Landfill Siting for Municipal Waste: A Case Study in Ardebil

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Abstract

Landfilling has been recognized as the cheapest method for the disposal of municipal solid waste and as such has been the most used method in Iran. Landfill site selection is a complex process involving social, environmental, and economical parameters as well as government regulations. The aim of this study is to propose suitable sites for burial municipal waste in the Ardebil using Multi Criteria Decision Making (MCDM) method, field investigations and environmental study. In the first stage, restriction areas are identified and eliminated using integration Geographic Information System (GIS) and Analytical Hierarchical Process (AHP). Then other criteria categorized and weighted using AHP method. By overlapping all of criteria maps 12 sites are recognized as landfill prone areas. In the second stage, eight sites were eliminated during the site investigations study and remining 4 sites were introduced as suitable sites. Finally site No. 6 is proposed as the most appropriate site based on the environmental and social-economical considerations were carefully evaluated with Technique

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for Order Preference by Similarity to Ideal Solution (TOPSIS) method.

Keywords: Ardebil, Landfill Sitting, GIS, MCDM

Introduction

The rapid growth of population and urbanization result to decreasing the non renewable resources and inceasing municipal waste [1]. Therefore it is necessary to have a waste management scheme that is comprehensive and consistent across an urban area in which the division of responsibility is clarified, recognized and accepted by all [2]. Solid wastes that are generated from industrial organizations and urban areas create serious environmental problems. At present, there are various techniques being used for solid waste management such as landfill, thermal treatment, biological treatment, and recycling [3]. Sanitary landfill is the most cost-effective system of solid waste disposal for most urban areas in developing countries. The first and most important step in planning solid waste landfill is the site selection for solid waste disposal [4]. Landfill sitting requires an extensive evaluation process in order to identify the best available disposal location. This location must comply with the requirements of governmental regulations and at the same time must minimize economic, environmental, health, and social costs [5]. It is evident that many factors, with spatial dimension, must be combined into landfill sitting decisions. Geographic Information Systems (GIS) are ideal for such studies due to their ability to collect, store, manipulate, process and analyze large volumes of spatial data from a variety of sources.

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GIS have the capability to handle and integrate the necessary economic, environmental, social, technical, and political factors and constraints [6]. Site selection is a kind of decision making process that requires criteria to be weighted and alternatives to be evaluated and ranked. Integration between Multi Criteria Decision Making (MCDM) and GIS is needed to solve the site selection problem as GIS is used to handle the spatial aspect of the problem and MCDM is used to calculate weights of the criteria ranking of alternatives [7].

A number of multi criteria decision techniques have been used in the landfill sitting process in the past. For example, Shahba et al (2013) investigated landfill sitting in Sirjan- Iran by using Analytic Network Process (ANP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) approach [8]. Huang et al. (2006) presented GIS- based Analytical Hierarchical Process (AHP) for the suitability analysis of nuclear waste disposal site in Canada [9]. Yahaya et al (2010) used GIS and multicriteria evaluation identified a suitable landfill site for waste disposal in North Local Government Area of Ibadan, Nigeria [10]. Sener et al. (2011), determined candidate sites for an appropriate landfill area in Cumra County of Konya by using the integration GIS and multi-criteria evaluation (MCE) [11]. Paul (2012), proposed a site for urban waste disposal using multi-criteria analysis and GIS in West Bengal, India [12]. Issa and Shehhi (2012) stated that 30% of the Abu Dhabi, United Arab Emirates was as highly suitable for construction of landfill by using GIS and multi-criteria evaluation [6]. Ferretti (2011) generated a suitability map for locating a waste landfill in the province of Torino in Italy based on the

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integration GIS and ANP [13]. Kontos et al. (2005) has utilized spatial methodology such as multiple criteria analysis, GIS, spatial analysis and spatial statistics ~~and~~ based on Greek and EU legislation that identified 9.3% of the island of Lemons is suitable for landfill sitting [14]. Hanbali et al. (2011) selected optimum solid waste disposal sites within Mafraq City, Jordan using GIS-based weighted linear combination analysis and remote sensing techniques [15]. Tamilenthi et al (2011) found out the potential waste disposal sites using remote sensing and GIS techniques for Karaikudi Municipality in India [16]. Elalfy et al. (2010) identified five areas as the most suitable location for landfill in Mansoura city, Egypt by using an integration of GIS and MCDM [17]. In another example Chang and others (2008) reported combining GIS with fuzzy multicriteria decision-making for landfill siting in a fast-growing urban region of Texas [18]. Azizi Ghalati el al. (2014) with application of hierarchical fuzzy TOPSIS method found suitable sites for burring municipal wastes in Shahriar town [19]. Saiedi et al. (2010) using from GIS and methods of DRASTIC and MPCA determined prone zones for burial waste then for evaluation prone zones used from method of AHP [20]. Jafari et al. (2013) using two methods AHP and Simple Additive Weighting (SAW) in environment GIS determined prone areas for burial wastes municipal in Kohkiloieh and Boerahmad province [21]. In this study, a most suitable lansfill site for Ardebile city is proposed based on a 4 steps study including eliminated of restricted areas, producing landfill prone area map, elimination of unstuitable sites by site visiting and finally selection of most sutitable site using TOPSIS method.

