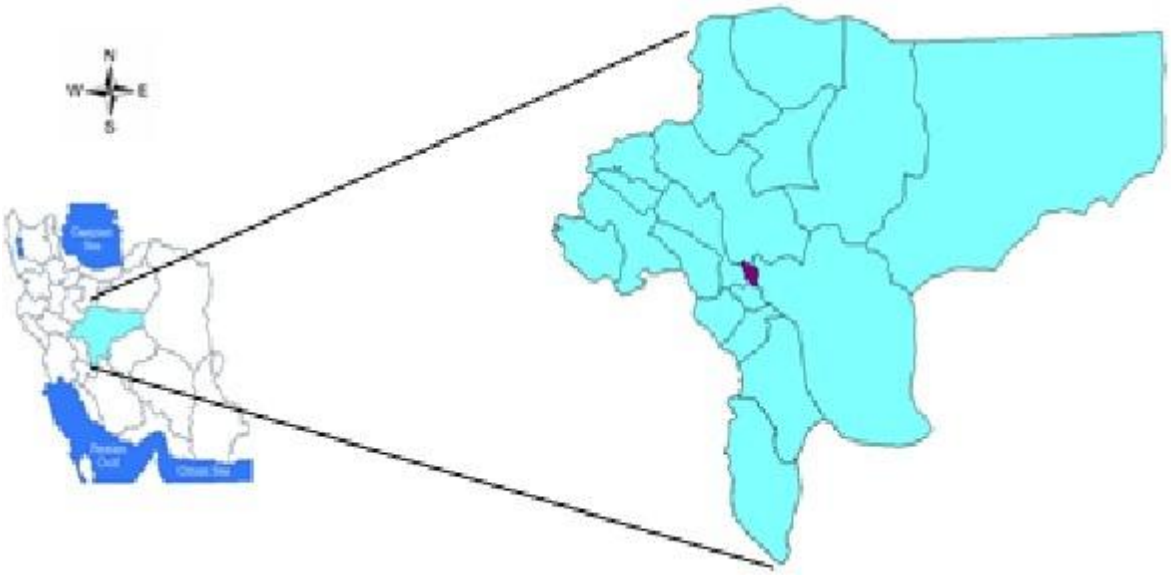

Figure 1 – The location map of the study area, Khomeynishahr city (dot).s

Table 1 –The composition and amount of Khomeynishahr city waste

Composition	*Weight (ton) per day*	*Weight percentage*	*Solid waste type*
Food remaining	*122.9*	*63.4*	*Recyclable Organic wastes*
Garden remaining	*15.1*	*7.8*	
metal	*2.1*	*1.1*	
paper	*12*	*6.2*	
plastic	*4.1*	*2.1*	
glass	*4.6*	*2.4*	
fabric	*2.9*	*1.5*	
rubber	*10.1*	*5.2*	*Unrecyclable nonorganic wastes*
soil	*12*	*6.2*	
Other materials	*7.9*	*4.1*	

Analysis Method

Different criteria should be considered for landfill site selection. MCE method is used in solving site selection problem by breaking it into its sub criteria and then combining them in a logic trend. The final map is produced from considering all the criteria, which shows the suitability of the site. Boolean logic is one of the combination methods that all the criteria are considered as constraints. There is no relation ship among criteria in this method and a constraint criterion cannot compensate the unsuitability of another constraint [9]. Criteria weighing is on the basis of 0 (unsuitable) and 1 (suitable) value. Values and mathematical formulation in site selection is expressed as:

$$SI = \prod_{j=1}^{K} b_j$$

Where: SI= total suitability index value (0 or 1); b_j= suitability index value for each constraint criterion (0 or 1) and K= total number of constraint criteria[5].

Evaluated Criteria

In this study the importing of information layers in GIS environment (Idrisi Klimanjaro) was performed. Boolean logic was applied for identification of suitability and unsuitability of the proposed sites (values of 0 and 1).

In this study, the evaluated criteria are investigated in three categories namely physical, environmental and socio economic criteria. These criteria have been defined according to

the local authority requirement and conditions of the study area. The physical criteria are consisted of underground water, surface water (rivers), water permeability, slope, faults and flood plains, while the environmental criteria only considers sensitive habitats. Finally, the socio economic criteria are limited to the landuse, residential areas and road accessibility.

The hierarchical structure of the decision making problem consists of three levels. The first level presents the final goal (landfill site selection) and the second and third levels present the used criteria and sub criteria, respectively. The summary of the input information layers, their limitations, values and ranking are shown in Table 2.

