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MEGHDAD KAHVAND[1], NIMA GHEITARANI[1], MOJTABA KHANIAN[1], RAZIEH GHADARJANI[1]

URBAN SOLID WASTE LANDFILL SELECTION BY SDSS. CASE STUDY: HAMADAN

One of the major problems human beings are confronted with in urban setting is the removal of urban waste. This problem has persuaded the urban authorities to use various tools such as Geographic Information System (GIS) to locate landfills. To do that, Sloan Digital Sky Survey (SDSS) has been used in which or multi-criteria decision making (MCDM) methods and GIS are combined. The selection of the burial place and landfill has great importance and different criteria must be considered. SDSS, using MCDM is able to investigate locating landfill using various criteria simultaneously and it determines its importance. This research aims at presenting suitable solution through using computer and GIS related to solid urban waste and their locating in Hamadan based on standard criteria. A comprehensive model based on GIS, to get the suitable burial place and landfill can help to save time and cost. The model of locating burial place of urban solid waste has been presented.

1. INTRODUCTION

Following the ever-increasing growth of cities, urban needs have been focused on environmental issues; there appeared a lot of problems in urban setting which need suitable solutions. The removal and burial of urban waste are the most serious issue. The most important stage in this process is to find suitable place to bury the waste. Lack of attention to the selection of burial place of urban residues can have irreversible effects on soil and water resources. The process of selecting the waste burial place is based on considering a variety of criteria and assessment to identify the best place of burial and removing disturbing factors (odor, dust, noise) and side long term effects (environmental pollution through underground water and water tables) [1].

Landfill selection is an important municipal planning process which affects different regions in economic, ecological, and environmental health sectors [2]. The landfill selection is driven by many issues such as availability of land, multiple regional and

[1]Young Researchers and Elite Club, Hamedan Branch, Islamic Azad University, Hamedan, Iran, corresponding author M. Kahvand, e-mail: M.Kahvand@iauh.ac.ir

state regulations, increasing amounts of waste production that complicate the process as well as the lack of information given to the public creates such as the "not in my backyard" (NIMBY) syndrome for sitting new landfills [3]. For example, in Japan, Ishizaka and Tanaka [4] discussed an attempt to create public awareness and alleviate the NIMBY syndrome through a risk communication approach. Baban and Flannagan [5] discuss the importance of two major issues for landfill selection: (1) approval of the local population, which is driven by social and political considerations and economic incentives, and (2) engineering and technical protocols for planning and protection of the physical environment. Although some recent techniques are intended to address both issues such as spatial decision support systems (SDSSs), which foster strategic planning by involving multiple stakeholders to incorporate conflicting views and preferences [6], herein we focus solely on the engineering and technical protocols for planning. The engineering and technical protocols for planning landfill sites also require a combination of diverse planner backgrounds for achieving a single decision goal using best management strategies while minimizing impacts to public health and the environment [7]. Geographic Information Systems (GIS) approaches are popular for planning and management because of their interdisciplinary character and because they link different backgrounds and disciplines. Such approaches have been widely used for variety of applications including: regional and urban planning [8], water resource management [6, 9], habitat site development, health care resource allocation [10], land suitability analysis [11, 12], and natural hazards [13].

Hamadan has a long history of traditional burial and recently there has a movement to its mechanized form in which the waste is scattered in an open area and the layer of soil is placed on it. The age of the waste burial site is 20 years and is estimated to reach 30–35 years in 20 years. Therefore, topology of burial is very important and many issues such as topography, slope, geology, land use seismology, surface water resources, faults, precipitation, vastness, population density, communication network, vegetation and distance from cities must be considered. The management of the residual removal is necessity in urbanization process.

2. MATERIAL AND METHODS

Waste burial development. Waste burial operations were considered to be a health process in 1950 in developing countries. In a research named application of GIS in topology of waste burial in Vermont, America, a 210 ha region was assessed by Hendrix [15] in terms of physical and economical indexes such as suitable soil, ground depth, land use, ground water and height to identify a suitable place. Naseri et al. did a GIS-base research in Ghahavand considering criteria such as geology faults, slope, urban centers, communication centers, distance from airport and weighing the indexes through paired comparison and found 5 separated sites in different dimensions. Locating the burial place based on fuzzy logic and geo-referencing data was carried out in north-eastern Sanandaj by Khorasani and Koraki [16], they applied different parameters of slope, earth statics, precipitation, distance from city to choose the site for waste burial. Some other scientists such as Narayanan et al. [17], and Nasiri et al. [18] did similar researches.