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Materials and Methods

Study Area

Ardebil city is located in the northwest Iran in central part of Ardebil province (Figure 1). This region is part from west Alburz-Azarbayjan zone. North parts of area are formed from volcanic, andesitic basalt, trachy andesite, trachy basalt, pyroxene andesite and basaltic lava flows of Eocene. West parts of area involving conglomerate with some tuff, volcanic ashes, lahar deposites, Sabalan tephra with mainly vesicular basaltic fragments, porphyritic andesitic and lava flows of Quaternary. Neogene units including marl with intercalations of fresh water limestone, conglomerate and sandstone were observed in south of study area. Central part of area includes recent alluvium, plain deposits, young alluvial terraces and gravel fans. Generation sources of municipal solid waste in Ardebil city are households, markets, restaurants, government offices, parks, hospitals, collages and schools. The total quantity of waste generated in Ardebil is 300 ton/day. A qualitative analysis indicates that the solid waste generated in Ardebil contains a fairly high percentage of organic matter and wet.

Data and information used

Data and maps necessary collected from difference sources. In this study used from GIS for site selection as that the available information for the study area were digitized to UTM coordinate system (WGS 1984 UTM Zone 39N) in environment software package ArcGIS 9.3. Table.1 is shown data and information used from different sources and their application type in this study.

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Table1. Data and information used from different sources and their application type

Data and maps	Data sources	Application type
Geology map of Ardebil with scale 1:100000	Geological and mineral exploration organization of Iran	Digitizing geological and lithology layers and faults
Topographic maps of Ardebil1, Ardebil 2, Sarein and Somarian with scale 1:50000	Geographical organization of Iran	Digitizing topographic map in order to build TIN and extracting slope and elevation difference relative to city layers and Digitizing roads, industrial settlement, mines, airport, city and rural of areas and central of tourism
Map of studies Resource assessment and capability territorial province Ardebil with scale 1:250000	Agricultural jihad organization of Ardebil province	Digitizing geomorphologic and soil texture layers
Vegetation cover map of Ardebil with scale 1:250000	Natural resource organization of Ardebil province	Digitizing vegetation cover layer
Earthquake hazard map of Ardebil with scale 1:250000	Governor of Ardebil province	Digitizing earthquake hazard layer
Data weather of Ardebil municipality (temperature, precipitation, evaporation, wet and prevailing wind orientation)	Meteorological Organization of Ardebil province	Building interpolate layer from excel data and extracting isorain map
Data water resource of Ardebil municipality (well, spring, quant, pizometer, lake, dam and river)	Ardebil province regional water authority	Building interpolate layer from excel data and extracting isopize and isoconduct electrical maps, providing change depth of water and change electrical conduct of water layers, digitizing water resource layers
Data and statistics rate produced waste, waste composite and management municipal waste in Ardebil city	Waste and recycling organization of Ardebil city	calculating rate produced waste for a period 20 year in order to calculate area used for a period 20 year
Data location clay resource	Industrial and mineral organization Ardebil province	Providing layer of distance from resource fine material

Methods used

In this study, landfill site selection is performed using AHP and TOPSIS methods. The AHP process is developed into three principal steps. The first hierarchy of a structure is the goal. The final hierarchy involves identifying alternatives, while the middle hierarchy levels appraise certain factors or conditions.

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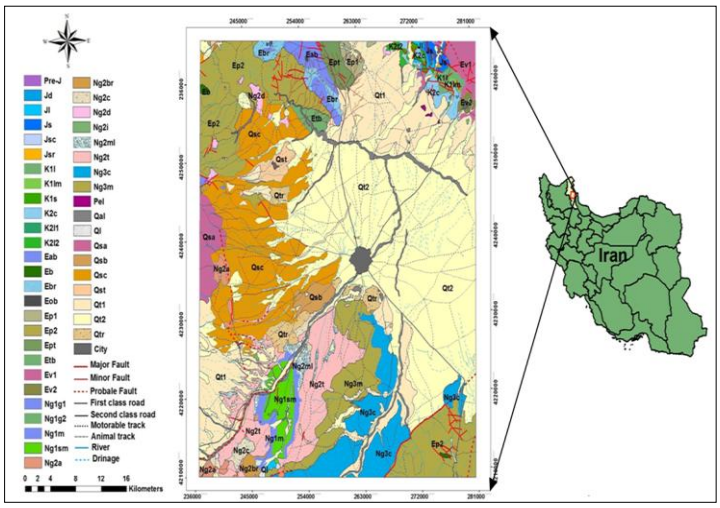

Figure 1. Location and geology of the study area [22]

The second step computes the element weights of various hierarchies by means of three sub-steps. The first sub-step establishes the pair- wise comparison matrix. In particular, a pair-wise comparison is conducted for each element based on an element of the upper hierarchy that is an evaluation standard. The second sub-step computes the eigenvalue and eigenvector of the pair-wise comparison matrix. The third sub-steps perform the consistency test. In particular, the difference between the dominant eigenvalue of the pair-wise

comparison matrix, λ_{max} , and the matrix dimension, k, is used in defining the inconsistency index, II:

$$II= [(\lambda_{max}-K)/(K-1)]$$

The inconsistency ratio, IR, is then defined as:

$$IR=II/CRI$$

Where CRI is the inconsistency index of the random matrix obtained by calculating II for a randomly filled matrix. If IR<10%, then the consistency criterion is satisfied [23].

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In TOPSIS method, after forming an initial decision matrix, the procedure starts by normalizing the decision matrix. This is followed by building the weighted normalized decision matrix in Step 2, determining the positive and negative ideal solutions in Step 3, and calculating the separation measures for each alternative in Step 4. The procedure ends by computing the relative closeness coefficient. The set of alternatives (or candidates) can be ranked according to the descending order of the closeness coefficient. Figure 2 presents the stepwise procedure of Hwang and Yoon (1981) for implementing TOPSIS [24].