Table 2 –The summary of the input layers used in the GIS analysis

Layer name	Source map	Buffer zone	Ranking
Water table	Available reports from local water organization	0-10 m >10 m	0 1
Distance from rivers	1/250 000 scale topographical maps	0-100 m >100 m	0 1
Water permeability	Soil map	Rocky terrain Light to moderate texture Moderate texture High texture High to very High texture	0 0 1 1 1
Slope	DEM derived from 1/250 000 scale topographical maps	>20% 0-20%	0 1
Faults	Geology map	faults and a 100-meter buffer >100 m	0 1
Flood plains	Soil map	Flood plains Other areas	0 1
Sensitive habitats	Available maps of sensitive habitats	Sensitive ecosystems and a 500-meter buffer Non-sensitive ecosystems	0 1
Land uses	Available map from natural resources office	residential areas agricultural lands artificial forests Rocky terrains dispersed rangeland	0 0 0 0 1
Residential areas	Land use	0-2 km >2 km	0 1
road access	1/250 000 scale topography maps	0-100 m >1000 m 100-1000 m	0 0 1

RESULTS AND DISCUSSION

Landfill site selection is a multi criteria problem with many factors for consideration. In the present study, the layers of input related to 10 criteria were superposed by applying Boolean logic method. Figures 2 to 9 present each of the criteria map based on the Boolean logic ranking of either 0 or 1 indicating the unsuitability and suitability, respective. The results of superposing showed that Khomeynishahr city is not suitable for landfill establishment. In other words, when superposing the maps related to different criteria, all parts of the study area have a 0 value, indicating the unsuitability of the site.

The most important cause of the unsuitability is the high density of residential areas (Figure 2). In addition, the water permeability is one of the reasons for unsuitability in the north and northwest parts of the area due to the condition of the soil, which is light to moderate in texture (Figure 3). In addition, some parts of the north area are sloppy because of rocky terrains (Figure 4). Roads are scattered in the study area. However, its accessibility is limited only to the city area (Figure 5). Thus, other parts of the study area are not considered as suitable for landfill site. There are only a few rivers in the study area and the option for landfill sites are many based on this criterion alone (Figure 6). Similarly, the option for landfill site are many based on the water table criteria where most of the study area (except of a small part of the area in the most southern region) having low underground water table (Figure 7). Thus, contamination of ground water is less probable. The existence of Ghameshloo protected area (protection of habitat) has made the northwest part of the study area unsuitable for landfill site (Figure 8). On the contrary, according to the geology map the area does not have any geological fault or contain flood plains, thus these two are not considered as the main issue in the selection of landfill site in the area. In the land use criterion, residential areas, agricultural lands, artificial forests and rocky trains except dispersed rangeland are considered unsuitable for landfill siting (Figure 9).