The criteria of selecting burial site are as follows:

1. Access through highways or roads under construction.
2. Distance to the gravity center of producing materials. This distance depends on the method of gathering. For example in the method of gathering with stationary vessels and movable vessels, the greater and less distance is ideal, respectively.
3. Land use and attention to future development of the city.
4. The life history of site (the selected site must be used for 20 years).
5. Aesthetical dimensions such as view.
6. Geological features of burial site.
7. Soil type and the structure of underground layers and access to coating materials.
8. The direction of underground water and its static level.
9. Natural situation of burial site.
10. Lowing lands.
11. Environmental conditions [19].

Site selection. It is to determine the most suitable place to establish and implement a project or a factory regarding social, economic and technical conditions [19].

The factors affecting the typology of burial. In general, a burial site must be located in a place which brings about the least damage economically and socially. A proper typology can remove half of the concerns for burial site. In Table 1, a list of all problems available in typology of a burial site are shown.

Economic, quality and quantity examination of produced waste, aesthetics and popular acceptance, topography, climatic situation geology and soil, assessment of hydrology of burial sites, transportation distance, access to road, water, and electricity and purification plant are most important factors [20].

Sloan Digital Sky Survey (SDSS). Densham [21] divided the decision making process to solve the spatial problems into the structural and non-structural process and SDSS was supposed to be the effect of interaction between computer systems and decision maker. SDSS combining the human knows to solve spatial problems with numerical data, proposes some measures to decision maker and enlarges the view horizon of decision maker. In other word, SDSS uses models including spatial information as input, and the output are different solutions to solve the problem. SDSS is an active system as it always helps the decision maker to create different strategies continuously and to compare them. SDSS is an interactive computer based system to support a user or a group of users to make decision in multi-criteria decision spatial problems which are located at the border of structural and non-structural decision making. The structural part is subordinate to automatic solution by computer with non-structural forms (unplanned) by programmers who are committed to do SDSS decision making. The effect is possible by combining computer based programs and decision makers judgment in decision making process [20].

Decision Support Systems (DSS), a branch of information systems, has been a topic of ongoing research for the past 30 years. They used data, models, and user interface components to help decision makers solve semi-structured or unstructured problems [22]. Unstructured decisions are defined as those for which no algorithm can be written, whereas algorithms can be specified for structured decisions. Semi-structured decisions fall between the other two [23].

GIS as an instrument for decision support. GIS can be seen as providing three essential types of facility: database, graphical display and spatial analysis. The first two, database and linked graphical display, can already provide a powerful instrument for decision support in many contexts, particularly in facilities management. The possibility to interrogate appropriate spatially referenced information through a map-based graphical interface can frequently provide the decision-makers with the information needed to address and manage their problems. Spatial analysis provides a way of enriching the information available to the decision-makers by generating new parameters from the spatially referenced data. In environmental management such parameters are typically indicators of the environmental impacts of proposed developments, or the number of people or other living species exposed to risk, noise and pollution. Existing GIS now provide a range of spatial analysis facilities, such as Boolean and numerical operations on different thematic layers, area analysis and network analysis, but it is frequently necessary to link the spatial analysis to other external calculations or simulation models in order to arrive at the required parameters on which to base a decision. One of the interesting challenges posed by currently available GIS technology is to devise ways of using the available spatial analysis facilities to generate parameters that are of most relevance to the required decisions. Another challenge is to develop new types of spatial analysis which are appropriate for a given decision context. An important aspect of GIS that is relevant to any planning situation is the capacity to integrate spatially referenced information coming from different sources. For example, in the context of urban planning different sources could typically include cadastral maps, population census data, maps of technical networks such as water and electricity lines, aerial photographs and even satellite remote sensing data. Once the data from different sources are structured in an integrated system, with possibilities for analysis and combination, the whole becomes more useful than the sum of the separate parts. An overview of applications and progress in the use of GIS in urban and regional planning is given by Scholten and Stillwell [24].

The status quo of a region. Many parts were investigated in this research to identify the region to get the information in decision making: geographical studies (plateau, hills, low height mountains, height zoning, ground water, mountains reservoir, faults, seismic actively), natural studies (political situation, climatic situation, climatic architectural division, bioclimatic division in the subdivisions, city slop, topographic situation of city, wind direction, plant action features, regional plant soil type, seismology of Hamadan), social and demographic studies (population change, household numbers, growth rate, management of waste removal residual management in Hamadan, features of a burial site).

3. RESULTS

The analysis of GIS by means of the Arc Map software has been used to characterize the burial site of landfill in Hamadan. The output of the system is presented on a map in a picture and raster form. In general, the factors influencing the topology of solid waste burial site can be divided into three groups of natural, economic and engineering factors. Geology factors, soil layer type, hydrology of land use, topography slope, physical development, access to city and climate problems such as dominate wind direction are the determining factors.