Step 1: Construct normalized decision matrix
$r_{ij}=x_{ij} / \sqrt{(\sum x^2_{ij})}$ For $i= 1, \dots , m$ $j= 1, \dots , n$ (1)
where x_{ij} and r_{ij} are original and normalized score of decision matrix, respectively respectively

Step 2: Construct the weighted normalized decision matrix
$v_{ij} = w_j r_{ij}$ (2)
where w_j is the weight for j criterion

Step 3: Determine the positive ideal and negative ideal solutions.
$A^*= \{v_1^*, \dots , v_n^*\}$ (3) Positive ideal solution
$v^*= \{ \max (v_{ij}) \text{ if } j \in J ; \min (v_{ij}) \text{ if } j \in J'\}$
$A^- = \{v_1^- , \dots , v_n^-\}$ (4) Negative ideal solution
$v^- = \{\min (v_{ij}) \text{ if } j \in J ; \max (v_{ij}) \text{ if } j \in J'\}$

Step 4: Calculate the separation measures for each alternative.
The separation from positive ideal alternative is:

Step 5: Calculate the relative closeness to the ideal solution C^*_i
$C_i^*= s_i^- / (s_i^*+ s_i^-)$ $0 < C_i^*< 1$
Select the Alternative with C_i^* closest to 1.

Figure 2. Stepwise procedure for performing TOPSIS methodology [24]

Results and Discussion

1. Mapping areas of prone for landfill using AHP method

In preliminary restriction areas which means that those areas where landfill sitting was impossible such as urban and rural areas, airport, tourism areas, roads, rivers and drains, groundwater resources (wells,

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springs, quant), power lines, fault zone, dams, mines, industrial areas, lakes and irrigation canals were identified. Buffering process was assigned from section of ArcToolbox/Analysis Tools/proximity in environment software package ArcGIS 9.3 according to the literature [4, 6, 10, 13, 17, 25, 26, 27, 28, 29, 30, 31 and 32] for elimination restriction areas from suitability map. Buffer zones considered for restriction areas are shown in Table 2. Figure 3 and 4 are presented restriction areas and buffer zones, respectively.

Table 2. Buffer zones considered for restriction areas

Restriction areas	Buffer performed in this study (meters)	Sources used
Urban areas	2000	[17, 26 and 27]
Rural areas	1000	[26, 28 and 29]
Airport	2000	[17, 25, 27, 28 and 29]
Tourism areas	2000	[6, 17 and 27]
Major road	500	[4, 6, 10, 13, 28, 29, 30 and 32]
Minor road	100	
River	500	[4, 6, 13, 17, 26, 28, 29, 30 and 32]
Seasonal drain	250	
Lakes, irrigation canals and dams	300	
Wells, springs, quant	300	[4, 6, 26, 27 and 30]
Power lines	50	[31]
Fault	300	[26, 27 and 30]
Industrial areas	500	[13, 29 and 31]
Mines	500	[31]

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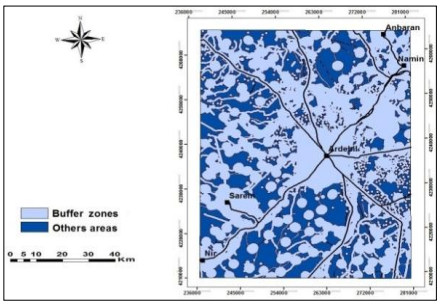

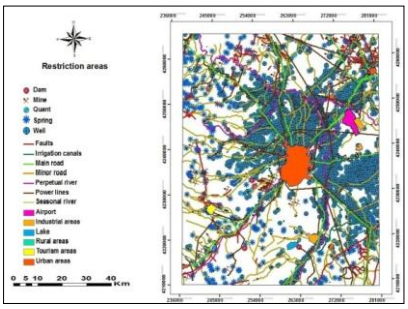

Figure 3. The restriction areas map **Figure 4. The Buffer zones map**

In the second stage, thirteen criteria that play an important role in selecting a landfill site were identified. These criteria are including ground water depth, ground water quality, lithology, geomorphology slope, soil texture, vegetation cover, elevation difference relative to city, distance from city, availability of fine grain, earthquake hazard, distance from major road and distance from minor road. Pair-wise comparison matrix was constructed for comparing pairwise thirteen criteria. Then relative important each criterion determined. Criteria weights were calculated using arithmetic average method in Matlab software environment. Highest and lowest weight is allocated to criterion groundwater depth and distance from minor road, respectively. Pair-wise comparison matrix developed for thirteen criteria is shown in Table 3. The consistency ratio (IR) of matrix was calculated according to the methodology proposed by Saaty (1980). According to this method amount IR should be lower than 0.1. If IR>0.1, making some changes in comparisons and weighting, we should adjust the IR at an acceptable level. IR this matrix was 0.08

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and was lower than 0.1 which indicated that comparisons and weightings were done with accuracy.

In the third stage, each criterion separately according to local conditions for landfill sitting and Iran Waste Management Regulations and also based on the reviews of the literatures [11, 13, 27 and 30] were classified into four classes very suitable, suitable, fairly suitable and unsuitable (except earthquake hazard criteria). In Table 4 is presented classify each criterion into four sub- criteria and maps of criteria classified into sub-criteria is shown in Figure 5. Pair-wise comparisons matrices were constructed for sub-criteria comparisons and after evaluating sub-criteria their weights were also calculated using arithmetic average method in Matlab software environment. Then consistency ratio is also calculated that were lower than 0.1 in the whole matrices. Weights are calculated for each sub - criterion is presented in Table 4. Final weight each sub-criterion calculated via multiply weights each criterion in its sub-criteria weights. Results calculate final weight each sub-criterion is presented in Table 4.