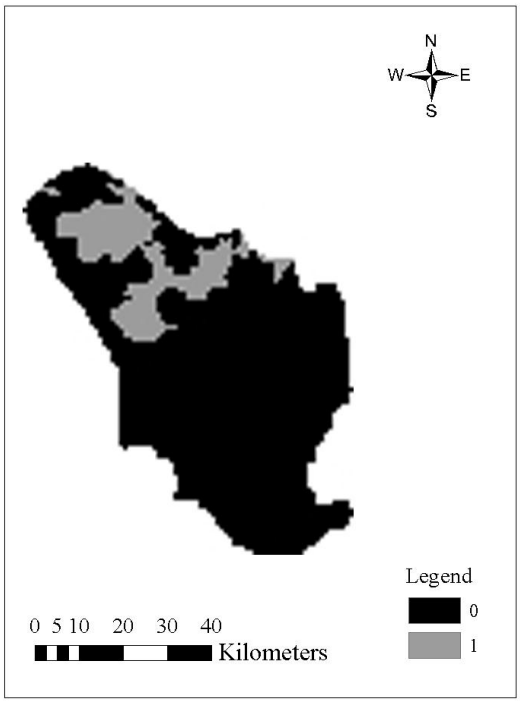

Figure 2 –The residential area map

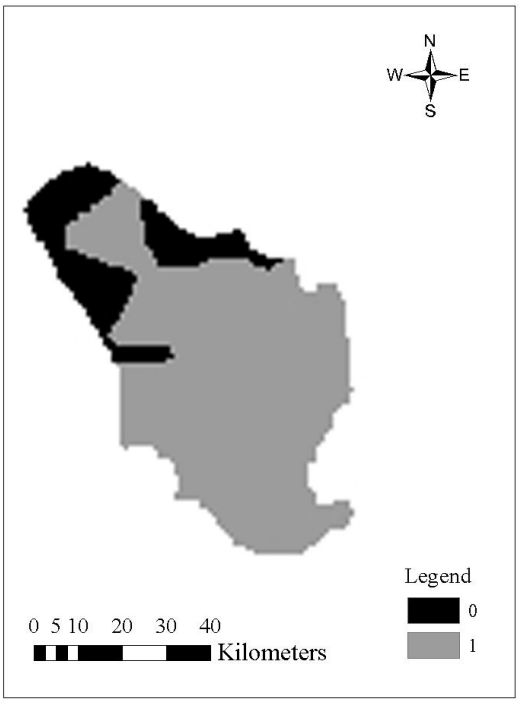

Figure 3 –The water permeability map

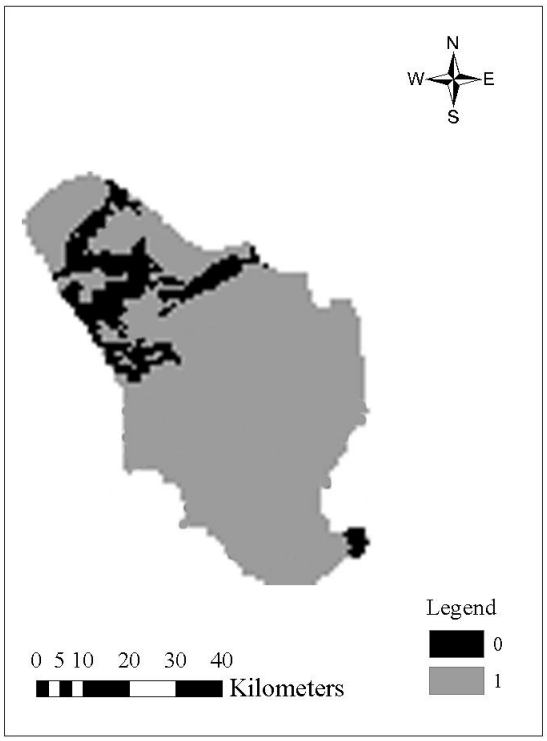

Figure 4 -The slope map

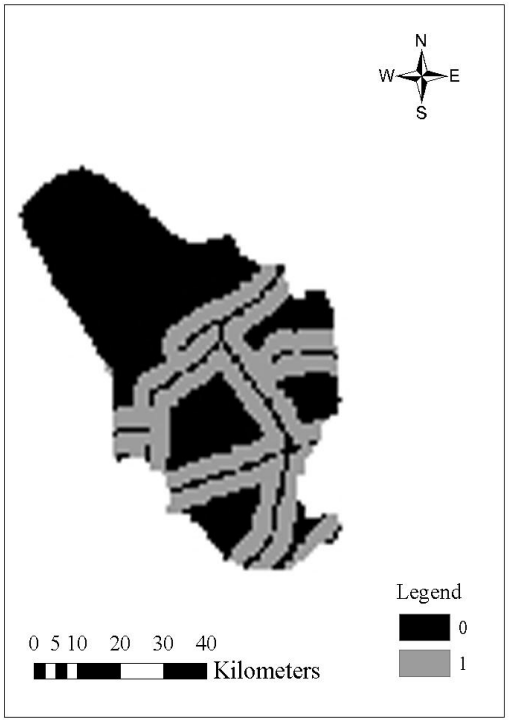

Figure 5 -The road accessibility map

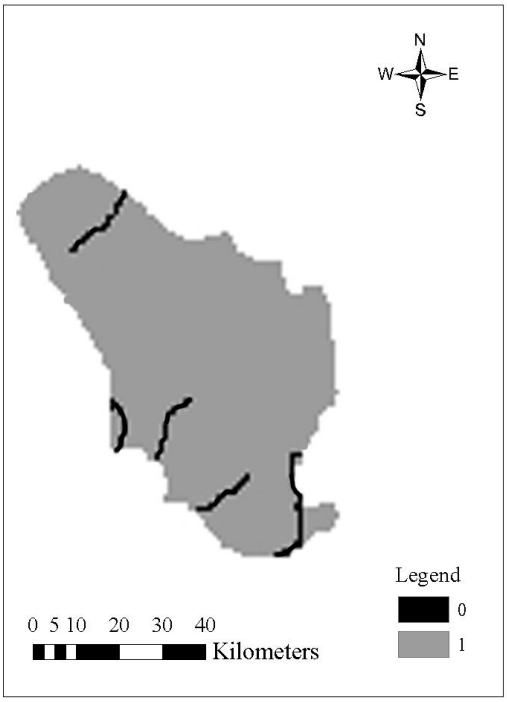

Figure 6 -The river map

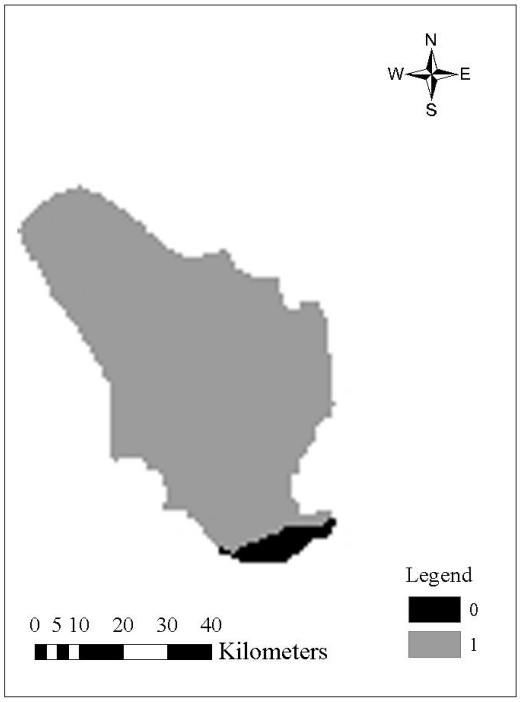

Figure 7 -The water table map

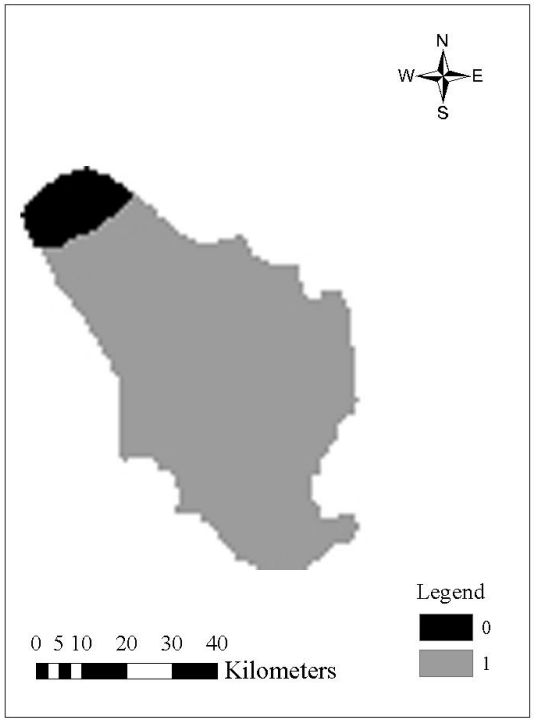

Figure 8 –The sensitive habitat map

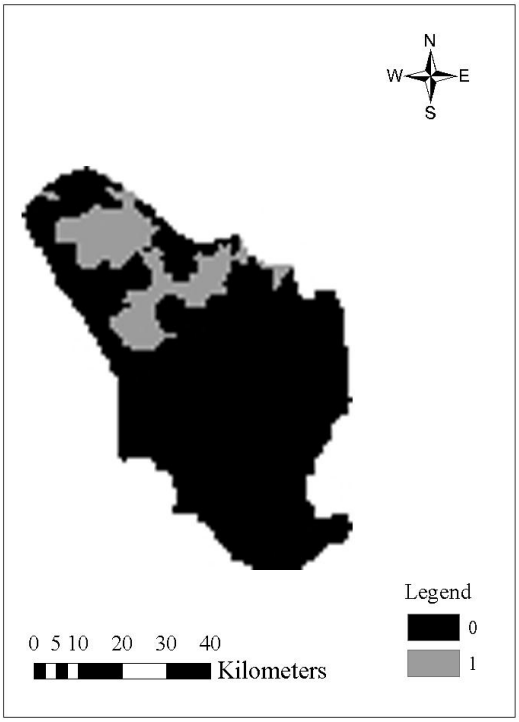

Figure 9 –The land use map

CONCLUSION

The present study shows that the combination of GIS, Boolean logic and multi criteria evaluation techniques in identifying solid waste landfill site suitability and selection. Spatial data analysis on the basis of GIS is a new specialized process, which is capable of analyzing complex features such as landfill site selection investigation. Use of GIS reduces both the margin of error and the time needed for the analysis of variables. Furthermore GIS application provides the possibility of evaluated criteria expansion.

Multi criteria evaluation method combines the information layers related to different criteria and helps the decision makers in the selection of appropriate option. The result from overlaying from Boolean logic model is widely used because of its less complexity and application feasibility. This model has a low accepted risk and is considered suitable model for implementation conditions in developing countries. Khomeynishahr city has a dense population and limited area and is not suitable for landfill establishment. In this case consideration of adjacent cities and finding a common landfill site between two or more cities could be a viable solution of solving this problem. In addition, common landfill for two or more municipalities ultimately could reduce the construction and operational costs through sharing. The technique employed in the site selection in this study can help the decision makers in solid waste management activities.

There are policies and programs that available for the youth and young adults for their education and life skills development[20], in order to improve their quality of life. All relevant stakeholders such as the Ministry of Youth and Sports, and Ministry of Rural and Regional Development, need to collaborate closely and effectively to ensure the needs of young adults are met. More equity in health should be created or strengthened to those with chronic diseases and mental distress.

ABBREVIATIONS

MCE- Multi Criteria Evaluation, GIS-Geographical Information System.

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COMPETING INTERESTS

There is no conflict of interest.

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