Table 1

Indices used for urban solid waste landfill selection

Rank	Index	Features
1	Situation	at least 10 km distance from urban region at least 1 km distance from populated centers, school and restaurant at least 1 km distance from industrial clusters at least 8 km distance from air port
2	Slope	less than 40%
	Slope direction	not in the south and west south direction
	Accessibility	there must be at least 800 m and at most 1 km distance from main roads
3	Precipitation	not in high precipitation region
	Wind	not in the direction of the west and north west wind
4	Geology	located in districts with low permeability
	Flout	100 m from faults
5	Soil science	the lower solid must not be from clay the covering soil must be from silite clay
6	Vegetation	not located in sites dangerous for vegetation
7	Land use	not adjacent to residential, agricultural and ranching regions
8	Ground water	at least 100 m from ground water recourses
	Stream	not in the direction of main stream
	Under ground water	at least 300 m from underground water resources
	Water wells	at least 200 m from water wells

The steps to locate the landfill in Hamadan. In this section, various steps of using the index in typology are explained and suitable options are suggested.

1. The criteria determined in the studies are listed on the layers on GIS in Arc Map software: They are: topology, land use, road networks, underground water, ground water, faults, slope direction, wind direction, urban physical development, protected regions, ranches, precipitation estimate, soil estimation.

2. After these layers were prepared in GIS, they were collected again in Arc Map and the criteria were determined, the layers prioritized.

3. The prioritized layers were reclassified, and systematized from most suitable to most unsuitable. As Figure 2 shows, in road network, surface water and groundwater factors, white color represents suitable areas and black color shows inappropriate locations.

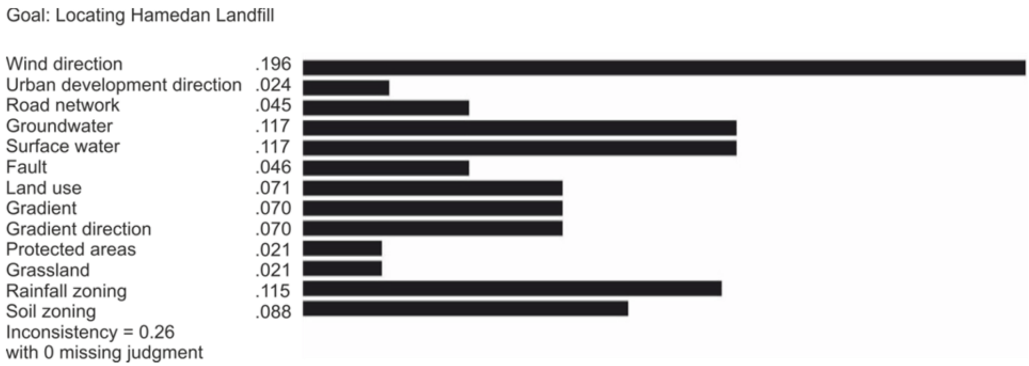

Fig. 1. Weighed criteria

4. After layers were classified the importance of each was specified by weighting by the AHP method (Fig. 1) on each other through mathematical overlapping and the most suitable landfill was found.

Figure 2a shows the buffered distance for roads where no landfill site is suitable to be constructed in, while Figs. 2b, c show the surface and groundwater. Based on the World Bank guidelines to encounter the leachate problem, a buffer distance of 300 m from the river and at least 100 m from groundwater recourses is considered for landfill location.

After these layers are combined in analytic advanced space of Arc Map, a raster layer is obtained which shows the suitability in the region. This raster layer shows the value of the lands for landfill as bright to dark tonality in that the brighter region is the most suitable region (Fig. 3). It is worth mentioning that the region under study is the 15 km radius of Hamadan and the city is separated from the study region as specified by white color.

Through presenting a model in GIS which includes all steps of locating a suitable landfill, we can save time and cost and use it in other cities by modeling the criteria and elementary data.