In the next stage, in GIS environment total layers were converted to raster based on their final weight of fields. Then in part of raster calculator calculated sum of weights of layers and created suitability map with change of score from 0.02 to 0.32. Score range with quantile method was classified into four classes of unsuitable (to range 0.02-0.1), fairly suitable (to range 0.1-0.17), suitable (to range 0.17-0.25) and very suitable (to rang 0.25-0.32). Although buffer zones are typically excluded at the start of research, the exclusion step is this

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study was carried out at the end, after the AHP evaluation and obtaining a suitability map. Eliminating buffer zones from suitability map

Table 3. pair-wise comparison matrices of thirteen criteria

Criteria	Ground water depth	water quality	Lithology	Geomorphology	Slope	Soil texture	Vegetation cover	Elevation difference	Distance from city	Availability of fine grain	Earthquake hazard	Distance from major road	Distance from minor road	Weight each criteria
Ground water depth	1	3	3	4	4	3	4	4	5	5	5	7	8	0.21
Ground water quality	0.33	1	2	3	3	2	3	4	4	3	4	5	7	0.14
Lithology	0.33	0.5	1	3	3	2	3	4	4	4	5	6	7	0.13
Geomorphology	0.25	0.33	0.33	1	2	2	3	4	4	3	5	5	6	0.1
Slope	0.25	0.33	0.33	0.5	1	2	3	5	4	4	4	5	6	0.09
Soil texture	0.33	0.5	0.5	0.5	0.5	1	3	4	4	2	4	4	5	0.08
Vegetation cover	0.25	0.33	0.33	0.33	0.33	0.33	1	3	3	3	4	4	5	0.06
Elevation difference	0.25	0.25	0.25	0.25	0.2	0.25	0.33	1	2	2	4	4	5	0.05
Distance from city	0.2	0.25	0.25	0.25	0.25	0.25	0.33	0.5	1	2	4	3	4	0.04
Availability of fine grain	0.2	0.33	0.25	0.33	0.25	0.5	0.33	0.5	0.5	1	4	3	4	0.04
Earthquake hazard	0.2	0.25	0.2	0.2	0.25	0.25	0.25	0.25	0.25	0.25	1	2	3	0.02
Distance from major road	0.14	0.2	0.16	0.2	0.2	0.25	0.25	0.33	0.33	0.33	0.5	1	3	0.02
Distance from minor road	0.12	0.14	0.14	0.16	0.16	0.2	0.2	0.25	0.25	0.25	0.33	0.33	1	0.01

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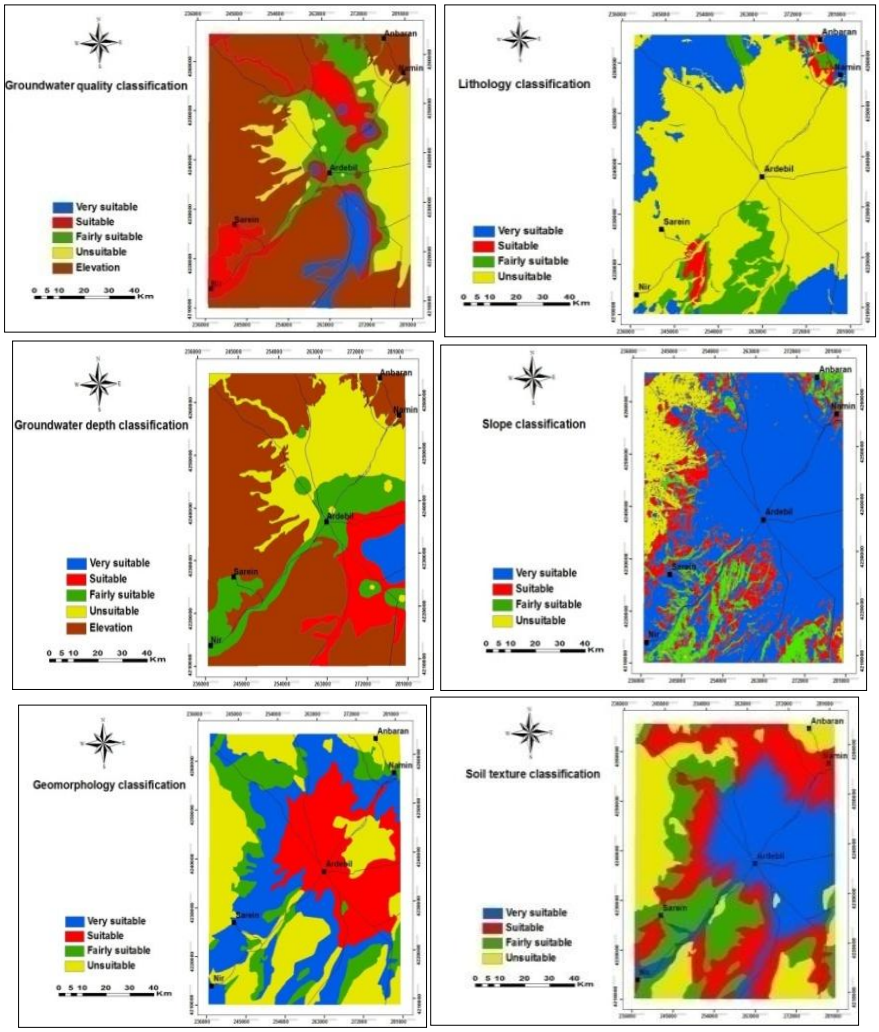
Showed that very suitable class with involving 96km^2 of the Ardebil area was presented 12 sites suitable for the construction of landfill. Figure 6 is presented final suitability map combined with buffer zones and location 12 sites.



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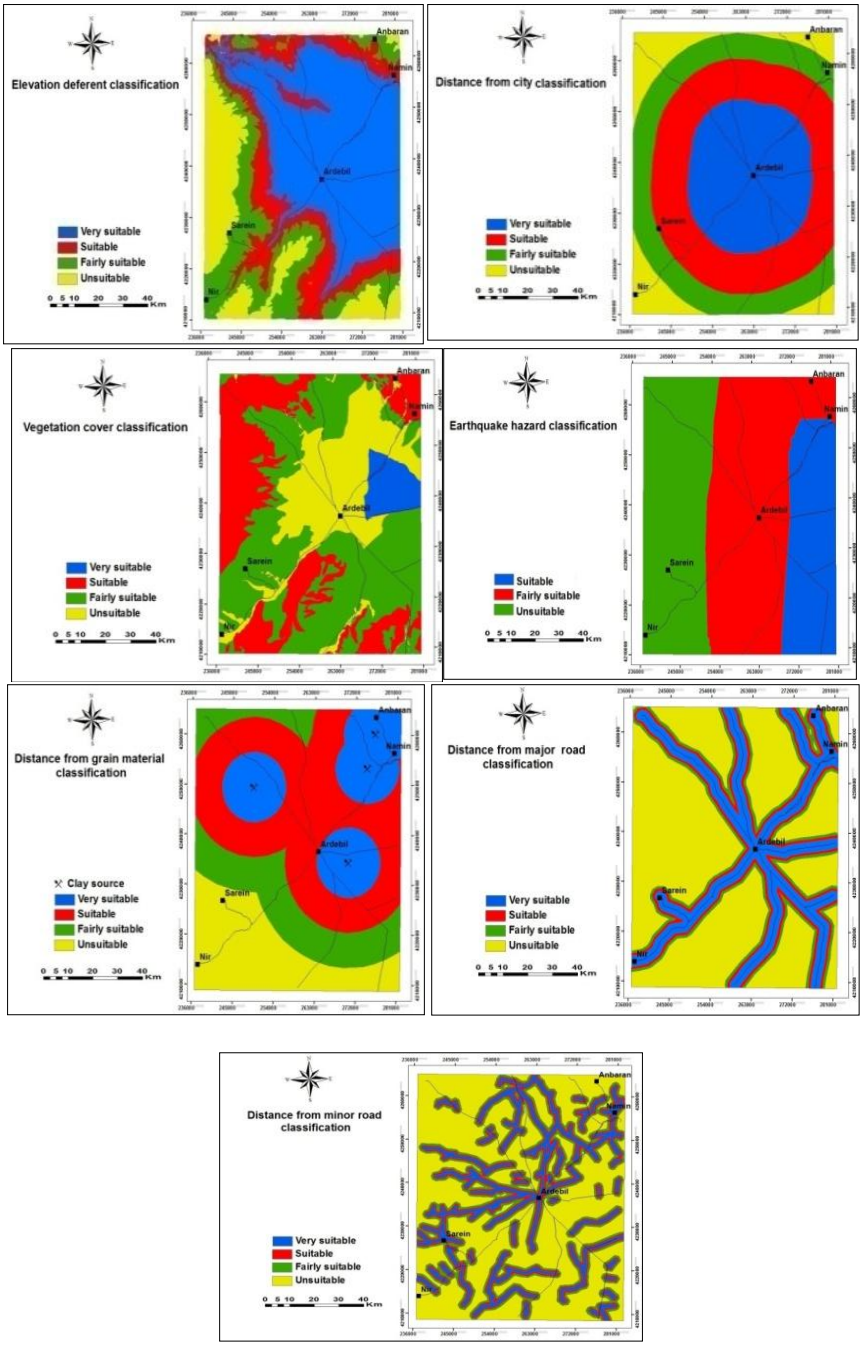

Figure 5. Maps of criteria classified into sub-criteria

Table 4. Results calculating weights of criteria and sub-criteria is used in this study using arithmetic average method

Criteria	Sub-criteria classification	Qualitative description each sub-criteria for landfill sitting	Weight each sub-criteria	Weight each criteria	Final weight each sub-criteria
Ground water depth (m)	40<	Very suitable	0.62	0.21	0.1302
	25-40	suitable	0.21		0.0441
	10-25	Fairly suitable	0.11		0.0231
	<10	Unsuitable	0.04		0.0084
Ground water quality (EC)	2250<	Very suitable	0.56	0.14	0.0784
	1750-2250	suitable	0.25		0.035
	1250-1750	Fairly suitable	0.11		0.0154
	<1250	Unsuitable	0.05		0.007
Lithology	Porphyritic andesitic basalt andesitic lava flows, dacite, ignimbrite, trachy basalt and pyroxene andesite, olivine basalt and analcime bearing trachyandesite	Very suitable	0.58	0.13	0.0754
	Red sandstone and shale, alternation of shale and sandstone with intercalations of limestone and dolomitic, alternation of siltstone and shale with intercalation of limestone	suitable	0.25		0.0325
	Crystallized limestone, thin bedded marly limestone, alternation of red sandstone and marl with intercalation of gypsum	Fairly suitable	0.11		0.0143
	Recent alluvium and young alluvial terraces, plain deposits and gravel fans, conglomerate with some tuff, volcanic ashes and lahars deposits, travertine, yellowish tuff	Unsuitable	0.05		0.0065
Geomorphology	Flats and terraces	Very suitable	0.56	0.1	0.056
	Plain of alluvium, plain of deposit	suitable	0.25		0.025
	Hills	Fairly suitable	0.13		0.013
	Mountains areas, active flood plains	Unsuitable	0.05		0.005