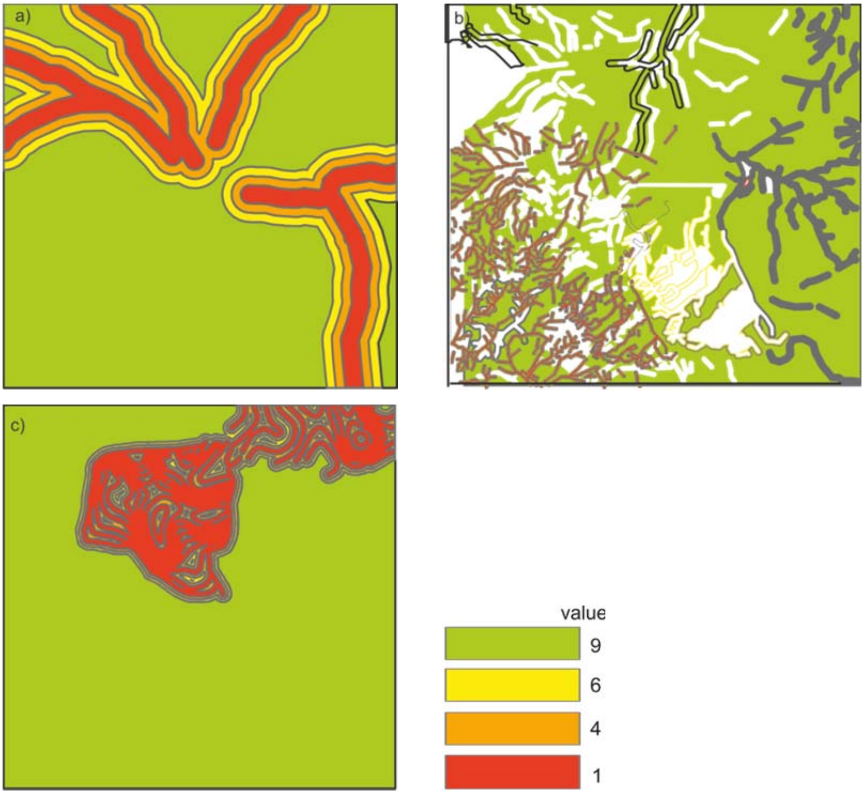

Fig. 2. Suitability maps (scale – 1:50 000) of environmental factors:
a) road network, b) surface water, c) groundwater

Fig. 3. The value of the lands in the studied region;
scale: 1:50 000

The presented model organized the criteria of selecting landfill in 11 layers as input. Then layer construction process will perform SHP layers, creating raster layers and reclassifying. Afterward, the model uses mathematical overlap for reclassified layers and makes raster. Finally raster layers are converted to the vector (Fig. 4).

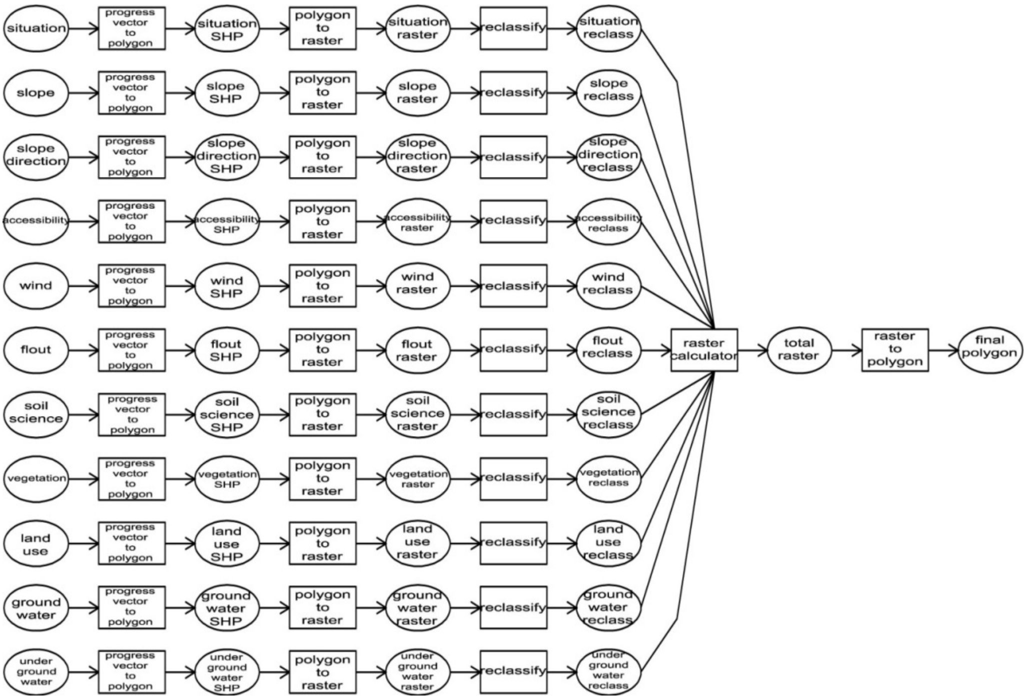

Fig. 4. GIS model for landfill selection

4. CONCLUSIONS

The aim of this study is to arrive at a suitable site for landfill sitting. Three potential sites were identified and one selected as a better alternative. This study has shown that the integration of GIS and SDSS is of the uttermost importance to effective and efficient waste management, as GIS enables one to manipulate data which are spatially referenced. Various spatial operations performed help to arrive at suitable sites for waste disposal. The north and northwest of Hamadan seems to be occupied with different land uses and high concentration of people, suitable sites for landfill were still found. Some areas are not provided for landfill and this has led to creation of many illegal dump sites, thereby degrading the environment at an alarming rate.

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