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Criteria	Sub-criteria classification	Qualitative description each sub-criteria for landfill sitting	Weight each sub-criteria	Weight each criteria	Final weight each sub-criteria
Slope (percent)	<5	Very suitable	0.55	0.09	0.0495
	5-10	suitable	0.26		0.0234
	10-15	Fairly suitable	0.12		0.0108
	>15	Unsuitable	0.05		0.0045
Soil texture	Deep soils to very deep with heavy texture to very heavy	Very suitable	0.58	0.08	0.0464
	Semideep soils to deep with mean texture to heavy	suitable	0.26		0.0208
	Shallow soils to semideep with mean texture to heavy and involving gravel	Fairly suitable	0.09		0.0072
	Very shallow soils to shallow, areas without soil cover with rock outstanding	Unsuitable	0.04		0.0032
Vegetation cover	Uncultivated lands	Very suitable	0.57	0.06	0.0342
	Range lands	suitable	0.26		0.0156
	Dry farming	Fairly suitable	0.1		0.006
	Irrigated farming, orchards	Unsuitable	0.05		0.003
Elevation difference (m)	0±50	Very suitable	0.53	0.05	0.0265
	50±150	suitable	0.27		0.0135
	150-300	Fairly suitable	0.13		0.0065
	>300	Unsuitable	0.05		0.0025
Distance from (Km) city	<10	Very suitable	0.56	0.04	0.0224
	10-15	suitable	0.25		0.01
	15-20	Fairly suitable	0.12		0.0048
	>20	Unsuitable	0.06		0.0024
Availability of (fine grain Km)	<7	Very suitable	0.56	0.04	0.0224
	7-14	suitable	0.28		0.0112
	14-21	Fairly suitable	0.11		0.0044
	>21	Unsuitable	0.06		0.0024
Earthquake hazard	low	suitable	0.67	0.02	0.0134
	mean	Fairly suitable	0.24		0.0048

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Criteria	Sub-criteria classification	Qualitative description each sub-criteria for landfill sitting	Weight each sub-criteria	Weight each criteria	Final weight each sub-criteria
	high	Unsuitable	0.08		0.0016
Distance from major road (m)	500-1000	Very suitable	0.5	0.02	0.01
	1000-1500	suitable	0.27		0.0054
	1500-2000	Fairly suitable	0.15		0.003
	>2000	Unsuitable	0.07		0.0014
Distance from minor road (m)	100-300	Very suitable	0.46	0.01	0.0046
	300-600	suitable	0.3		0.003
	600-1000	Fairly suitable	0.13		0.0013
	>1000	Unsuitable	0.07		0.0007

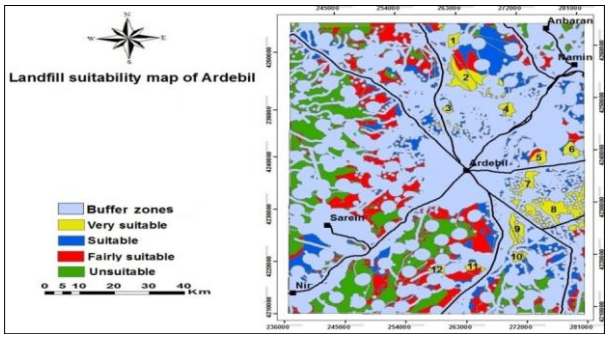

Figure 6. The suitability map with taking into buffer zones and location 12 sites determined

Considering map 5 it can be realized that 96% of the whole study area isn't suitable for the construction of landfill. Accordingly, only 4% of the study area can be evaluated in more details based on the standards. Considering exceptional conditions of Ardebil city e.g. irrigated farming of city surrounding, shallow groundwater in more extent from north and east north of study area, high concentration wells in central part the Ardebil plain, high dispersal villages with

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distance lower from each other in the whole study area, unsuitable location of landuses, limit be much part from surrounding of study area with elevations, future development of the Ardebil city toward southwest and tourism be part of area southwest scarcity of lands for construction of landfill is a dominant limiting factor.

2. Field investigations

In order to check the suitability of the determined areas, field investigations were performed from the 12 sites. 8 sites were eliminated and 4 sites were selected. As the site1 is located in too far from producing center and access roads and also high cost construction of landfill, furthermore is located on agricultural lands with high ownership cost. The site 3 is located in draining zone of Ardebil aquifer toward Gharaso River where that groundwater level is very high and also on irrigated farming with high ownership cost. Sites 7, 8 and 9 are located in zones irrigated farming with high ownership cost. Site 10 is located in too far from producing center and access roads. Site 11 and 12 are located in too far from producing center and access roads and also in on draining surfaces toward Ghorichay River. Sites 2, 4, 5 and 6 resulted as suitable zones. In Figure 7 is shown location selected sites and eliminated sites.

3. The most appropriate site

Sustainable develop can be considered as maximizing develop economical and social to minimizing environmental destructive impacts. In order to exist sustainable develop should be taken

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integration environmental and economical considerations in decision different surfaces in order to assess site implementation projects. In this stage in order to select the most appropriate site point of views economical-environmental, the 4 alternatives (sites 2, 4, 5 and 6) were evaluated with TOPSIS method.

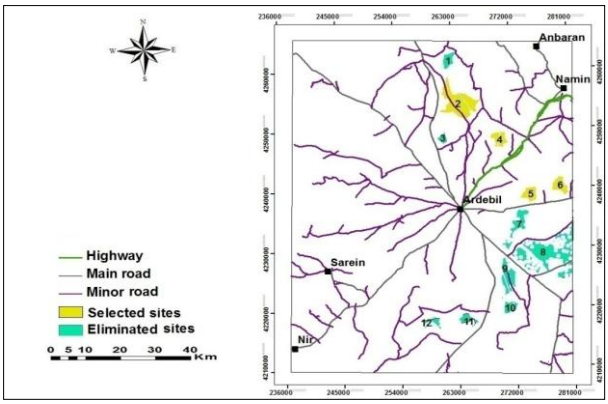

Figure 7. Location selected sites and eliminated sites

4 alternatives (sites 2, 4, 5 and 6) were evaluated by 24 parameters of distance from power line, surface drainage, road construction cost, elevation difference relative to city, land ownership, region extent, distance from city, distance from major and minor roads, availability to fine materials, flood protection cost, leveling cost, earthquake hazard, soil depth, geomorphology, soil texture, slope, lithology, precipitation, distance from perpetual river, landuse, orientation wind, water quality and groundwater depth. Decision matrix $4^{*}24$ is constituted based on 4 alternative and 24 parameters (Table 5).

Alternatives were evaluated with parameters investigation and were scored from 1 to 7 based on effectiveness each alternative on the each parameter. The decision matrices normalized and calculated the

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weighted normalized decision matrices (considering important coefficient for each parameter from 1 to 9). After determining the ideal and negative-ideal solutions, distances of each alternative from the ideal and negative-ideal solutions were determined. In the end, similarity index was calculated that the result is represented in Table 6. Similarity index values change from 0 to 1. The best alternative is the one with the greatest relative closeness to 1(or highest similarity index). Site 6 with 0.65 similarity index is introduced as the most appropriate site.

Calculating the area of required for burring Ardebil municipal waste in the following 20 year

In order to calculate the area of required for burring Ardebil municipal waste in the following 20 year should be considered factors such as: the rate of waste producing, the rate of population growth, the density of condensed waste, produce rate of annual waste, volume of annual waste, estimating of waste volume during the following 20 year and volume of daily cover. According to the information given from the census, the population of Ardebil city in 1375 and 1385 was 340386 and 418262 respectively [34]. Comparing statistics years of 1375 and 1385 show the rate of population growth is 2 percentages. Considering the population of Ardebil city by 1415 is required for estimating waste volume and land area, therefore population of year 1415 calculated using formula following:

$$P_t=P_0(1+r)^t$$

P_o population in start year, P_t population in destination year, t the number of years considered for landfill project and r is the rate of

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Table 5. The decision matrix

Parameter	Distance from power line	Surface drainage	Road construction cost	Elevation difference relative to city	Land ownership	Region extent
Important coefficient	2	6	6	6	6	5
Site 2	6	6	7	6	7	5
Site 4	4	7	6	5	7	6
Site 5	7	1	4	3	3	1
Site 6	7	3	2	7	3	7
Parameter	Distance from city	Distance from major roads	Distance from minor roads	Availability to fine materials	Flood protection cost	Leveling cost
Important coefficient	5	2	4	7	5	5
Site 2	7	1	7	7	6	7
Site 4	4	7	6	6	5	7
Site 5	5	4	4	5	1	7
Site 6	3	7	1	۲	7	4
Parameter	Earthquake hazard	Soil depth	Geomorphology	Soil texture	Slope	Lithology
Important coefficient	4	6	7	7	7	8
Site 2	7	7	7	7	7	7
Site 4	7	7	7	7	7	7
Site 5	5	5	7	7	7	4
Site 6	5	3	3	2	5	4
Parameter	Precipitation	Distance from perpetual river	Landuse	Orientation wind	Water quality	Groundwater depth
Important coefficient	4	6	6	9	8	9
Site 2	2	7	7	1	1	6
Site 4	1	7	7	4	1	7
Site 5	4	1	3	7	5	1
Site 6	4	2	3	7	5	3

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Table 6. Results of similarity index calculations

Alternatives	Site 2	Site 4	Site 5	Site 6
Similarity Index	0.47	0.46	0.6	0.65

population growth [35]. Considering the rate of population growth, the population of Ardebil city is 509859 person in 1395. Calculating population of Ardebil city in 1415 is as follows:

$$P_t = 509859\ (1+0.02)^{20} = 742768$$

According to information taken from Ardebil mayor rate of waste produced in 1395 year in Ardebil city is 300 ton/day. Therefore amount volume of waste annual is as follows:

Weight of waste annual = 300×1000×365=109500000 kg

Density of condensed waste = 620 kg/m^3

Considering waste density, volume of waste annual equal to:

109500000/620=176613m^3

Considering the rate of population growth, volume of total Ardebil municipal wastes in the following 20 year (years 1395-1415) will be 4417022 m^3. Assuming volume of clay soil for covering waste is equal to 25 percentage of volume of condensed wastes, therefore considering volume equal to 1104255 m^3 as cover soil, total volume of materials entrance to status during the following 20 year is equal to 5521277 m^3.

In order to calculate surface of land required for burial waste in the following 20 year preliminary assumes that wastes will bury in trenches with dimension 10*4 and depth 4 meter and distance between trenches is 4m. Considering trenches width and distance among those assumes equal, therefore effect surface includes 50 percentage of surface total. Considering waste volume produced in the following 20 year (5521277 m^3) and trench depth, effect surface required for burial

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of Ardebil municipal waste is equal to 1380319 m^2 and total surface is equal to 2760638m^2 (with an area of approximately 276 hectare or 2.760638km^2). Considering infrastructures of landfill construction would require an area of approximately 4 km^2.

Area of sites 2, 4, 5 and 6 are 12.6 km^2, 4.53 km^2, 4 km^2 and 4.73 km^2 respectively. Thus sites 4, 5 and 6 are appropriate just for landfill construction in a period 20 year and other methods of waste disposal such as construction of combustion plant cannot perform. Considering area site 2 is very high in this status either can perform landfill construction or combustion plant construction.

In results of study landfill sitting in Shahriar town by Azizi Ghalati el al (2014), preliminary using hierarchical fuzzy TOPSIS method determined 31 alternatives. Then alternatives evaluated with TOPSIS method and 3 sites concluded. Although in this study was tried with aid GIS and hierarchical fuzzy TOPSIS method determines the best site, however field investigations wasn't performed for comparison and adjustment of findings with realities [19]. In study of Saiedi et al (2010) using from GIS and methods of DRASTIC and MPCA determined 9 sites for construction landfill in Ghazvin province. In the next stage prone zones scored using AHP method and in the end selected one alternative. Considering one of important parameters in landfill site selection is prevention from water contamination, therefore in this study use from methods of DRASTIC and MPCA for mapping of prone areas is a definite. One of defects this study it is that sites determined from the stage first without field investigations was scored [20]. In study Jafari et al (2013) using two methods AHP and

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SAW in environment GIS in Kohkiloieh and Boerahmad province, only was paid to compare use from two methods AHP and SAW in finding prone areas for burial waste and results showed AHP is better than SAW [21]. On the other hands one of other defects studies mentioned it is that restriction areas identify and didn't eliminate. Ferretti (2011) in study of siting a landfill in the province of Torino (Italy) based on the integration of GIS and ANP concluded that the spatial ANP is useful tool to help technicians to make their decision process traceable and reliable [13]. In result study Nas el al (2010) about of landfill siting for Konya in Turkey determined three sites and in result study Vasiljevic et al (2012) about of landfill siting in Serbia determined five sites. In both studies authors concluded that selection the best site require further field research [4 and 25].

In studies that stated, authors only suggested a methodology to select best solid waste disposal site based on integration of GIS and MCDM. In this study tried either with application GIS and AHP method or field investigations selects the best site. Study of first stage performed with use from integration GIS and AHP based on data and information collected. Study of second stage performed based field checks. In this stage investigated findings of first stage during field studies and compared findings with realities and aims. Unsuitable sites eliminated and suitable sites evaluated with TOPSIS method for selecting the best.

Conclusion

Adopting approaches of prevented in programming environmental is the most effectives of approach for avoiding from environmental

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consequences of human actives in each level. In among prevented approaches, environmental sitting of different projects such as waste burial sites will have effective role for avoiding from possibility hazardous. MCDM methods such as AHP with creating of brain comparisons between qualitative and quantitative of parameters cause of easy analysis for selecting suitable sites in order to construct landfill. In this research, is paid to study landfill site selection municipal waste in the Ardebil. In the first stage using integration AHP and ArcGIS 9.3, 12 sites determined. After from finishing study of the first stage and determining 12 sites suitable for landfill construction, in order to completion and adjustment information and comparing of findings with realities and aims performed field investigation from 12 sites. Based on field checks 8 sites eliminated and 4 sites selected. The most important of reasons eliminating these sites during field checks was their locating on irrigated farming with high ownership cost, very high the price of lands and public no acceptance.

Site 5 with area 4 km^2 is located in land with slope lower from 7 percentage, clay soil texture, distance 11km from city, distance 21km from fault and 50m from groundwater level. Site 6 with area 4.73 km^2 is located in land with slope lower from 7 percentage, silty-clay soil texture, distance 16km from city, distance 22km from fault and 45m from groundwater level. Site 4 with area 4.53 km^2 is located in land with slope lower from 7 percentage, clay soil texture, distance 14km from city, distance 15km from fault and 15m from groundwater level. Site 2 with area 12.6 km^2 is located in land with slope lower from 7

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percentage, silty-clay soil texture, distance 18km from city, distance 13km from fault and 30m from groundwater level. Four sites were evaluated with TOPSIS method. In result site 6 is introduced as the most appropriate site. From advantages site 5 and 6 can mention low level groundwater, depth being soil of fine texture, near to usable roads and near to city that caused these alternatives take high score in TOPSIS method. One of disadvantages site 4 is high level groundwater, which caused this alternatives take low score in TOPSIS method. One of advantages site 2 is high extent this site relative to other sites that in this status either can perform landfill construction or combustion plant construction.

Field checks is performed from current burial site showed that this site isn't located in suitable status point of view parameters such as soil texture, soil depth, slope, availability of fine grain, landuse, elevation difference relative to city and distance from city center. Also point of views performance operation firstly didn't perform any preparation in this status before from exploitation and wastes relieve without any preservative. Secondly now that this site is in exploitation stage doesn't observe sanitary actions such as covering of daily wastes with soil, spraying poison to burial area and fencing of burial site. Thus with existence this critical condition will create serious environmental problems in future. Site offered in this study point of views geological, environmental and economical of criteria is located in site better relative to current burial site. Thus with constructing a landfill sanitary- engineering in this site can implement effective project from programs of Ardebil municipal waste management.

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